PALYNOFACIES ANALYSIS OF MIDDLE JURASSIC SEDIMENTS FROM THE INNER HEBRIDES

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Declaration

I hereby certify that this work is my own, except where otherwise acknowledged, and that it has not been submitted previously for a degree at this, or any other university

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Well, I think that's about it, if I've forgotten to mention anybody I should have please feel free to pencil your name in the space provided below.

Abstract

A quantitative palynofacies study of thermally immature Middle Jurassic sediments of Skye, Raasay, and Eigg has been undertaken in order to examine kerogen and palynomorph distributions in relation to various potential controlling factors (lithology, lithofacies, depositional environment, sequence stratigraphy). This has involved performing rigorous kerogen and palynomorph counts on 440 samples from 12 localities (average sampling density 5 per metre in sampled sections), supported by 250 TOC and 57 'Rock-Eval' pyrolysis analyses.

The facies of the Middle Jurassic sediments of the Inner Hebrides range from subtidal marine to freshwater alluvial mudflats. The succession is divided into three major units: the Bearreraig Sandstone Formation (Aalenian-Bajocian) which is 400m thick, and represents the deposition of tidal-subtidal sand sheets, the ?Bathonian Great Estuarine Group (250m thick) which represents a range of mostly lagoonal-deltaic freshwater to hypersaline facies, and finally the Staffin Bay Formation (lower-middle Callovian; thickness 18m) which represents a transgressive lagoon-barrier bar complex.

The extent of lithological control on assemblages has been established by comparing parameter values in different lithologies to the palynological 'norm' of shale, and by the use of discriminant function analysis (DFA). The former approach has shown that lithological effects can be identified even when changes in lithology are only subtle (e.g. shale to silty shale); the high overall classification accuracies obtained from DFA support a strong lithological control. The dominant lithology of sections has also been shown to strongly affect kerogen assemblages; shales from sand-dominated intervals have reduced %AOM and increased %phytoclasts; the DFA overall classification accuracies suggest that dominant lithology may actually exert a stronger control on kerogen assemblages than does lithology.

The nature of other potential controlling factors has also been established using DFA, together with cluster and factor analysis, and this has been combined with visual examination of stratigraphic variation in individual parameters. These results suggest that proximal-distal variation is the strongest single control on assemblage composition, with variations in palaeosalinity showing increased importance 'locally' in the Lealt Shales and Duntulm formations. The DFA results suggest that the formations are the most distinct (of any) subdivisions of the succession present. In most cases the kerogen variables are better at distinguishing the different subdivisions of the succession, but the environment classification of Hudson and Harris (1979) is best distinguished by the variables derived from the palynomorph counts. Sequence stratigraphic changes are best reflected in the black equant:lath shaped wood ratio, which shows an increase in equant particles through regressive cycles, and an increase in laths over transgressive boundaries.

The detailed subdivision of the phytoclast group has permitted the calculation of a phytoclast preservation index (PPI) which summarises the overall degradation state of the phytoclast assemblage for each sample. The highest PPI values (= most refractory phytoclast assemblages) are found in the mudflat-alluvial facies of the Skudiburgh Formation, lowest PPI values, reflecting 'fresh' phytoclast input, are found in the transgressive Staffin Bay Formation.

The TOC values are generally <2.5%, but reach up to 3-4% in parts of the Dun Caan Shales Member (Bearreraig Sandstone Formation) and the Lonfearn Member (Lealt Shales Formation), and 6-8% in the Upper Ostrea Member (Staffin Bay Formation). Hydrogen Index (HI) values mostly fall below 300 (organic facies C or CD), but are increased in parts of the Lonfearn and Upper Ostrea members (400-500, organic facies B), and particularly in the Kilmaluag Formation where values of over 800 are found (= organic facies AB). The correlation between the optical and geochemical data varies from very poor to very good. In some cases TOC is correlated with %AOM, and also %*Botryococcus*. Multiple regression on the HI suggests that in most cases %AOM is the variable best correlated with the HI; this procedure has allowed the calculation of a predicted HI value for all 440 samples.

Preface

The palynofacies technique has been used extensively in the discrimination and subdivision of siliciclastic reservoir sequences of the UK onshore and North Sea, and its use looks set to continue with the increasing industrial demand for quantitative palynofacies data. In order to critically evaluate the potential of the palynofacies technique in studies of Middle Jurassic siliciclastic facies, two complementary Ph.D. investigations have been undertaken in the Fossil Fuels and Environmental Geochemistry (Postgraduate Insitute), Newcastle-upon-Tyne (the other by Adrian Piper). This particular study concerns the Middle Jurassic sediments of the Inner Hebrides. The Middle Jurassic was chosen because it is coeval with the Brent reservoir sequence of the North Sea and similar sequences from other offshore basins which have recently been assessed for their hydrocarbon potential. The Inner Hebrides sequence has been used because the stratigraphic control is good, and the sediments have been extensively studied in terms of their sedimentology, palaeontology, and palaeoecology. They also present a wide range of sedimentary environments.

As used in this study, the palynofacies technique involves the quantitative examination of both the total kerogen and palynomorph distributions in the sediments studied, and their correlation with bulk organic geochemical analyses (TOC and Hydrogen Index). The kerogen and palynomorph distributions have been examined within the context of the following aims:

a) To assess the influence of sediment grain size and lithology on organic matter character.

b) To determine the inter- and intra-facies, vertical and lateral variations in organic matter assemblages with reference to depositional environment, lithofacies, palaeosalinity, proximal-distal variation, and sequence stratigraphic controls.

c) To investigate the extent and nature of the correlation between the optical and geochemical data.

d) To determine the usefulness of multivariate statistical techniques in the interpretation of quantitative palynofacies data.

e) To assess the relative usefulness of total kerogen versus palynomorph data, and the relative resolution achievable with each.

f) To determine the extent to which the palynofacies results agree with previous interpretations of the sediments studied.

g) To provide an assessment of the potential usefulness of the palynofacies technique in sub-surface reservoir studies.

This thesis has been arranged into eleven chapters. The first three describe the area under study and present the methods used, while the next seven present the results. The first two results chapters consider the effect of lithology and trends in the mean values (which give a general overview of the dataset). The next two deal with particular aspects of the data (geochemistry and phytoclast preservation index). These are followed by two chapters dealing with multivariate statistical analysis of the data. In the penultimate chapter the palynofacies data is examined in a stratigraphic context, while the concluding chapter reviews the main findings in terms of the aims stated above.

CONTENTS

CHAPTER 1.0
INTRODUCTION

1.0 INTRODUCTION

The distribution of organic matter in sedimentary rocks results from interaction between the biosphere and geosphere, the study of this material requires an understanding of:

a) The environmental controls which govern the production of organic matter in the biosphere.
b) The ecological and sedimentological processes which control the distribution and decomposition of organic matter.
c) The biogeochemical and geomicrobiological factors which influence the preservation of organic matter.
d) The geochemical and physical processes which determine the modification of organic matter during its incorporation into the geosphere.
(after Tyson, 1995)

These factors result in a complex interrelationship between the origin, transport and deposition of organic particles (Traverse, 1994; Fig. 1.1). The study of this sedimentary organic matter therefore requires a multidisciplinary approach, perhaps more so than many other areas of earth science (Tyson, 1995).

In this study transmitted light microscopy and bulk organic geochemical methods (Table 1.1) have been used to characterise the particulate organic matter present in sedimentary rocks from the Middle Jurassic of the Inner Hebrides (section 1.3). The main emphasis of this work is palaeoenvironmental, but where appropriate hydrocarbon source rock potential has been discussed.

Microscopy	Geochemistry
Transmitted light	Total Organic Carbon (TOC)
Incident blue light fluorescence	'Rock-Eval' pyrolysis

Table 1.1. *Analytical techniques used in this study.*

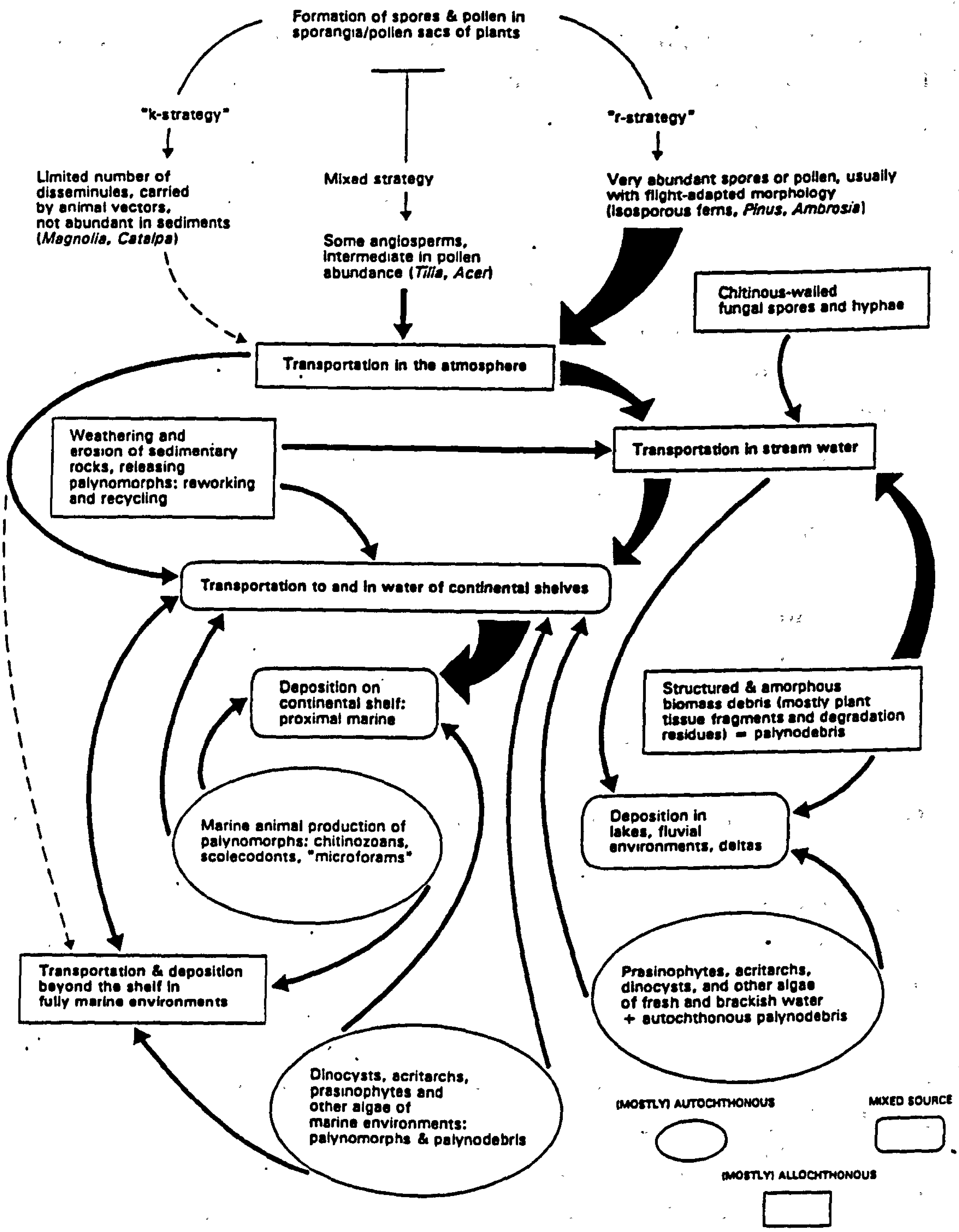


Fig. 1.1. *The complex origin, transportation and deposition of robust organic particles. The size of the arrows indicates the approximate relative magnitude of particle movements (taken from Traverse, 1994).*

1.1 Palynofacies

The term palynofacies was first introduced by Combaz (1964) in order to describe the palynological study of the total assemblage of particulate organic matter contained in a sediment following the removal of the sedimentary matrix by hydrochloric and hydrofluoric acid. Prior to this palynology was exclusively concerned with the study of palynomorphs (discrete organic walled microfossils) for biostratigraphic and palaeobotanical applications. Subsequently it was realised that the character of the total organic matter assemblage could be used to determine the depositional environment and the type of hydrocarbons that would be expelled from the rock on thermal maturity (Tyson, 1995).

Tyson (*ibid.*, p.3) states that palynofacies analysis involves the identification of the individual particulate components, assessment of their absolute and relative proportions, and their size and preservation states. He (p.4) defines palynofacies analysis as:

> *" The palynological study of depositional environments and hydrocarbon source rock potential based upon the total assemblage of particulate organic matter."*

Individual palynofacies units are defined as:

> *" A body of sediment containing a distinctive assemblage of palynological organic matter thought to reflect a specific set of environmental conditions, or to be associated with a characteristic range of hydrocarbon generating potential."*

Some workers have defined palynofacies purely in terms of palynomorph assemblages (e.g. Traverse, 1988). Traverse (1994) suggests that the term 'palynolithofacies' be employed if the palynological organic matter is used to indicate information about the enclosing rock, and 'palynobiofacies' used to describe the relationship between the palynomorph (and palynological organic matter?) assemblage and the biosphere. The combined term 'palynobiolithofacies' is suggested for the results of studies where the goals are elucidation of the enclosing rock and the biosphere association from which the palynomorphs are derived. In this study the definitions of Tyson (1995) have been used throughout.

1.2 Organic facies

The organic facies concept resulted from the integration of microscopy and bulk organic geochemical methods, particularly relating to the prediction of the likely occurrence of hydrocarbon source rocks as a function of depositional environment (e.g. Jones, 1987). Jones (*ibid.*, p.2) defines an organic facies as:

> *" A mappable subdivision of a designated stratigraphic unit, distinguished from the adjacent subdivisions on the basis of the character of its organic constituents, without regard to the inorganic aspects of the sediment. "*

Tyson (1995, p.5) defines an organic facies as:

> *"A body of sediment containing a distinctive assemblage of organic constituents which can either be recognised by microscopy, or is associated with a characteristic bulk organic composition. "*

These definitions show that the organic facies concept is very similar to the palynofacies concept, but lacks the reference to a specific methodology or analytical technique. Palynofacies assemblages can therefore be viewed as palynologically defined organic facies (Tyson, 1995; e.g. Habib, 1982). Tyson (*ibid.*) considers palynofacies analysis the single most discriminating technique for characterising organic facies due to the direct nature of the observation of what is in the sediment, and the increased number and diversity of parameters that can be generated from palynofacies data compared with bulk organic geochemical techniques. This allows the analysis of more detailed and subtle variations in the environment of deposition and organic matter source and preservation (Tyson, 1995). Therefore, if organic facies units are defined by bulk organic geochemical techniques there can be significant variation in palynofacies assemblages within these individual units. In this study the term organic facies has been used only where the results of microscopy and bulk organic geochemistry have been combined in order to define the organic facies *sensu* Jones (1987). This avoids confusion with the palynofacies which have been defined using microscopy only and the kerogen Types which have been defined using 'Rock-Eval' pyrolysis.

1.3 Geological background and previous research

The Mesozoic sediments of the Inner Hebrides rest unconformably on Precambrian or Palaeozoic basement and are overlain by Cenozoic lavas; they are also cut by Cenozoic volcanic intrusions (Hudson, 1983). The Jurassic succession is around 1000m thick and is of varied lithology, with silty shales and sandstones predominating over limestones and shales. Much of the sequence can be correlated with the standard ammonite zones recognised in England and Northwest Europe (Cope *et al.*, 1980; Hudson, 1983). The Middle Jurassic is around 500m thick and consists of three major divisions: The Bearreraig Sandstone Formation, The Great Estuarine Group, and The Staffin Bay Formation. The overlying Staffin Shale Formation begins in the middle Callovian but is mostly Upper Jurassic in age (Hudson, 1983; Table 1.2).

1.4 Structure

The Hebrides Basin formed part of an extensive system of fault controlled Mesozoic basins developed on the Eastern Atlantic continental margin between the Lusitanian Basin of Portugal and the East Greenland Basin. These basins, now isolated, have a common tectonic history, and evolved in an extensional tectonic setting during a rifting phase in the North Atlantic (Morton, 1992a). The Hebrides, Celtic Sea, Porcupine, and West of Shetland basins all have common features, particularly during the Upper Triassic to Middle Jurassic (Morton, 1987, 1989, 1990a, 1992a, 1992b); Figure 1.2 shows that each is characterised by two episodes of a three phase evolution of i) extension (late Triassic-early Sinemurian and latest Toarcian-late Bajocian), ii) subsidence (mid Sinemurian-earliest Toarcian and late Bajocian-late Bathonian), and iii) stability (Toarcian and late Bathonian-Callovian). This common history also extends to the basins of the northern North Sea which formed part of the Atlantic rift system (Morton, 1992a; see Morton *et al.*, 1987 for a detailed review of the latter basins).

Age	Thickness	Lithostratigraphy	Facies
Bathonian-Callovian	8-18m	Staffin Bay Formation	Transgressive shallow marine
Bathonian	137-264m	Great Estuarine Group	Paralic; lagoonal-deltaic
Aalenian-Bajocian	38-488m	Bearreraig Sandstone Formation	Shallow marine sand sheet

Table 1.2. *Middle Jurassic lithostratigraphy and facies.*

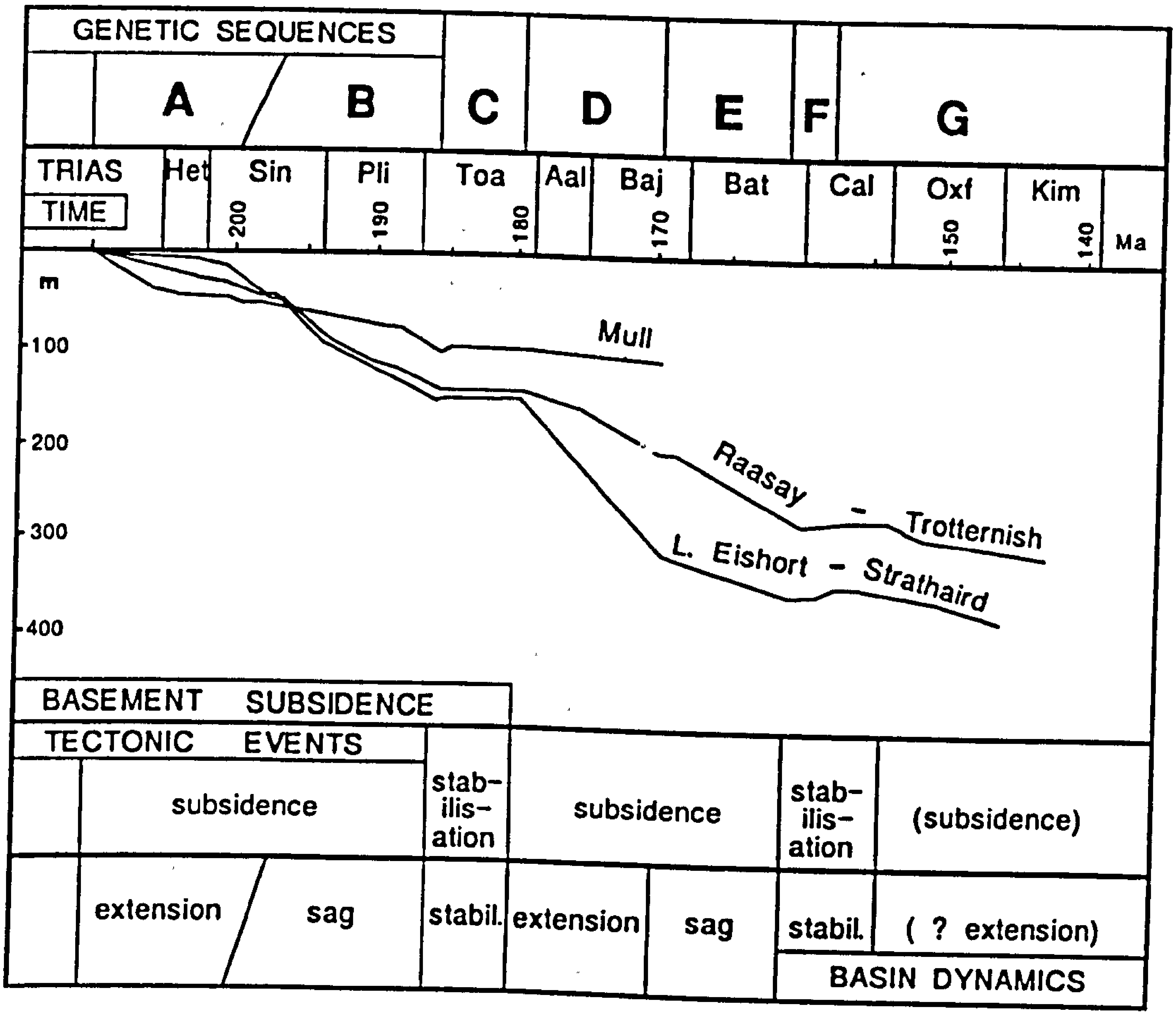


Fig. 1.2. *Tectonic phases in the evolution of the Hebrides Basin. The genetic sequences relate to those discussed in section 1.9, D, E and F represent the Middle Jurassic units examined in this work; D = Bearreraig Sandstone Formation, E = Great Estuarine Group, F = Staffin Bay Formation (taken from Morton 1992b).*

1.5 The Hebrides Basin

The Hebrides basin is a north-south oriented half graben some 50-60 miles wide. It is bounded on its western margin by the Minch Fault Zone, but its eastern margin is unfaulted and lies near the coastline of the present day mainland of Scotland (Morton *et al.,* 1987; Morton, 1992b). Internally the basin is divided by the Camasury-Skerryvore Fault into the Sea of the Hebrides Block to the north and the Inner Hebrides Block to the south (Morton *et al.,* 1987; Morton, 1992b; Fig. 1.3). The effect of this fault, and the associated potential structural high (the 'mid Skye palaeohigh') during the Middle Jurassic is controversial. Binns *et al.* (1975) first identified the structure and used it to divide the Hebrides Basin into two half graben basins, the Sea of the Hebrides Basin and the Inner Hebrides Basin; subsequent work on Triassic palaeogeography (Steel 1977), and the Great Estuarine Group (Andrews, 1985; Harris, 1989; Andrews & Walton, 1990; Harris, 1992) has generally supported this division. However, Hudson (1980) states that during the transgressive argillaceous episodes within the Great Estuarine Group the Inner Hebrides behaved as a single Minch Basin. Morton *et al.,* (1987) and Morton (1992b) state that movement on the Camasury Fault was mainly post-Jurassic and that the Hebrides Basin acted as one unit during Middle Jurassic sedimentation, although there may have been some fault activity during the Aalenian-Bajocian that affected the depositional style of the sandstones (Morton, 1983); the latter evidence was used by Andrews and Walton (1990) to support the 'two basin' hypothesis (see Morton, 1992b and Harris, 1992 for detailed discussion of both theories). It should be noted that the 'mid-Skye palaeohigh' was not a source of sediment during the Middle Jurassic (Harris, 1992), and was probably just a more slowly subsiding area (Harris 1989); what is certain is that Mesozoic sediments do thin over this mid-Skye area (A.Stein pers.comm. *in* Harris, 1992).

1.6 Palaeogeography and Sediment Provenance

The palaeogeography of the Inner Hebrides area has been established for some time. Hudson (1964) showed the presence of two source areas for siliciclastic sediment supplied to the Hebrides Basin during the Middle Jurassic. To the east, in the area now occupied by the Scottish mainland, there was a positive area of Moine and Dalradian cover capped by a regolith of Old Red Sandstone, and to the west there was a less well defined source terrane of Lewisian Gneiss (now the Outer Hebrides; Fig. 1.3). Subsequent work by Harris (1992) on the ?Bathonian Valtos Formation has confirmed

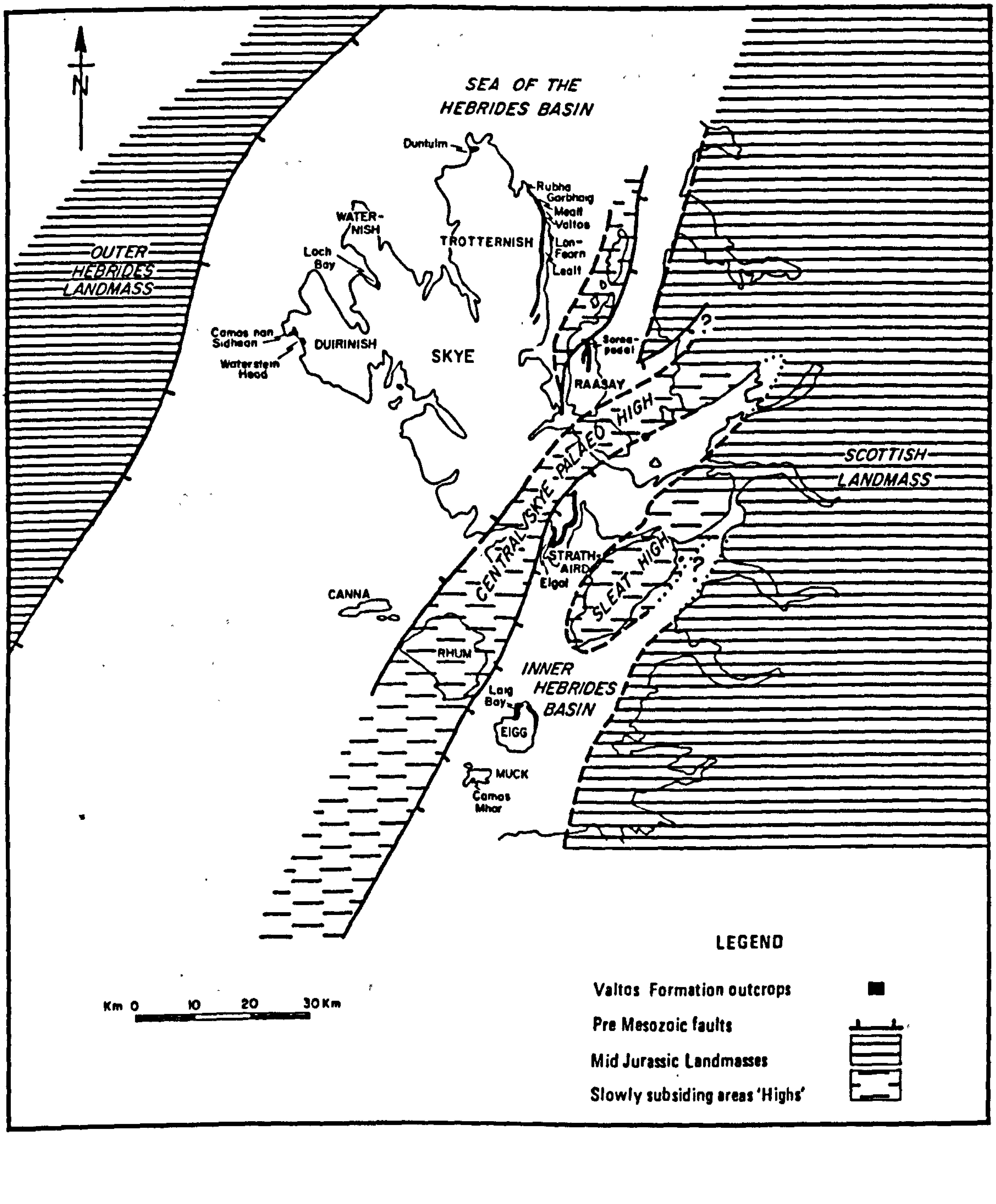


Fig. 1.3. *Structure and general palaeogeography of the Hebrides Basin (taken from Harris 1992).*

this hypothesis, with the identification of a garnet-poor, staurolite- and rutile-rich mineral assemblage in Inner Hebrides Basin sediments, indicating a significant, but indirect, contribution from the Dalradian of the Scottish Highlands, and an assemblage dominated by green epidote in the sediments of west Skye (Sea of the Hebrides Basin) suggesting supply from the Outer Hebrides landmass. Harris also identified a second garnet-rich assemblage from the Sea of the Hebrides Basin, indicating a greater contribution from Moinian rocks, probably sourced from the Scottish landmass, and he interpreted this as indicating the presence of two distinct hinterland areas in this Scottish Highlands region (Harris, 1992, his Fig. 19).

This palaeogeographical framework apparently only showed limited changes through the Middle Jurassic time period. Immediately prior to the Middle Jurassic the mid-Toarcian palaeogeographical map (Fig. 1.4a) shows the Hebrides Basin area has open marine connections to the north and south, and there is an open seaway between Ireland and Britain (Bradshaw *et al.*, 1992). Bradshaw *et al.* (*ibid.*) show that the palaeogeography was very similar through the Aalenian and Bajocian stages, with the Hebrides and North Minch Basins probably connected and with an open marine connection to the Donnegal basin (to the northeast of present day Ireland) in the south (Fig. 1.4b). Figure 1.4c shows that by the mid-Bathonian the newly-emergent 'Rubh Reidh Ridge' formed the northern boundary of the Hebrides Basin, separating it from the North Minch Basin, and the connection to the Donnegal Basin had probably been reduced to a narrow and shallow portal in Lealt Shale Formation times (Bradshaw *et al.*, 1992). The late-Bathonian regressive phase (Kilmaluag and Skudiburgh Formations) resulted in much of the Hebrides Basin being isolated from the sea to the south; the Rudh Reidh Ridge continued to provide the northern boundary (Fig. 1.4d). The Early Callovian transgession re-established the pre-Middle Jurassic (mid-Toarcian) palaeogeography of the area with marine connections to the North Minch and Donnegal Basins and the re-opening of the seaway between Ireland and Britain (Fig. 1.4e).

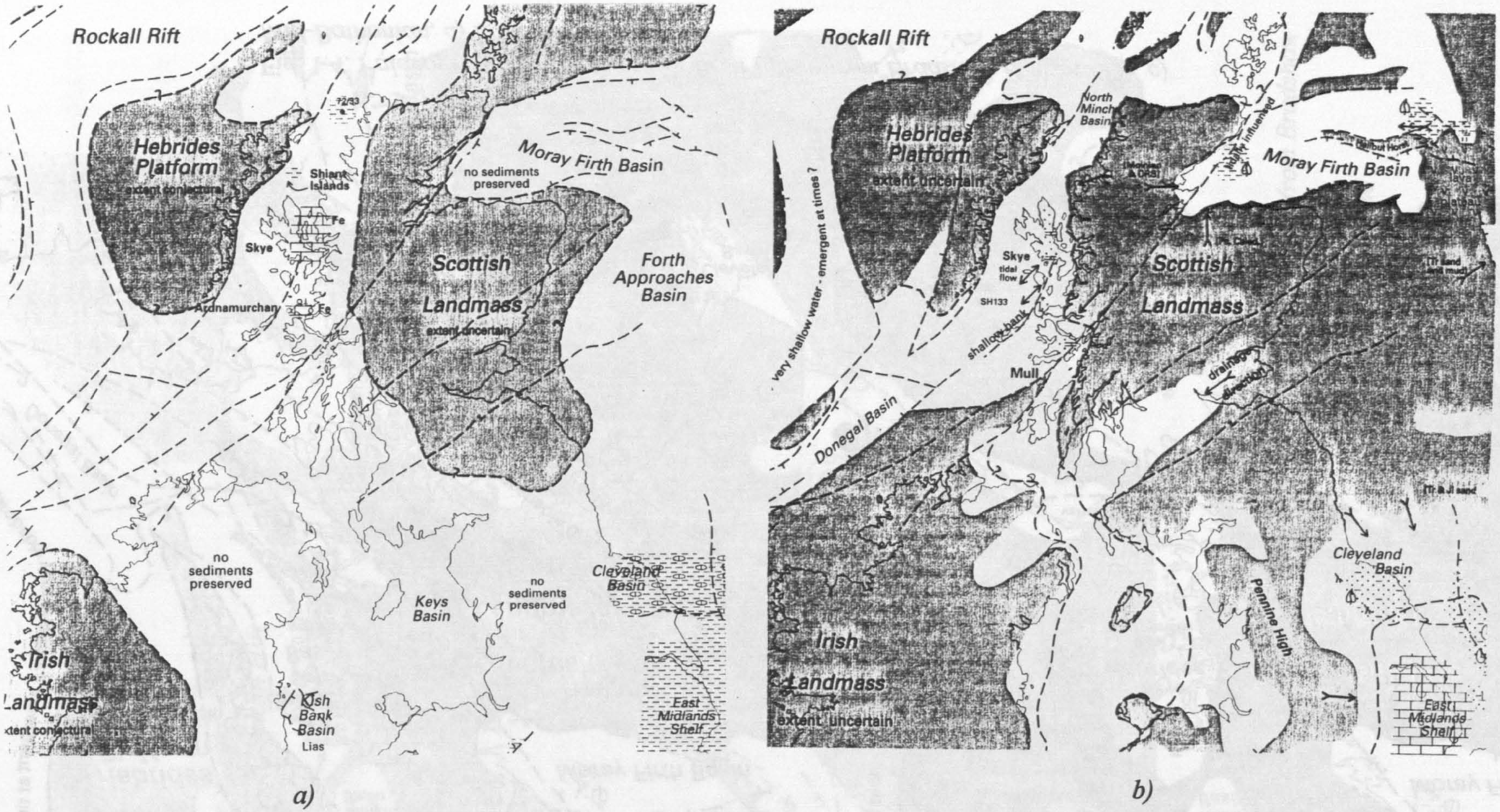


Fig. 1.4. *Palaeogeography of the study area (taken from Bradshaw* et al.*, 1992). a) Mid-Toarcian, b) Early Bajocian.*

Fig. 1.4. *Palaeogeography of the study area (taken from Bradshaw* et al.*, 1992). c) Mid-Bathonian, d) Late Bathonian.*

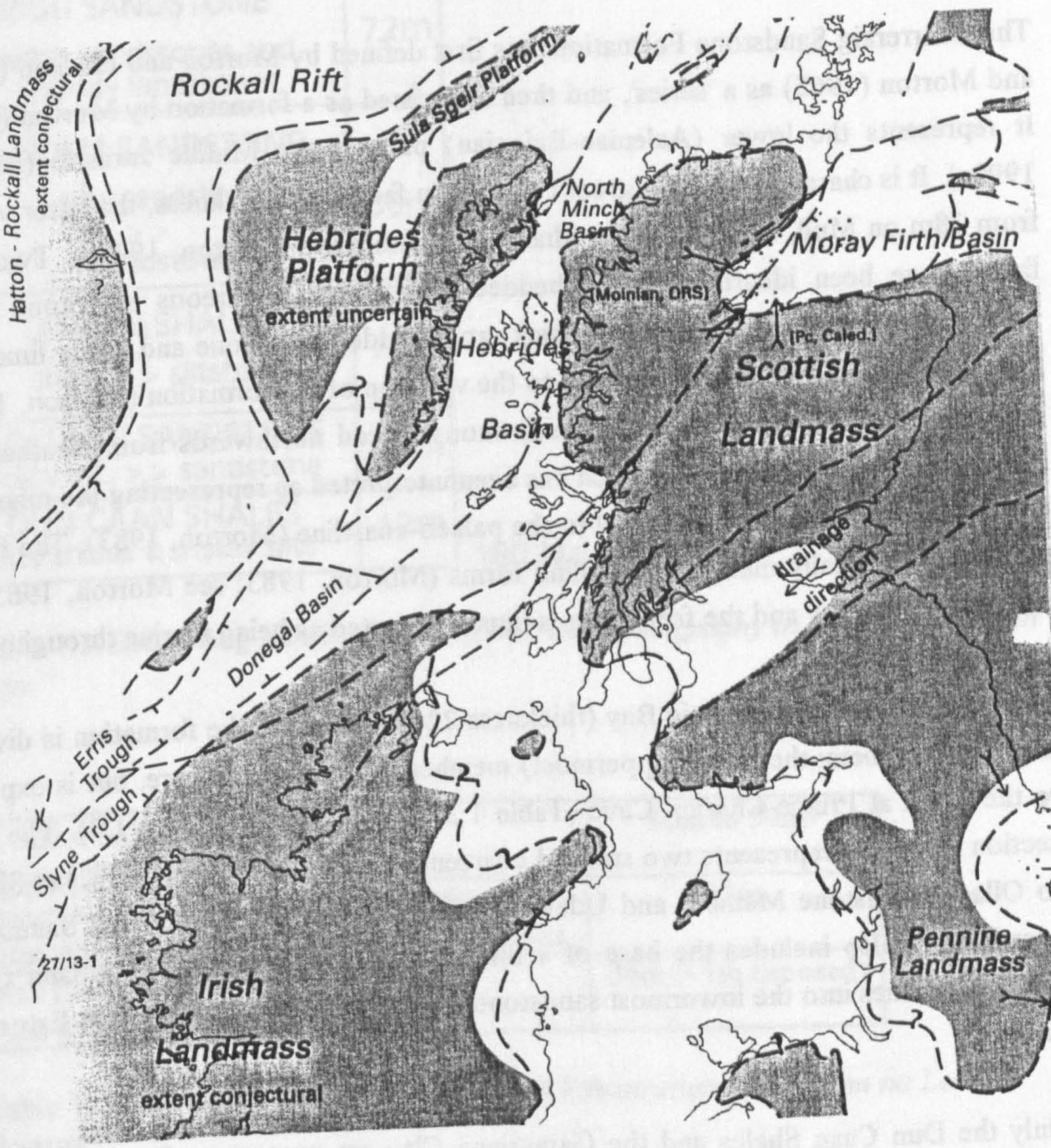


Fig. 1.4e. *Early Callovian palaeogeography of the study area (taken from Bradshaw* et al., *1992).*

1.7 Lithostratigraphy

1.7.1 The Bearreraig Sandstone Formation (BSF)

The Bearreraig Sandstone Formation was first defined by Morton and Hudson (1964), and Morton (1965) as a 'series', and then re-defined as a formation by Morton (1976). It represents the lower (Aalenian-Bajocian) part of the Middle Jurassic (Morton, 1990a). It is characterised by a great variation in facies and thickness, the latter varying from 38m on Mull, to 488m in Strathaird on south Skye (Morton, 1990a). Two main facies have been identified: a flat-bedded to massive calcareous sandstone facies interbedded with silty shales, and a thick cross bedded sandstone and sandy limestone facies; a third shale facies is restricted to the very top of the formation (Hudson, 1983). The second of the facies shows a diachronous spread northwards from Strathaird to Raasay and south Trotternish, which has been interpreted as representing the migration of tidal sand waves running parallel to the palaeo-coastline (Morton, 1983). The fossils present are typically marine stenohaline forms (Morton, 1983; see Morton, 1965, for taxonomic details), and the formation is thus interpreted as being marine throughout.

The type section is Bearreraig Bay (thickness 220m) at which the formation is divided into five members; the sixth, (uppermost) member is not exposed here, but is exposed to the south at Prince Charles' Cave (Table 1.3, Fig. 1.5, Plates 1.1 to 1.3). The type section (Fig. 1.6) represents two stacked coarsening-upwards cycles (Dun Caan Shales to Ollach Sandstone Member and Udairn Shales to Holm Sandstone/Rigg Sandstone Member); it also includes the base of a third cycle marked by the Garantiana Clay, which continues into the lowermost sandstone (Elgol) formation of the Great Estuarine Group.

Only the Dun Caan Shales and the Garantiana Clay are present on Raasay, the Dun Caan Shales being overlain by the Beinn na Leac Sandstone followed by the Raasay Sandstone at the type section, Beinn na Leac (Morton, 1976; Table 1.4 & Fig. 1.5).

GARANTIANA CLAY shaley clay	2m	169 Ma
RIGG SANDSTONE muddy sandstones and sandy limestones	72m	
HOLM SANDSTONE silty sandstone >> sandstone	36m	
UDAIRN SHALES shale >> siltstone	72m	
OLLACH SANDSTONE silty Lst. >> sandstone	16m	
DUN CAAN SHALES silty shales & shaley silts	12m	180 Ma

Table 1.3. *Bearreraig Sandstone Formation lithostratigraphy in Trotternish, north Skye.*

RAASAY SANDSTONE MEMBER Cross-bedded sandstone	Seen to 50m+
BEINN NA LEAC SANDSTONE MEMBER Interbedded sandy limestones and silty shales	21m
DUN CAAN SHALES MEMBER Dark grey silty shales	36m (<1m exposed)

Table 1.4. *Bearreraig Sandstone Formation lithostratigraphy, Beinn na Leac, Raasay.*

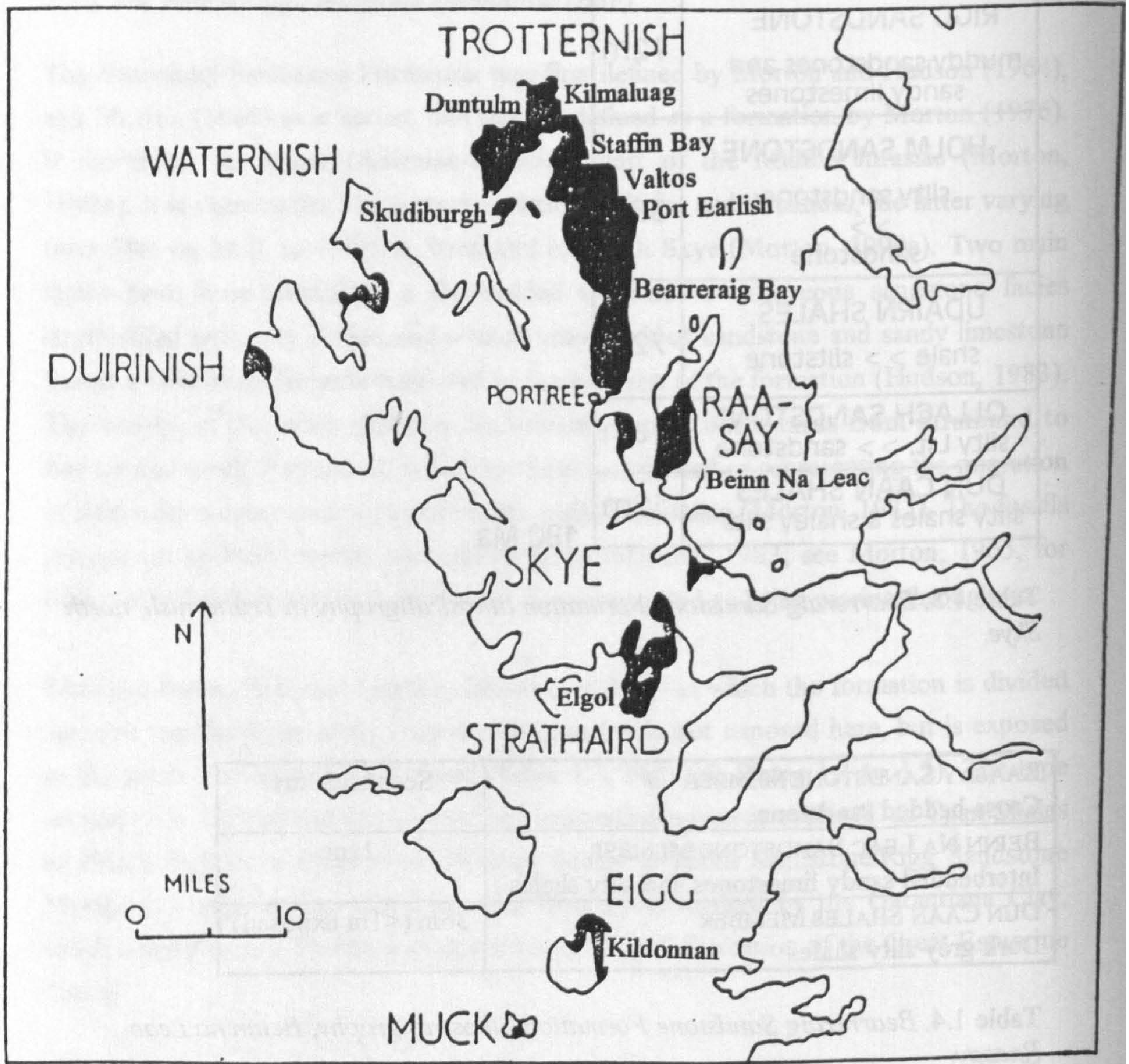


Fig. 1.5. *Distribution of Middle Jurassic rocks of the Inner Hebrides with type section localities mentioned in the text (adapted from Morton 1965; Harris & Hudson 1980).*

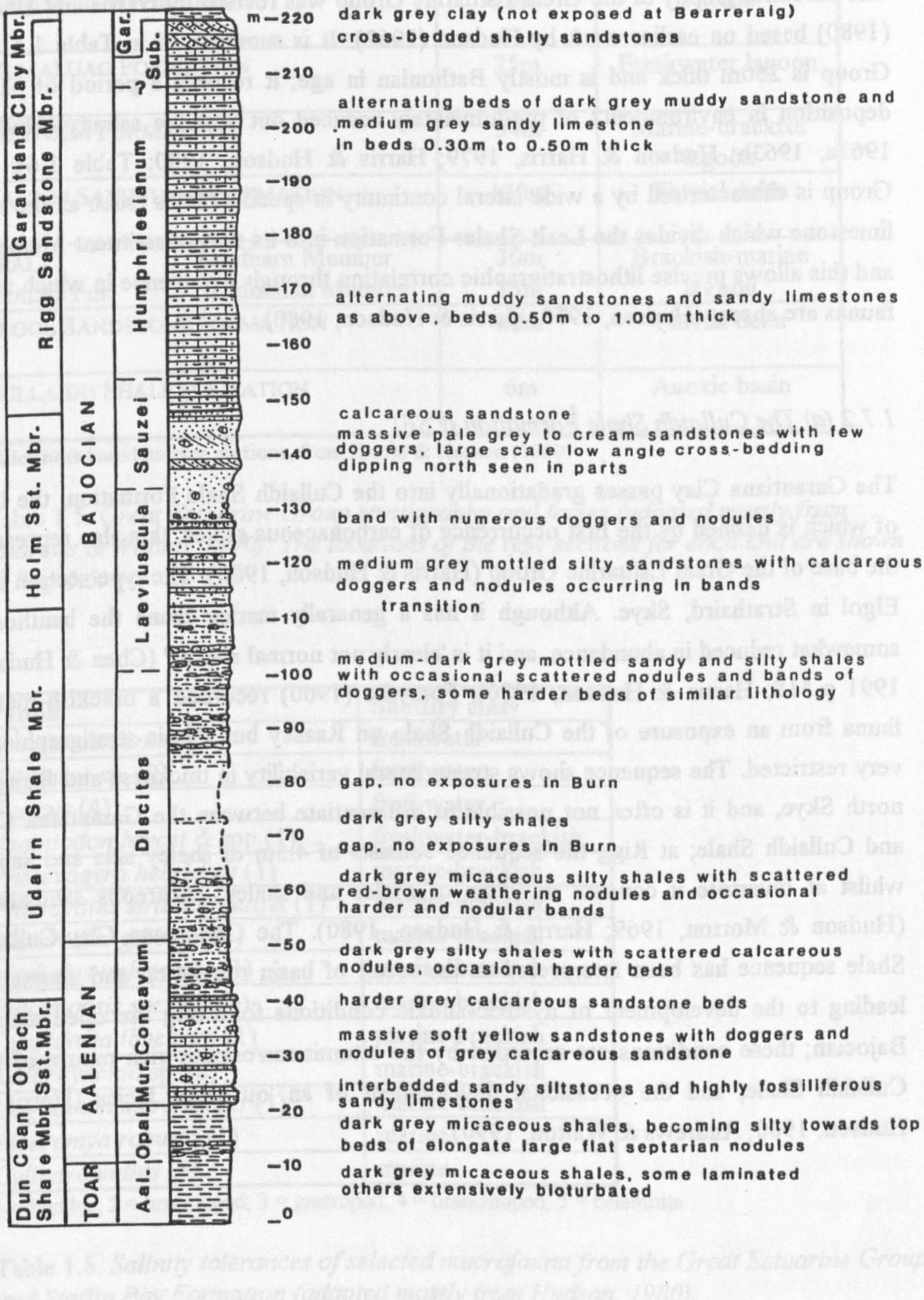


Fig. 1.6. *Schematic log of the Bearreraig Sandstone Formation type section (taken from Morton, 1992a).*

1.7.2 The Great Estuarine Group (GEG)

The lithostratigraphy of the Great Estuarine Group was revised by Harris and Hudson (1980) based on earlier work by Hudson (1962). It is summarised in Table 1.5. The Group is 250m thick and is mostly Bathonian in age; it records a period of paralic deposition in environments of predominately reduced but variable salinity (Hudson, 1963a, 1963b; Hudson & Harris, 1979; Harris & Hudson, 1980; Table 1.6). The Group is characterised by a wide lateral continuity in specific facies (such as the algal limestone which divides the Lealt Shales Formation into its two constituent Members) and this allows precise lithostratigraphic correlation through a sequence in which zonal faunas are absent (Hudson, 1970; Harris & Hudson, 1980).

1.7.2 (a) The Cullaidh Shale Formation (CSF)

The Garantiana Clay passes gradationally into the Cullaidh Shale Formation, the base of which is defined by the first occurrence of carbonaceous shales; this also represents the base of the Great Estuarine Group (Harris & Hudson, 1980). The type section is at Elgol in Strathaird, Skye. Although it has a generally marine fauna the benthos is somewhat reduced in abundance, and it is 'clearly not normal marine' (Chen & Hudson, 1991 p.518; Harris & Hudson, 1980). Forsythe (1960) recorded a brackish-marine fauna from an exposure of the Cullaidh Shale on Raasay but this is stratigraphically very restricted. The sequence shows strong lateral variability in thickness and facies in north Skye, and it is often not possible to differentiate between the Garantiana Clay and Cullaidh Shale; at Rigg the sequence consists of 4.5m of shaley silts and sands, whilst at Invertote it consists of 95cm of shales and shaley calcareous sandstones (Hudson & Morton, 1969; Harris & Hudson, 1980). The Garantiana Clay-Cullaidh Shale sequence has been interpreted as the result of basin restriction and stagnation leading to the development of dysoxic-anoxic conditions following the open marine Bajocian; these conditions are recorded by the bituminous/organic-rich nature of the Cullaidh Shale, and the occasional development of an 'oil shale' facies (Harris & Hudson, 1980; Andrews & Walton, 1990).

Formation		Thickness	Facies
SKUDIBURGH FORMATION		16m	Fluvial
KILMALUAG FORMATION		25m	Freshwater lagoon
DUNTULM FORMATION		54m	Marine-brackish lagoon
VALTOS SANDSTONE FORMATION		120m	Fluvial delta
LEALT SHALES Fm.	Lonfearn Member Kildonnan Member	30m 23m	Brackish-marine lagoon
ELGOL SANDSTONE FORMATION		22m	Fluvial delta
CULLAIDH SHALE FORMATION		6m	Anoxic basin

Thickness based on type sections, from Harris & Hudson (1980)

Table 1.5. *Great Estuarine Group stratigraphy and facies (adapted mostly from Andrews & Walton, 1990). The locations of the type sections for each unit are shown in Fig. 1.5.*

Fauna	Salinity class
Unio andersoni (1)	freshwater
Viviparus sp. (3)	freshwater
Cyzicus (4)	freshwater
Neomiodon brycei & spp.(1)	freshwater-brackish
Praeexogyra hebridica (1)	marine-brackish
Praemytilus strathairdensis (1)	marine-brackish
'Tancredia' gibbosa (1)	marine-brackish
Modiolus imbricatus (1)	marine-brackish
Placunopsis socialis (1)	marine-brackish
Cuspidaria ibbetsoni (1)	marine-brackish
Kallirhynchia sp. (2)	marine-brackish
Isognomon murchisonii (1)	marine-brackish
Pleuromya robusta (1)	marine
Cylindroteuthis (5)	marine

1 = bivalve; 2 = brachiopod; 3 = gastropod; 4 = branchiopod; 5 = belemnite

Table 1.6. *Salinity tolerances of selected macrofauna from the Great Estuarine Group and Staffin Bay Formation (adapted mostly from Hudson, 1980).*

1.7.2 (b) The Elgol Sandstone Formation (ESF)

This formation marks the first appearance of coarse siliciclastic material in the Great Estuarine Group. It consists of a 9-25m thick classic deltaic coarsening-upwards sequence, from fine argillaceous sandstone at the base to a pebbly granule conglomerate at the top. The type section is at Elgol in Strathaird, Skye (Fig. 1.7). The base is gradational to the Cullaidh Shale, the basal sands being intercalated with prodeltaic muds (Harris & Hudson, 1980). It is interpreted as representing deposition from small river deltas prograding into the confined water bodies of the Cullaidh Shale basin (Hudson, 1962, 1964; Hudson & Harris, 1979). Harris (1989) recognised three facies associations which reflect three styles of delta progradation:

i) Thick channel sands with bi-polar palaeoflow directions representing tidally influenced distributaries, with beachface sequences providing evidence of wave re-working, interpreted as a fluvial-wave-tide interaction system.
ii) A gradationally coarsening upwards sequence of structureless sands representing a gently sloping delta-front. Very fine-fine grained sand deposition due to deceleration and dispersal of buoyantly supported plumes of river water in a saline receiving basin.
iii) Elongate delta lobes interpreted as recording density controlled underflow of cold sediment laden river water below warmer fresh basin water within a friction dominated shallow water delta system.

The three facies represent delta forms in different areas: i) and ii) are from the Sea of the Hebrides Basin, in north Trotternish and south Trotternish-Raasay respectively; iii) is restricted to Strathaird in S.Skye in the Inner Hebrides Basin.

1.7.2 (c) The Lealt Shales Formation (LSF)

This formation has a composite thickness of 48m in north Skye. It separates the two main sandstone bodies within the Great Estuarine Group; its base is defined by the abrupt change to silty shales above the coarse top of the Elgol Sandstone Formation. It is divided into two members by a laterally extensive algal limestone. The lower Kildonnan Member contains a distinctive fauna dominated by *Praemytilus strathairdensis*; in the Lealt-Lonfearn area this member is 18m thick. The upper Lonfearn Member is thicker (30m) and is characterised by different faunal elements (Hudson & Harris, 1979; Harris & Hudson, 1980).

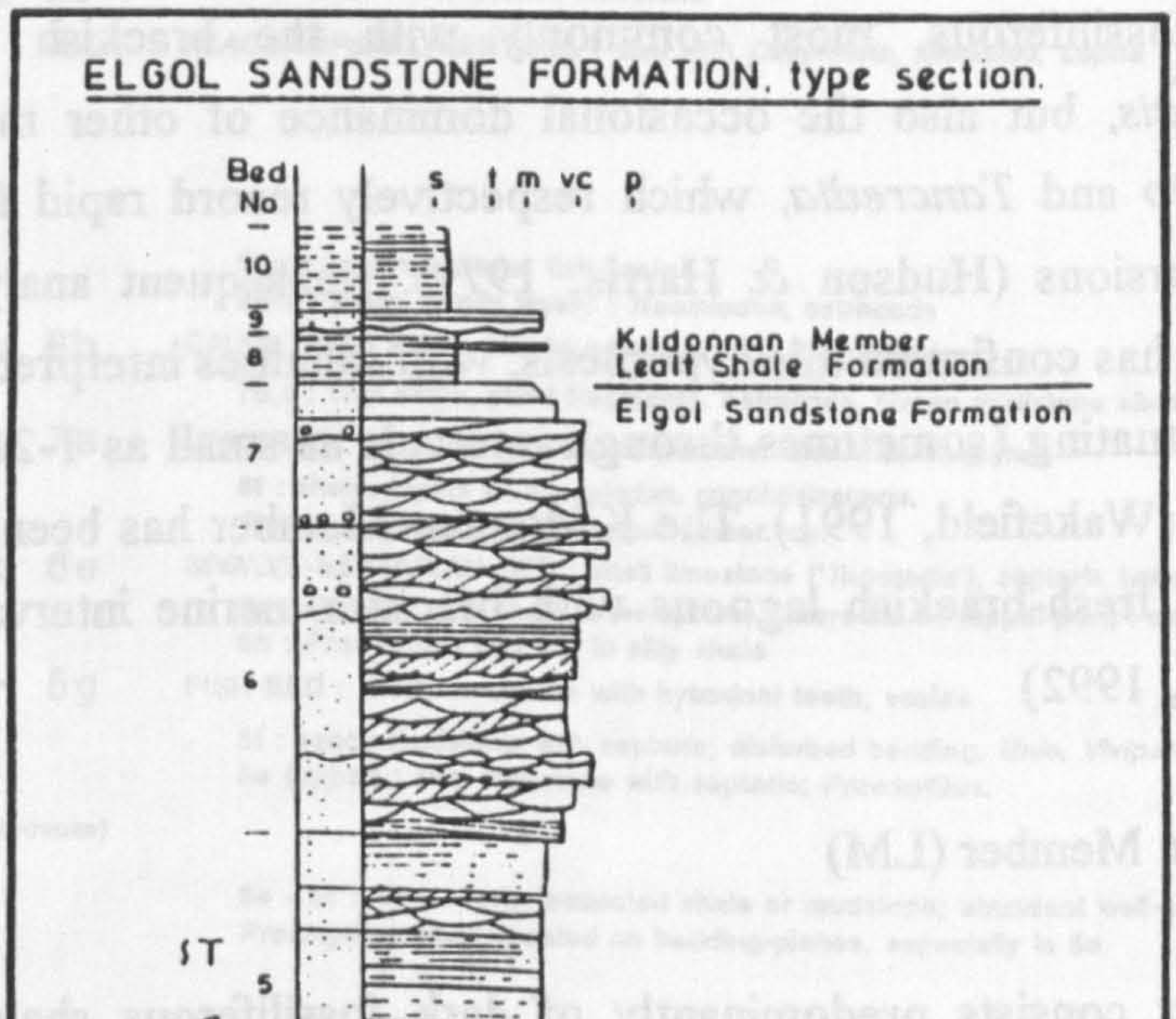


Fig. 1.7. *Sedimentary log of the type section of the Elgol Sandstone Formation (taken from Harris & Hudson, 1979).*

The Kildonnan Member (KM)

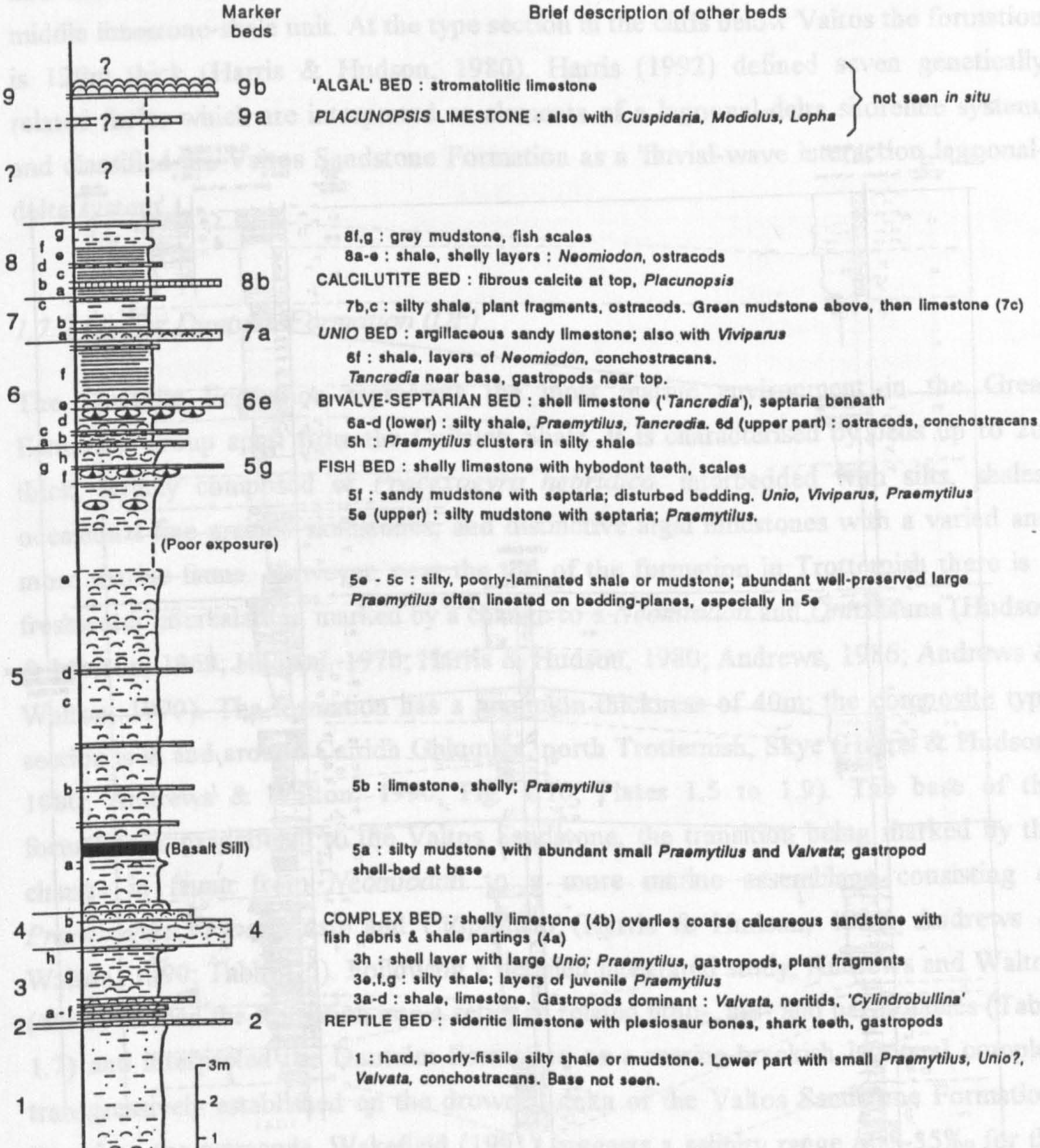
The type section on the Isle of Eigg is 23m thick and consists predominantly of silty shales with subordinate limestones, sandstones and shales (Fig. 1.8 & Plate 1.4). It is extremely fossiliferous, most commonly with the brackish bivalve *Praemytilus strathairdensis,* but also the occasional dominance of other macrofaunal elements, such as *Unio* and *Tancredia,* which respectively record rapid freshwater to marine salinity excursions (Hudson & Harris, 1979). Subsequent analysis of the ostracod assemblages has confirmed this hypothesis, with salinities interpreted as being generally low but fluctuating (sometimes through intervals as small as 1-2cm), but never rising above 18‰ (Wakefield, 1991). The Kildonnan Member has been interpreted as being deposited in fresh-brackish lagoons with brackish-marine intervals (Hudson, 1963a, 1983; Harris, 1992)

The Lonfearn Member (LM)

This member consists predominantly of dark fossiliferous shales interbedded with limestones, and has a thickness of 30m in all areas including its type section south of Port Earlish in Trotternish, Skye (Harris & Hudson, 1980; Hudson, 1983). The freshwater branchiopod *Cyzicus* and ostracods are abundant in the shales, and bivalves are also present, again recording variable but generally brackish salinities, although less variable than in the Kildonnan Member (Hudson & Harris, 1979; Hudson, 1980). Similar results have been obtained from analysis of the ostracod assemblages, which also suggest more stable salinities of generally less than 10‰ (Wakefield, 1991). The top of the member passes gradationally into the Valtos Sandstone Formation with an upward change into *Neomiodon*-bearing silts (Harris & Hudson, 1980).

1.7.2 (d) The Valtos Sandstone Formation (VSF)

This is the second major sandstone formation within the Great Estuarine Group; it is essentially rather similar to the Elgol Sandstone and consists predominantly of medium-coarse grained sandstones deposited in coarsening-upwards cycles, with subordinate limestones and silts, and characteristic large ferroan concretions (Harris & Hudson, 1980; Harris, 1992; Fig. 1.9). The fauna is dominated by monotypic occurrences of the freshwater-brackish opportunistic bivalve *Neomiodon,* interpreted as recording rapid variations in salinity (Hudson & Harris, 1979; Harris, 1992; cf. Hudson, 1963b, 1980 for a discussion of the palaeoecology of all the macrofaunal



Schematic log of the type section of the Kildonnan Member, Lealt Shale Formation, near Kildonnan, Eigg, showing bed numbers, lithology (conventional symbols) and principal fossils.

Fig. 1.8. *Sedimentary log of the type section of the Kildonnan Member, Lealt Shales Formation (taken from Hudson, unpublished).*

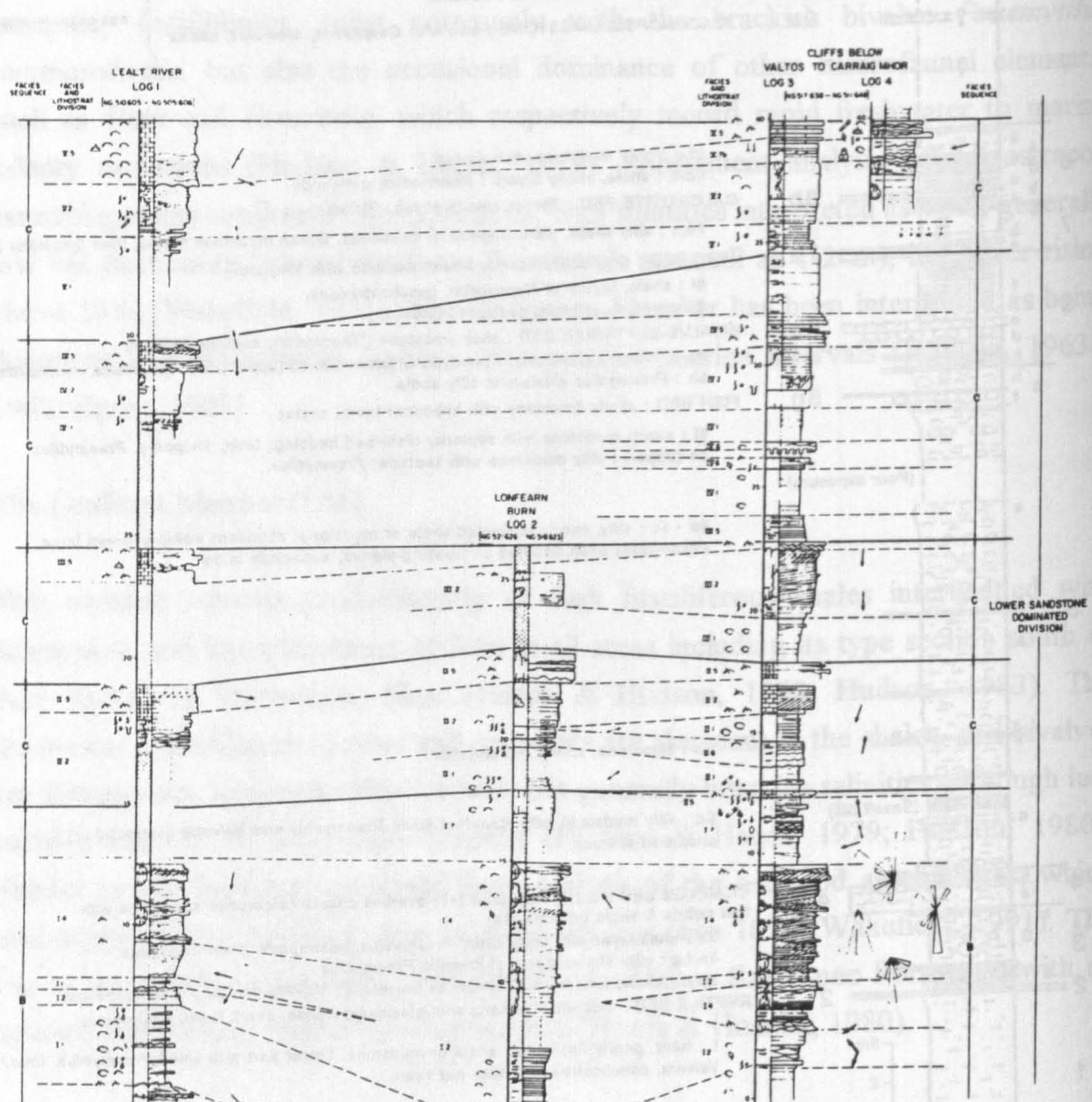


Fig. 1.9. *Sedimentary logs of sections of the Valtos Sandstone Formation (taken from Harris, 1992).*

elements found in the Great Estuarine Group). In Trotternish the formation is divided into three lithostratigraphic units, an upper and lower sandstone being separated by a middle limestone-shale unit. At the type section in the cliffs below Valtos the formation is 120m thick (Harris & Hudson, 1980). Harris (1992) defined seven genetically related facies which are interpreted as elements of a lagoonal-delta shoreline system, and classified the Valtos Sandstone Formation as a 'fluvial-wave interaction lagoonal-delta system'.

1.7.2 (e) The Duntulm Formation (DF)

The Duntulm Formation represents the most marine environment in the Great Estuarine Group apart from the Cullaidh Shale. It is characterised by beds up to 2m thick, largely composed of *Praeexogyra hebridica,* interbedded with silts, shales, occasional fine grained sandstones, and distinctive algal limestones with a varied and more marine fauna. However, near the top of the formation in Trotternish there is a freshwater intercalation, marked by a change to a *Neomiodon* and *Unio* fauna (Hudson & Morton, 1969; Hudson, 1970; Harris & Hudson, 1980; Andrews, 1986; Andrews & Walton, 1990). The formation has a minimum thickness of 40m; the composite type section is in and around Cairidh Ghlumaig, north Trotternish, Skye (Harris & Hudson, 1980; Andrews & Walton, 1990; Fig. 1.10, Plates 1.5 to 1.9). The base of the formation is gradational to the Valtos Sandstone, the transition being marked by the change in fauna from *Neomiodon* to a more marine assemblage consisting of *Praeexogyra, Placunopsis* and *Cuspidaria* (Harris & Hudson, 1980; Andrews & Walton, 1990; Table 1.6). Following a detailed integrated study, Andrews and Walton (1990) divided the formation into a series of related litho-, bio- and palynofacies (Table 1.7) and interpreted the Duntulm Formation as a marine-brackish lagoonal complex transgressively established on the drowned delta of the Valtos Sandstone Formation. Based on the ostracods, Wakefield (1991) suggests a salinity range of 5-35‰ for the main (non-Lon Ostatoin) part of the type section.

1.7.2 (f) The Kilmaluag Formation (KF)

The Kilmaluag Formation marks the start of a period of regression that resulted in the deposition of the two uppermost formations of the Great Estuarine Group (Harris & Hudson, 1980; Andrews, 1985). It is characterised by alternating calcareous mudstones and argillaceous calcilutites with common dessication cracks (Fig. 1.11); the Inner Hebrides Basin deposits also contain groups of beds with accumulations of

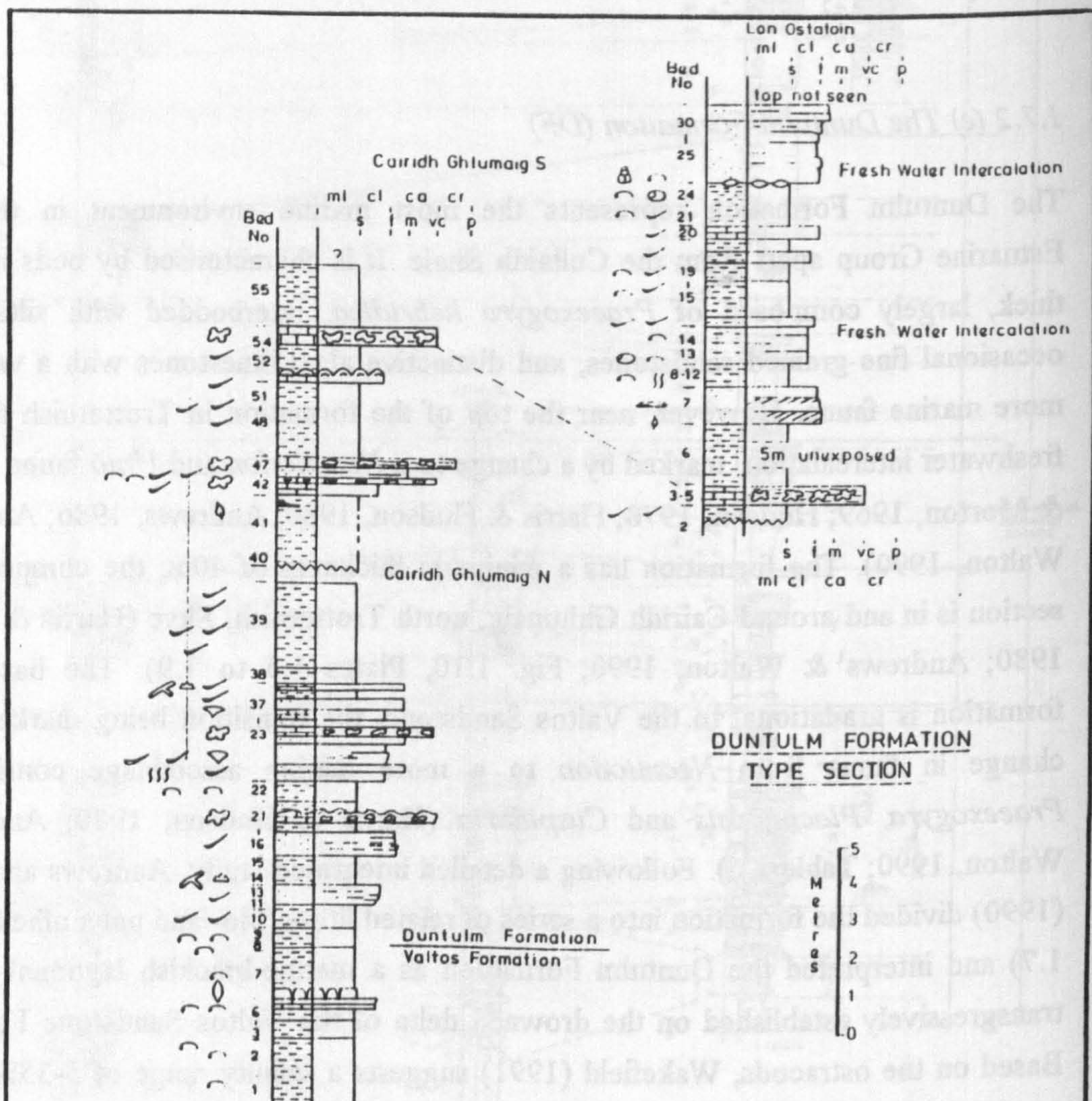


Fig. 1.10. *Sedimentary logs of the Duntulm Formation composite type section (taken from Harris & Hudson, 1980).*

Lithofacies	Biofacies	Palynofacies
1 *Praeexogyra* limestone-shales	1a Oyster shell-bank community 1b Marine community	1 Abundant dinocysts; high diversity
2 Argillaceous limestones	2 Inter shell-bank mud community	as above
3a Algal limestones 3b Cryptalgal-rippled siltstones	3 Algal marsh community	2 Low dinocyst abundance; low diversity
4 Sandstone	4 Sandy lagoon community	Litho- and biofacies 4 deposits contain palynofacies 1
5 *Unio-Neomiodon* mudstones and sandstones	Low-salinity community	3 Dinocysts absent; *Botryococcus* common

Table 1.7. *Duntulm Formation litho-, bio-, and palynofacies of Andrews and Walton (1990).*

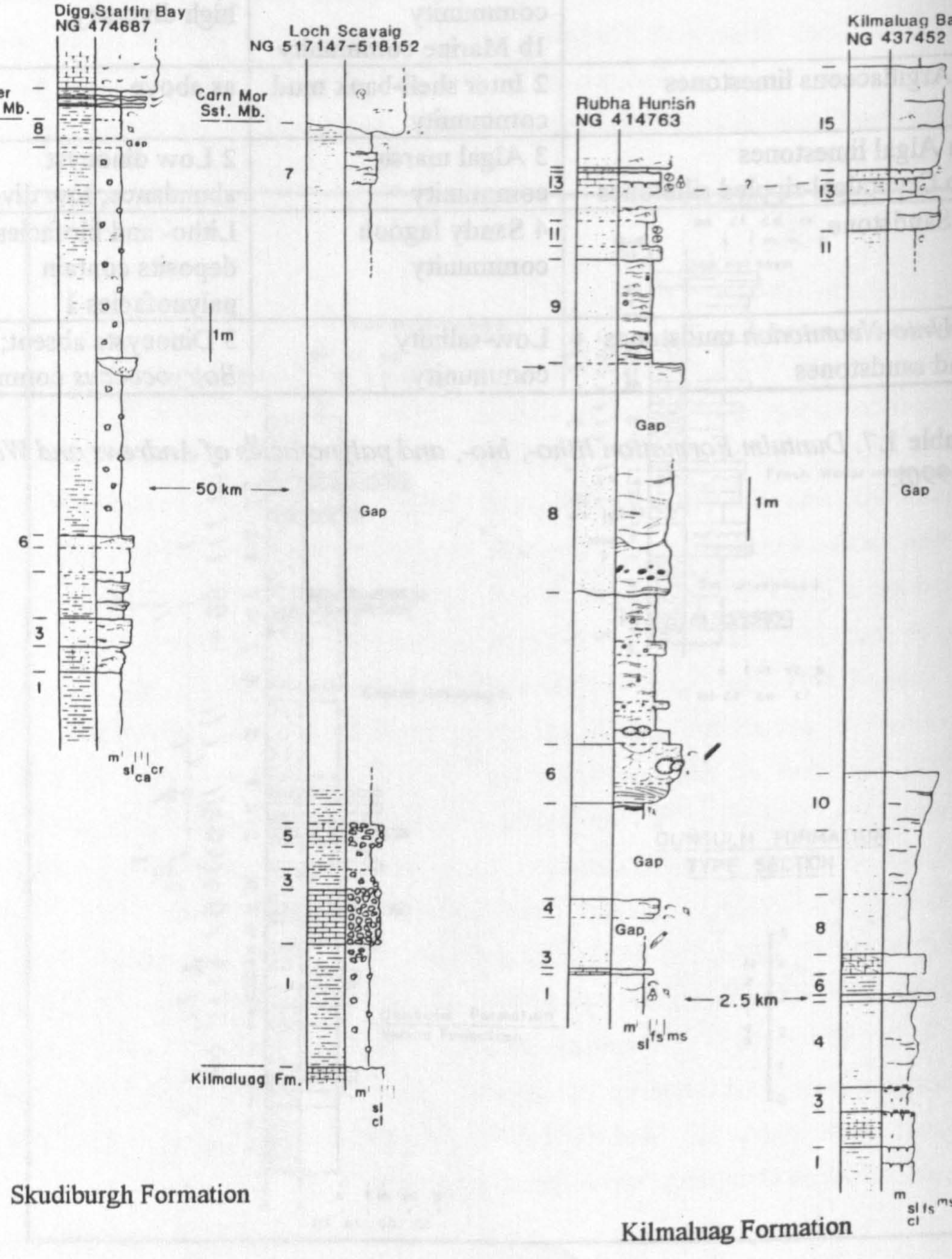


Fig. 1.11. *Sedimentary logs of sections of the Kilmaluag and Skudiburgh formations (taken from Andrews, 1985).*

vertebrate remains. The base of the formation is marked by the incoming of argillaceous limestones rich in ostracods and the dying out of the Duntulm Formation oyster beds (Andrews & Walton, 1990). The fauna has a freshwater-brackish affinity; ostracods continue in abundance throughout the formation, and the commonest macrofossil is the gastropod *Viviparus* (Hudson, 1963a; Harris & Hudson, 1980; Table 1.6). At the type section in Kilmaluag Bay, where the exposed thickness is 17m, plant cuticle is common, particularly *Equisetum* and *Gingko* (T.M. Harris *in* Hudson & Morton, 1969; Andrews, 1985).

Andrews (1985) distinguished two lithofacies in the Kilmaluag Formation: the 'clastic facies' which is restricted to Sea of the Hebrides Basin sediments exposed in north Skye, and the 'argillaceous limestone facies' which only occurs in the Inner Hebrides Basin sediments of south Skye. The formation has been interpreted as a low-salinity closed lagoon or coast-margin lake facies (Hudson, 1980; Andrews, 1985). Detailed work on the ostracods by Wakefield (1991) has revealed the presence of three salinity-controlled assemblages migrating within the lagoon according to the relative amounts of freshwater and brackish-marine input, and he estimates salinity values generally in the range 0-7‰ but up to a maximum of 18‰.

1.7.2 (g) The Skudiburgh Formation (SF)

This formation defines the top of the Great Estuarine Group, and comprises 16m of red and grey-green mudstones with subordinate thin sandstones (Fig. 1.11). It is mainly unfossiliferous except for rare *Unio* and plant fragments (Harris & Hudson, 1980; Hudson, 1983; Andrews, 1985). The facies is interpreted as alluvial mudflats/floodplain deposits (mudstones) cut by thin channels (sandstones), reflecting continued regression following the Kilmaluag Formation (Hudson, 1983; Andrews, 1985).

1.7.3 The Staffin Bay Formation (SBF)

The Staffin Bay Formation was first defined by Hudson (1962), and the lithostratigraphy was revised and updated by Sykes (1975b). It is the thickest transgressive sequence in the Scottish lower Callovian (Sykes 1975a); at its type section in Staffin bay it is 17.6m thick and is divided into two members (Plates 1.10 to 1.12). It is ?upper Bathonian-lower Callovian in age (Hudson, 1962; Hudson & Morton, 1969; Sykes 1975a, 1975b). The formation coarsens upwards from the lower argillaceous Upper Ostrea Member to the coarser Belemnite Sands Member, and has been interpreted as a transgressive lagoon-barrier bar complex (Hudson & Morton, 1969; Hudson & Harris, 1979; Hudson, 1983; Table 1.8). For a full discussion of the development of this sequence see Sykes (1975a).

The Upper Ostrea Member

The transition from the Skudiburgh Formation to the Upper Ostrea Member seen at Digg (Staffin Bay) is probably conformable (Andrews, 1985), being marked only by the incoming of a rich *Neomiodon* fauna following a basal shell bed with abundant *Isognomon* (Table 1.6). This change is interpreted as brackish waters flooding the coastal plains of the Skudiburgh Formation (Hudson, 1962; Hudson & Morton, 1969; Sykes, 1975a; Harris & Hudson, 1980; Andrews, 1985).

The member is 10.6m thick, and is dominated by dark grey shales with shell beds and subordinate rippled and laminated sandstones (Sykes, 1975b; Fig. 1.12). Sykes (1975a) identified three facies:

1) Calcareous Clays
2) Bituminous Shales with shell laminae
3) Fine-grained sands with parallel and ripple cross lamination

Facies 1 occurs only at the base of the section, whilst the other two facies occur as coarsening-upwards sequences in the rest of the member (Sykes, 1975a). The fauna is dominated by *Neomiodon* in the bituminous shales but *Isognomon* occurs in other facies. *Praeexogyra hebridica* is present throughout, but all other elements of the fauna are rare (Hudson, 1963a, 1963b; Hudson & Morton, 1969; Sykes, 1975a, 1975b; see Anderson & Dunham, 1966, for a complete faunal list). Hudson (1963a) interprets this low diversity, high density fauna as an indicator of brackish conditions and suggests salinity values of about 30‰ for the Upper Ostrea Member.

The Belemnite Sands Member

The base of this member is marked by a change to a more open marine fauna of *Pleuromya* and rare *Cylindroteuthis* in a coarsening-upwards sequence which began at the top of the Upper Ostrea Member (Sykes, 1975a; Table 1.6). It is 7m thick and is dominated by fine-medium grained carbonaceous sandstone with small scale

Member	Thickness	Facies
Upper Ostrea	11m	Brackish-marine lagoon
Belemnite Sands	7m	Barrier bar

Table 1.8. *Staffin Bay Formation lithostratigraphy and facies.*

Fig. 1.12. *Sedimentary logs of the Staffin Bay Formation type section (taken from Sykes, 1975a).*

cross-, and occasionally flaser, bedding (Fig. 1.12). The fauna is typically more stenohaline than in the Upper Ostrea Member, including forms such as *Oxytoma inaequivalis,* and *Cylindroteuthis,* but *Neomiodon* is still present (Sykes, 1975b; cf. Anderson & Dunham, 1966). Hudson (1963a) considered the fauna to be representative of fully marine conditions, but Sykes (1975a) argues for reduced or fluctuating salinities on the grounds of the abundance of *Neomiodon* and the rarity of cephalopods throughout most of the member.

Sykes (1975a) recognised two genetically different units within the member. The lower of these units is composed of well sorted, lignitic fine sand, generally bioturbated but with occasional parallel and ripple cross lamination. Shell beds in this unit are composed of *Pleuromya, Neomiodon* and *Vaugonia.* The upper unit is composed of poorly sorted medium-coarse grained glauconitic sandstone, occasionally more argillaceous, with a fauna of large *Pleuromya, Neomiodon, Lopha,* and abundant *Cylindroteuthis.*

1.8 Palaeoclimate

The Hebrides basin was at a palaeolatitude of 34° north during the Middle Jurassic (Smith *et al.,* 1973), and the Middle Jurassic climate is generally regarded as being quite equable, with average temperatures of around 21°C (Schwarzbach, 1963). However, there is evidence for climatic variation in the Hebrides Middle Jurassic, much of which is contained in the Great Estuarine Group, including the variations between carbonate and argillaceous rocks found near the top of the Group.

1.8.1 The Bearreraig Sandstone Formation

It is suggested by Morton (1992a) that the Bearreraig Sandstone was deposited under a semi-arid climate. Evidence for this is the high proportion of coarse sediment input and the xeromorphic adaptations found in Aalenian-Bajocian floras from the Scottish Highlands hinterland (Morton, 1990a; R.M. Bateman *in* Morton, 1992a). Also, there are indications of similar semi-arid conditions in the correlative sequence of the Porcupine Basin in the form of calcrete fragments and red colouration (Croker & Shannon, 1987). Although these suggestions are tentative, it would seem that the climate during the Aalenian-Bajocian in the Inner Hebrides was certainly somewhat drier (or less wet) than during deposition of the overlying Great Estuarine Group, as also in the Porcupine Basin (Morton, 1992a).

1.8.2 The Great Estuarine Group

The reduced salinity of these paralic environments is in its self suggestive of a substantially wetter climate, as it implies sufficiently increased runoff to maintain brackish conditions, but there is also much evidence for occasional or prolonged periods of aridity and a markedly seasonal climate (Morton, 1992a). Oxygen isotope studies by Tan and Hudson (1974) suggest an average temperature of around 22°C, but with marked seasonality. Hudson (1980) states that this temperature could be reduced by 4-5°C given an ice-free Earth, and that average temperatures could have been significantly lower than this if shell growth mainly took place in the summer months, as suggested in Hudson (1968). Harris (1989) gives the average temperature as 17-72°C; a similar estimate of 17-18°C is given by Wakefield (1991).

During the period of deposition of the two sandstone formations rapid runoff would have been necessary to supply the large amounts of siliciclastic sediment (Hudson & Harris, 1979). Harris (1989) states that the rapid progradation seen in Elgol-type deltas requires an uplifted hinterland with a thick regolith and heavy seasonal rainfall. The widely fluctuating salinities seen within the Valtos Formation are also considered to demonstrate seasonally fluctuating runoff, and the reduction in siliciclastic supply and the corresponding increase in salinities at the Valtos-Duntulm transition is also probably climatically controlled (Harris, 1992). Another phase of deposition that demonstrates a possible climate change, this time towards the end of Duntulm Formation times, is the 'freshwater intercalation' near the top of this formation (Andrews & Walton, 1990). In this case the climate has possibly become wetter, with increased runoff causing a freshening of lagoonal waters.

Any potential temperature variations would have been wider in the shallow lagoons which characterise the Great Estuarine Group than in open ocean. The desiccation features (Kilmaluag Formation) and algal horizons (Lealt and Duntulm Formations) are indicative of arid conditions (Hudson, 1980). However, neither Hudson (1970) or Andrews (1985) interpret these features as resulting from an arid climate, instead attributing them to temporary cessations of runoff and the rapid development of dessication features in particular lagoon margin facies (cf. Hudson, 1980).

The top two formations of the Great Estuarine Group hold perhaps the most complete evidence of climatic fluctuations. The Kilmaluag Formation shows alternations between carbonates and calcareous shales, interpreted by Andrews (1985) as reflecting small scale (tens of years) alternations of humid and arid conditions, and also a potentially larger scale variation (hundreds of thousands of years) producing the groups of beds (such as the vertebrate beds) which characterise parts of the formation (Andrews, 1985). The calcretes which are common in the Skudiburgh Formation are indicative of a seasonal climate, whose formation requires periods of significant precipitation alternating with more arid conditions (Andrews, 1985).

1.8.3 The Staffin Bay Formation

This formation was included in the oxygen isotope analyses of Tan and Hudson (1974) and presumably was deposited under the same temperature regime as the Great Estuarine Group. Tan *et al.* (1970) give a similar palaeotemperature (22°C) derived from belemnites from the very top of the Belemnite Sands Member and the overlying Oxford Clay, and note that this is broadly similar to other Callovian palaeotemperatures determined by oxygen isotopes. However, given the considerations of Hudson (1980), this temperature is probably overestimated by 4-5°C, possibly more if shell growth was seasonal. There are no other palaeoclimatic indicators in the Staffin Bay Formation and it was probably laid down under similar conditions to the Great Estuarine Group; however, the lack of development of desiccation features or algal limestones suggests a possible decrease in aridity (although this may also be facies related).

1.9 Sequence Stratigraphy and Basin Evolution

1.9.1 Introduction

Sequence stratigraphic analysis has been applied to the Mesozoic sediments of the Hebrides basin by Morton (1989, 1990b, 1992b, 1993). His analyses have been based primarily on the objective recognition of genetic stratigraphic sequences without consideration of their causal mechanisms (Morton, 1989). Morton (1993, p.285) defines these sequences as:

> *"Packages of conformable strata within which facies changes are gradational in both space and time, and Walther's law is applicable because of the gradual evolution through time of the depositional environments. The packages are separated by stratal surfaces across which there are abrupt changes of facies, and these are frequently (but not always, at the very precise level of biostratigraphic resolution available in the Hebrides with ammonite subzones) associated with hiatuses and unconformities. Genetic sequences represent the naturally occurring episodes in the dynamic development of the sedimentary fill of a basin and are, therefore, the basic units for analyses of basin evolution. Note that this definition is not identical with those of either Galloway (1989) or Van Waggoner et al. (1990)."*

The abrupt changes in facies are due to major perturbations in one of the controlling factors (e.g. base level) and are commonly tectonic in origin in the Hebrides Basin (Morton, 1989). Morton (1987) has demonstrated that changes in palaeobathymetry within the Hebrides Basin were insignificant through the time interval studied, ranging only between a little above sea level to shallow inshore marine with maximum estimated depths of around 40m, therefore any lateral variability in the thickness of the units is primarily due to differential subsidence (Morton, 1989).

1.9.2 Middle Jurassic Sequences

Three sequences were identified in the Hebrides Middle Jurassic by Morton (1989). See also Morton (1990b, 1992a, 1992b, 1993) and Figure 1.13.

1.9.2 (a) Sequence D

The base of sequence D rests with a sharp change in facies on the Raasay Ironstone, and its upper boundary is marked by the dark shales of the Garantiana Clay which abruptly follow the coarse sands of the topmost Bearrreraig Sandstone Formation. Morton (1989, p.251) states that this is 'an obvious sequence boundary'. The large thickness variation (Table 1.9) shows that variable subsidence was occurring, and this may have masked any minor sequence boundaries, although the sharp change from sandstone to shale between the two coarsening-upwards cycles in Trotternish may represent one such boundary (Morton, 1989).

1.9.2 (b) Sequence E

The basal boundary of this sequence, marked by the Garantiana Clay, is zonally complete, showing no evolutionary hiatus, and its upper boundary is marked by the transition from the upper non-marine silts of the Great Estuarine Group to the marginal-normal marine deposits of the Staffin Bay Formation (Morton, 1989). This succession is probably conformable in Trotternish (Andrews, 1985), but in south Skye there is a hiatus and erosion surface (Morton, 1989; cf. Sykes 1975a, 1975b). The sequence shows three regressive cycles (Fig. 1.13) separated by two minor sequence boundaries at the Elgol-Lealt and Valtos-Duntulm transitions (Hudson, 1963b, 1980; Hudson & Harris, 1979; Morton, 1989). Lateral variation probably decreases upwards within the sequence indicating a change to much more uniform subsidence compared with sequence D (Morton 1989, 1990b, 1992b; Table 1.9).

1.9.2 (c) Sequence F

Above the basal hiatus in south Skye the Carn Mor Sandstone beds belong to the *Calloviense* zone, whilst in the north the Belemnite Sands are referred to the *Macrocephalus* zone, indicating a lateral uniformity of facies following the Great Estuarine Group-Staffin Bay Formation transition. The upper sequence boundary is also marked by a hiatus; the Belemnite Sands are abruptly overlain by the StaffinShale

SEQUENCE		LITHOSTRATIGRAPHY		AGE
F		STAFFIN BAY FORMATION		CALL.
E	E3	GREAT ESTUARINE GROUP	Skudiburgh Formation	BATHONIAN
			Kilmaluag Formation	
			Duntulm Formation	
	E2		Valtos Sandstone Formation	
			Lealt Shales Formation	
	E1		Elgol Sandstone Formation	
			Cullaidh Shale Formation	
			Garantiana Clay Member	BAJOCIAN
D	D2	BEARRERAIG SANDSTONE FORMATION	Rigg Sandstone Member	
			Holm Sandstone Member	
			Udairn Shales Member	
	D1		Ollach Sandstone Member	AAL.
			Dun Caan Shales Member	

Key: Sequence boundary ———
Minor sequence boundary - - - - - -

Fig. 1.13. *Middle Jurassic genetic sequence units (adapted from Morton, 1989). Note minor sequence boundaries and ages in sequences E and F are approximations only.*

Sequence	Stratigraphy	N	M	σ	V
F	Staffin Bay Formation	4	8.6	7.2	83.7
E3	Duntulm, Kilmaluag and Skudiburgh Formations	4	66	16.8	25.4
E2	Lealt Shales and Valtos Sandstone Formations	4	123.3	26.7	21.7
E1	Garantiana Clay Member; Cullaidh Shale and Elgol Sandstone Formations	11	24.2	9.2	38
D	Bearreraig Sandstone Formation (not Garantiana Clay Member)	12	205.2	124.7	60.8

N = number of measurements; M = mean; σ = standard deviation; V = coefficient of variation (V = 100σ/M).

Table 1.9. *Thickness variation of Middle Jurassic sequences in the Hebrides Basin (adapted from Morton, 1989).*

Formation (Sykes, 1975b; Morton, 1989). The large variation in thickness of this unit is attributed to the difference in the development of hiatuses in different areas (Morton, 1989; Table 1.9).

1.9.3 Sequence Boundaries

Morton (1989) states that sequence boundaries are related to relative sea level changes which can be caused by either tectonic events or eustatic changes in sea level. He also notes that eustatic sea level changes can only be positively recognised if they are shown to occur simultaneously in tectonically unrelated basins.

1.9.3 (a) Boundary C-D

This has been attributed to a major tectonic event, correlated with lithospheric extension leading to renewed subsidence (Morton, 1987, 1989); this boundary can also be recognised in other related basins (cf. Morton *et al.*, 1987; Morton, 1992a). The minor sequence boundary D1 is thought to be due to eustatic rise as it correlates precisely with one of Hallam's (1978) 'deepening events' (Morton, 1989, his Fig.9).

1.9.3 (b) Boundary D-E

Again tectonically controlled, this boundary is related to a change in the tectonic regime from extension-related differential subsidence to thermal cooling-sediment loading giving much more even subsidence. The cause of the minor boundaries is impossible to determine due to imprecise biostratigraphy within the Great Estuarine Group (Morton, 1989). This boundary can also be recognised in related basins (Morton, *ibid.*)

1.9.3 (c) Boundary E-F

Interpreted by Morton (1989) as a eustatic rise which correlates (at the sub-zonal level) with another of Hallam's (1978) deepening events, there being no apparent mechanism within the tectonic evolution of the basin to bring about such a change in facies (Morton, 1987, 1989, 1990b, 1992b).

1.9.4 Comparison with other Basins

In the Hebrides Basin the hiatuses between genetic sequences are minor, suggesting that the Exxon model of sea level falling to or below the shelf edge is inappropriate; comparison between the Hebrides Basin and others where boundaries have been established by seismic stratigraphy is not possible (Morton, 1989, his Fig.9). However, the sequence statigraphic and basin evolution patterns of the Hebrides can be applied to less well known related offshore basins, where sequences are similar (cf. Morton *et al.*, 1987; Trueblood & Morton, 1991; Morton 1992a, 1993).

1.10 Previous Palynological Research

There have been few publications on the palynology or palynofacies of Inner Hebrides Middle Jurassic strata, and these have dealt mainly with palynostratigraphy (e.g. Riding *et al.*, 1991; Riding, 1992). One integrated study on the Duntulm Formation (see section 1.7.2) has involved the use of 'palynofacies analysis' (Andrews & Walton, 1990). However, their palynofacies were identified using only quantitative palynomorph data, mostly on the dinoflagellate cysts, and included only qualitative observations on the total kerogen component (Andrews & Walton, 1990, p.12).

The latter study identified three palynofacies groups which were found to relate to the various independently defined lithofacies and biofacies (Andrews & Walton, 1990, their Figs 12 & 13; Table 1.7). Their 'palynofacies 1' has the highest dinoflagellate content (50%+) and diversities, which were positively correlated with macrofaunal estimates of salinity (their biofacies 1a and 1b). The kerogen assemblages from this palynofacies were described as having common structureless and disseminated AOM, varying quantities of black and brown wood and rare cuticle, and were interpreted as having been deposited in a quiet water setting (Andrews & Walton, *ibid.*). However, this rather vague kerogen description cannot be regarded as diagnostic.

Palynofacies 2 is dominated by gymnosperm pollen with low proportions of dinoflagellate cysts (*ca.* 10%) suggestive of limited marine influence or potentially high sporomorph dilution (but the latter is unlikely if the facies is occuring in the algal limestones, and if the pollen is mainly buoyant, distal types). The occurrence of this palynofacies in some lithofacies 3a (algal limestone) deposits was interpreted as indicating deposition on mudflats remote from the lagoon margin.

Palynofacies 3 has no dinoflagellate cyst content, but the spore and *Botryococcus* percentages are relatively high. The kerogen assemblage has abundant black and brown wood, and AOM is absent. This palynofacies was deposited in the fresh-brackish water of lithofacies 5 (Andrews & Walton, 1990). Again these features are common to many terrestrially-dominated kerogen assemblages and are not very diagnostic of facies.

The palynology of the Toarcian-Bathonian of the Inner Hebrides was studied by Riding *et al.* (1991), mostly in order to improve the dating of the Great Estuarine Group (which lacks zonal macrofaunas) and to provide a reference for comparison with related offshore basins. A very general review of their paper is given below, together with any palaeoenvironmental conclusions that are relevant to this project.

The Bearreraig Sandstone Formation is described as having a relatively diverse palynomorph assemblage, in which gymnosperm pollen (e.g. *Callialasporites*) are the dominant component. The greatest dinoflagellate cyst diversity occurs in the Dun Caan Shales Member (20 species); diversity is significantly lower in the rest of the formation (4 to 5 species), and the florules are consistently dominated by the genus *Nannoceratopsis*. The occasional presence of *Botryococcus* is taken to indicate fresh-brackish water input where it occurs. The palynology confirms the age assigned to this formation, the topmost Garantiana Clay Member being dated as no younger than late Bajocian.

The Great Estuarine Group age is confirmed as being Bathonian in age and in general the palynologic assemblages reflect (and confirm) the sedimentologic, palaeontologic and palaeoenvironmental interpretations of Hudson and co-workers. The salinity variations determined by macrofaunal assemblages are mirrored by variations in marine microplankton and the freshwater-brackish alga *Botryococcus* (cf. Andrews & Walton 1990; Wakefield 1991). Where dinoflagellate cysts occur they are predominantly low diversity-high dominance assemblages, apart from in the more marine parts of the Duntulm Formation (Andrews & Walton, 1990). The sporomorph assemblages are consistently dominated by gymnosperm pollen, and they and the spores are both made up of long-ranging taxa (e.g. *Callialasporites, Cerebropollenites, Leptolepidites*). Kerogen assemblages are characterised by significant amounts of AOM in the lagoonal formations and more 'woody' tissue in the sand-rich Elgol and Valtos Formations.

Riding (1992) found similar low diversity-high dominance dinoflagellate cyst assemblages in the Staffin Bay Formation (Upper Ostrea Member), again reflecting a marginal marine palaeoenvironment subject to salinity variation. He determined the age of this member as no older than earliest Callovian. Bradshaw and Fenton (1982) also describe a single sample from this member as having a diverse microflora and high terrestrially derived kerogen, reflecting a 'marginal' environment.

1.11 Previous Organic Geochemical Research

Publications dealing with the organic geochemistry of the Inner Hebrides Middle Jurassic are as limited as those dealing with its palynology, and are mostly related to maturation (e.g. Thrasher, 1992; Bishop & Abbot, 1995). Ambler (1989) does include some palaeoenvironmetal work based on biomarkers and on qualitative palynofacies analysis (performed by D.J. Batten). A brief review of the more relevant points of these papers is given below.

The organic geochemical measures of maturity used by Thrasher (1992) demonstrate that the effect of the Cuillins igneous intrusion is localised, sediments more than 15km away from it being extremely immature, except in the vicinity of minor intrusions, which have an effect in proportion to their thickness. She also gives %TOC values for some of the Middle Jurassic sediments (Thrasher, 1992, her Table 1). Most of the samples analysed were from the Dun Caan Shales Member of the Bearreraig Sandstone Formation (41), with a further 18 samples from the Great Estuarine Group. The TOC values are mostly less than 2%, but reach a maximum of 15% in the Cullaidh Shale Formation.

Bishop and Abbot (1995) report vitrinite reflectance values between 0.35 and 0.45% R_0(ave) from immature sites not affected by minor intrusions; these accord well with values of 0.23-0.5% given by Hudson and B.S. Cooper *in* Hudson and Harris (1979). Hudson and Andrews (1987) give a range of values from areas with different levels of igneous activity; they report R_0 values of less than 0.5% from outcrops with few or no minor intrusions (their category 1) and 0.5-1.3% from areas with many minor intrusions (their category 2). In Strathaird close to the Cuillins Complex, levels are all over 1.5%. The samples studied in this work were all from areas where R_0 values are less than 1.3% (categories 1 and 2).

Ambler (1989) attempted to combine biomarker and qualitative palynofacies data from selected sections in order to determine the source of organic matter in the sediments. She achieved varying degrees of success. For example, in the Dun Caan Shales Member of the Bearreraig Sandstone Formation, biomarkers suggest a strong marine planktonic input, with only an insignificant contribution from higher plants, while the palynofacies of these samples is described as having abundant amorphous algal organic matter with only rare higher plant material, showing a good correlation between the techniques. However, in more complex settings such as the 'freshwater intercalation' near the top of the Duntulm Formation there was no agreement; sediments with monotypic dinoflagellate cyst assemblages gave biomarker distributions dominated by C25 and C27 *n*-alkanes for which a cryptic algal source is suggested.

Plate 1.1. Example of characteristic lithology from the type section of the Dun Caan Shales Member (Bearreraig Sandstone Formation), Bearreraig Bay, Skye (locality 1). The bed is intensely bioturbated. Note also the sharp change in colour 2/3 of the way up the bed, and the concretion near the top. Lenscap = 5cm.

Plate 1.2. Gradational transition between the Dun Caan Shales and Ollach Sandstone members, Bearreraig Sandstone Formation, Bearreraig Bay, Skye (locality 1). Note the thin beds (indicative of stratigraphic condensation). The typical lithology of the Ollach Sandstone Member can be seen at the very top of the picture.

Plate 1.3. The Udairn Shales to Holm Sandstones members (Bearreraig Sandstone Formation) type section, Bearreraig Bay, Skye (locality 1). The stream section represents the Udairn Shales, the cliff section the Holm Sandstone; the boundary is gradational, but is placed at the base of the waterfall.

Plate 1.4. The Bivalve-Septaria marker bed (6e), Kildonnan Member (Lealt Shales Formation) type section, Kildonnan, Eigg (locality 6). Hammer = 30cm.

Plate 1.5. Cairidh Ghlumaig, Trotternish Skye (locality 10). The lower (foreshore) part of the Duntulm Formation composite type section can be seen in the foreground, the middle (cliff) section can be seen at the other (south) end of the bay. The upper (Lon Ostatoin) section occurs on the other side of the headland that marks the end of the bay.

Plate 1.6. Nodular algal limestone (lithofacies 3a of Andrews & Walton, 1990) from the foreshore at Cairidh Ghlumaig.

Plate 1.7. *Praeexogyra* limestone-shale (lithofacies 1 of Andrews & Walton, 1990) from the top part of the foreshore section at Cairidh Ghlumaig. Lenscap = 5cm.

Plate 1.8. The stream section of the Duntulm Formation exposures at Lon Ostatoin (locality 11). The sand and clay-mudstones are rich in *Neomiodon* (= lithofacies 5 of Andrews & Walton, 1990) and represent the lower part of the 'freshwater intercalation'. The limestones mark the return to marine conditions, before another lithofacies 5 unit above.

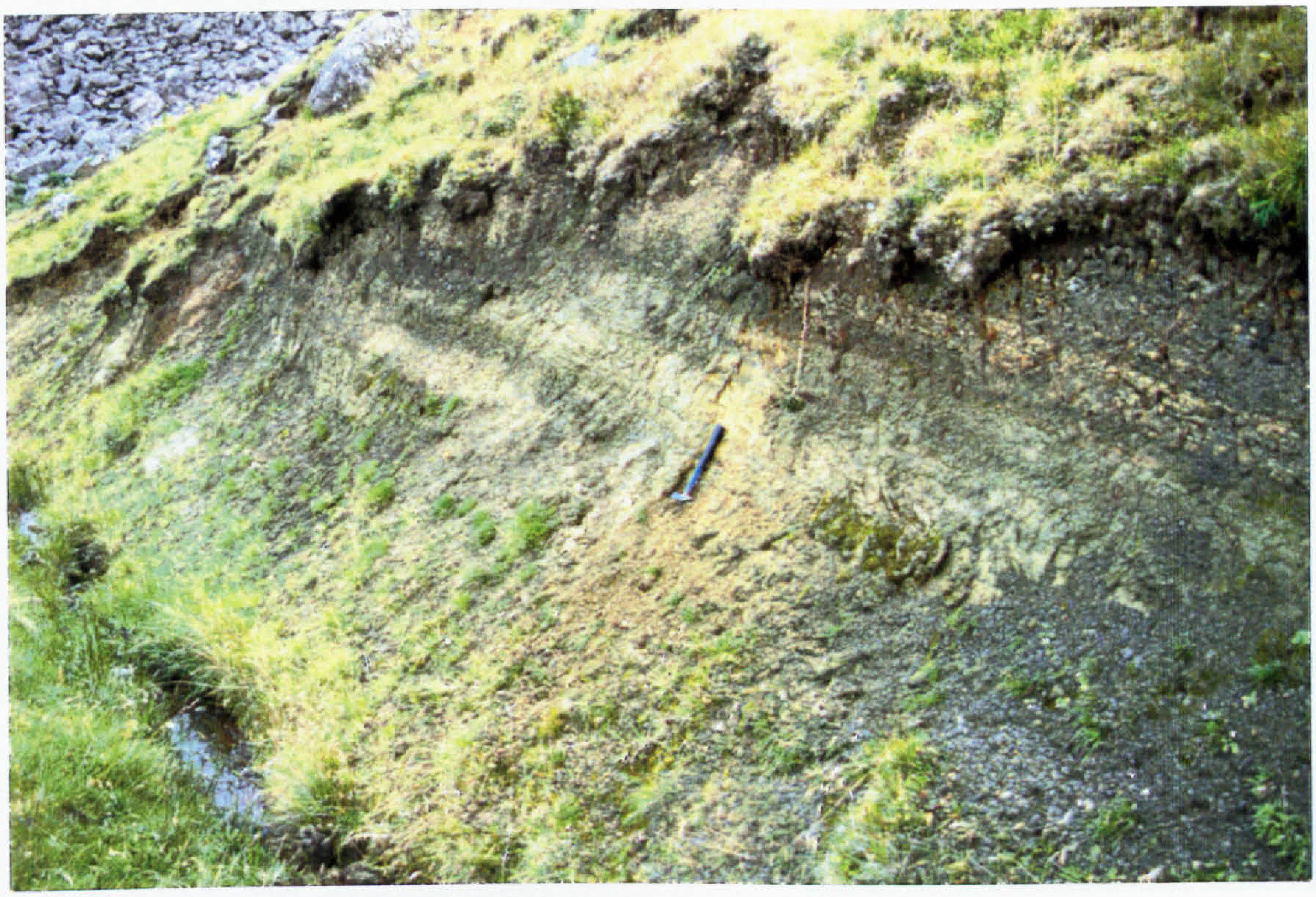


Plate 1.9. The Lon Ostatoin roadside section, this occurs round the corner from the stream section and exposes a similar sequence of rocks. However, the upper lithofacies 5 unit was better exposed here during the present study. Hammer = 30cm.

Plate 1.10. The Staffin Bay Formation type section, Staffin Bay, Skye (locality 18). The steeply dipping rocks of the type section can be seen running away from the camera.

Plate 1.11. Typical lithology of the Upper Ostrea Member (Staffin Bay Formation). This bed belongs to the bituminous shales lithofacies of Sykes (1975a). Hammer = 30cm.

Plate 1.12. The top of the Belemnite Sands Member (Staffin Bay Formation). The sideritic limestone is the upper bed of the member. Note the abundance of belemnites in the bed below. Hammer = 30cm.

CHAPTER 2.0
METHOD

2.0 METHOD

2.1 Sampling

2.1.1 Selection of Sample Sites

Sample localities were chosen following advice from Prof. J.D.Hudson of the University of Leicester, and also with reference to the sample localities used in the study by Riding *et al.* (1991), which were known to be productive and had the additional advantage of being biostratigraphically constrained. For this study the samples had to be essentially unaffected by igneous intrusions, therefore the whole of South Skye had to be omitted because of the effect of the Cuillins intrusion. Many other exposures in the Inner Hebrides have been thermally affected by associated sills and were similarly discounted. Sample localities selected for this study are shown in Fig. 2.1; full details of the sample sites are shown in Table 2.1. Table 2.2 gives the vitrinite reflectance categories of Hudson and Andrews (1987) for each of the areas sampled. A number of the localities sampled have been intruded by small dykes (e.g. Bearreraig Bay); the sediments adjacent to these bodies have been subject to baking and were not sampled. A number of studies have documented the effects of igneous intrusions such as these in the Hebrides, and have concluded that the dykes have a thermal effect directly proportional to their thickness (Thrasher, 1992; Bishop & Abbott, 1995); based on these studies no samples were taken from within distances equivalent to 150% of dyke thickness.

2.1.2 Sampling Strategy

The sampling strategy for this project was based on that described in Tyson (1995). Samples were taken in order to give adequate stratigraphic coverage and to encompass any major lithologic and facies variations; additional features such as coarsening-upwards sequences were subject to detailed sampling where possible. Given the often inaccessible, and rather poorly exposed nature of much of the Hebrides Middle Jurassic, together with the extent of the regional and local baking, it was not possible to fulfil these objectives for the whole of the sequence. Only a limited number of samples were taken from poorly exposed intervals (e.g. the Kilmaluag Formation type section) or heavily intruded localities (e.g. the Lonfearn Member of the Lealt Shales Formation). Table 2.3 shows the number of samples taken from each stratigraphic unit.

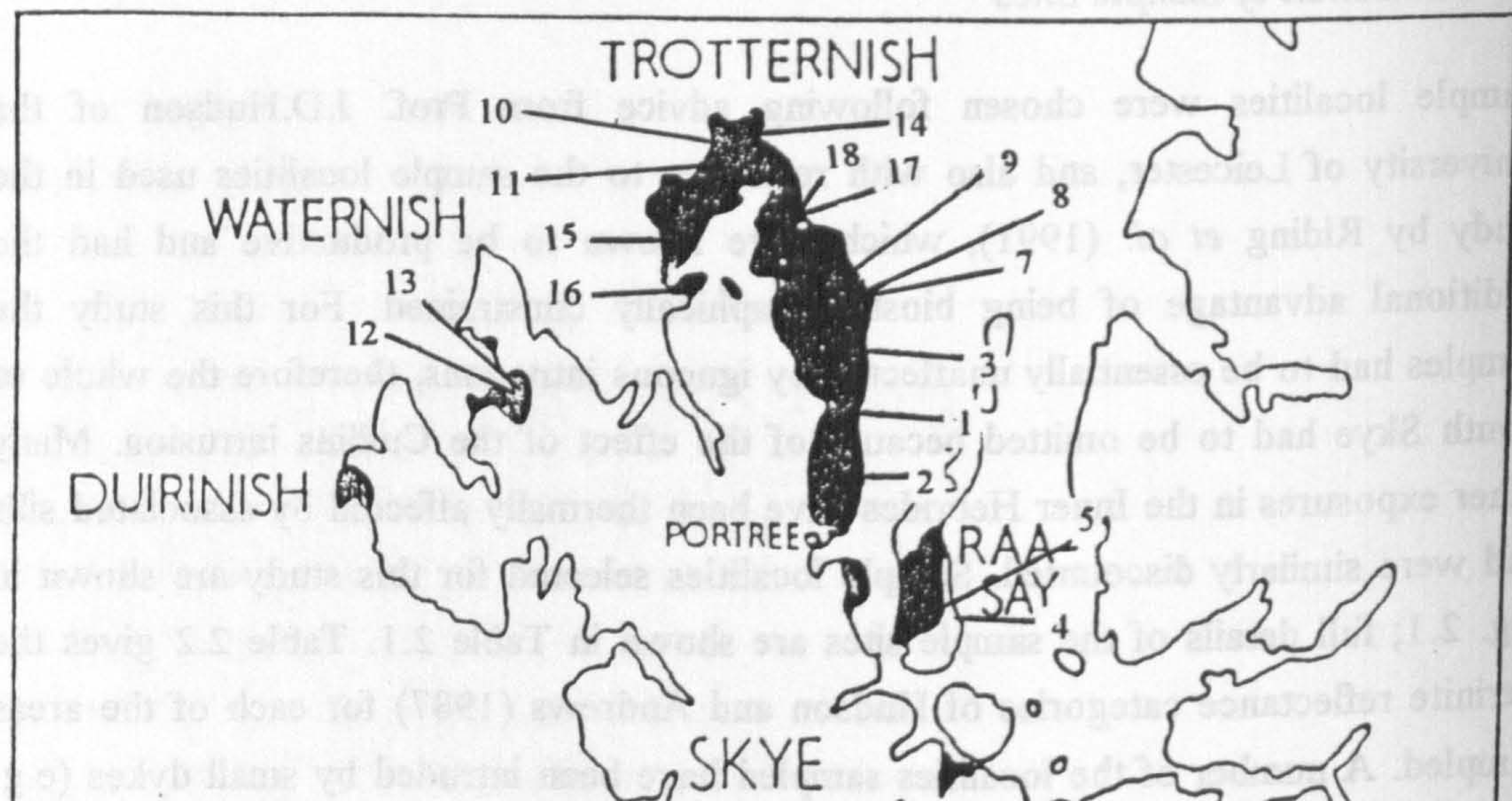


Fig. 2.1. *Distribution of Middle Jurassic rocks and sample localities. Key to numbers in Table 2.1.*

Table 2.1. *Sample localities and details. Numbers relate to Fig. 2.1.*

1)

LOCALITY:	Bearreraig Bay, Trotternish, Skye
MAP REF.:	NG 517 527
UNIT:	Bearreraig Sandstone Formation
AGE:	Aalenian-Bajocian
SAMPLE CODES:	BBE1-48 Dun Caan Shales Member BBE 49 Ollach Sandstone Member BBO1,2 Udairn Shales Member BBU1-30 Udairn Shales Member BBH1-12 Holm Sandstone Member BBR1-19 Rigg Sandstone Member
NO. SAMPLES:	111
THICKNESS:	220m

2)

LOCALITY:	Prince Charles' Cave, Trotternish, Skye
MAP REF.:	NG 513 476
UNIT:	Garantiana Clay Member (Bearreraig Sandstone Fm.) Cullaidh Shale Formation Elgol Sandstone Formation
AGE:	Upper Bajocian-?Lower Bathonian
SAMPLE CODES:	GC1-23*
NO.SAMPLES:	23
THICKNESS:	6.5m sampled

3)

LOCALITY:	Lealt River Mouth, Invertote, Trotternish, Skye
MAP REF.:	NG 520 605
UNIT:	Cullaidh Shale Formation
AGE:	?Lower Bathonian
SAMPLE CODES:	LR1-6*
NO. SAMPLES:	6
THICKNESS:	0.5m sampled

4)

LOCALITY:	Beinn na Leac, Raasay
MAP REF.:	NG 598 379
UNIT:	Dun Caan Shales Member (Bearreraig Sandstone Fm.) Beinn na Leac Sandstone Member (Bearreraig Sandstone Fm.)
AGE:	Aalenian-Bajocian
SAMPLE CODES:	BNL1-17
NO. SAMPLES:	17
THICKNESS:	20m sampled

5)

LOCALITY:	Braes, Raasay
MAP REF.:	NG 563 415
UNIT:	?Garantiana Clay Member (Bearreraig Sandstone Fm.) Cullaidh Shale Formation Elgol Sandstone Formation
AGE:	Upper Bajocian-?Lower Bathonian
SAMPLE CODES:	RGC1-4 ?Garantiana Clay Mbr. RCS1-4 Cullaidh Shale Fm. RCS5-15 Elgol Sandstone Fm.
NO.SAMPLES:	19
THICKNESS :	3m composite

6)

LOCALITY:	Kildonnan, Eigg
MAP REF.:	NM 495 870
UNIT:	Kildonnan Member, Lealt Shales Formation
AGE:	?Bathonian
SAMPLE CODES:	KE1-58
NO. SAMPLES:	58
THICKNESS:	23m

7)

LOCALITY:	Ruhda Nam Braithairean, Trotternish, Skye
MAP REF.:	NG 526 625
UNIT:	Lonfearn Member, Lealt Shales Formation
AGE:	?Bathonian
SAMPLE CODES:	RNB1-20
NO. SAMPLES:	20
THICKNESS:	9m sampled

8)

LOCALITY:	Lonfearn Burn Mouth, Trotternish, Skye
MAP REF.:	NG 521 627
UNIT:	Lonfearn Member, Lealt Shales Formation Valtos Sandstone Formation
AGE:	?Bathonian
SAMPLE CODES:	VLB1-5*
NO. SAMPLES:	5
THICKNESS:	3m sampled

9)

LOCALITY:	Cliffs Below Valtos, Trotternish, Skye
MAP REF.:	NG 517 638
UNIT:	Valtos Sandstone Formation
AGE:	?Bathonian
SAMPLE CODES:	VS1-9
NO. SAMPLES:	9
THICKNESS:	3.5m sampled (Total section 120m)

10)

LOCALITY:	Cairidh Ghlumaig, Trotternish, Skye
MAP REF.:	NG 411 739
UNIT:	Duntulm Formation
AGE:	Bathonian
SAMPLE CODES:	CGD1-68
NO. SAMPLES:	68
THICKNESS:	20m

11)

LOCALITY:	Lon Ostatoin, Trotternish, Skye
MAP REF.:	NG 406 728
UNIT:	Duntulm Formation
AGE:	Bathonian
SAMPLE CODES:	LOS1-8 Lon Ostatoin stream section (field season 1) LOD1-16 Lon Ostatoin stream section (field season 2) LOK1-39 Lon Ostatoin roadside section
NO. SAMPLES:	63
THICKNESS:	10m exposed (16m total thickness)

12)

LOCALITY:	Loch Bay River Mouth, Waternish, Skye
MAP REF.:	NG 264 539
UNIT:	Duntulm Formation
AGE:	Bathonian
SAMPLE CODES:	LBM1-7
NO. SAMPLES:	7
THICKNESS:	4.5m

13)

LOCALITY:	Loch Bay River Tributary, Waternish, Skye
MAP REF.:	NG 264 539
UNIT:	Duntulm Formation
AGE:	Bathonian
SAMPLE CODES:	LBT1-17
NO. SAMPLES:	17
THICKNESS:	4m

14)

LOCALITY:	Kilmaluag Bay, Trotternish, Skye
MAP REF.:	NG 437 748
UNIT:	Duntulm Formation Kilmaluag Formation
AGE:	?Bathonian
SAMPLE CODES:	KBD1-2* (Duntulm Fm.) KBK1-11 (Kilmaluag Fm.)
NO. SAMPLES:	13
THICKNESS:	9m composite section sampled

15)

LOCALITY:	Prince Charles' Point, Trotternish, Skye
MAP REF.:	NG 376 666
UNIT:	Kilmaluag Formation
AGE:	?Bathonian
SAMPLE CODES:	PCP1-5**
NO. SAMPLES:	5
THICKNESS:	1.5m

16)

LOCALITY:	Skudiburgh Bay, Trotternish, Skye
MAP REF.:	NG 375 652
UNIT:	Skudiburgh Formation
AGE:	?Upper Bathonian
SAMPLE CODES:	SB1-14
NO. SAMPLES:	14
THICKNESS:	1m sampled (6m total thickness)

17)

LOCALITY:	Digg, Staffin Bay, Trotternish, Skye
MAP REF.:	NG 474 687
UNIT:	Skudiburgh Formation Upper Ostrea Member, Staffin Bay Formation
AGE:	?Upper Bathonian
SAMPLE CODES:	SBS1-4 (Skudiburgh Fm.) SBS5 & SBU1 (Upper Ostrea Mbr., Staffin Bay Fm.)
NO. SAMPLES:	6
THICKNESS:	3m sampled (total thickness 16m)

18)

LOCALITY:	Staffin Bay, Trotternish, Skye
MAP REF.:	NG 472 708
UNIT:	Staffin Bay Formation
AGE:	Lower-Middle Callovian
SAMPLE CODES:	UOB1-37 (Upper Ostrea Mbr.) BS1-15 (Belemnite Sands Mbr.)
NO. SAMPLES:	53
THICKNESS:	18m

The Great Estuarine Group = Cullaidh Shale-Skudiburgh Formations.

* Thermally affected samples, not included in final spreadsheet, but briefly examined.
** Completely baked samples, not examined further.

Vitrinite Reflectance%	Description of Igneous effects	Locality
Group 1 (Ro <0.5)	Few or no minor intrusions; not close to major sills; no sign of baking	Bearreraig Bay; Duntulm; Staffin Bay; Kilmaluag Bay, Skye; Kildonnan, Eigg
Group 2 (Ro 0.5-1.3)	Many minor intrusions, sills and dykes; pervasive baking of the country rocks	Lealt area, Skye

Table 2.2. *Vitrinite reflectance of sample areas (adapted from Hudson & Andrews, 1987). The oil window corresponds to a* R_O *value of 0.5-1.55%.*

Unit	No. of samples
Bearreraig Sandstone Fm. (total)	131
Dun Caan Shales Mbr.	48
Ollach Sandstone Mbr.	1
Udairn Shales Mbr.	32
Holm Sandstone Mbr.	12
Rigg Sandstone Mbr.	18
Dun Caan Shales Mbr. (Raasay)	6
Beinn na Leac Sandstone Mbr. (Raasay)	10
?Garantiana Clay Mbr. (Raasay)	4
Cullaidh Shale Fm. (Raasay)	4
Elgol Sandstone Fm. (Raasay)	11
Lealt Shales Fm. (total)	78
Kildonnan Mbr. (Eigg)	58
Lonfearn Mbr.	20
Valtos Sandstone Fm.	9
Duntulm Fm.	138
Kilmaluag Fm.	10
Skudiburgh Fm.	7
Staffin Bay Fm. (total)	54
Upper Ostrea Mbr.	39
Belemnite Sands Mbr.	15
Overall total	440

Table 2.3. *Number of samples taken from each unit that were included in the final spreadsheet. Unless otherwise specified the samples are from Skye.*

2.1.3 Sampling Method and Sample Description

Samples were obtained using a geological hammer and chisel, were free from weathered surfaces and contamination, and were generally limited to a 5 or 10cm vertical range depending on the nature and reason for sampling (e.g. a 10cm shale bed may have been subsequently split into two 5cm samples if testing for variation within it, or one sample may have been taken from the whole bed if it was part of the overall stratigraphic sequence). On return from the field, the samples were described in hand specimen and the parameters listed below (after Tucker, 1982) were recorded (Appendix I).

A) Colour of fresh surfaces (using the GSA Munsell colour chart)
B) How the specimen weathers (e.g. fissile, earthy, papery)
C) Any sedimentary structure (e.g. silt laminae)
D) Any conspicuous non-clay minerals (e.g. mica flakes, pyrite)
E) Organic content (e.g. bituminous, carbonaceous)
F) Fossils (type, abundance)

2.1.4 Sample Preparation

For any study incorporating a large number of samples, it is important that the processing method is simple, consistent and controllable. Preparation was carried out using standard non-oxidative palynological procedures (e.g. Barrs & Williams, 1973; Batten & Morrison, 1983). This consisted of first cleaning and removing any weathered surfaces and then crushing (using a pestle and mortar) the rock material down to 2-5mm fragments. A fraction (5g for shales) of the crushed material was then placed into a 600ml plastic beaker ready for maceration. The first stage of the maceration technique was to add 20% concentrated hydrochloric acid (HCl) to the sample (topping up if necessary) until all reaction ceased in order to remove any carbonates present; once this had occurred the beaker was topped up with distilled water and left to settle for 24 hours. The liquid was then decanted.

The next stage of processing involved the addition of enough cold 40% hydrofluoric acid (HF) to cover the sample (*ca.* 100 ml) in order to remove any silicates present; the sample was then left for 48 hours before the addition of distilled water. After 24 hours the sample was again decanted before the addition of 20% HCl (*ca.* 200ml) for a second time to remove any fluoride crystals which may have precipitated during the HF treatment. This was left for a few minutes then the sample was topped up with distilled water, left for 24 hours and decanted. The sample was then subjected to a further two washes with distilled water. The next stage consisted of sieving the organic residue through a 10μm nylon mesh using distilled water; the fraction retained in the sieve suspended in distilled water was pipetted into clearly labelled air tight plastic vials ready for mounting on slides.

The processing procedure is summarised below:

Rock cleaned and crushed to 2-5mm fragments
20% conc. HCl to excess to remove carbonates
40% conc. HF 48 hours to remove silicates
20% conc. HCl-washing
Washing with distilled water (×3)
Sieve through 10μm mesh

All processing involving acids was carried out in a 'HF' grade fume cupboard and according to COSHH regulations, including other appropriate safety precautions such as rubber gloves, safety glasses and laboratory coat for procedures using HCl, with the addition of elbow-length thick rubber gloves, a thick rubber apron and a full face visor for the stage of the work involving HF.

The amount of material processed depended on the sample lithology in question and is shown below:

Shales *ca.* 5g
Silts *ca.* 7.5g
Sands *ca.* 10g
Limestones *ca.* 10g

The slides were strew mounted on standard palynological slides. About 0.25ml of water suspended residue was pipetted evenly over a coverslip and allowed to dry for 24 hours. A few drops of Elvacite (DuPont) were placed on the centre of the slide and the coverslip lowered onto it; the finished slides were then allowed to set for 24 hours before use (note this procedure should be carried out in a fume cupboard). The mounting medium was made up by adding 65g of Elvacite 2044 powder to 100ml of the solvent xylene; again, this should be carried out in a fume cupboard using gloves and safety glasses. Elvacite is the preferred mounting medium as it does not fluoresce when exposed to blue-light excitation; this allows the easy estimation of the fluorescent intensity of the particles on the slide. This is not the case with glycerol which is highly fluorescent and so makes the identification of low-medium fluorescent particles practically impossible.

In the early part of this project (during the processing of the samples from the Bearreraig Sandstone Formation) glycerol was used as the mounting medium. In this case the glycerol was melted on a hot plate and a small amount was placed in a glass vial and *ca.* 0.25ml of residue was then mixed with the glycerol. This mixture was then pipetted onto a coverslip which was also on the hot plate and allowed to dry. The slide was placed on the hot plate and a few drops of glycerol were placed on the centre of the slide, the coverslip was lowered onto the slide and the finished slide was removed from the hotplate and allowed to dry and cool before use.

2.2 Analysis

2.2.1 Fluorescence and Scanning

Each slide was examined under incident blue light fluorescence using an Olympus BH2-RFCA microscope at ×20 magnification (or ×40 for more detailed examination of particular particles). This was primarily to determine the preservation of any amorphous organic matter (AOM) and palynomorphs present, according to the preservation scale of Tyson (1995) which is summarised in Table 2.4. See Tuweni and Tyson (1994) for an example of the application of this scale.

Notes were also made on the relative fluorescent intensity (= preservation) of the remainder of the liptinitic fraction of the assemblage (i.e. cuticle, sporomorphs, dinocysts and *Botryococcus*), and on the abundance of particles which are more easily observed under fluorescence, such as some *Botryococcus* and acritarchs.

As the fluorescence observations were carried out on an Olympus BH2-RFCA microscope, which is also equipped with normal transmitted white light, these observations were combined with scanning the slide (with a ×20 objective) for the apparent presence/absence of palaeoecologically significant palynomorphs which might not have shown up during counting (if either rare or strongly diluted).

1) Kerogen is completely non-fluorescent (except for rare fluorescing palynomorphs).

a) AOM rare/absent.

b) AOM present.

2) Most palynomorphs fluoresce but matrix of autochthonous AOM remains predominantly non-fluorescent.

a) Palynomorphs show dull orange-yellow fluorescence

b) Palynomorphs show yellow-green fluorescence.

3) Most palynomorphs fluoresce; matrix of AOM shows dull fluorescence just visible above background.

4) AOM matrix shows moderate and heterogeneous fluorescence (visible but clearly less than *in situ* palynomorphs).

5) AOM matrix shows strong and heterogeneous fluorescence (intensity is close to that of ordinary *in situ* palynomorphs).

6) Matrix of AOM shows rather homogeneous and very strong fluorescence, bright yellow, like telalginite (not encountered in this study).

Table 2.4. *A qualitative preservation scale, based on immature kerogen examined under incident blue light fluorescence (from Tyson, 1995).*

2.2.2 *Kerogen Counts*

Point counts of 500 particles were carried out at ×20 magnification on all slides in the study, with additional counts being made where necessary to give a minimum total of 50 particles in the key opaque phytoclast category. The data was recorded on an electronic point counter, but the counts were made using manual traverses and took between fifteen and thirty minutes to perform (average *ca.* twenty-five minutes) per slide. The particles were classified into the kerogen categories shown in Table 2.5 (see section 2.3 for definitions).

The phytoclast fraction was subjected to a much more detailed classification system than is normal in palynofacies studies to try to find out if any extra palaeoenvironmental or palaeobotanical information could be obtained. This classification also allowed the development of a 'phytoclast preservation index' and assessment of potential degradation pathways for the phytoclast fraction (see Chapter 7.0).

2.2.3 *Palynomorph Counts*

Most slides were then also subjected to a detailed analysis of the palynomorph fraction based on a further count of 300 palynomorphs which took between fifteen and forty-five minutes to perform (average twenty to twenty five minutes). Table 2.6 shows the categories used for the palynomorph counts. The data was again recorded on an electronic point counter and traverses made manually. The decision whether to perform this second count was based mostly on the amount of palynomorphs seen on the slide, together with the position and importance of the sample under consideration. Previous studies have often based this decision on a cut off point of a certain percentage of palynomorphs of kerogen (e.g. Tyson, 1989); however, in this study it was noted that whilst percentages of palynomorphs of kerogen could be quite low the absolute numbers of these particles on the slide were sufficient for counts to be performed. In practice this meant that only around 90 slides were rejected (out of a total of 470); this includes thermally affected samples not included in the final spread sheet. In many of the formations examined AOM percentages are high; large amounts of AOM on a slide can often mask other particle types, particularly palynomorphs. The use of routine fluorescence observations showed that this was not taking place apart from in the Lealt Shales Formation where the abundance of AOM in some samples was masking many of the small acritarchs and some of the *Botryococcus* colonies present, causing under-representation of these palynomorphs in the counts. In

AOM (AOM)			
Phytoclasts (Tphy)	Black wood (Blk)	Equant (Equ)	
		Lath (Lath)	
	Brown wood (Bro)	Biostructured (Str)	Undegraded (Undg)
			Degraded (Deg)
			Striate (Stria)
			Striped (Stp)
			Banded (Ban)
			Pitted (Pit)
		Non-biostructured (Ust)	Undegraded (Und)
			Corroded (Cor)
			Pseudoamorphous (Psu)
	Cuticle (Cu)		
	Membranes (Mem)		
	Fungal Hyphae (Hyph)		
Palynomorphs (Tpaly)	Sporomorphs (Sporo)		
	Marine plankton (Mp)		
	Undifferentiated (Undiff)		
	Botryococcus (Bot)		
Others	Foram linings (For)		

Notes were also made as to phytoclast and palynomorph preservation, and phytoclast size and sorting.

Table 2.5. *Kerogen count categories; rank of categories decreases from right to left. Also shown are the abbreviations as used in Tables 2.13 to 2.21.*

Sporomorphs (Sporo)	Spores (Sp)	Thick-walled (Tks)
		Thin-walled (Tns)
	Pollen (Poll)	Other (unidentified) (OP)
		Bisaccates (Bis)
		*Cerebropollenites** (Cere)
		Callialasporites (Cal)
Marine plankton (Mp)	Dinocysts** (Din)	
	Acritarchs (Acri)	
	Tasmanites type (Tas)	
	Leiospheres (Lei)	
Others	*Botryococcus* (Bot)	
	Undifferentiated (Undif)	

Notes were also made on the preservation state of the various categories and the type of any acritarchs (long- or short-spined).
**Cerebropollenites* was not used as a category for Duntulm Formation samples.
** The Dinoflagellate cyst category was subdivided into different genera common in particular parts of the Middle Jurassic sequence based on Riding *et al.* (1991) and Riding (1992), summarised in Table 2.7; an unidentified dinocyst category was also used.

Table 2.6 Palynomorph count categories; rank of categories decreases from right to left. Also shown are the abbreviations as used in Tables 2.13 to 2.21.

Stratigraphic sequence	Main dinoflagellate genera	Also counted
Bearreraig Sandstone Formation	*Batiacasphaera* *Caddasphaera* *Nannoceratopsis*	*Parvocysta*
Great Estuarine Group	*Batiacasphaera* *Ctenidodinium* *Dissiliodinium* *Durotrigia* *Meiourogonyaulax* *Pareodinia* *Sentusidinium*	*Jansonia manifesta* *Caddasphaera*
Staffin Bay Formation	*Batiacasphaera* *Durotrigia* *Meiourogonyaulax* *Pareodinia*	*Rhychodiniopsis* *Adnatosphaeridium*

Table 2.7 *Genera used to subdivide the dinocyst category within each major stratigraphic sequence.*

such cases quantitative notes were made on acritarch and *Botryococcus* abundance when the slides were examined under fluorescence.

2.3 Definitions of Kerogen and Palynomorph Categories

The components of the kerogen can be separated into three main groups: the phytoclasts and palynomorphs (both of which are structured) and Amorphous Organic Matter, which is structureless (Tyson, 1993, 1995). Palynomorphs are all HCl and HF resistant organic-walled microfossils; phytoclasts are plant derived particles that are literally clasts (Tyson, 1993).

2.3.1 Kerogen Classification

2.3.1 (a) Phytoclasts

Black wood

Black or opaque in colour even at grain boundary; sharp outline; mostly no internal structure, but laths may show pits (Tyson, 1989; Tuweni & Tyson, 1994); subdivided into:

Equant (length:width ratio <2)
Lath (length:width ratio >2)

Biostructured (= botanically structured) brown wood

Translucent, generally brown in colour; lath to equant in shape; clearly visible internal structure, subdivided into:

Striate: Shows thin (regular) fibrous lineation (? = degraded bundles of Boulter & Riddick, 1986; Boulter, 1994).
Striped: Irregular or unequal stripes (may be thickenings).
Banded: Regular and equal parallel sided (fusiform) thickenings (Tyson, 1989).
Pitted: Bordered or scalariform pits (Tyson, 1989).

The striate, striped, banded and pitted material is probably derived from the tracheid tissue of higher plants (Boulter & Riddick, 1986; Tyson, 1989; Boulter, 1994). All the biostructured brown wood categories were also divided into:

Undegraded: Sharp outline (may be slightly irregular); may be splintered.
Degraded: More diffuse outline; irregular; if striate then often looks fibrous at ends; striped and banded material often shows associated multiple splitting along lines of structure.

Non-biostructured (= no botanical structure) brown wood

Translucent, generally brown in colour; lath to equant in shape. Divided into:

Undegraded: Sharp outline (may be slightly irregular); may be splintered.
Corroded: More diffuse outline; irregular.
Pseudoamorphous: Often light brown in colour; usually equant in form; starting to show some features of AOM, particularly gradational margins, but mostly homogeneous in appearance, not pyrite specked, no inclusions.

Cuticle

Pale yellow-green in colour; irregular; sheet like; cellular; usually strongly fluorescent; epidermal tissue of higher plants (Tyson, 1989).

Membranes

Pale grey; thin; sheet-like; irregular; often pyrite specked; occasional poorly defined ?cellular structure; may be weakly fluorescent.

2.3.1 (b) Palynomorphs

Sporomorphs

All palynomorphs produced by terrestrial macrophytes; fluorescence properties vary.

Marine plankton

Includes dinocysts, acritarchs, prasinophytes; fluorescence properties variable; some taxa may tolerate brackish conditions (see Chapter 10.0).

Undifferentiated palynomorphs

Unidentifiable palynomorphs that may belong to either of the above two categories.

Botryococcus

Brown to green-yellow; colonial freshwater algae; often globular in appearance; sometimes visible pseudo-radial structure at periphery; typically strongly fluorescent; cell cups visible under fluorescence.

2.3.1 (c) Other

Fungal hyphae

Brown in colour; uni- or multicellular thin tubes; probably chitinous (Boulter & Riddick, 1986; Boulter, 1994).

Foraminiferal linings

Tectinous linings derived from certain marine benthic foraminifera (Tyson, 1989, 1995).

Amorphous Organic Matter (AOM)

Yellow, orange, brown or grey; irregular particles; rounded to angular; gradational margins; heterogeneous; usually pyrite specked; varied common micro-inclusions; often strongly fluorescent, but can be variable (Tyson, 1989).

2.3.2 Palynomorph Classification

Spores

Produced by pteridophyte plants; usually exhibit a trilete mark; often show variable orange-yellow fluorescence. Subdivided into:

Thick-walled: Markedly thickened outer wall, also often ornamented and large.
Thin-Walled: 'Normal' or simple spores, often smaller than above.

Pollen

Produced by gymnosperm plants, subdivided into:

Bisaccates: Conifer (usually) pollen with two distinct sacci (Traverse, 1988); usually show variable yellow-green fluorescence.
Callialasporites: Long-ranging monosaccate pollen genus, probably coniferous (Traverse, 1988); may show orange-yellow fluorescence.
Cerebropollenites: Long ranging multisaccate pollen genus; usually show variable yellow-green fluorescence.
Unidentified Pollen: All pollen grains not in above categories; usually show variable fluorescence.

Dinoflagellate cysts

Sporopollenoid (algaenan) cysts of dinoflagellates; usually show quite strong yellow-green fluorescence.

Acritarchs

Resistant walled microscopic organic body of uncertain origin, characterised by varied ornament but mostly acanthomorph or polygonomorph taxa (Traverse, 1988); typically strongly fluorescent (yellow-green).

Leiospheres

Thin-walled spherical body lacking sculpture, probably (prasinophyte) algae (Traverse, 1988); typically brightly fluorescent.

Tasmanites type algae

Large, thick, perforate walled palynomorph; phycomata (fossilising pelagic organic body) of prasinophyte algae; typically brightly fluorescent (Traverse, 1988; Tyson, 1993, 1995).

Botryococcus

As in kerogen classification.

2.3.3 Discussion of Classification

This classification system, parts of which appear in Tyson (1984, 1989), is one of the most detailed that has been applied in palynofacies analysis (c.f. the proposed standard classification system in Traverse 1994 p.3, and the comparison of various systems given in Tyson, 1993, p.156-157). It attempts to satisfy the criteria laid down in Tyson (1993, 1995) for detailed palynofacies work, taking into account the variables summarised below (see also section 2.4):

a) The biological provenance of the particles (e.g. different types of biostructured brown wood).
b) Any ecologically significant groupings that may be reflected by particle types (e.g. different types of plankton and algae).
c) The preservation states of the various particle types (e.g. degradation state of the brown wood).
d) Any consistent or significant variation in size , morphology , or density likely to be reflected in the hydrodynamic behaviour of the particles (e.g. different types of black wood and spores).
e) Any components with predictable differences in their geochemical character (e.g. AOM preservation, black *vs.* brown wood, telalginitic *vs.* ordinary palynomorphs).

Most systems that have been used in the past have been biased towards one particular variable or another, for example in the system of Whitaker *et al.* (1992) the particles are grouped primarily by their expected hydrodynamic behaviour.

2.4 Trends in the Distribution of the Different Particle Types

This topic is more fully reviewed in Tyson (1993, 1995) and is only briefly reviewed below. The trends are summarised in Table 2.8, and the selective preservation scheme for phytoclasts is shown in Table 2.9 (see Chapter 7.0 for further discussion of this). The most important variable controlling the parameter trends is proximality; the concept of proximality used in palynofacies work involves a number of interrelated factors which are listed below (from Tyson, 1993, 1995):

a) Proximity to the fluvio-deltaic point source of siliciclastic sediment and terrestrial organic matter (phytoclasts).
b) The magnitude of the fluvio-deltaic point source(s) (i.e. its discharge rate).
c) The magnitude and nature of terrestrial primary productivity in the sediment source area.
d) The relative total duration of transport (intermittent or continuous) between the particle source area and its final site of deposition.
e) The gradient in palaeoenvironment between the source area and site of final deposition.

2.4.1 Kerogen

Percentage phytoclasts

A high percentage of phytoclasts in the kerogen assemblage can reflect high supply, preferential preservation or preferential sedimentation depending on the nature of the assemblage (Tyson, 1993). Poorly sorted assemblages of mixed composition containing tissues which would not normally be preserved are characteristic of proximal settings close to the parent flora, where there is sufficient supply to dilute other kerogen groups (Tyson, *ibid.*). This situation generally characterises inner shelf settings as most terrestrial organic matter in estuarine systems sediments out before salinities reach 3-10‰, large amounts only reach the outer shelf when markedly high discharge occurs, or the shelf is particularly narrow (Muller, 1959; Wollast, 1983; Tyson,1993).

Parameter response	Proximal >>>Distal	Increasing % sand
% phytoclasts of kerogen	high>>>low	increases
% AOM of kerogen	low>>>high	decreases
% palynomorphs of kerogen	low>>>high	decreases
AOM fluorescence	variable	decreases
Translucent:opaque phytoclasts	high>>>low	decreases
Black equant:lath wood	high>>>low	increases
% biostructured (of brown wood)	low>>>high	may increase
% corroded (of non-biostructured brown wood)	high>>>low	may increase
% banded/pitted (of biostructured brown wood)	low>>>high	may increase
% cuticle (of phytoclasts)	high>>>low	may increase
% sporomorphs (of palynomorphs)	high>>>low>>>high	increases
% spores (of sporomorphs)	high>>>low	increases
% thick-walled (of spores)	high>>>low	increases
% bisaccates (of pollen)	low>>>high	decreases
% marine plankton (of palynomorphs)	low>>>high>>>low	decreases
% dinocysts (of marine plankton)	low>>>high>>>low	may decrease
% acritarchs (of marine plankton)	high>>>low	may increase
% *Botryococcus* (of palynomorphs)	high>>>low	decreases
Foraminiferal lining frequency	high>>>low	decreases
Tetrad frequency	high>>>low	may increase

Table 2.8 Palynofacies trends (adapted mainly from Tyson, 1993, 1995).

Proximal **Distal**

>>>>>> Increasing Oxidation >>>>>>
Selective Preservation

Non-Biostructured Brown Wood (Undegraded–Degraded)——Biostructured Brown Wood (Striate–Striped)–(Banded–Pitted)——Black Wood

Table 2.9 Selectively preserved phytoclast types at different points on a relative proximal-distal gradient; the assemblage at each point is characterised by relatively increased percentages of the component indicated (see Chapter 7.0).

Dominantly refractory phytoclast assemblages are characteristic of oxidising situations where only resistant (lignitic) woody material survives, such as fluvial and delta top settings where there is a strong chance of post-depositional oxidation. Similar assemblages dominate distal oxidising settings where only the resistant material has survived extended transport (Tyson, 1993). The hydrodynamic equivalence of phytoclast material leads to high percentages occurring in sediments of predominantly coarse silt/fine sand grain size; in terrestrially dominated facies it is this relationship that largely controls TOC values (Tyson, 1993).

Percentage of AOM and its fluorescent intensity

Tyson (1993, p.1ö2) states that 'high percentages of fluorescent AOM reflect enhanced preservation under reducing conditions and, to a lesser extent, sedimentation removed from active sources of terrestrial organic matter'. Most of the marine organic matter in sediments is represented by AOM, but it is easily degraded when exposed to aerobic conditions. However, due to the large reservoir of marine organic aggregates available, when conditions are sufficiently reducing it often swamps other kerogen components (Tyson, 1987, 1989, 1993).

The fluorescent intensity of the AOM is controlled by the redox conditions under which it was deposited; dysoxic-anoxic conditions preserve the labile hydrogen-rich components of the AOM. As the fluorescence as a whole is partly controlled by the planktonic source and inclusions within the particles, it is the fluorescence of the easily degraded matrix of heterogeneous amorphous particles that is the most sensitive indicator of redox conditions (Tyson, 1993).

Percentage of palynomorphs

The percentage of palynomorphs is primarily controlled by dilution by either AOM or phytoclasts; therefore, it is highest in settings where these two parameters are reduced (Tyson, 1993). In such cases the interpretation depends on the nature of the assemblage; bisaccates and other pollen are often concentrated in low energy distal environments (see later), whilst dinocyst-dominated assemblages may reflect areas of high primary productivity (Tyson, 1993).

Sorting effects can also lead to concentrations of palynomorphs in sediments rich in medium-fine silt grade material, with which they are hydrodynamically equivalent (Muller, 1959; Wall *et al.*, 1977; Tyson, 1993).

Translucent:opaque phytoclast ratio

Opaque phytoclasts can be produced by either the oxidation of translucent particles (during prolonged transport or post depositionally), or as charcoal by wildfire (Tyson, 1993). They are commonly reported as being dominant in coarse grained, high energy, organic-poor facies such as distributary channel sands and point bars (Fisher, 1980; Denison & Fowler, 1980; Parry *et al.*, 1981; Batten, 1982; Boulter & Riddick, 1986; Bustin, 1988). This relationship has lead to the development of the idea that opaque phytoclasts are hydrodynamically equivalent to sand grade material (Fisher, 1980; Denison & Fowler, 1980; Parry *et al.*, 1981). However, post-depositional oxidation is also common in such facies, as shown by the abundance of non-charcoal opaques in the deltaic facies of Fisher (1980), Denison and Fowler (1980), Hancock and Fisher (1981), and Fisher and Hancock (1985), so the relationship is probably due to a combination of the two elements (Tyson, 1993).

Whitaker *et al.* (1992) consider blade-shaped opaque phytoclasts to be the most buoyant material in the kerogen assemblage, but also note that it is resistant to degradation and can be concentrated in high energy environments (see below). Tyson (1989) shows an increase offshore in fine grained opaque phytoclasts relative to translucent material. Tyson (1995) suggests that the transition from translucent to opaque phytoclasts is primarily a subaerial effect that happens before the particles enter the sea; the subsequent ratio reflects relative preservation (opaque greater than translucent) and size sorting (as opaque particles are generally smaller).

Equant:lath black wood ratio

The interpretation of the opaque:translucent phytoclast ratio depends greatly on the morphological form of the opaque (black) wood that is encountered. Lath-shaped black wood is supposedly 'extremely buoyant' (Whitaker *et al.*, 1992, p.173), and is selectively transported to more distal settings where it is commonly dominant. This relationship may also be partly due to the fact that the lath material is the result of break down of larger particles (lath or equant in shape) and is extremely resistant in nature (Whitaker *et al.*, 1992). Relative decreases in the equant:lath ratio can therefore be used to indicate a shift to more distal deposition (Parry *et al.*, 1981; Van der Zwan, 1990; Gorin & Steffen, 1991). However, Van der Zwan (*ibid.*) also shows that the opposite trend can occur, as do Frank and Tyson (1995). It would appear that the equant:lath sorting trends are also partly size dependant with lath-shaped particles increased in some high energy, proximal facies as they can be significantly larger than any equant particles (Tyson, 1995; Frank & Tyson, 1995).

Percentage of cuticle

Cuticle debris is derived primarily from leaves (Tyson, 1993). It was considered by Fisher (1980) to be the most buoyant type of terrestrially-derived organic matter, only deposited from the suspended load when energy conditions were particularly low. High percentages of cuticle have been found in deltaic distributary and prodeltaic facies by Parry *et al.* (1981) and Nagy *et al.* (1984); Batten (1973) shows a strong correlation between cuticle in the kerogen assemblage and macroscopic plant debris in the sample. In modern sediments cuticle debris shows a rapid decrease in abundance offshore (Muller, 1959).

Particle size

The particle size of tracheids, charcoal and cuticle have all been shown to decrease in an offshore direction, but phytoclast particle size is also strongly affected by the granulometric composition of the sediment, proximity to source, and any fragmentation during maceration (Tyson, 1993).

2.4.2 Palynomorphs

Percentage sporomorphs of total palynomorphs

This is dependant on the proximity to a fluvio-deltaic source and on the productivity of fossilising plankton, especially dinoflagellates (Tyson, 1993). Therefore, the highest percentages are found in proximal areas where lowered salinities suppress any plankton production and sporomorph input is high (Muller, 1959; Cross *et al.*, 1966; Davey & Rogers, 1975; Tyson, 1993). High percentages are also found at sites near to the parent flora, characterised by an over representation of locally derived sporomorphs and high variability (Muller, 1959; Darrell & Hart, 1970; Tyson, 1993).

Percentage marine plankton of total palynomorphs

High percentages occur in essentially the opposite situations to those of sporomorph maxima: areas that are removed from fluvio-deltaic sources, poorly vegetated or with high primary productivity (Tyson, 1993).

Percentage spores of sporomorphs

The presence of significant percentages of spores indicates substantial pteridophyte vegetation and humid conditions. The predominance of spores over pollen indicates proximality as they are produced in lower numbers and transported less efficiently, the percentage then decreases offshore (Tschudy, 1969; Habib, 1982; Tyson, 1989, 1993).

Percentage thick-walled spores of total spores

Decreases away from source due to hydrodynamic equivalence, larger, denser spores being generally deposited first (e.g. Parry *et al.*, 1981; Habib, 1982). However, these spores can also be selectively concentrated in any coarser sediment as there are no other palynomorphs of similar hydrodynamic equivalence (Tyson, 1993).

Percentage bisaccates of total pollen

Due to their buoyancy, these grains are selectively transported to more offshore settings, their percentage increasing in relation to other pollen; relatively high percentages therefore indicate a (relatively) distal setting (Hopkins, 1950; Habib, 1982; Heusser, 1983; Traverse, 1988; Tyson, 1989, 1993). However, Tyson (1993) shows that there may be problems with this simple relationship due to waterlogging reducing buoyancy. Although Whitaker *et al.* (1992, p.174) claim that these pollen have a '.......waxy outer layer, rendering them less susceptible to waterlogging', Tyson (1995) cites evidence that demonstrates that waterlogging is definitely significant. Size sorting of the grains, and 'saturation' of the basin (if parent plant distribution is widespread) are also important.

Percentage *Botryoccocus* of palynomorphs

Botryococcus is known to be exclusively freshwater in origin and most fossil records of its occurrence are from lacustrine, fluvial, lagoonal and deltaic facies. However, their buoyant nature means that the colonies are often flushed out to outer shelf settings (Tyson, 1993). High percentages of *Botyrococcus* may therefore indicate proximality to a fluvio-deltaic source, and its presence in assemblages has been used to indicate at least some freshwater input to a system (e.g. Riding *et al.*, 1991).

Percentage acritarchs of marine plankton

Significant percentages of acritarchs in Mesozoic sediments generally characterise shallow, marginal marine facies where dinocyst production in suppressed by brackish conditions (Wall, 1965; Tyson, 1993). They are therefore the most tolerant (euryhaline) of the marine plankton groups and have been used to recognise saline influences in generally non-marine settings (e.g. Hancock & Fisher, 1981).

Percentage dinocysts of marine plankton

Tyson (1993, p.169-170) states that 'In most marine situations dinocysts are the predominant form of fossilising phytoplankton, and they normally form a very high percentage of the total organic-walled microplankton assemblage'. This is particularly the case in areas of high primary productivity.

Percentage prasinophytes of marine plankton

Prasinophyte algae dominate the marine palynomorph assemblage when the production of other groups was suppressed, especially in dysoxic-anoxic facies. Although modern fossilising representatives are 'almost exclusively marine' (Tyson 1993, p.170) the fossil phycomata (pelagic organic bodies) have often been regarded as having a brackish affinity, and have been found dominating lagoonal and shallow water carbonate facies. This could be attributed to the reason given above, or due to the holoplanktonic nature of the prasinophytes allowing them to be transported into these facies (Tyson, 1993); also the apparent brackish affinity is often based more on earlier interpretations rather than direct evidence (Tyson, 1995).

Dinoflagellate diversity and dominance

Diversity generally increases offshore, but onshore assemblages (particularly those in estuarine facies) show the most variability in diversity and are frequently characterised by high dominance (Wall *et al.*, 1977). Low diversity high dominance assemblages are generally typical of stressful environments which can only be tolerated or exploited by specialised forms (Wall *et al.*, 1977). If conditions are eutrophic, high productivity can give rise to high dinocyst density and high dominance in such facies (Davey & Rogers, 1975; Honigstein *et al.*, 1989). For the purposes of this study the diversity is simply the number of different genera present in each sample (seen during counting or scanning); dominance was calculated using the formula of Goodman (1979):

$$\text{Dominance (\%)} = (N_1 + N_2) / N_t$$

where N_1 is the number of specimens of the most abundant genera in the sample; N_2 is the number of specimens of the second most abundant genera in the sample; N_t is the total number of specimens counted (discounting the unidentified dinocysts).

Frequency of foraminiferal linings

Although they often form only <1% of the kerogen assemblage foram linings are an important indicator of normal marine conditions (Muller, 1959; Tschudy, 1969). They also have the advantage of providing evidence independent of palynomorphs as the foraminifera are larger, heavier and not transported in the same way (Tyson, 1993).

2.5 Reliability and Reproducibility of Counts

2.5.1 Introduction

Palynofacies workers have often failed to fully consider the reproducibility and potential errors in their data; in this respect reflected light microscopy has been far more rigorous. Many published palynofacies studies give no reference to potential variations produced by the point counting technique (e.g. Nagy *et al.*, 1984), although it is often assumed to be around ±5% (absolute). In those studies that do include error assessments the methodology presented is often far from rigorous. Oboh (1992) assessed reproducibility by point counting the same slide twice, and found a difference of less than 5%. Gorin and Steffen (1991) tried to establish a minimum number of points to count by counting 100 to 500 points and calculating the percentages for each increment of 100 counts to determine what addition to accuracy each extra 100 points brought. They concluded that 300 points should be counted because less than 1% in accuracy was added by continuing to count after this level, but that not much confidence should be placed on any variations in the parameters of less than 5%.

In this study both of the approaches referred above have been used to try to get an understanding of what levels of variation were likely to be significant, rather than artifacts of the counting method, and to demonstrate why 500 point counts were employed when the maximum for most published studies is 300.

2.5.2 Number of Total Counts

A slide containing a wide range of particle types (RCS 14) was counted for a maximum 500 particles; after each 100 points the percentage values for each of the parameters were calculated to give values for the 100, 200, 300, 400, and 500 count totals so that any changes in the percentage values of different categories could be determined.

The major reason for counting 500 points is that in this study many subsets of the total count have been employed in order to calculate the various parameters used to interpret assemblages (e.g. biostructured brown wood, black wood, etc.). The 500 total is needed so that there are enough counts in the rarer categories to allow the reliable calculation of these subset percentages and some ratios (Tyson, 1993, 1995). This is shown by Tables 2.10 and 2.11. Table 2.10 shows the standard deviation for a value of 5% of the total population and for various sub-totals when the total count is 200. Table 2.11 shows the same values when the total count is 500. The standard deviation values have been derived from Traverse (1988, p.490, his Fig. A.11).

The two tables show that when only a total of 200 points are counted the standard deviations for a 5% component of some of the subsets reach around 50% in relative terms for even some of the larger subsets (e.g. total phytoclasts, total non-biostructured brown wood), and are ≥150% in some of the smaller subsets (e.g. total biostructured brown wood). However, when 500 points are counted the subsets are calculated out of larger totals and the standard deviations are consequently lower, but there are still some subsets in which the standard deviations are relatively high (e.g. black wood, palynomorphs). It was for this reason that the black wood category was counted until the total was at least equal to 50 (to allow reliable calculation of the equant:lath ratio), and the separate palynomorph count was performed (to allow subdivision into an increased number of significant categories).

The rest of the results are shown in Tables 2.12 to 2.15.

Category	Count No.	SD for 5%	66% of analyses within
Total population	200	32%	5 ± 1.6%
Total phytoclasts	84	47%	5 ± 2.4%
Total palynomorphs	26	88%	5 ± 4.4%
Total black	6	>150%*	5 ± >7.5%*
Total brown	76	50%	5 ± 2.5%
Total biostructured brown	8	>150%*	5 ± >7.5%*
Total non-biostructured brown	68	54%	5 ± 2.7%

* Not shown in Fig. A.11 but SD for 5% of 10 counts is 150%

Table 2.10. *Standard deviation for 5% value for count totals of different subsets; total count 200.*

Category	Count No.	SD for 5%	66% of analyses within
Total population	500	20%	5 ± 1%
Total phytoclasts	200	32%	5 ± 1.6%
Total palynomorphs	65	55%	5 ± 2.8%
Total black	20	99%	5 ± 5%
Total brown	170	34%	5 ± 1.7%
Total biostructured brown	20	99%	5 ± 5%
Total non-biostructured brown	150	37%	5 ± 1.9%

Table 2.11. *Standard deviation for 5% value for count totals of different subsets; total count 500.*

Count	Blkequant	Blklath	Undgstrbro	Degstrbro	Undustbro	Corustbro	Psuustbro	Cuticle
100	2	2	0	3	24	9	1	0
200	2	1	0	4	20	13	1	0
300	2	1	0	5	19	12	1	0
400	2	2	0	5	17	12	1	0
500	3	2	0	4	17	12	1	0
Count	Membranes	Hyph	AOM	Sporo	Mp	Foram	Bot	Undif
100	2	0	41	15	0	0	0	1
200	1	0	43	12	0	0	3	1
300	1	0	44	12	0	0	3	1
400	1	0	45	11	1	0	3	1
500	1	0	44	11	1	0	3	1

Table 2.12. *Percentage variations in particle frequency for 100-500 point counts: Simple percentages. (Key to abbreviations in Table 2.5).*

Count	Blkequant	Blklath	Undgstrbro	Degstrbro	Undustbro	Corustbro	Psuustbro	Cuticle
100-200	0.0	50.0		33.3	16.7	44.4	0.0	
200-300	0.0	0.0		25.0	5.0	5.4	0.0	
300-400	12.5	50.0		10.0	10.5	0.4	0.0	
400-500	15.6	6.7		2.2	1.2	1.2	20.0	
Count	Membranes	Hyph	AOM	Sporo	Mp	Foram	Bot	Undif
100-200	50.0		3.7	20.0				0.0
200-300	34.0		2.8	2.8			6.8	33.0
300-400	89.4		2.5	7.9	233.3		21.7	25.4
400-500	20.0		1.2	6.0	20.0		1.5	60.0

Table 2.13. *Relative percentage changes in simple percentages over each 100 count increment (key to abbreviations in Table 2.5).*

Count	AOM	Tphy	Tpaly	Sporo/Tpaly	Mp/Tpaly	Undif/Tpaly	Blk/Tphy	Brown/Tphy
100	41	43	16	94	0	6	9	86
200	43	42	13	92	0	8	7	90
300	44	41	13	92	2	5	7	91
400	45	40	12	88	8	4	9	87
500	44	40	13	88	6	6	11	87
Count	Mem/Tphy	Equ/blk	Lath/blk	Str/bro	Ust/bro	Und/ustbro	Cor/ustbro	Psu/ustbro
100	5	50	50	8	92	65	32	3
200	2	67	33	11	89	53	45	3
300	2	67	33	13	87	51	46	3
400	3	60	40	13	87	49	48	3
500	3	62	38	13	87	49	49	2

Table 2.14. *Percentage variations in particle abundance for 100-500 point counts: Recalculated percentages (key to abbreviations in Table 2.5).*

Count	Tphy	Tpaly	Sporo/Tpaly	Mp/TPaly	Undif/Tpaly	Blk/Tphy	Bro/Tphy	Cu/Tphy
100-200	2.3	18.8	1.5		23.1	23.2	5.1	
200-300	2.5	2.8	0.0		31.1	2.5	0.7	
300-400	3.0	3.1	5.0	243.9	23.0	28.8	4.0	
400-500	0.4	6.1	0.1	24.6	50.8	12.4	0.6	
Count	Mem/Tphy	Equ/blk	Lath/blk	Str/bro	Ust/bro	Und/ustbro	Cor/ustbro	Psu/ustbro
100-200	48.8	33.3	33.3	29.8	2.6	18.9	37.9	2.6
200-300	32.3	0.0	0.0	27.3	3.2	3.2	3.7	1.9
300-400	95.2	10.0	20.0	3.4	0.5	4.0	3.9	7.3
400-500	19.7	3.2	4.8	1.2	0.2	0.2	1.3	19.2

Table 2.15. *Relative percentage changes in the recalculated percentages over each 100 count increment (key to abbreviations in Table 2.5).*

Overall the simple (non-recalculated) percentages show an absolute range of generally ± 4%, apart from the non-biostructured undegraded brown wood (Undustbro) category which varies by up to 7%. Changes in most of the categories can be seen from the 100-200-300 levels (e.g. sporomorphs decreasing from 15% to 12%), but after this nearly all the categories show very little (less than 1%) variation over the 300-400-500 count levels, apart from the non-biostructured undegraded brown wood (Undustbro) category which continues to show relatively significant variation until the 400-500 level. Apart from the percentage changes it is important to note that some of the rarer items such as marine plankton (Mp) and *Botryococcus* (Bot) do not appear in the counts until the 200 or 300 point level. These data generally support previous studies indicating that 300 counts are sufficient for total population percentages.

The relative changes in some of the simple parameters approach 100% (the very high value seen in the marine plankton category is due to the lack of occurrence of this parameter in the first two counts). The larger relative changes are generally occurring in those parameters where the absolute percentage abundances are low (e.g. black lath wood, membranes) and the relative percentage changes are lowest where absolute percentage levels are high, e.g. AOM (Fig. 2.2). In the majority of categories there is an overall decrease from the 100-200 to the 400-500 level, although the decrease does not always take place progressively, e.g. undegraded non-biostructured brown wood (Fig. 2.3).

Tables 2.14 and 2.15 show that the recalculated percentages show a similar pattern to that described above with the components with low absolute percentage abundances (<10%) showing the greatest relative changes between count levels (e.g. black wood of phytoclasts). Those components with the greatest absolute percentage abundances show very low relative percentage changes (e.g. in the case of total phytoclasts the relative variation is less than 3%). Those parameters with neither particularly high or low absolute percentage levels show a characteristic pattern of a dramatic reduction in relative percentage changes between the 100-200 and 200-300 count increments and subsequent stabilisation of changes over the other increment levels, e.g. total palynomorphs (Tpaly) and undegraded (Und/ustbro) and corroded (Cor/ustbro) of non-biostructured brown wood (Figs 2.4 & 2.5). Note, however, that the biostructured of brown wood parameter (Str/bro) does not show this characteristic reduction until the 200-300 and 300-400 count increments (Fig. 2.6).

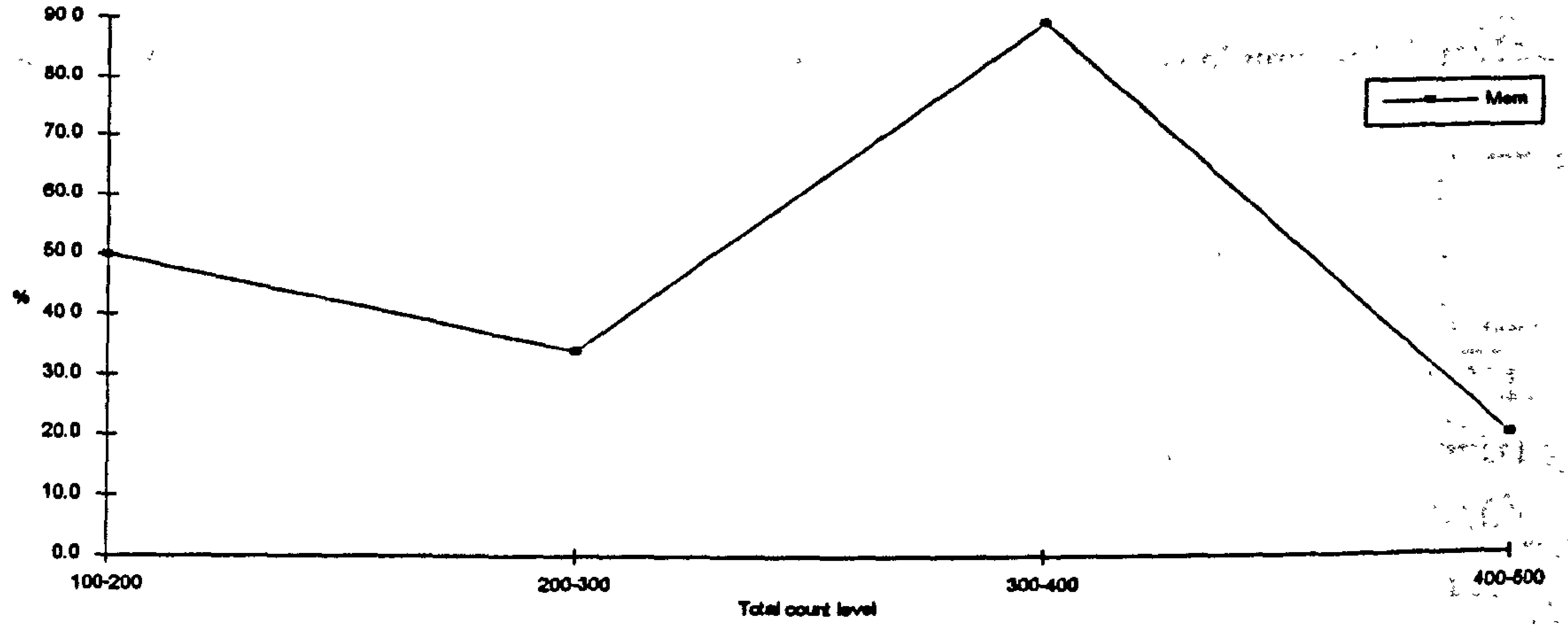


Fig. 2.2. *Relative percentage variation of the membrane category over each 100 count increase.*

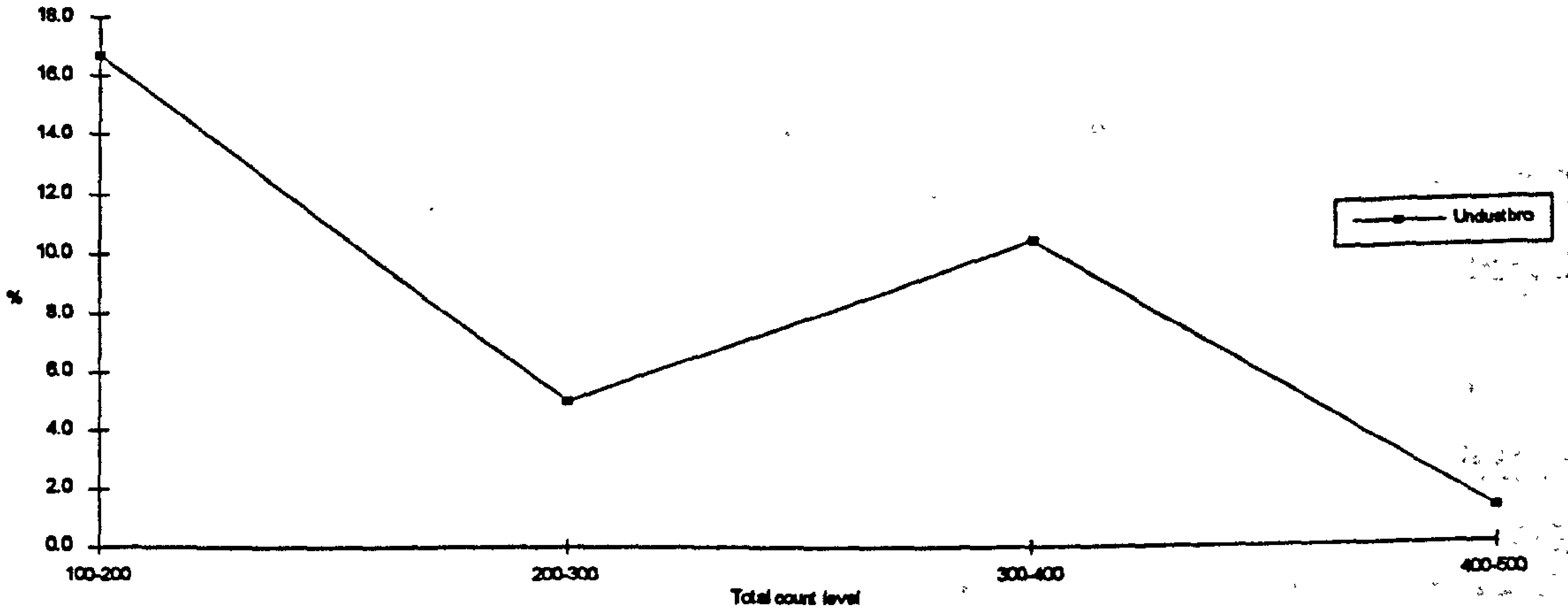


Fig. 2.3. *Relative percentage variation of the undegraded non-biostructured brown wood over each 100 count increase.*

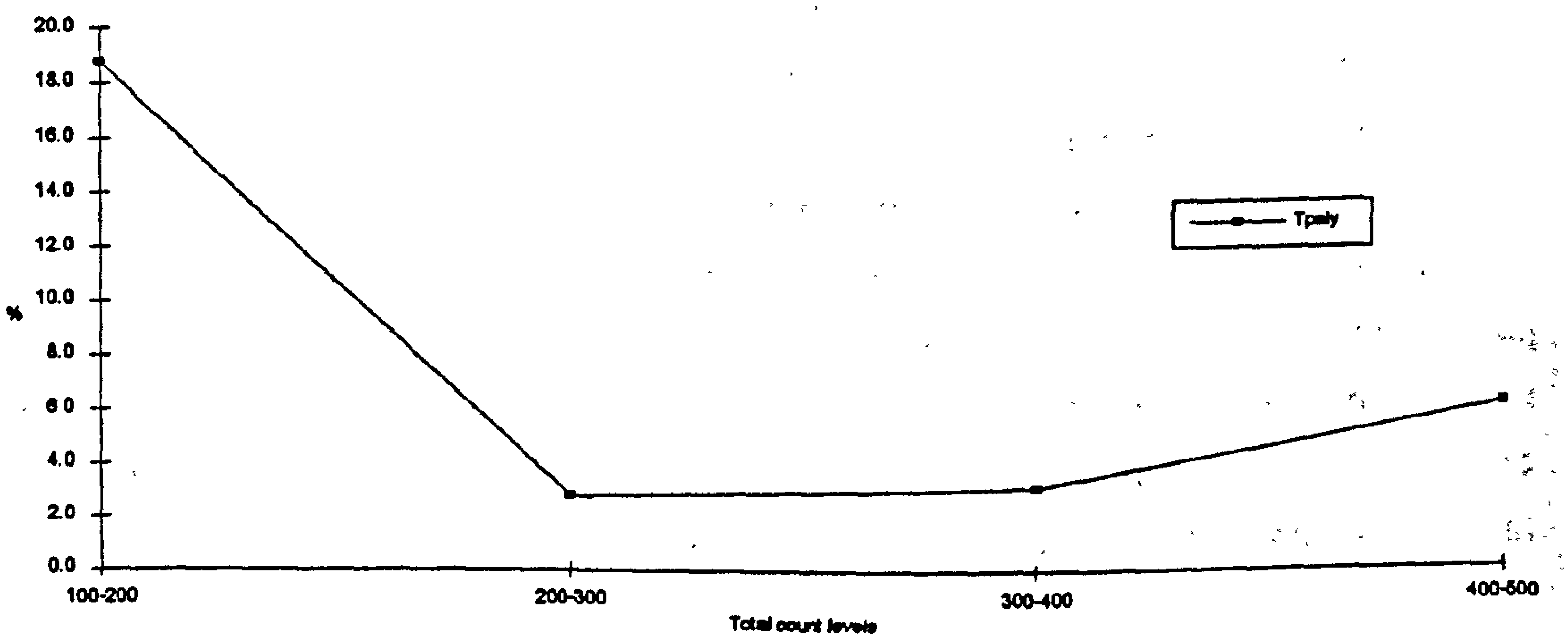


Fig. 2.4. *Relative percentage palynomorphs variation of the percentage palynomorphs of kerogen over each 100 count increase.*

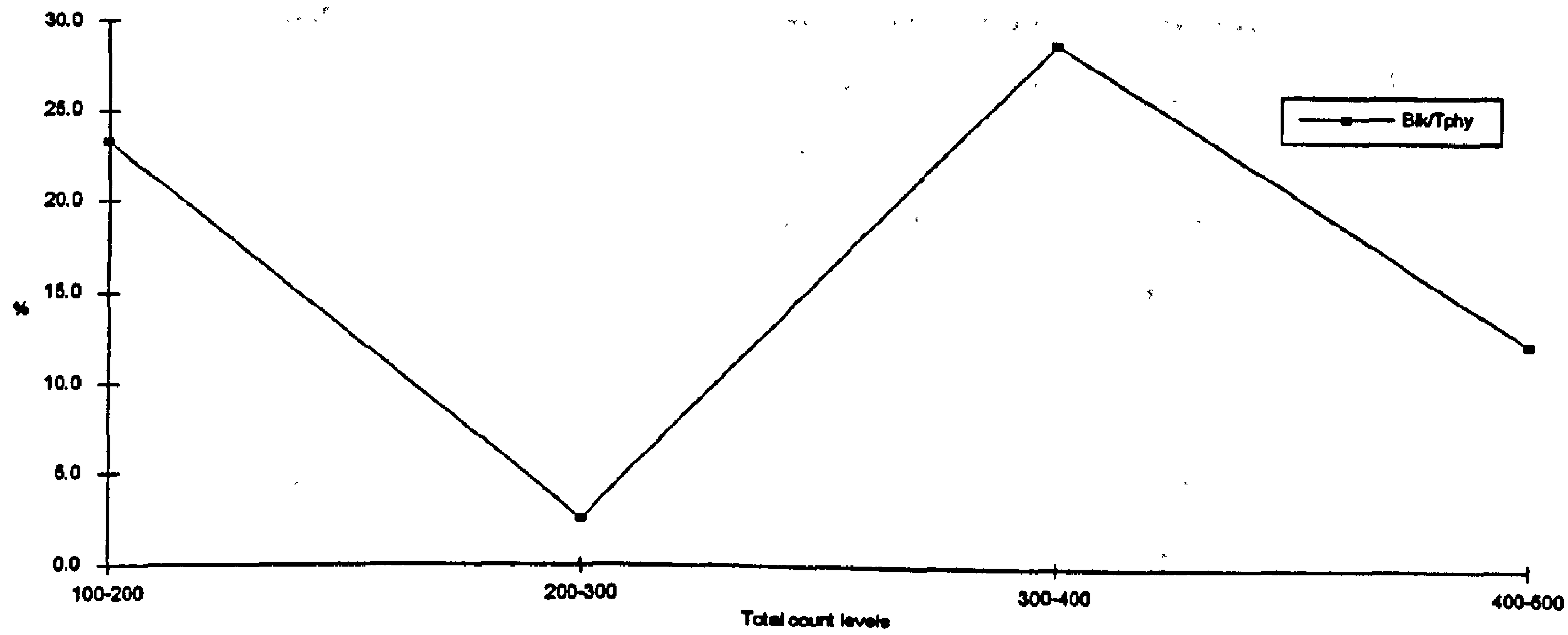


Fig. 2.5. *Relative percentage variation of the percentage black wood of phytoclasts over each 100 count increase.*

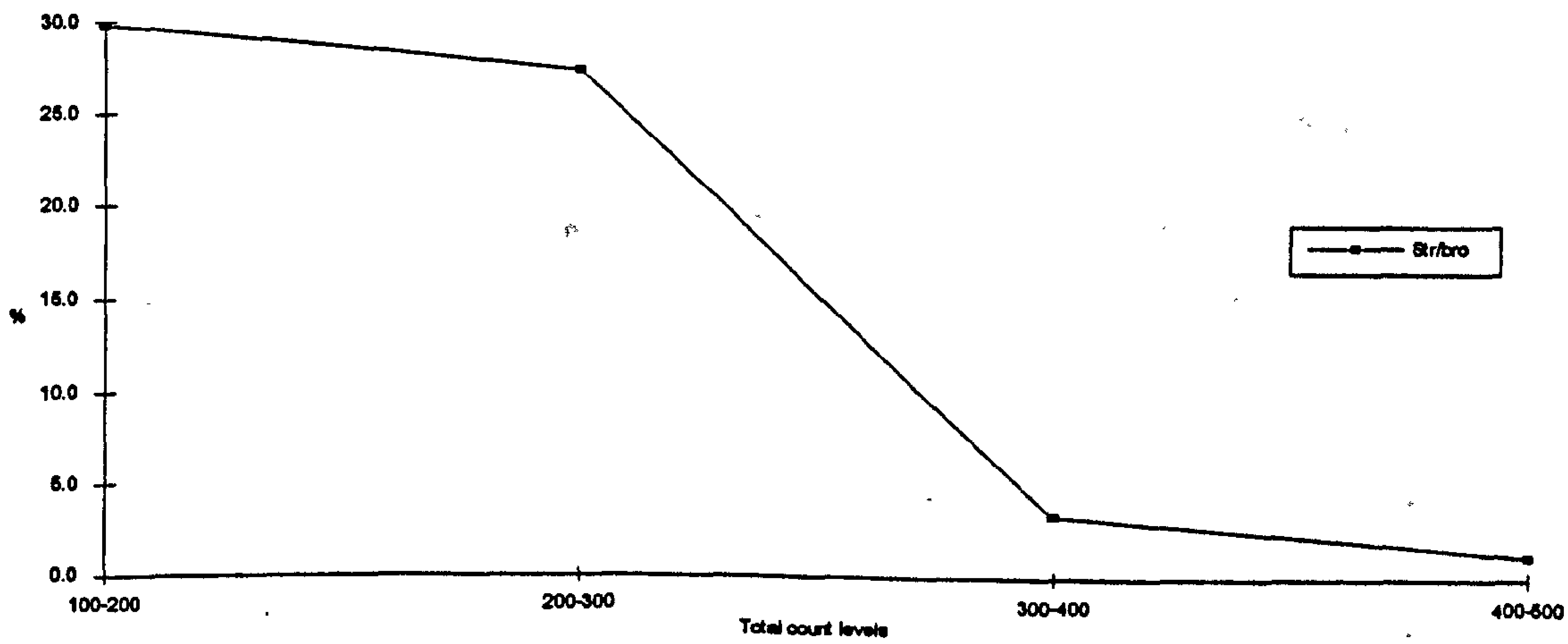


Fig. 2.6. *Relative percentage variation of the percentage of biostructured of brown wood over each 100 count increase.*

It is important to note that as the categories become smaller (e.g. brown wood, black wood etc.) the relative variations in the components become magnified from the simple percentage values. This particularly seems to be the case when the original simple percentages are lower than 3-4%, resulting in absolute recalculated percentages of less than 10%, showing potentially large relative variation, up to ± 95% in the case of membranes of phytoclasts (Mem/Tphy).

The results demonstrate the desirability of counting 500 particles when one wishes to employ recalculated percentages and a rigorous classification system (i.e. with many categories). The large count size also means that any rare (and often palaeoecologically significant) components will be represented in the data and any potential within-count variation in the categories will have reduced to non-significant levels (less than 1% in absolute terms).

2.5.3 Multiple Counts

Six counts (500 points) were made over different areas of the same slide (RCS 13) to try to determine any variations due to the potential unequal distribution of the residue on the slide, and to determine the range of variation in parameters that may be an artefact of the counting technique (i.e. its reproducibility). Two counts were made using traverses across the top side of the slide, two across the middle and two across the base of the cover slip. The simple and recalculated percentages for each count are shown in Tables 2.16 and 2.17 and in Figure 2.7.

There is no clear relationship between the data and the part of the slide used for the counts. The range of absolute variation of the simple percentage data shows a maximum of 6.4%, but this is limited to the AOM category and in fact the range of absolute variation in most of the categories is less than 3%, with only AOM and non-biostructured brown wood (range 4.4%) exceeding this figure. Although it has the greatest range, the standard deviation of the AOM category is only ± 2.05% (Table 2.18), this is the maximum for any of the simple percentages.

The amount of relative variation has been assessed by producing a value that is equal to the standard deviation divided by the mean, all multiplied by one hundred ((SD/mean)*100), this represents the final column in Table 2.18. This measure of relative variability, presented graphically in Fig 2.8, shows that the largest relative differences are occurring where the mean values of the categories are less than 1%, as in the case of many of the biostructured brown wood categories (e.g. striped). The

Sample No.	Blkequant	Blklath	Strundg	Strundgstria	Strundgstp	Strundgband	Strundgpit	Strdeg
RCS13m1	4.0	1.0	0.0	0.0	0.0	0.0	0.0	4.6
RCS13t1	4.4	1.0	0.2	0.0	0.2	0.0	0.0	4.0
RCS13b1	4.2	1.6	0.4	0.0	0.2	0.2	0.0	3.4
RCS13m2	3.0	1.0	0.0	0.0	0.0	0.0	0.0	4.0
RCS13t2	3.8	1.2	0.2	0.0	0.2	0.0	0.0	4.2
RCS13b2	6.2	0.8	0.0	0.0	0.0	0.0	0.0	4.8
Sample No.	Strdegstria	Strdegstp	Strdegband	Strdegpit	Ustund	Ustcor	Ustpsu	Cu
RCS13m1	0.4	2.8	1.0	0.4	15.8	8.0	0.8	0.2
RCS13t1	0.0	2.8	1.0	0.2	13.2	11.2	0.4	0.0
RCS13b1	0.0	2.4	1.0	0.0	13.8	10.8	0.8	0.2
RCS13m2	0.0	2.6	1.2	0.2	11.4	9.4	0.8	0.2
RCS13t2	0.4	2.6	1.0	0.2	15.6	10.8	0.6	0.2
RCS13b2	0.0	3.6	0.4	0.8	14.4	9.8	0.8	0.2
Sample No.	Mem	Hyph	AOM	Sporo	Mp	Foram	Bot	Undif
RCS13m1	0.6	0.0	50.8	10.8	0.4	0.0	2.0	1.0
RCS13t1	0.8	0.0	50.4	10.8	0.4	0.0	2.2	1.0
RCS13b1	0.4	0.0	50.0	11.4	0.4	0.0	1.8	0.8
RCS13m2	0.6	0.0	54.0	12.0	0.4	0.0	2.4	0.8
RCS13t2	1.0	0.0	47.6	12.0	0.0	0.0	2.0	0.8
RCS13b2	0.4	0.0	50.2	9.2	0.4	0.0	2.0	0.8

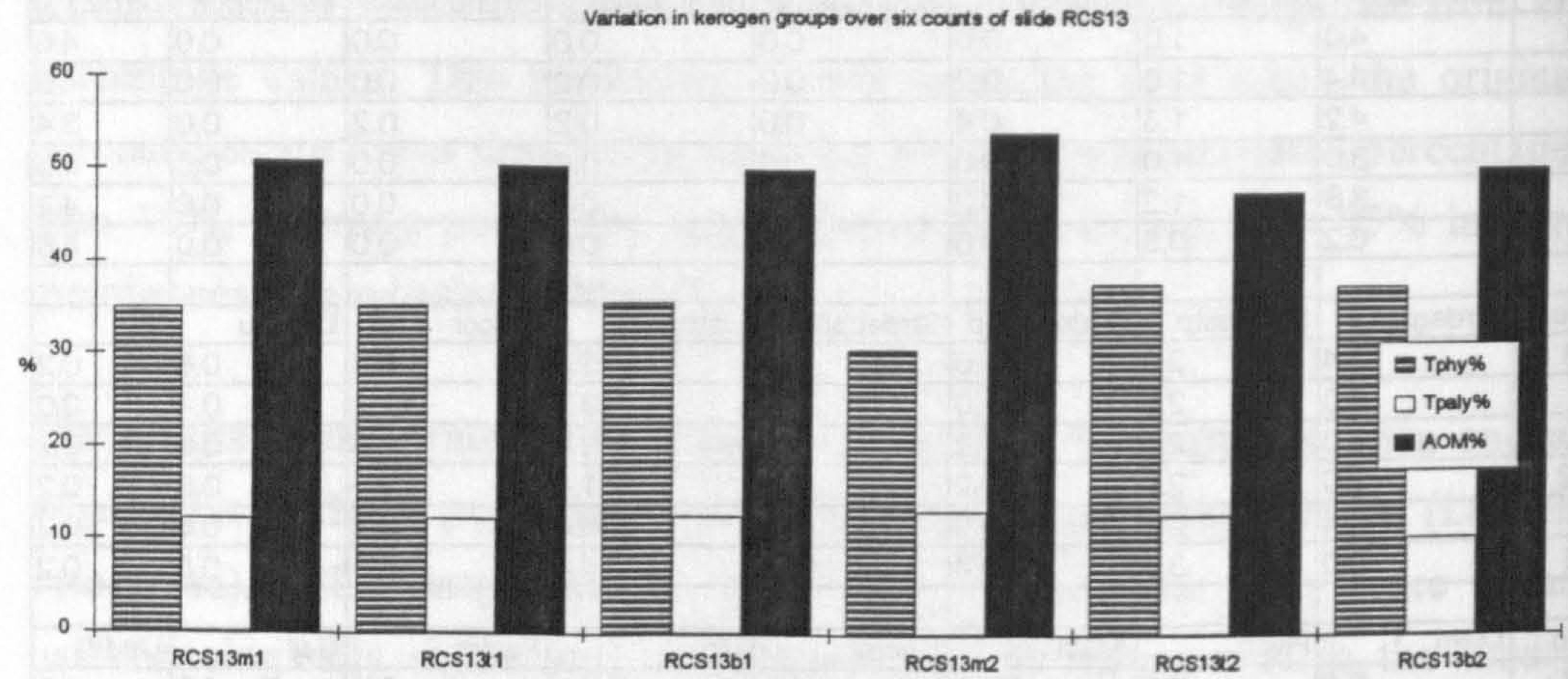
Table 2.16. Variations in simple percentages over six counts of slide RCS13 (key to abbreviations in Table 2.5).

Sample No.	Tphy	Tpaly	AOM	Blk/Tphy	Bro/Tphy	Cu/Tphy	Mem/Tphy	Equ/blk
RCS13m1	35.0	12.2	50.8	14.2	83.4	0.5	1.7	80.0
RCS13t1	35.2	12.2	50.4	15.3	82.3	0.0	2.2	81.4
RCS13b1	35.6	12.6	50.0	16.2	82.0	0.5	1.1	72.4
RCS13m2	30.4	13.2	54.0	13.1	84.2	0.6	1.9	75.0
RCS13t2	37.6	12.8	47.6	13.3	83.5	0.5	2.6	76.0
RCS13b2	37.4	10.4	50.2	18.7	79.6	0.5	1.0	88.5
Sample No.	Lath/blk	Str/bro	Ust/bro	Undg/strbro	Deg/strbro	Stria/strbro	Stp/strbro	Ban/strbro
RCS13m1	20.0	15.7	84.2	0.0	100.0	8.7	60.8	21.7
RCS13t1	18.5	14.4	85.5	4.7	95.2	0.0	71.4	23.8
RCS13b1	27.5	13.0	86.9	10.5	89.4	0.0	68.4	31.5
RCS13m2	25.0	15.6	84.3	0.0	100.0	0.0	65.0	30.0
RCS13t2	24.0	14.0	85.9	4.5	95.4	9.0	63.6	22.7
RCS13b2	11.4	16.1	83.8	0.0	100.0	0.0	75.0	8.3
Sample No.	Pit/strbro	Und/ustbro	Cor/ustbro	Psu/ustbro	Sporo/Tpaly	Mp/Tpaly	Undif/Tpaly	
RCS13m1	8.7	54.1	43.1	2.7	88.5	3.2	8.2	
RCS13t1	4.7	46.2	52.4	1.3	88.5	3.2	8.2	
RCS13b1	0.0	48.6	48.6	2.7	90.4	3.1	6.3	
RCS13m2	5.0	44.5	52.3	3.1	90.9	3.0	6.0	
RCS13t2	4.5	50.3	47.7	1.9	93.7	0.0	6.2	
RCS13b2	16.6	48.3	48.9	2.6	88.4	3.8	7.6	

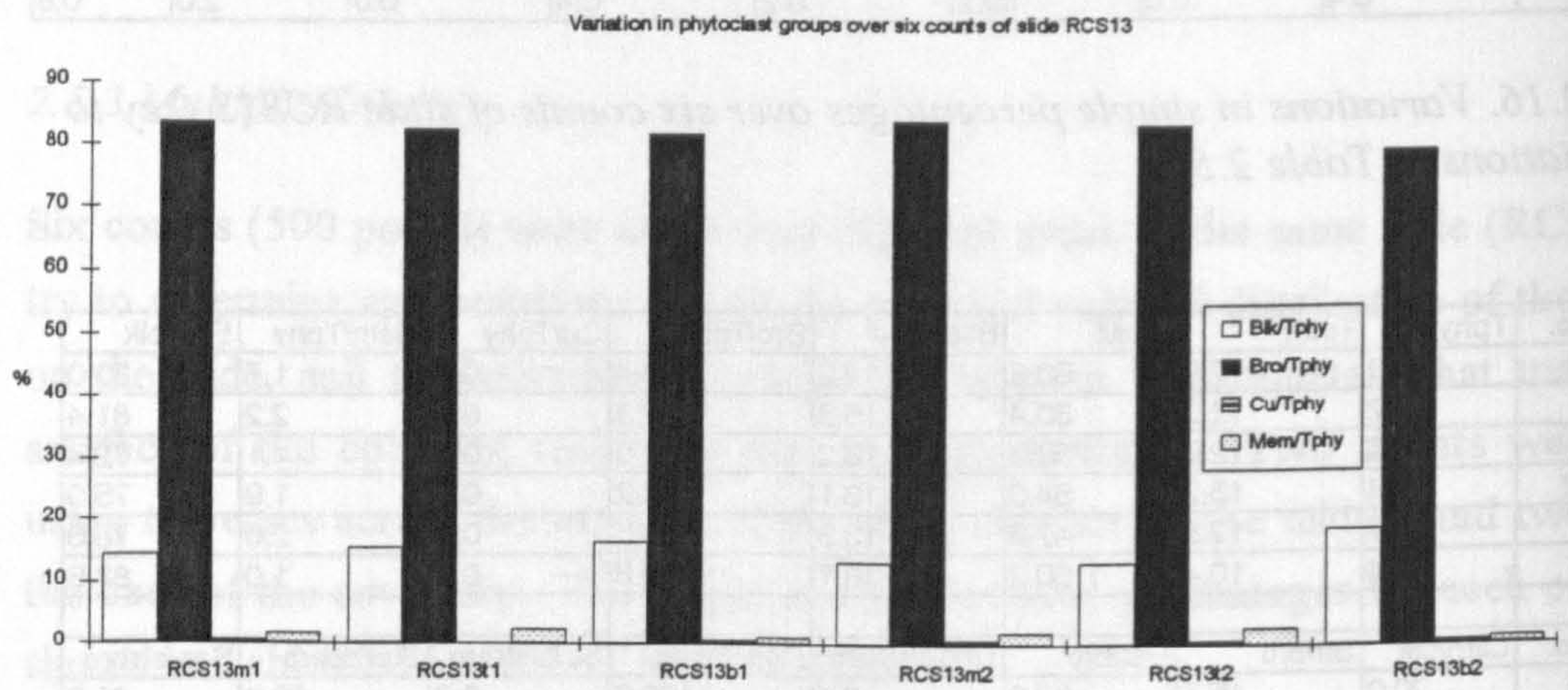
Key: m = traverse across middle of slide; t = traverse across top of slide; b = traverse across base of slide.

Table 2.17. Variation in recalculated percentages over six counts of slide RCS13 (key to abbreviations in Table 2.5).

a)



b)



c)

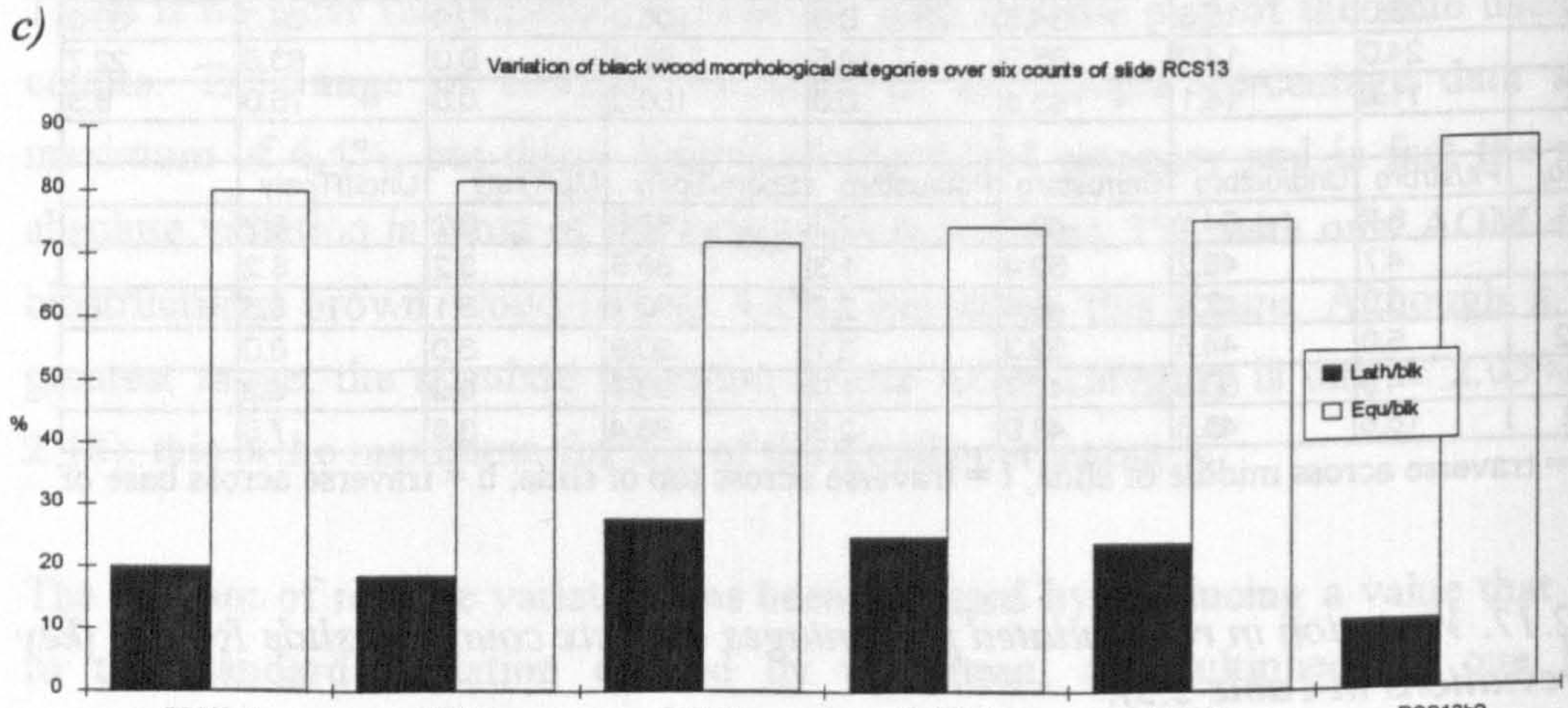
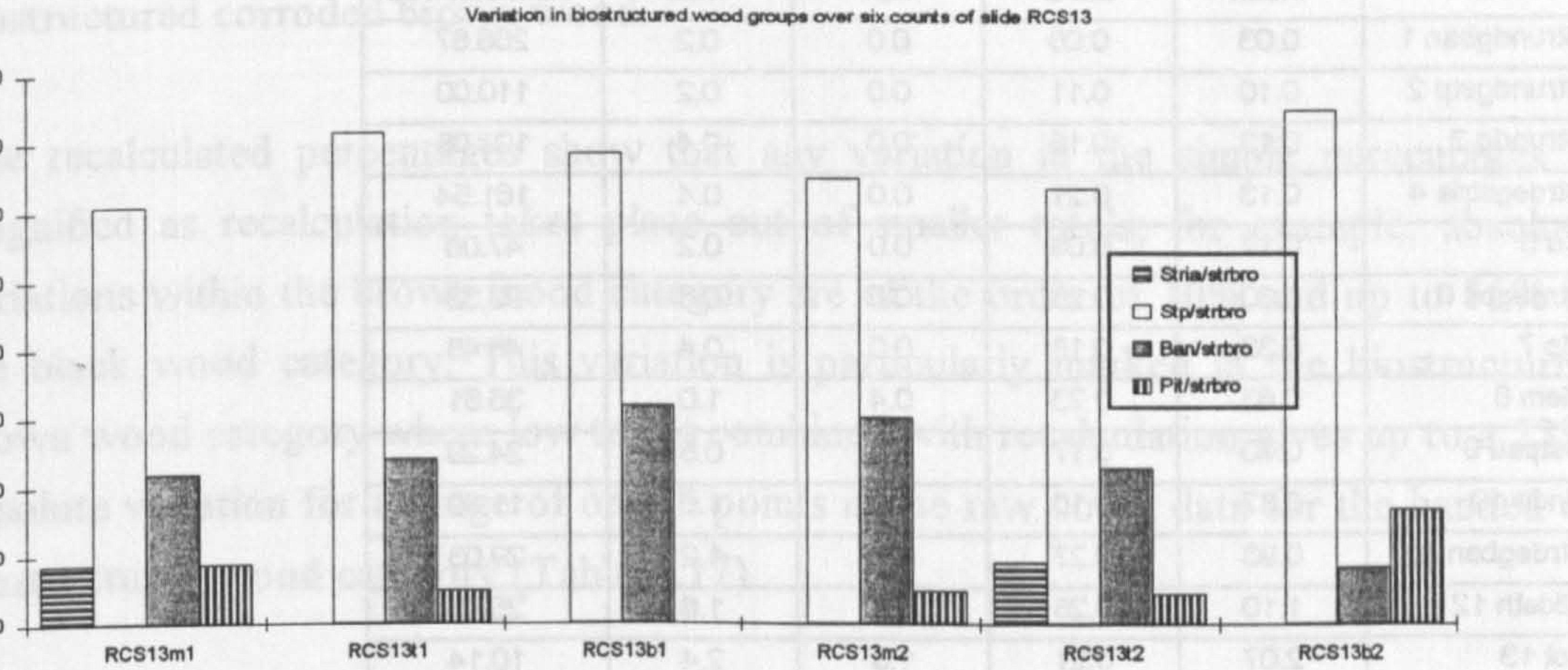
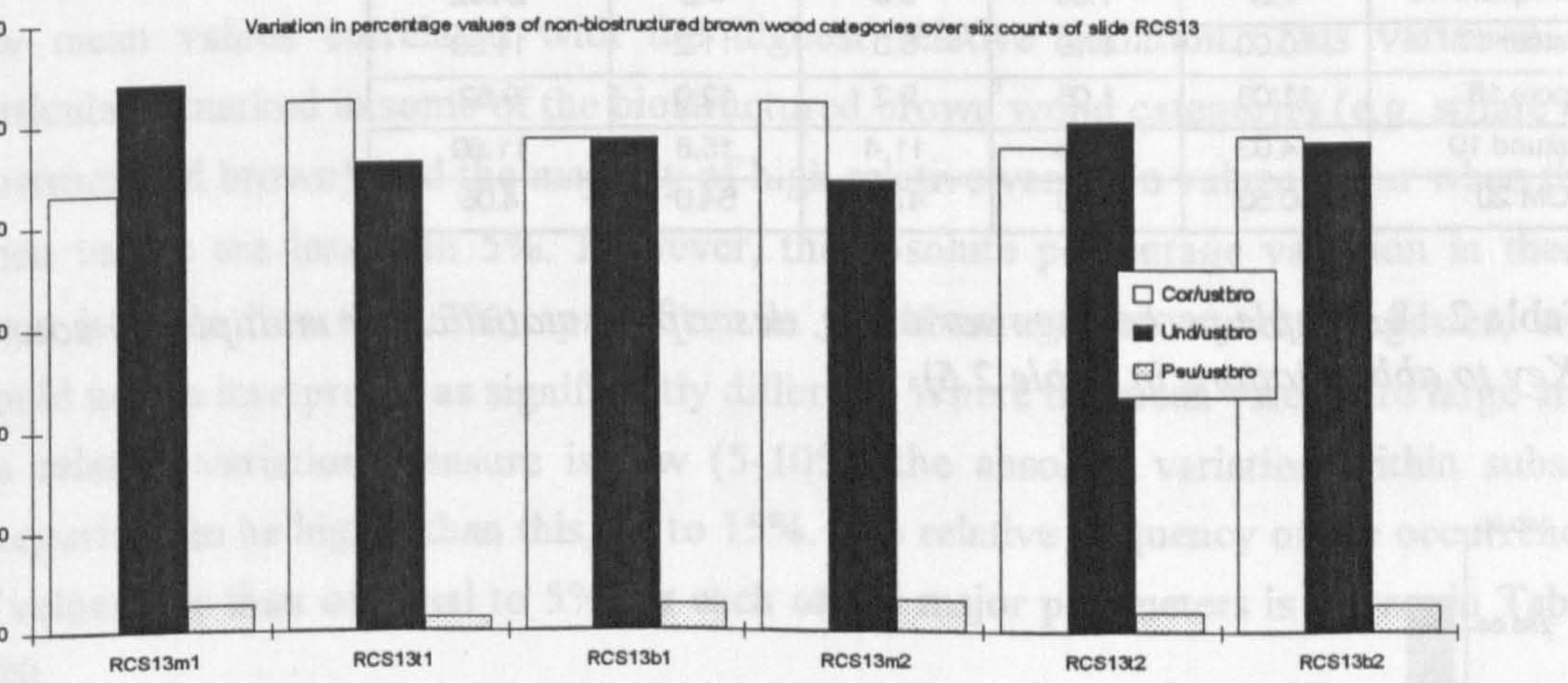


Fig. 2.7. a) to f) Variation in various kerogen categories over six counts of slide RCS13. (Key to abbreviations in Table 2.5).

d)



e)



f)

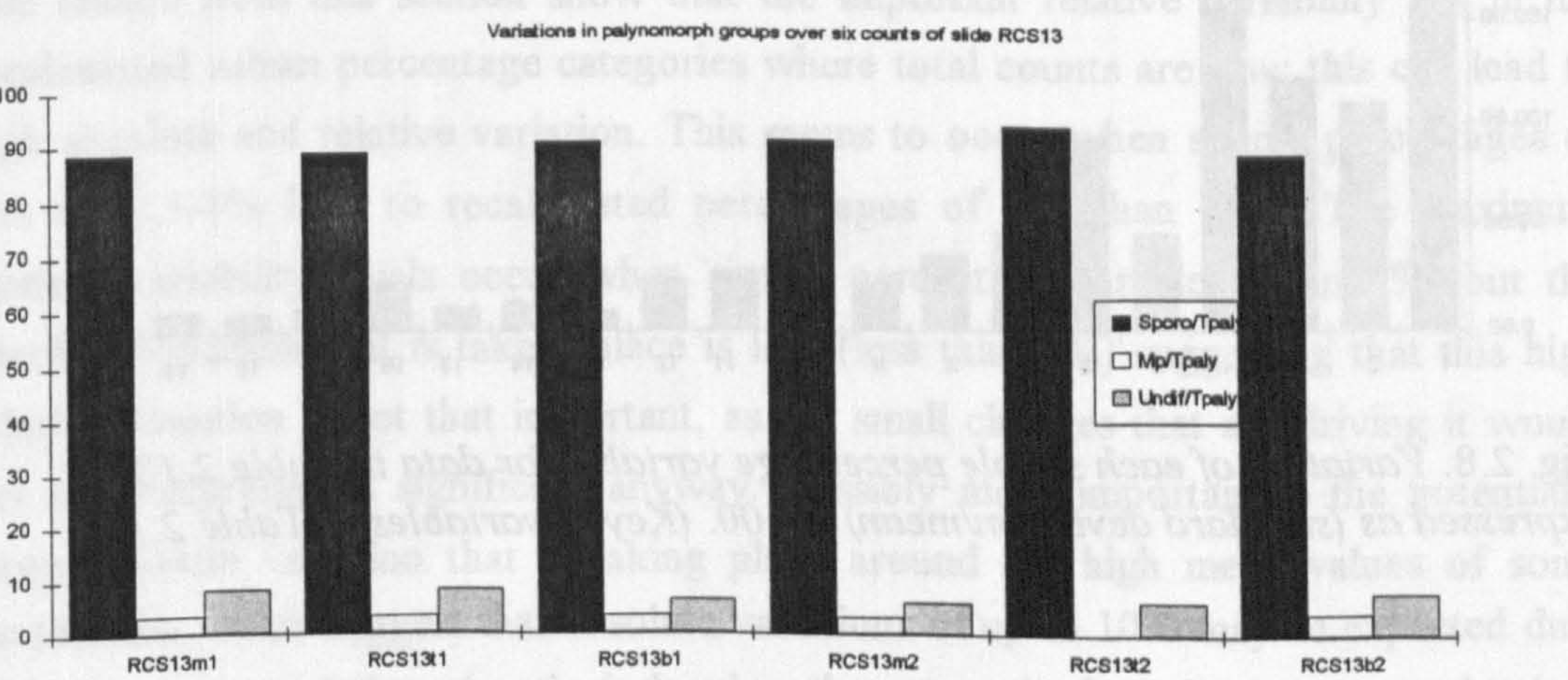


Fig. 2.7. a) to f) Variation in various kerogen categories over six counts of slide RCS13. (Key to abbreviations in Table 2.5).

Variable	Mean	Std D	Min	Max	SD/mean*100
Strundgban 1	0.03	0.08	0.0	0.2	266.67
Strundgstp 2	0.10	0.11	0.0	0.2	110.00
Strundg 3	0.13	0.16	0.0	0.4	123.08
Strdegstria 4	0.13	0.21	0.0	0.4	161.54
Cu 5	0.17	0.08	0.0	0.2	47.06
Strdegpit 6	0.30	0.28	0.0	0.8	93.33
Mp 7	0.33	0.16	0.0	0.4	48.48
Mem 8	0.63	0.23	0.4	1.0	36.51
Ustpsu 9	0.70	0.17	0.4	0.8	24.29
Undif 10	0.87	0.10	0.8	1.0	11.49
Strdegban 11	0.93	0.27	0.4	1.2	29.03
Blklath 12	1.10	0.28	0.8	1.6	25.45
Bot 13	2.07	0.21	1.8	2.4	10.14
Strdegstp 14	2.80	0.42	2.4	3.6	15.00
Strdeg 15	4.17	0.50	3.4	4.8	11.99
Blkequant 16	4.27	1.06	3.0	6.2	24.82
Ustcor 17	10.00	1.19	8.0	11.2	11.90
Sporo 18	11.03	1.05	9.2	12.0	9.52
Ustund 19	14.03	1.64	11.4	15.8	11.69
AOM 20	50.50	2.05	47.6	54.0	4.06

Table 2.18. *Simple percentage variables, descriptive statistics for multiple (6) counts. (Key to abbreviations in Table 2.5).*

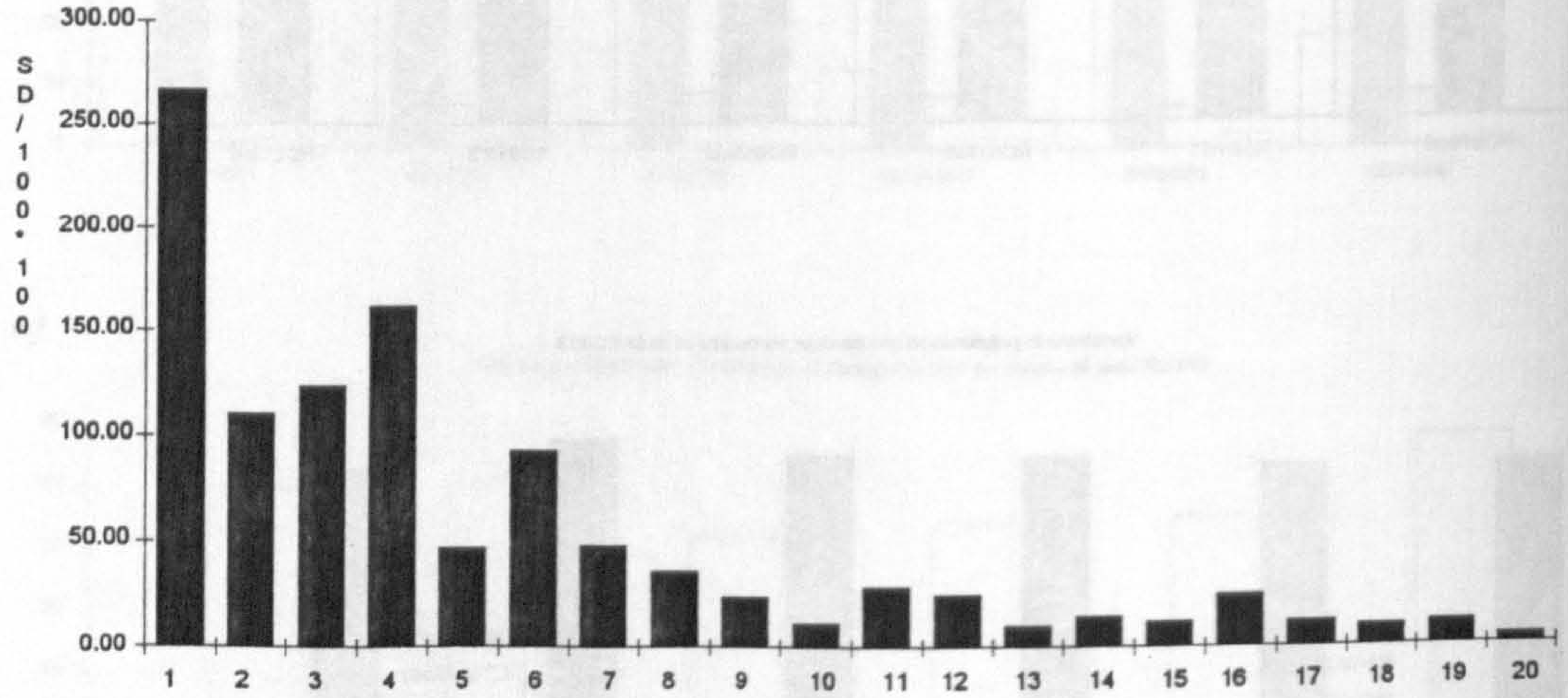


Fig. 2.8. *Variation of each simple percentage variable for data in Table 2.18, expressed as (standard deviation/mean) × 100. (Key to variables in Table 2.18).*

lowest relative variation occurs in the categories with higher mean values such as non-biostructured corroded brown wood.

The recalculated percentages show that any variation in the simple percentages is magnified as recalculation takes place out of smaller totals; for example, absolute variations within the brown wood category are of the order of 10% and up to 16% in the black wood category. This variation is particularly marked in the biostructured brown wood category where low totals combined with recalculation gives up to a 23% absolute variation for a range of only 5 points in the raw count data for the banded of biostructured wood category (Table 2.17).

The relative percentage variation has again been assessed using the (SD/mean)*100 parameter, as shown in Table 2.19 and Fig. 2.9. The figure shows a general pattern of low mean values correlated with the highest relative variation. This variation is particularly marked in some of the biostructured brown wood categories (e.g. striate of biostructured brown), and the majority of high relative variation values occur when the mean values are less than 5%. However, the absolute percentage variation in these cases is often less than 3%, apart from in the biostructured wood categories, and would not be interpreted as significantly different. Where the mean values are large and the relative variation measure is low (5-10%) the absolute variation within subset categories can be higher than this, up to 15%. The relative frequency of the occurrence of values less than or equal to 5% for each of the major parameters is shown in Table 2.20.

The results from this section show that the important relative variability lies in the recalculated subset percentage categories where total counts are low; this can lead to high absolute and relative variation. This seems to occur when simple percentages of less than 3-4% lead to recalculated percentages of less than 10%. The maximum relative variability levels occur when simple percentages are less than 1%, but the absolute variation that is taking place is low (less than 3%) suggesting that this high relative variation is not that important, as the small changes that are driving it would not be interpreted as significant anyway. Possibly more important is the potentially large absolute variation that is taking place around the high mean values of some parameters, which suggest that absolute variations of up to 10% may be expected due to the counting technique (particularly when the categories have low count totals), but the relative variability of these parameters is low indicating that all the counts are quite similar. The main problems are thus likely to occur in the subsets which are calculated

Variable	Reliability	Mean	Std D	Min	Max	SD/mean*100
Cu/Tphy 1	low	0.48	0.24	0.0	0.6	50.00
Mem/Tphy 2	low	1.80	0.63	1.0	2.6	35.00
Psu/ustbro 3	low	2.43	0.65	1.3	3.1	26.75
Mp/Tpaly 4	low	2.77	1.38	0.0	3.8	49.82
Stria/strbro 5	low	2.96	4.59	0.0	9.0	155.07
Undg/strbro 6	low	3.31	4.21	0.0	10.5	127.19
Pit/strbro 7	low	6.61	5.65	0.0	16.6	85.48
Undif/Tpaly 8	moderate	7.12	1.01	6.0	8.2	14.19
Tpaly 9	moderate	12.23	0.98	10.4	13.2	8.01
Str/bro 10	moderate	14.83	1.20	13.0	16.1	8.09
Blk/Tphy 11	moderate	15.18	2.11	13.1	18.7	13.90
Lath/blk 12	moderate	21.09	5.78	11.4	27.5	27.41
Ban/strbro 13	moderate	23.03	8.25	8.3	31.5	35.82
Tphy 14	high	35.20	2.60	30.4	37.6	7.39
Und/ustbro 15	high	48.69	3.34	44.5	54.1	6.86
Cor/ustbro 16	high	48.88	3.42	43.1	52.4	7.00
Stp/strbro 17	high	67.39	5.25	60.8	75.0	7.79
Equ/blk 18	high	78.91	5.78	72.4	88.5	7.32
Bro/Tphy 19	high	82.54	1.61	79.6	84.2	1.95
Ust/bro 20	high	85.17	1.20	83.8	86.9	1.41
Sporo/Tpaly 21	high	90.11	2.09	88.4	93.7	2.32
Deg/strbro 22	high	96.69	4.21	89.4	100.0	4.35

Table 2.19. *Descriptive statistics for recalculated percentage variables from multiple (6) count data. (Key to abbreviations in Table 2.5).*

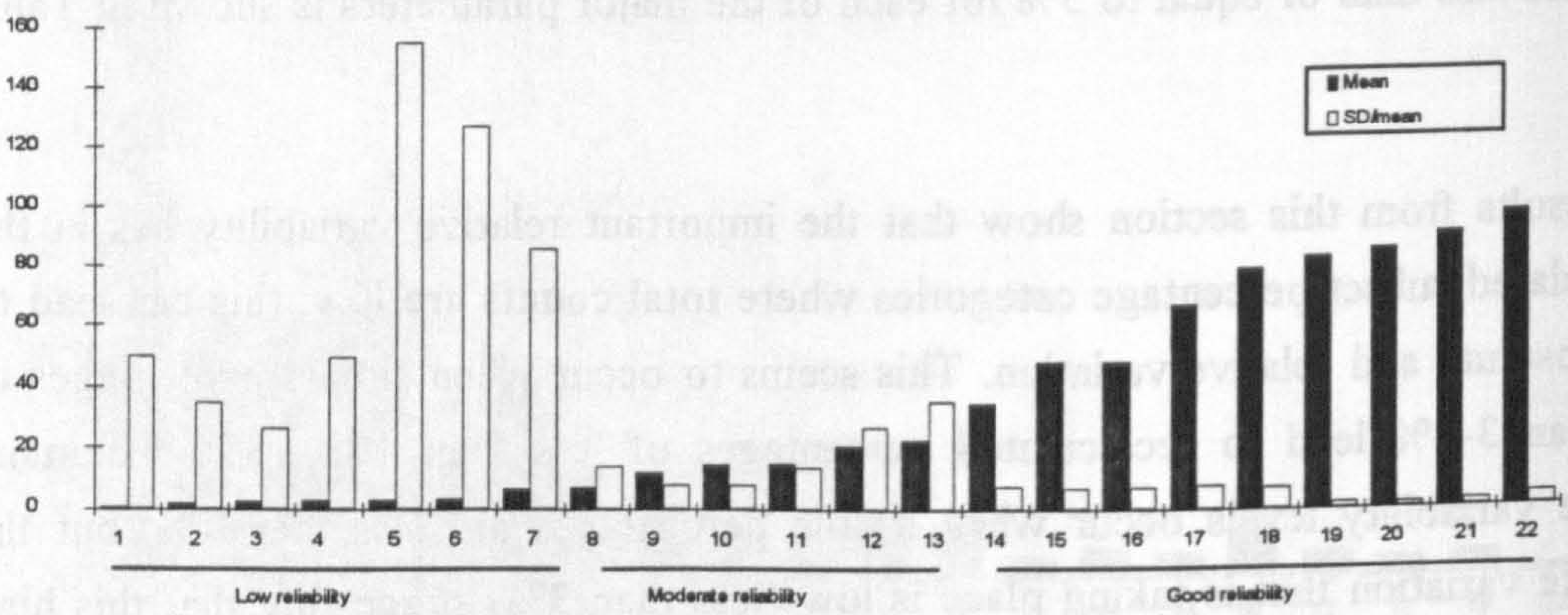


Fig 2.9 *Variation of each recalculated percentage variable, measured by the standard deviation/mean*100. (Key to variables in Table 2.19).*

Kerogen	Frequency (out of 440)	Palynomorph	Frequency (out of 356)
AOM/kerogen	76 (17%)	Sporomorphs/palynomorphs	1 (<1%)
Phytoclasts/kerogen	0	Marine plankton/palynomorphs	179 (50%)
Palynomorphs/kerogen	121 (28%)	Undifferentiated/palynomorphs	283 (80%)
Cuticle/phytoclasts	384 (87%)	*Botryococcus*/palynomorphs	244 (69%)
Membranes/phytoclasts	338 (77%)	Spores/sporomorphs	104 (29%)
Black/phytoclasts	29 (7%)	Pollen/sporomorphs	0
Brown/phytoclasts	0	Thick-walled/spores	173 (49%)
Biostructured/brown	132 (30%)	Thin-walled/spores	6 (2%)
Non-biostructured/brown	0	Unidentified/pollen	0
Equant/black	1 (<1%)	Bisaccates/pollen	14 (4%)
Lath/black	12 (3%)	Dinocysts/marine plankton	55 (15%)
Striate/biostructured brown	194 (44%)	Acritarchs/marine plankton	237 (67%)
Striped/biostructured brown	80 (18%)		
Banded/biostructured brown	130 (30%)		
Pitted/biostructured brown	236 (54%)		
Undegraded/ non-biostructured brown	144 (33%)		
Corroded/ non-biostructured brown	0		
Pseudoamorphous/ non-biostructured brown	277 (63%)		
Sporomorphs/palynomorphs	11 (3%)		
Undifferentiated/palynomorphs	135 (31%)		
Marine plankton/palynomorphs	158 (36%)		

Table 2.20. *Relative frequency of cases in which each major parameter gives values of less than 5%.*

out of low count totals, for it is here that high variability can occur. The categories where this effect is likely to be most apparent are:
From the kerogen counts:-

1) Black wood morphological types; the percentages should be treated with caution as totals are sometimes low, where possible the ratio derived from the extra counts should be used.
2) Biostructured brown wood structure types; for the whole of this work the proportions of each structure type in the undegraded and degraded sections have been totalled to try to reduce this effect, but sometimes counts can still be very low.
3) Total palynomorphs (from the kerogen count) palynomorph types; separate palynomorph counts have usually been performed, but occasionally this category has to be used.

From the palynomorph counts:-

4) Total spores, thin- vs. thick-walled; in this study spores often make up only *ca.* 3% of the total assemblage, so interpretation should be done with caution.
5) Marine plankton (dinocysts/acritarchs/prasinophytes/leiospheres); marine plankton can often be present at very low levels, in which case the percentage frequencies should be interpreted with care.
6) Dinocyst genera; dinocysts can be very low in abundance, when the percentage data probably becomes unreliable, but useful presence-absence data can often still be derived.

2.6 Details of Data Analysis

2.6.1 Introduction

All the raw count data was entered into a spreadsheet (EXCEL) and the simple and recalculated percentages were computed; section stratigraphic and ternary plots were generated using DELTAGRAPH, and the entire spreadsheet was imported into SPSS where statistical procedures and other forms of data manipulation were carried out, including the calculation of means, standard deviations etc. using the descriptive statistics option.

2.6.2 Variables Used

During this project two sets of data were generated from the two counts performed (Kerogen and Palynomorph counts). The variables generated from each count were used both separately (in order to examine the differences and reliability of the information given by each count) and together (in order to assess the extra detail made available by performing the palynomorph count, and for example, to give the best possible classification accuracy in discriminant function analysis; DFA). The variables used are shown in Tables 2.21 and 2.22.

2.6.3 "Dummy" Variables

Several factors were encoded in order to enter them into the spreadsheet so that they could be used as categorical (dependant) variables in DFA and other statistical procedures.

All the samples were classified into different lithological groups based on a combination of hand specimen descriptions, field descriptions and descriptions from the literature (Table 2.27). These categories were used in both the sample and dominant lithology classifications (see Chapter 4.0).

All the samples were then placed into gross lithology categories of shales (shales and silty shales), silts (shaley silts, silts, sandy silts), sands (argillaceous sands, silty sands, clean sands), and limestones (limestones, shaley limestones, argillaceous limestones, sandy limestones). See Table 2.27.

The shale and silty shale lithology samples were placed into categories based on their GSA Munsell colour classification (Table 2.27).

All the samples were placed into bioturbation level categories, based on field descriptions and published results (Table 2.27).

All the samples were placed into shell abundance categories based on hand specimen descriptions and published results (Table 2.27).

The whole sequence was divided following the classification by Hudson and Harris (1979) into environments based on macropalaeontological and sedimentological criteria (Table 2.23).

Variable	Abbreviation
AOM of kerogen	(AOM)
Phytoclasts of kerogen	(Tphy)
Palynomorphs of kerogen	(Tpaly)
Black wood of phytoclasts	(Blk/Tphy)
Brown wood of phytoclasts	(Bro/Tphy)
Cuticle of phytoclasts	(Cu/Tphy)
Membranes of phytoclasts	(Mem/Tphy)
Equant of black wood	(Equ/blk)
Lath of black wood	(Lath/blk
Biostructured of brown wood	(Str/bro)
Non-biostructured of brown wood	(Ust/bro)
Undegraded of biostructured brown wood	(Undg/strbro)
Degraded of biostructured brown wood	(Deg/strbro)
Striate of biostructured brown wood	(Stria/strbro)
Striped of biostructured brown wood	(Stp/strbro)
Banded of biostructured brown wood	(Ban/strbro)
Pitted of biostructured brown wood	(Pit/strbro)
Undegraded of non-biostructured brown wood	(Und/ustbro)
Corroded of non-biostructured brown wood	(Cor/ustbro)
Pseudoamorphous of non-biostructured brown wood	(Psu/ustbro)
Sporomorphs of palynomorphs+	(Sporo/Tpaly)
Marine plankton of palynomorphs+	(Mp/Tpaly)
Undifferentiated of palynomorphs+	(Undif/Tpaly)
Foram linings of kerogen	(Foram)
Botryococcus of kerogen+	(Bot)

When all variables were run together the palynomorph and Botryococcus groups (+) from the kerogen counts were not entered as they were replaced by the more reliable data from the palynomorph counts.

Table 2.21. *Variables generated from the kerogen count.*

Variable	Abbreviation
Sporomorphs of palynomorphs	(Sporo)
Marine plankton of palynomorphs	(Mp)
Botryococcus of palynomorphs	(Bot)
Undifferentiated of palynomorphs	(Undif)
Spores of sporomorphs	(Sp/sporo)
Pollen of sporomorphs	(Poll/sporo)
Thick-walled of spores	(Tks/sp)
Thin-walled of spores	(Tns/sp)
Bisaccates of pollen	(Bis/poll)
Callialasporites of pollen	(Cal/poll)
Cerebropollenites of pollen*	(Cere/poll)
Other (undifferentiated) of pollen	(Op/poll)
Dinocysts of marine plankton	(Din/mp)
Acritarchs of marine plankton	(Acri/mp)
Tasmanites type of marine plankton	(Tas/mp)
Leiospheres of marine plankton	(Lei/mp)

** this category was not entered into procedures run on the whole dataset or other sample sets including the Duntulm Formation.*

Table 2.22. *Variables generated from the palynomorph count.*

Each section from the Bearreraig Sandstone Formation was divided into proximal-distal units based on field evidence and the work of Morton (1987) who gives approximate depths of deposition for the various members. The units were numbered incrementally upwards, so they either correspond to a proximal-distal or distal-proximal shift (Table 2.27). The Dun Caan Shales Member type section was divided into two units, a lower more proximal unit that corresponds to most of the member, and an upper relatively distal unit which corresponds to the top part of the member which shows evidence of stratigraphic condensation. The section sampled through the Udairn Shales-Holm Sandstone Member type section was subdivided in a similar fashion; the section coarsens upwards from silty shales at the base to silty sand at the top: unit 1 (most distal) corresponds to the lowest exposure of the Udairn Shales sampled, unit 2 to the bulk of the Udairn Shales Member, unit 3 to the lower part of the Holm Sandstone Member, and unit 4 (most proximal) to the middle part of this member, which was the upper limit of the section sampled.

The Lealt Shales Formation was also divided using the salinity curve of Wakefield (1991) derived from ostracod assemblages (Table 2.24).

The Duntulm Formation was divided using the lithofacies, biofacies and palynofacies presented in Andrews and Walton (1990); Table 2.25.

The Staffin Bay Formation was divided in a similar fashion into the lithofacies of Sykes (1975a), and also according to the biofacies information in Hudson and Morton (1969) and Sykes (*ibid.*); Table 2.26.

Other factors were similarly encoded, such as each formation and member (see Table 2.27 for details).

Environment	Code No.
Open marine (OM)	1
Bar (Bar)	2
Anoxic basin (Ano)	3
Supra-tidal (SpT)	4
Marine-hypersaline (MHs)	5
Brackish-marine (BM)	6
Brackish (B)	7
Freshwater-brackish (FB)	8
Freshwater (FW)	9
Mudflat-alluvial (MfA)	10

Table 2.23. *Environment classification and codes for the whole succession.*

Ostracod-salinity (‰)	Code No.
0-5 (freshwater-miohaline)	1
5-10 (mesohaline)	2
10-18 (pliohaline)	3

Table 2.24. *Ostracod-derived salinity classifications of the Lealt Shales Formation*

Lithofacies	Code No.	Biofacies	Code No.
Praeexogyra Lst.-Shales (1)	1	Oyster shell bank community (1a)	1
Argillaceous Lsts. (2)	2	Inter-shell bank mud (2)	2
Algal Lsts. (3a)	3	Algal marsh (3)	3
Sandstones (4)	4	Sandy lagoon community (4)	4
Unio-Neomiodon mudstones and sandstones (5)	5	Low-salinity community (5)	5
Cryptalgal-rippled siltstones (3b)	6	'Marine' community (1b)	6

Table 2.25. *Litho- and biofacies classification of the Duntulm Formation (numbers in brackets represent designations in Andrews & Walton (1990), it was intended to use these as the codes but the SPSS program only accepts integers so they had to be redesignated).*

Lithofacies	Code No.	Biofacies	Code No.
Calcareous clay-Lst.	1	*Neomiodon*	1
Bituminous Shale	2	*Neomiodon* and others	2
Silts and fine sands	3	*Neomiodon-Pleuromya*	3
Argillaceous sands	4	*Ctenostrea-Pleuromya*	4
Muddy silts	5	Abundant *Cylindroteuthis*	5

Table 2.26. *Litho- and biofacies classification of the Staffin Bay Formation.*

Basin	**Formation**	**Strat sequence**
1 = Sea of the Hebrides Basin	1 = Bearreraig Sandstone Formation (BSF)	16 = BSF-DCSM
2 = Inner Hebrides Basin	2 = Cullaidh Shale Formation (CSF)	15 = BSF-OSM
	3 = Elgol Sandstone Formation (ESF)	14 = BSF-USM
	4 = Lealt Shales Formation (LSF)	13 = BSF-HSM
Location	5 = Valtos Sandstone Formation (VSF)	12 = BSF-RSM
1 = Trotternish, Skye	6 = Duntulm Formation(DF)	11 = BSF-GCM
2 = Waternish, Skye	7 = Kilmaluag Formation (KF)	10 = CSF
3 = Raasay	8 = Skudiburgh Formation (SF)	9 = ESF
4 = Eigg	9 = Staffin Bay Formation (SBF)	8 = LSF-KM
		7 = LSF-LM
	Member	6 = VSF
	1 = Dun Caan Shales (DCSM) (BSF)	5 = DF
	2 = Ollach Sandstone (OSM) (BSF)	4 = KF
	3 = Udairn Shales (USM) (BSF)	3 = SF
	4 = Holm Sandstone (HSM) (BSF)	2 = SBF-UOM
	5 = Rigg Sandstone (RSM) (BSF)	1 = SBF-BSM
	6 = Dun Caan Shales, Raasay (DCSM(R)) (BSF)	
	7 = Beinn na Leac Sandstone, Raasay (BNLSM (R)) (BSF)	
	8 = Garantiana Clay (GCM) (BSF)	
	9 = Kildonnan (KM) (LSF)	
	10 = Lonfearn (LM) (LSF)	
	11 = Upper Ostrea (UOM) (SBF)	
	12 = Belemnite Sands (BSM) (SBF)	

Table 2.27a. Key to encoded variables part I.

Lithology	Gross Lithology	Environment
1 = shale	1 = shales	1 = OM
2 = silty shale	2 = silts	2 = Bar
3 = shaley silt	3 = sands	3 = ANo
4 = silt	4 = limestones	4 = Spt
5 = sandy silt		5 = M-Hs
6 = silty sand	**Bioturbation**	6 = B-M
7 = argillaceous sand	1 = none	7 = B
8 = clean sand	2 = present	8 = F-B
9 = limestone	3 = strong	9 = FW
10 = limey shale		10 = MfA
11 = argillaceous limestone	**Shells**	
12 = sandy limestone	1 = absent	**Sequences**
13 = sandy shale	2 = present	Morton 1989
14 = shaley sand	3 = common/abundant	1 = D
15 = clay-mudstone	4 = shell bed	2 = E
		3 = F
	Shale Colour GSA Munsell	
	1 = black (ON1)	Cycles
	2 = greyish black (ON2)	1 = D1
	3 = dark grey (ON3)	2 = D2
	4 = medium dark grey (ON4)	3 = D3
	5 = medium grey (ON5)	4 = E1
	6 = medium light grey (ON6)	5 = E2
	7 = light grey (ON7)	6 = E3
	8 = olive black (5Y2/1)	
	9 = olive grey (5Y4/1)	
	10 = brownish black (5YR 2/1)	
	11 = brownish gey (5YR4/1)	

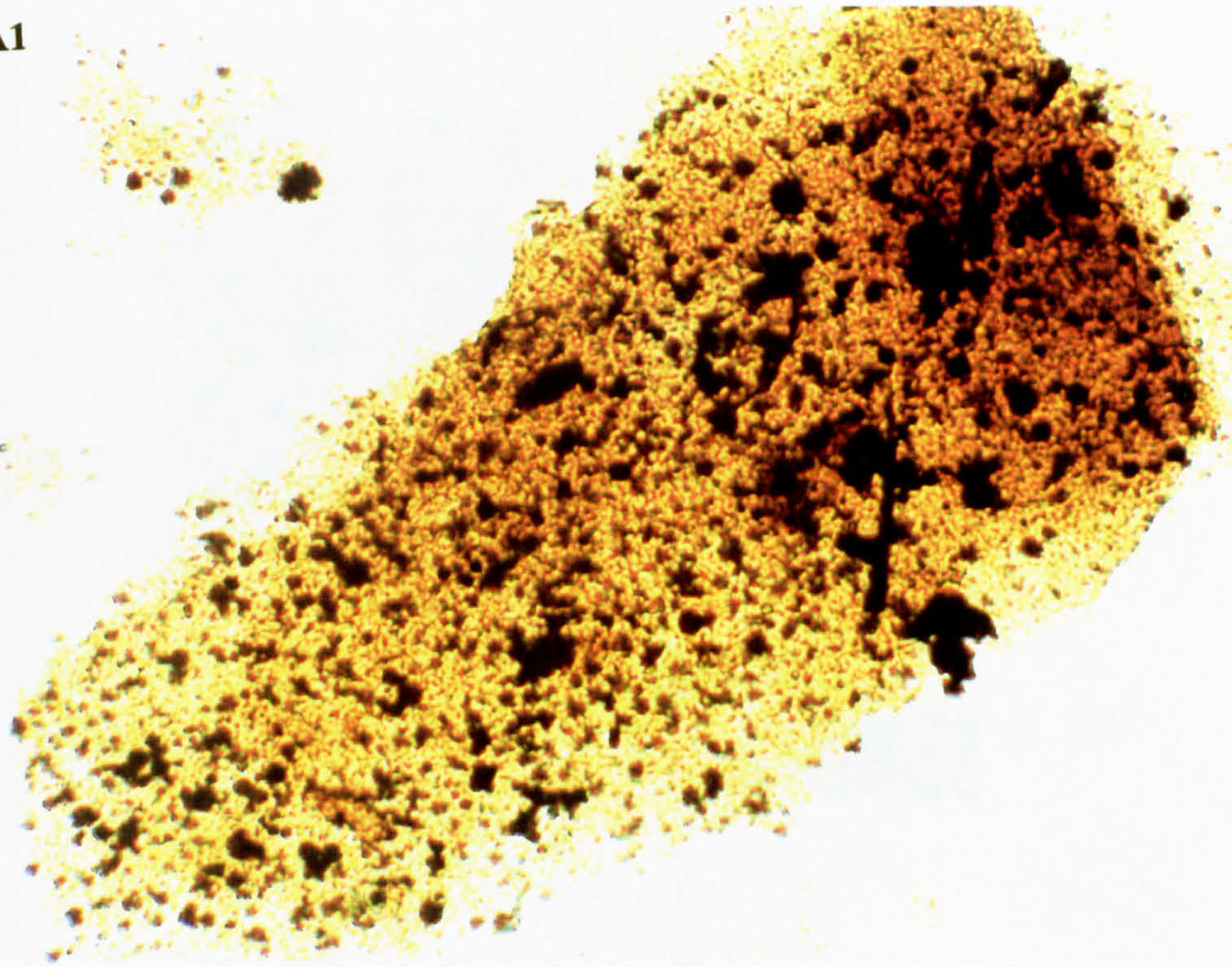
Table 2.27b. Key to encoded variables part II.

Proximal-distal	Lithofacies	Biofacies	Ostracods-salinity
BSF	DF	DF	LSF
DCSM	1 = 1	1 = 1a	KM+LM
1 = proximal	2 = 2	6 = 1b	1 = 0-5 (fw-miohaline)
2 = distal	3 = 3a	2 = 2	2 = 5-10 (mesohaline)
	6 = 3b	3 = 3	3 = 10-18 (pliohaline)
USM–HSM	4 = 4	4 = 4	
1 = most distal	5 = 5	5 = 5	**Palynofacies**
4 = most proximal			DF
	SBF	SBF	1 = 1
	UOM	UOM	2 = 2
	1 = calclay/Lst.	1 = *Neomiodon*	3 = 3
	2 = bit. shales	2 = *Neomiodon*+others	
	3 = silts/fine Sst.		
	BSM	BSM	
	4 = arg. Sst.	3 = *Neomiodon-Pleuromya*	
	5 = muddy silts	4 = *Ctenostrea-Pleuromya*	
		5 = Abundant *Cylindroteuthis*	

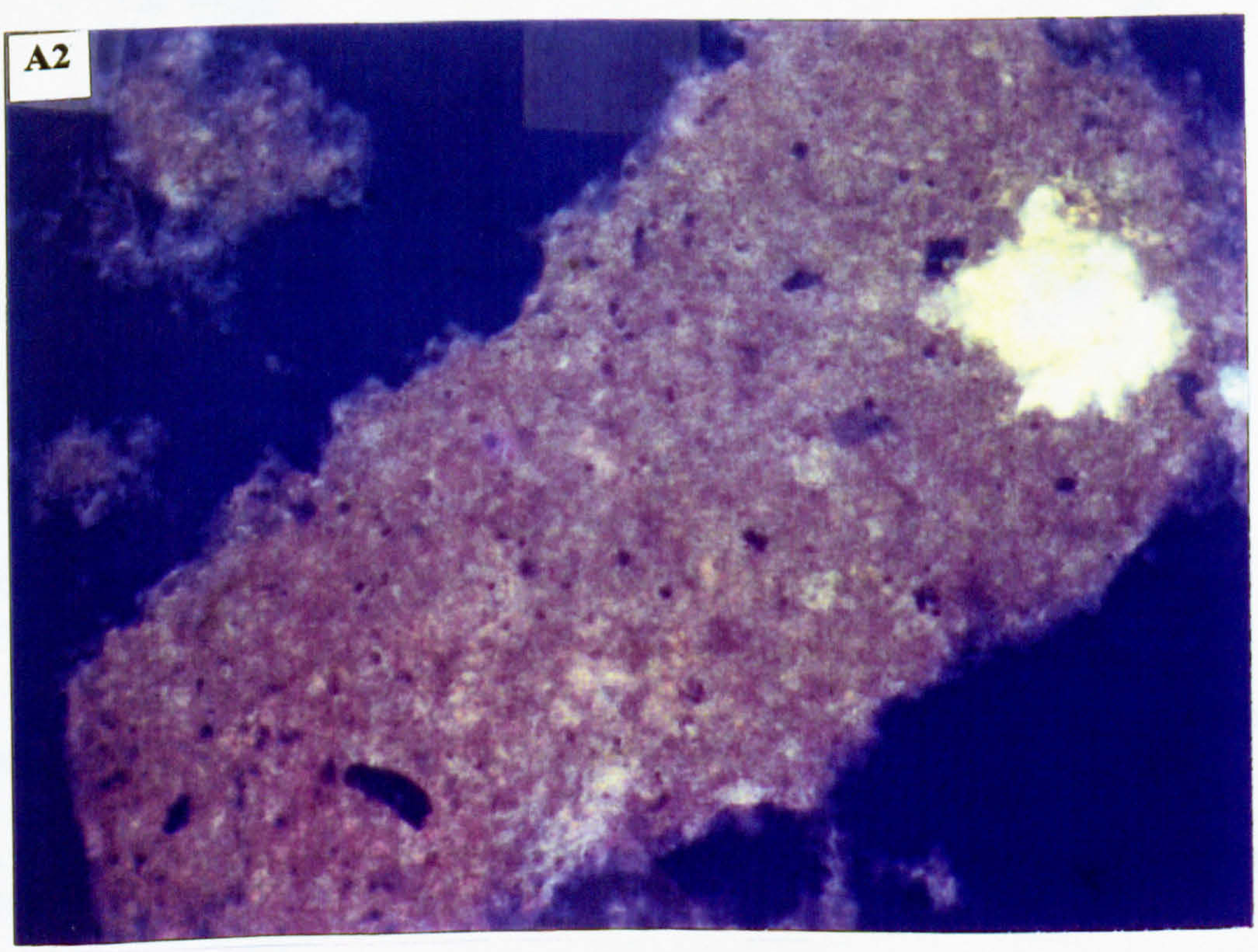
Table 2.27c. Key to encoded variables part III.

Plates A1-5. Amorphous Organic Matter (AOM).

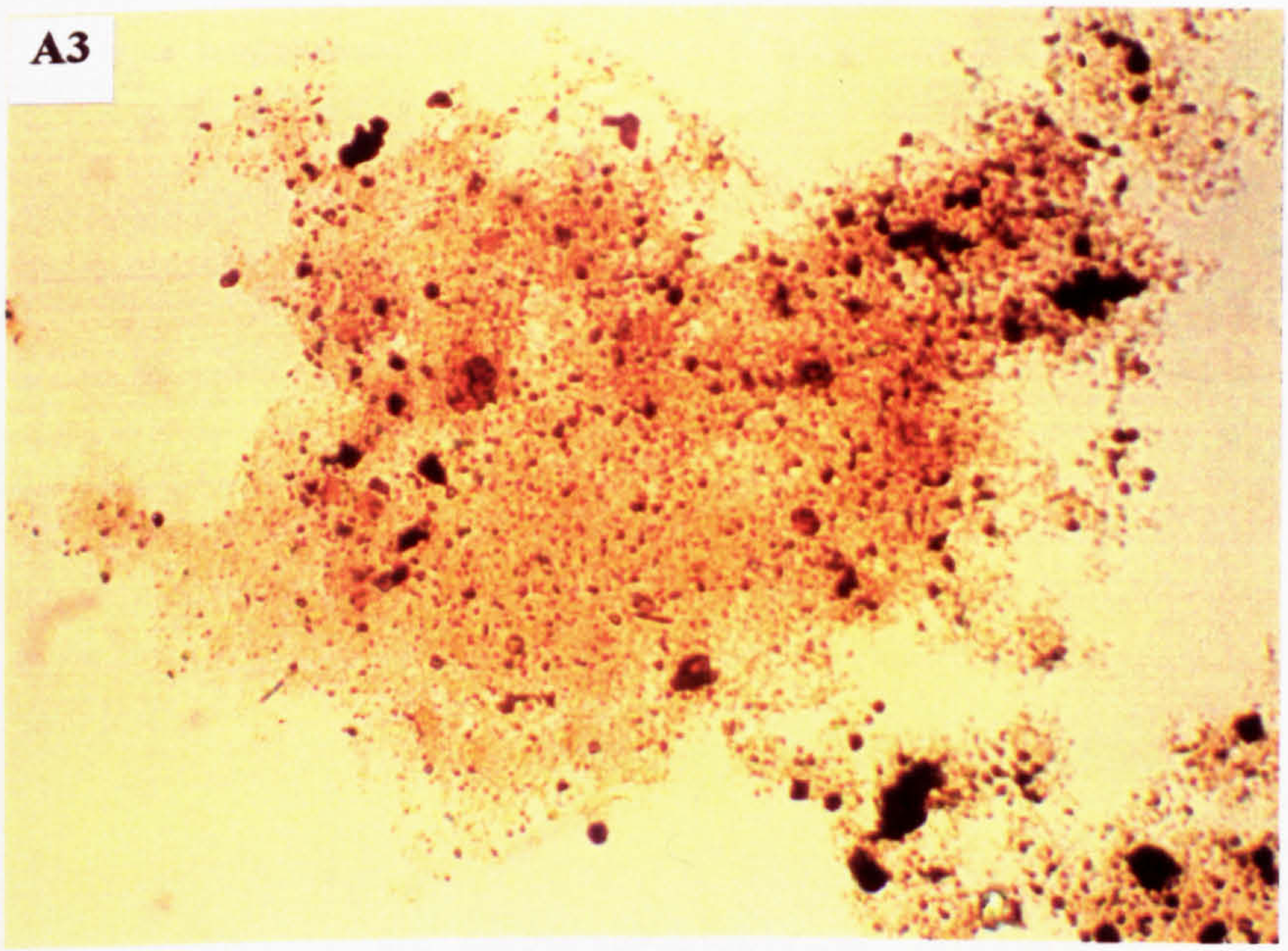
A1

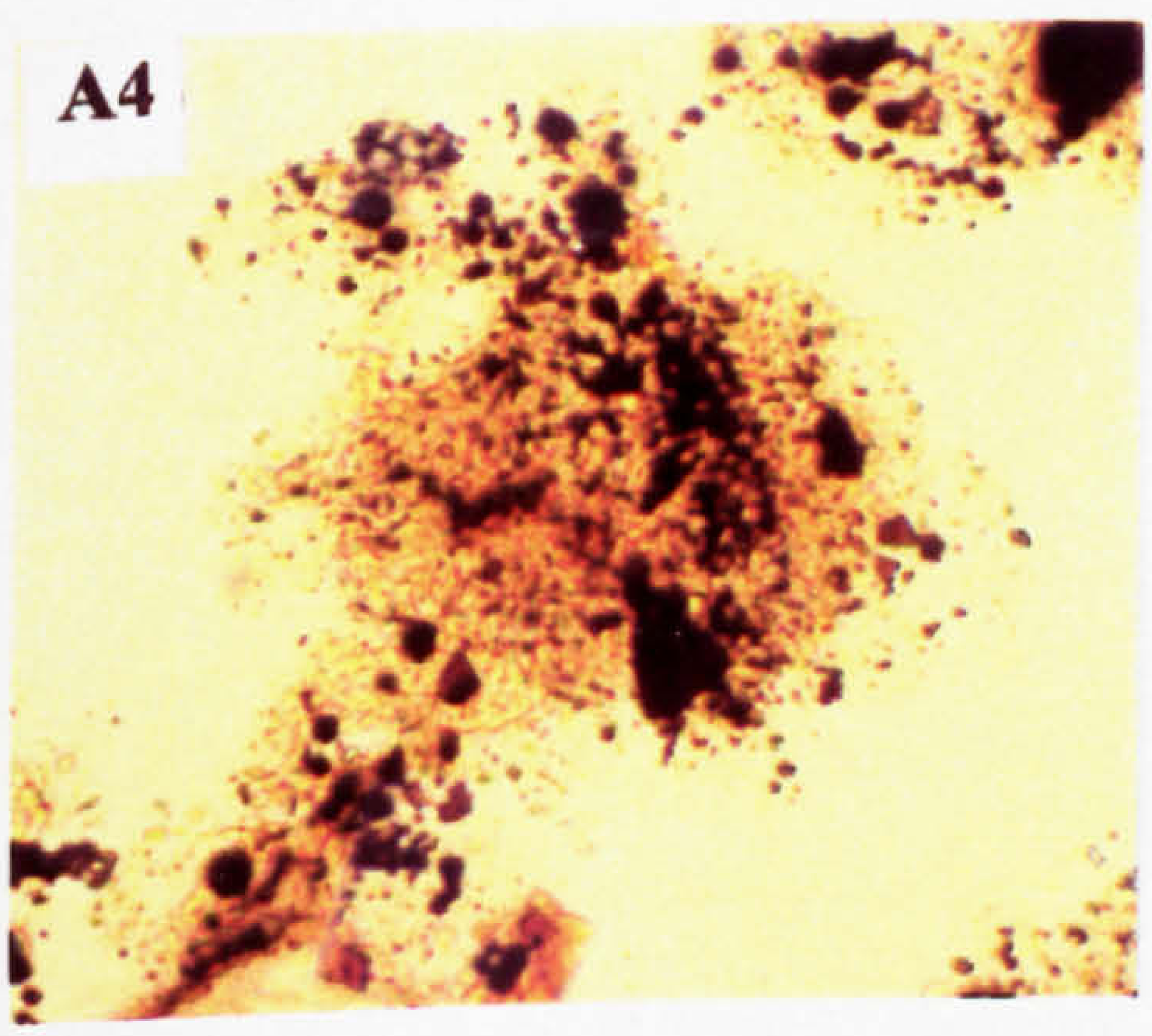


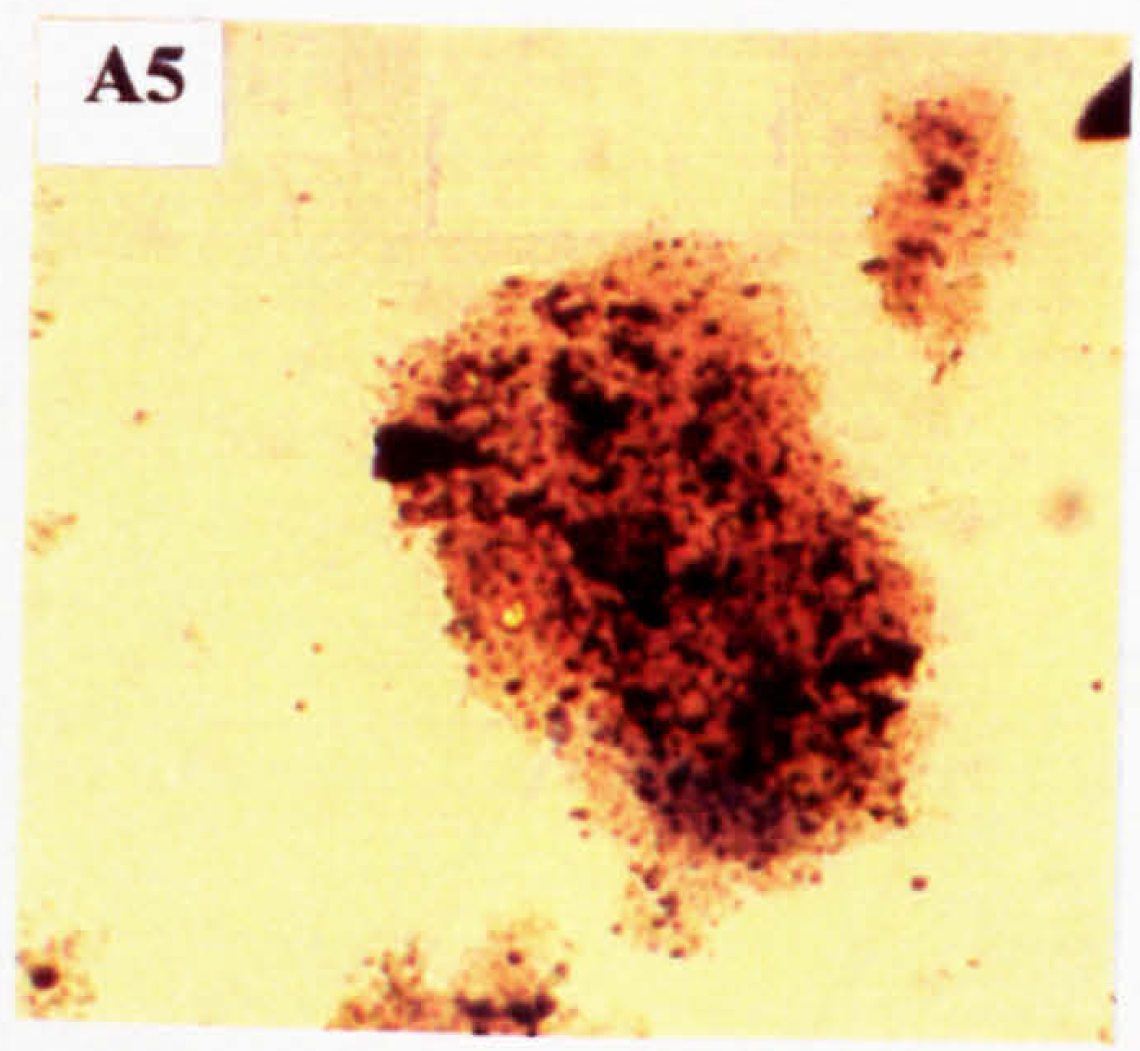
A1. Very well preserved AOM (fluorescence scale 5) seen in transmitted white light. Sample KBK8, Kilmaluag Formation. Long axis = 300μm.



A2. Same particle as A1 viewed under incident blue light fluorescence. Note the microparticulate nature of the AOM. The extremely brightly fluorescent area in the top right of the AOM particle is the colonial freshwater-brackish alga *Botryococcus*. This colony is not visible under transmitted light.







A3. Well preserved AOM (fluorescence scale 5), the particle is more sheet-like than that shown in plate A1. Sample RNB9, Lonfearn Member, Lealt Shales Formation. Long axis = 120μm.

A4. Moderately-well preserved AOM (fluorescence scale 4). Sample KE14, Kildonnan Member, Lealt Shales Formation. Long axis = 80μm.

A5. Poorly preserved disseminated AOM (fluorescence scale 2). Sample BBR9, Rigg Sandstone Member, Bearreraig Sandstone Formation. Long axis = 80μm.

Plates P1-20. Phytoclast group.

P1. Black equant wood, angular. Sample BBE47, Dun Caan Shales Member, Bearreraig Sandstone Formation. Diameter = 70μm.

P2. Rounded black equant wood. Sample LOK28, Duntulm Formation. Diameter = 30μm.

P3. Black lath-shaped phytoclast. Sample VS2, Valtos Sandstone Formation. Long axis = 90μm.

P4. Undegraded striate biostructured brown wood phytoclast. Sample VS2, Valtos Sandstone Formation. Long axis = 90μm.

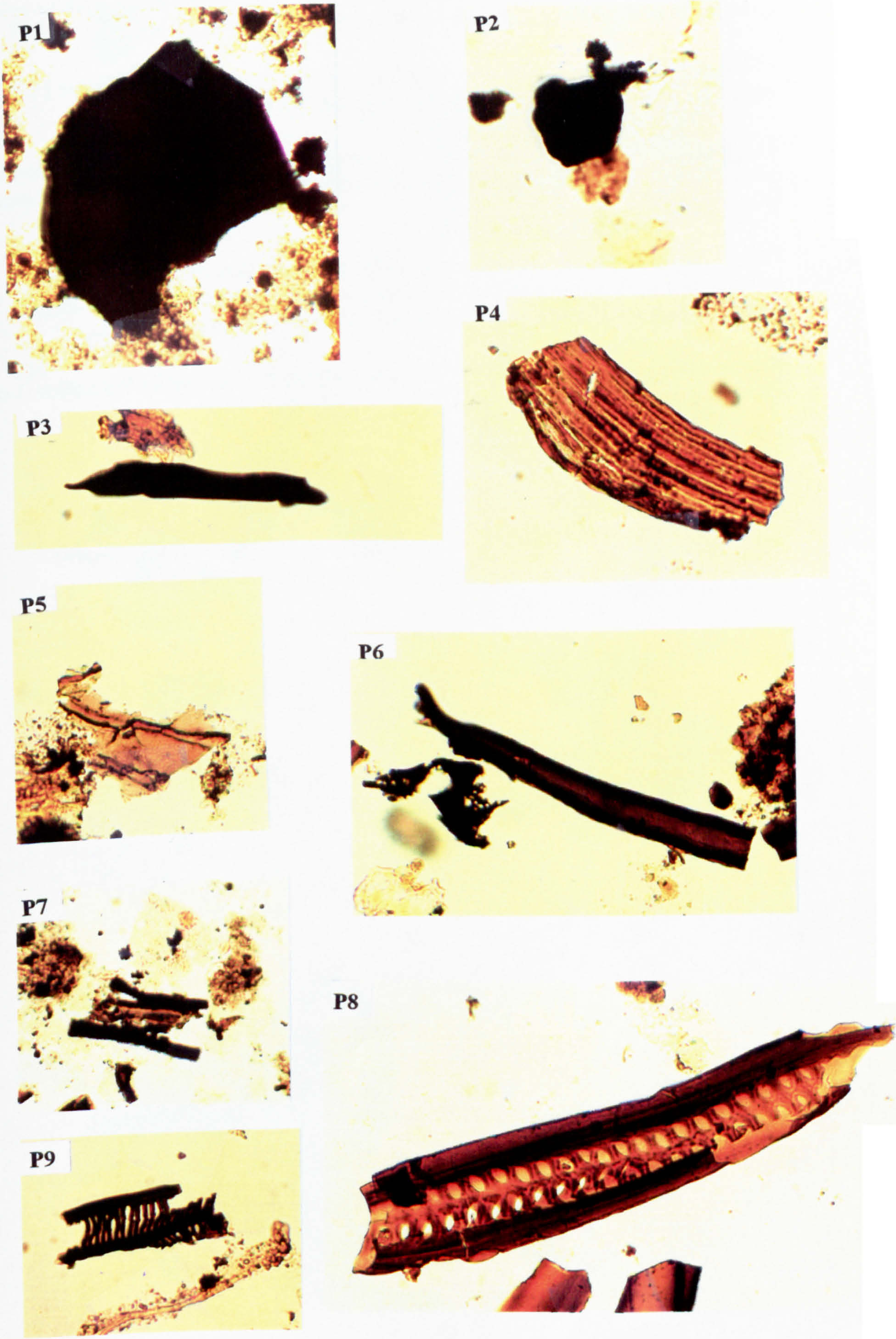
P5. Degraded striped biostructured brown wood phytoclast. Sample VS2, Valtos Sandstone Formation. Long axis = 80μm.

P6. Undegraded banded biostructured brown wood phytoclast. Sample VS2, Valtos Sandstone Formation. Long axis = 140μm.

P7. Degraded banded biostructured brown wood phytoclast. Sample BBE47, Dun Caan Shales Member (Bearreraig Sandstone Formation). Long axis = 50μm.

P8. Undegraded pitted phytoclast. Sample VS2, Valtos Sandstone Formation. Long axis = 200μm.

P9. Degraded pitted phytoclast. The pitting is scalariform ('ladder-like') in nature. Sample VS2, Valtos Sandstone Formation. Long axis = 60μm.


P1
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P9

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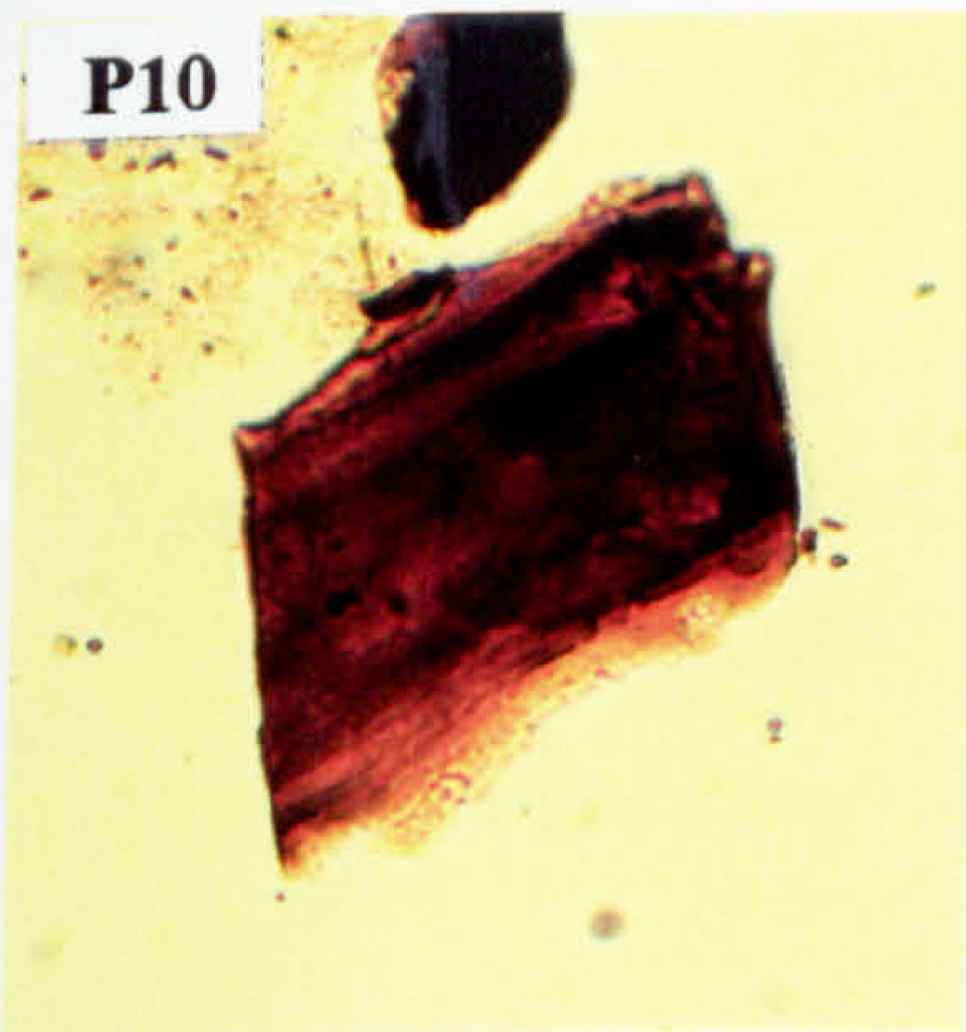
P10 and **P11**. Undegraded non-biostructured brown wood phytoclasts. Both sample LOK28, Duntulm Formation. Long axes 60 and 100μm respectively.

P12 and **P13**. Corroded non-biostructured brown wood phytoclasts. Samples LOK33 and LOK28, Duntulm Formation. Long axes 100 and 90μm respectively.

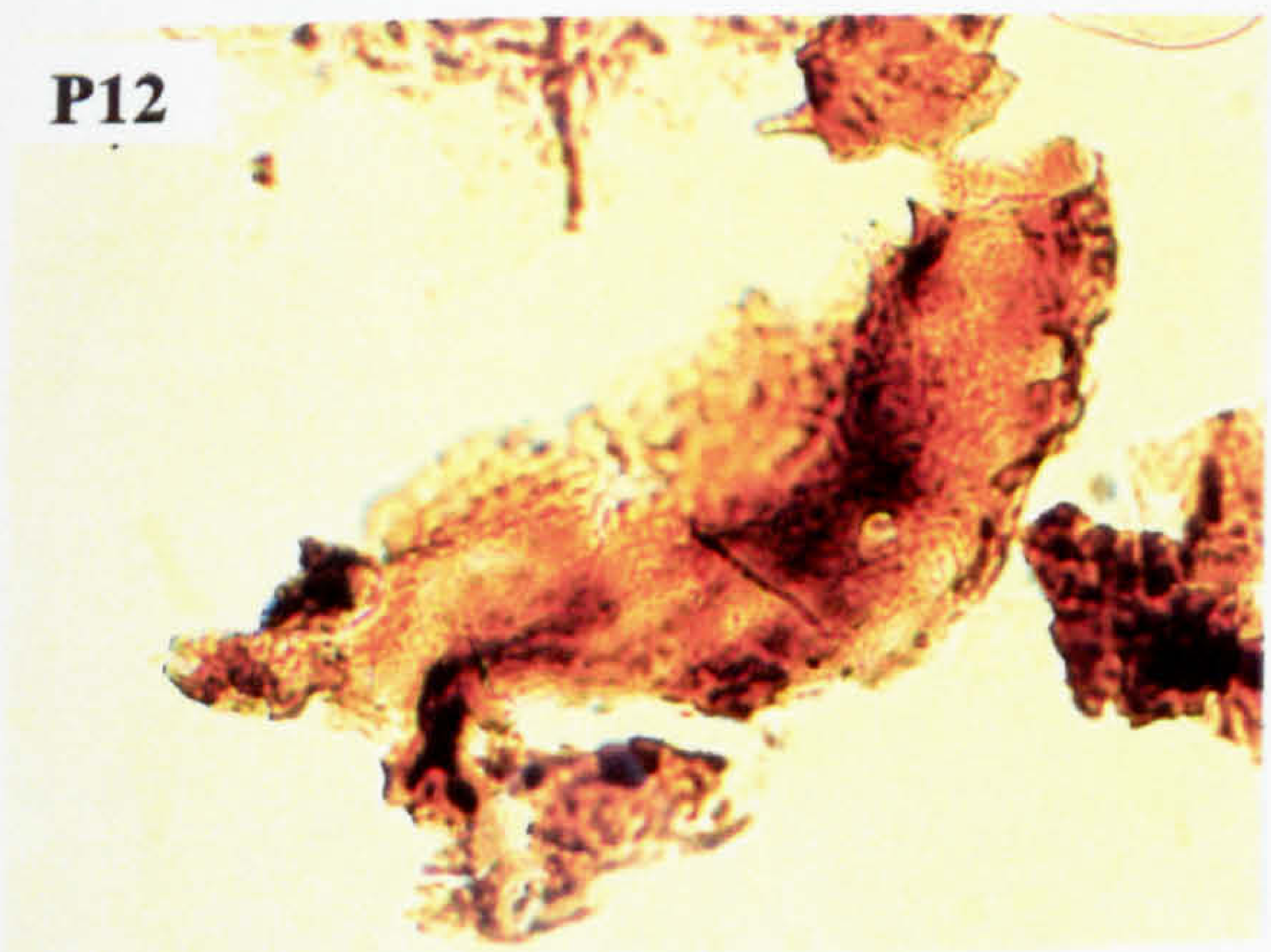
P14. Corroded/pseudoamorphous non-biostructured brown wood phytoclast, showing more degradation than **P12** and **13**. Sample LOK28, Duntulm Formation. Long axis = 80μm.

P15. Pseudoamorphous non-biostructured brown wood phytoclast. This particle shows gradational margins, but lacks the characteristic inclusions of AOM. Sample UOB15, Upper Ostrea Member, Staffin Bay Formation. Diameter = 70μm.

P16. Fungal hyphae. Sample KE51, Kildonnan Member, Lealt Shales Formation. Long axis = 300μm.


P10


P11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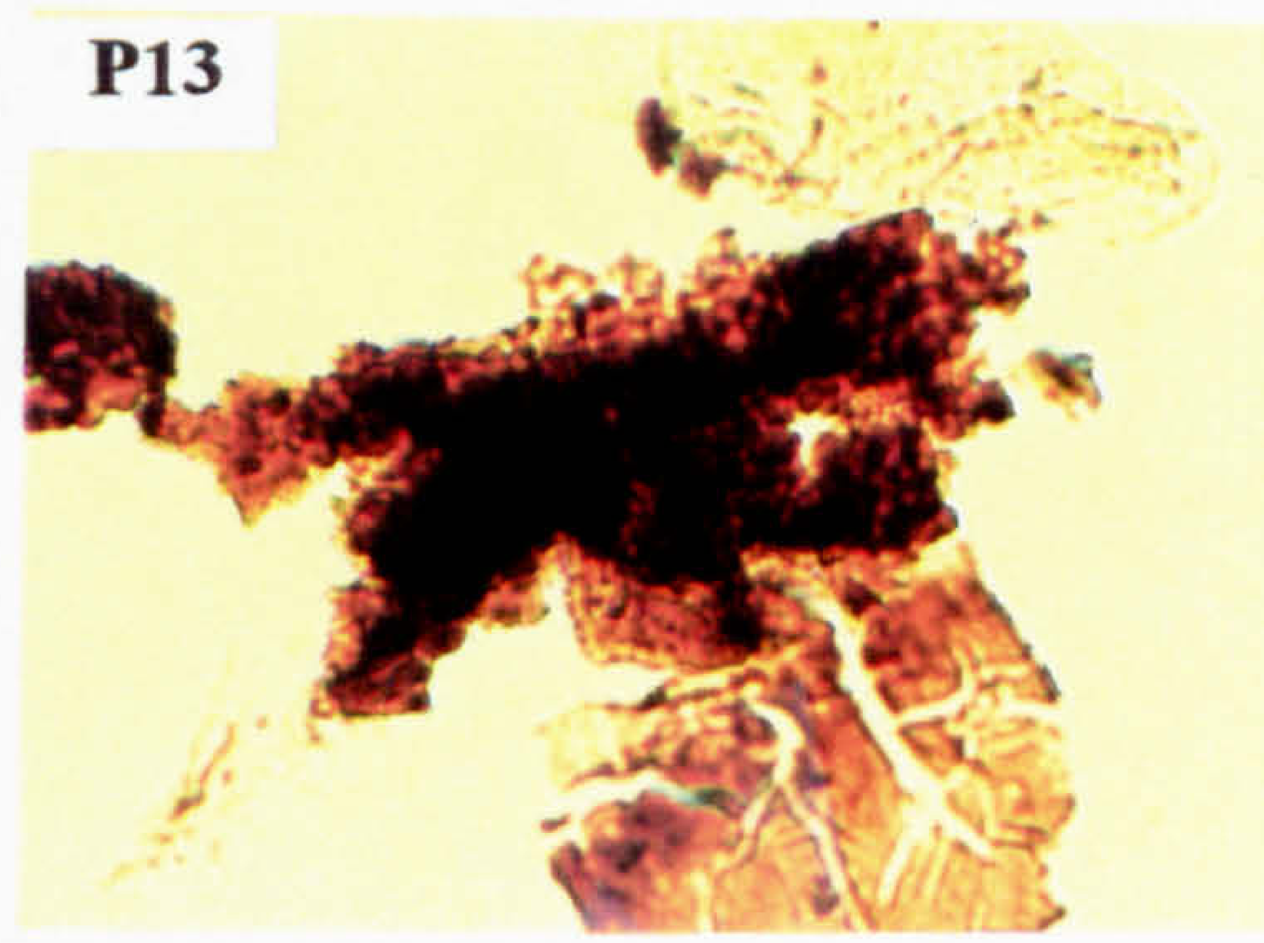
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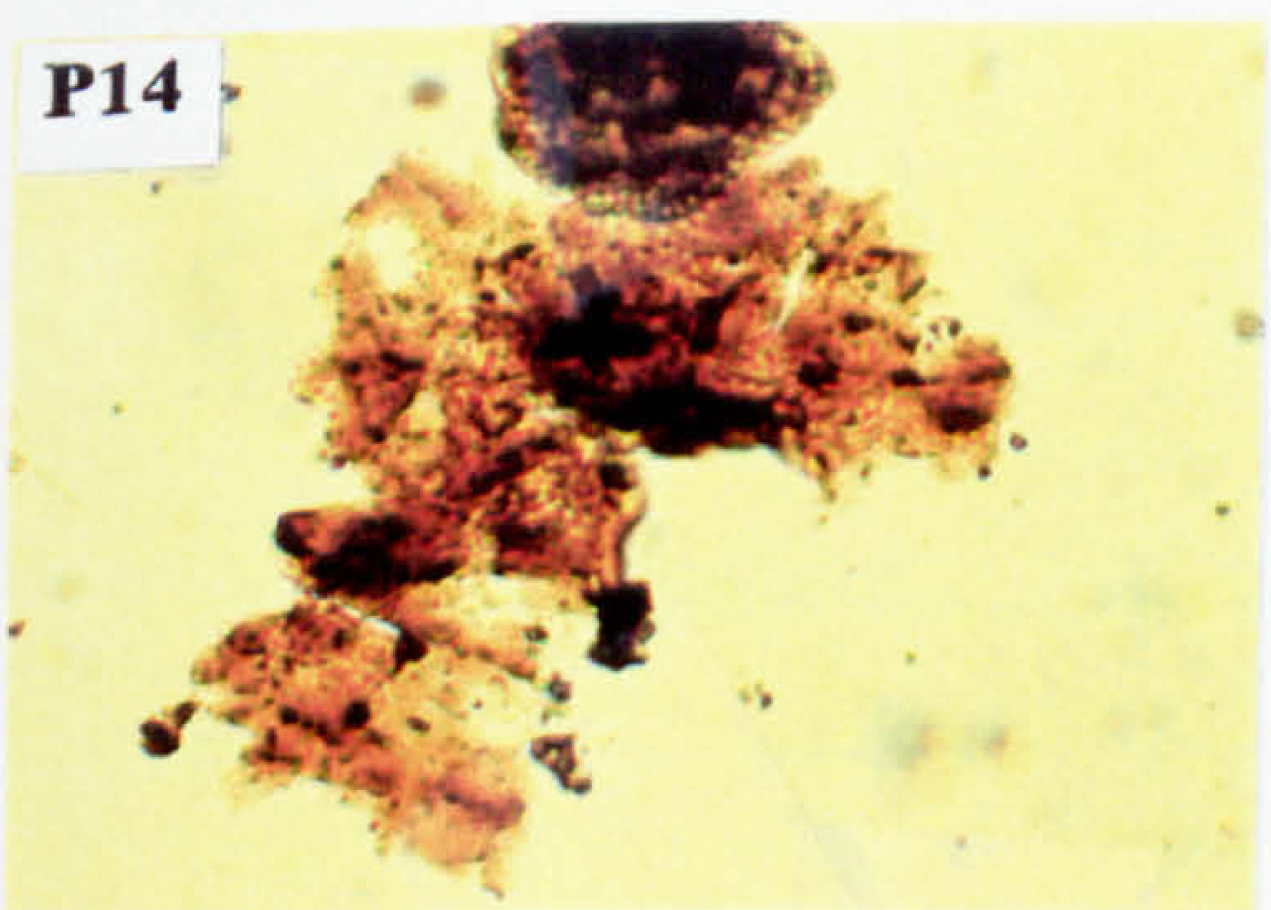
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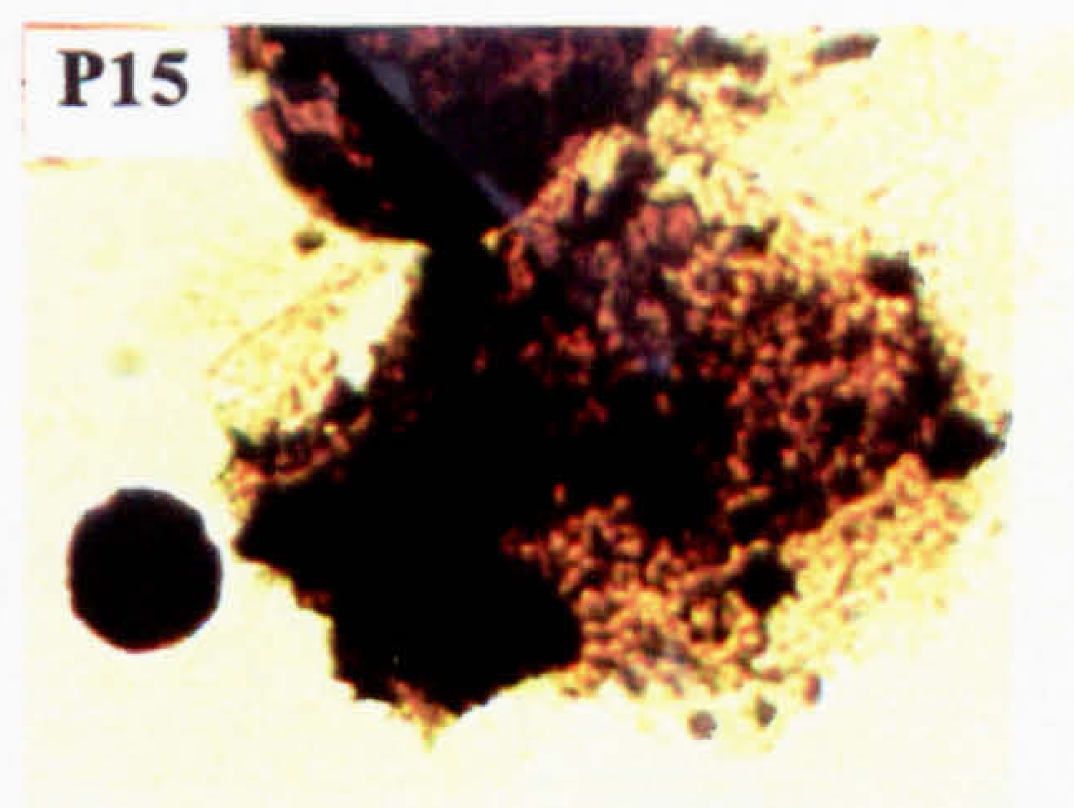
P15


P16

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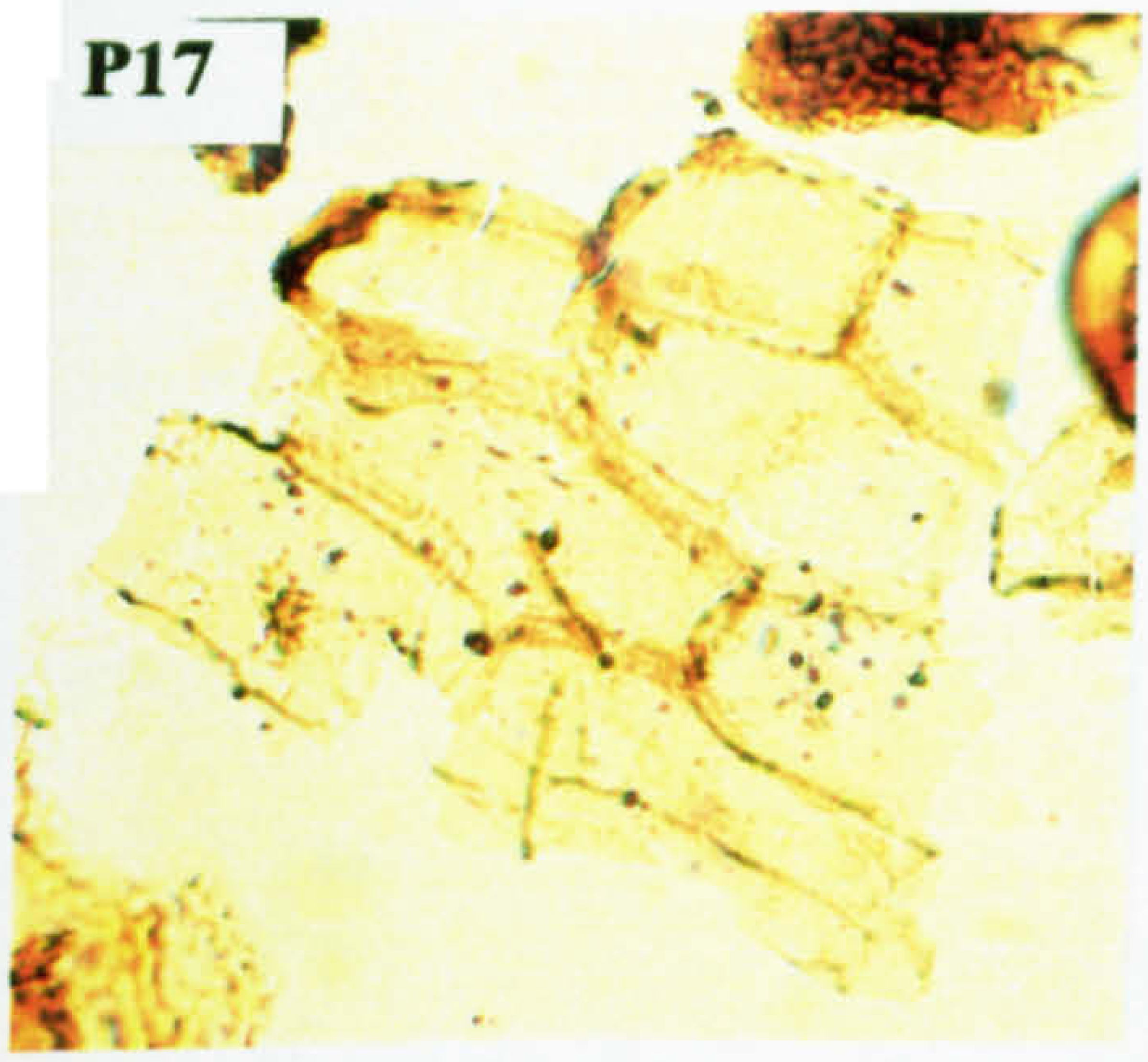
P17. Cuticle showing visible cell structure. This particle shows no fluorescence and its light colour may reflect bleaching under oxic conditions. Sample LOK33, Duntulm Formation. 'Diameter' = 150μm.

P18. Cuticle, cell structure less visible than in **P17**. The appearance of the phytoclast suggests significant degradation has occurred, but it remains strongly flourescent (**P19**). Sample LOK28, Duntulm Formation. Long axis = 660μm.

P19. Same particle as **P18** viewed under incident blue light fluorescence. Short axis of cell = 20μm.

P20. Membraneous phytoclast. Note the pyritic nature. This phytoclast is only weakly fluorescecent. Sample UOB3, Upper Ostrea Member, Staffin Bay Formation. 'Diameter' = 200μm.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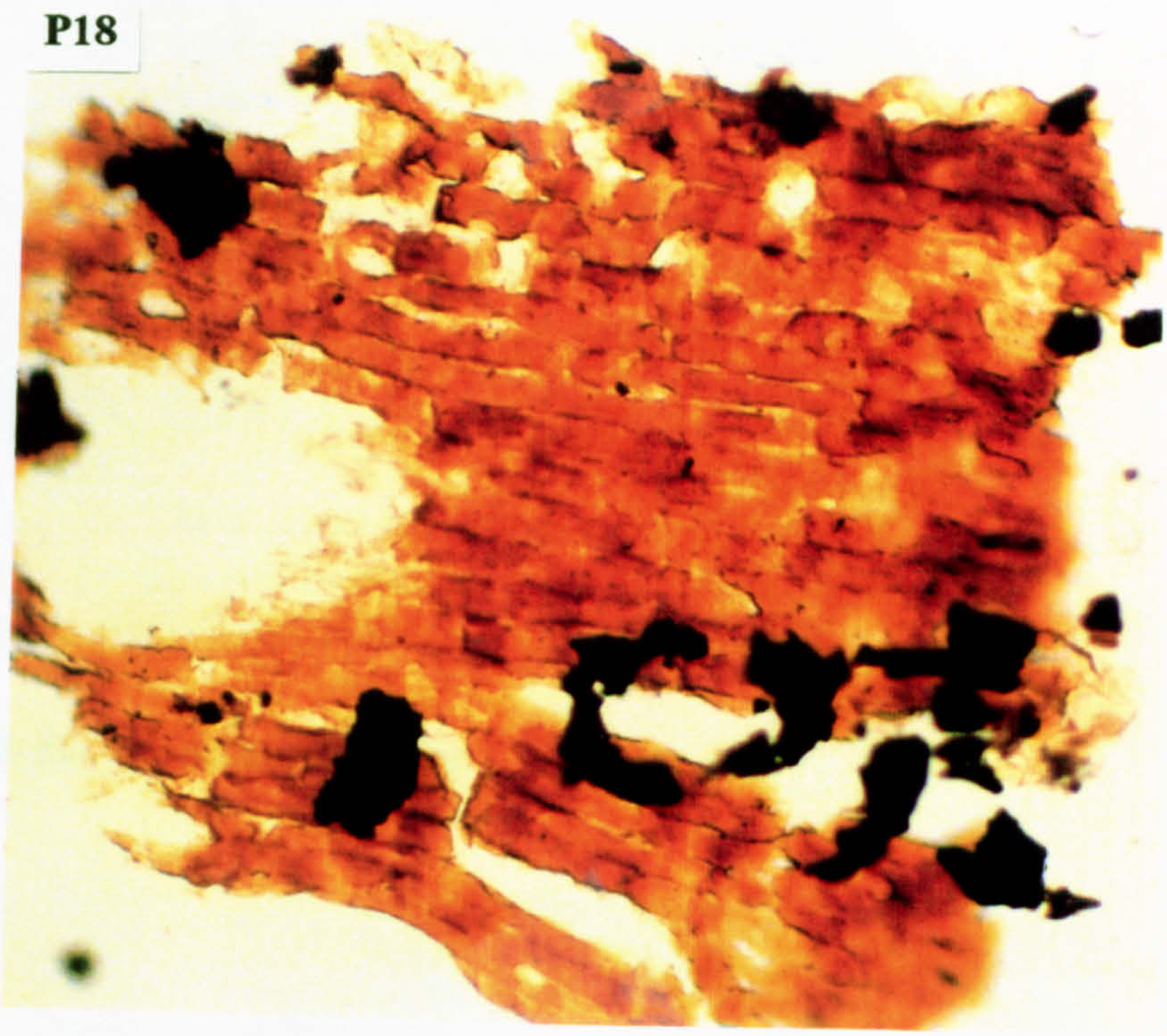
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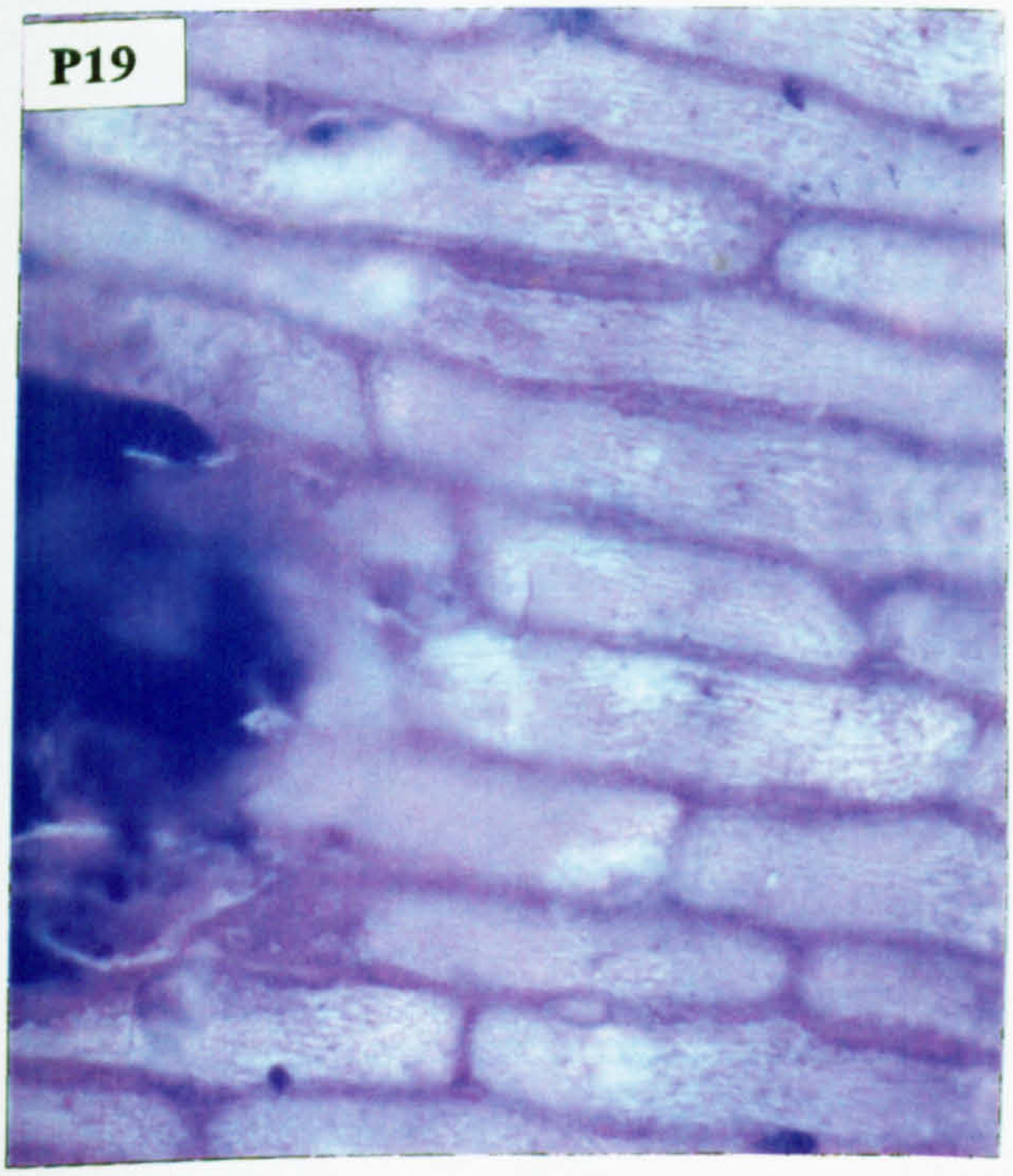
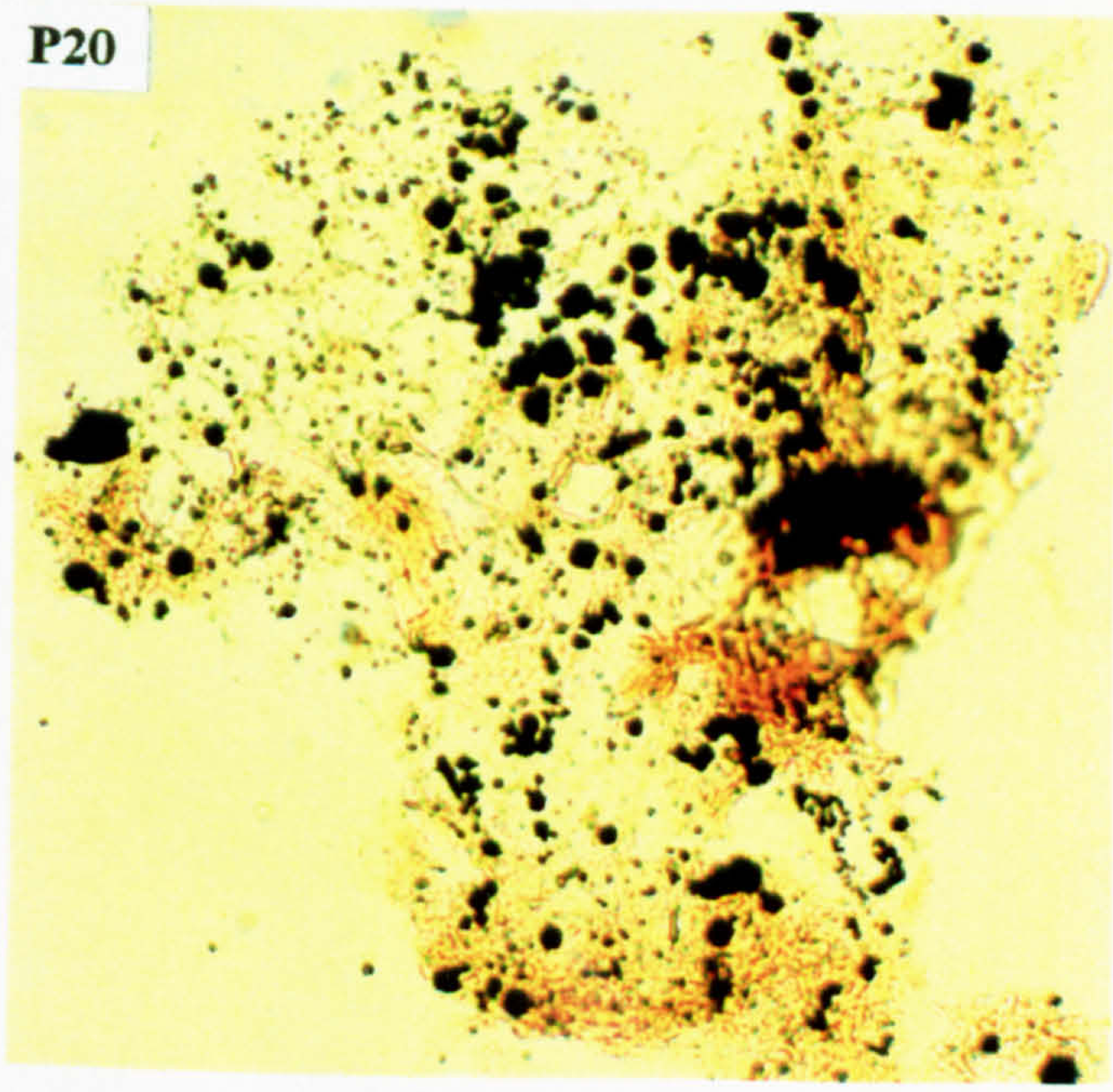

P19


P20

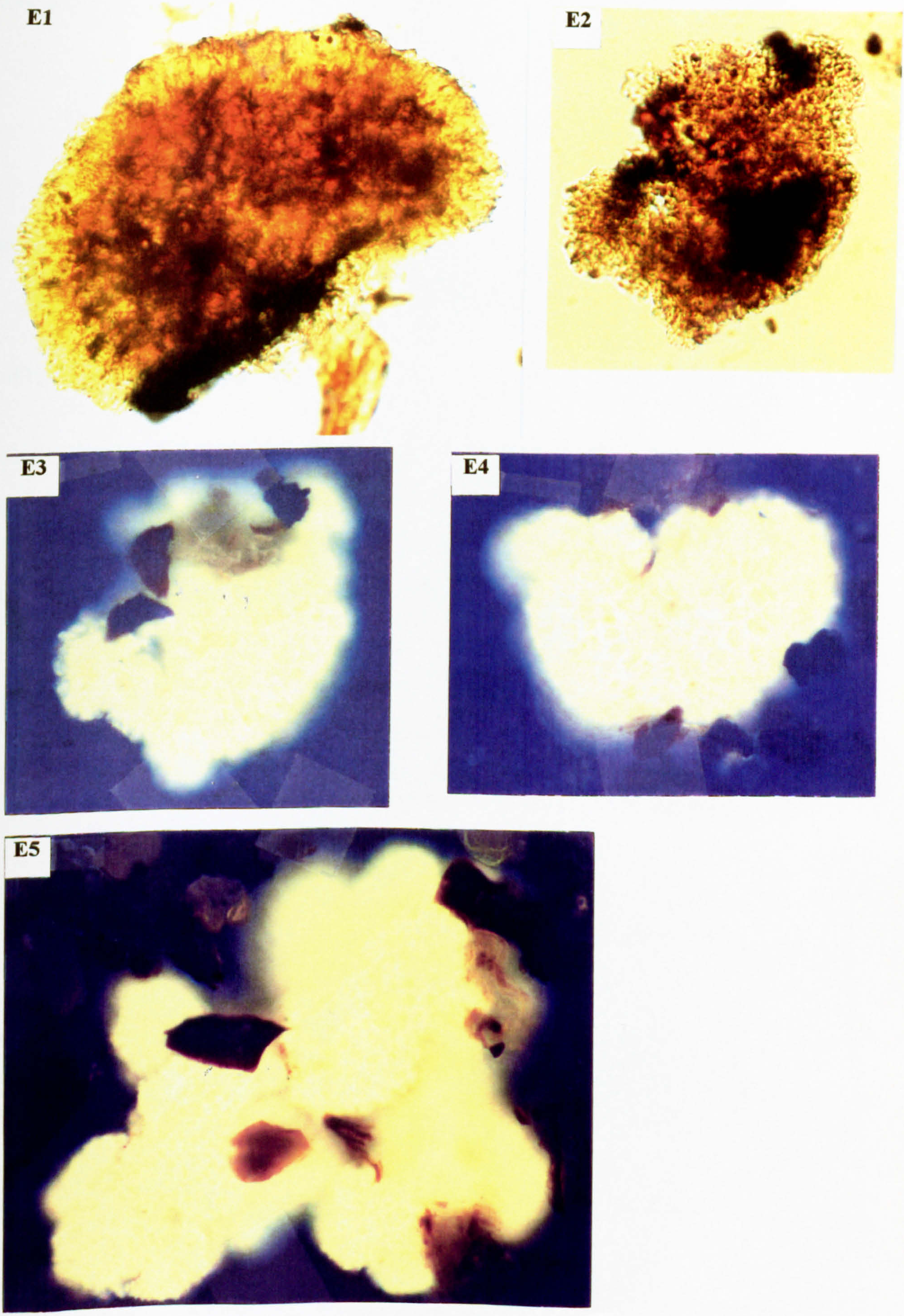
Plates E1-22. Palynomorph group.

E1. Colony of the freshwater alga *Botryococcus* seen in transmitted white light. Note the characteristic lustrous yellow colour and pseudo-radial appearance at the periphery of the colony. Sample LOK33, Duntulm Formation. Long axis = 180µm.

E2. *Botryococcus* colony viewed in transmitted white light. (see also **E3**). Sample LOK33, Duntulm Formation. Long axis = 100µm.

E3. As above viewed under incident blue light fluorescence. The cell cups are only just visible in this example. (see also **E4** and **E5**).

E4 and **E5**. *Botryococcus* colonies seen under blue light fluorescence. Note the typical brightly fluorescent nature and the visible cell cups. Both sample LOK33, Duntulm Formation. **E4** long axis = 140µm, **E5** 'diameter' = 220µm.


E1
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E3
E4
E5

E6. Thick-walled spore showing characteristic trilete mark. Sample CGD50, Duntulm Formation. Diameter = 55μm.

E7. Ornamented spore, also showing trilete mark. Sample LOK33, Duntulm Formation. Diameter = 40μm.

E8. Simple thin-walled spore showing trilete mark. Sample LOK36, Duntulm Formation. Diameter = 50μm.

E9. Unidentified pollen grain. Sample LOK36, Duntulm Formation. Diameter = 60μm.

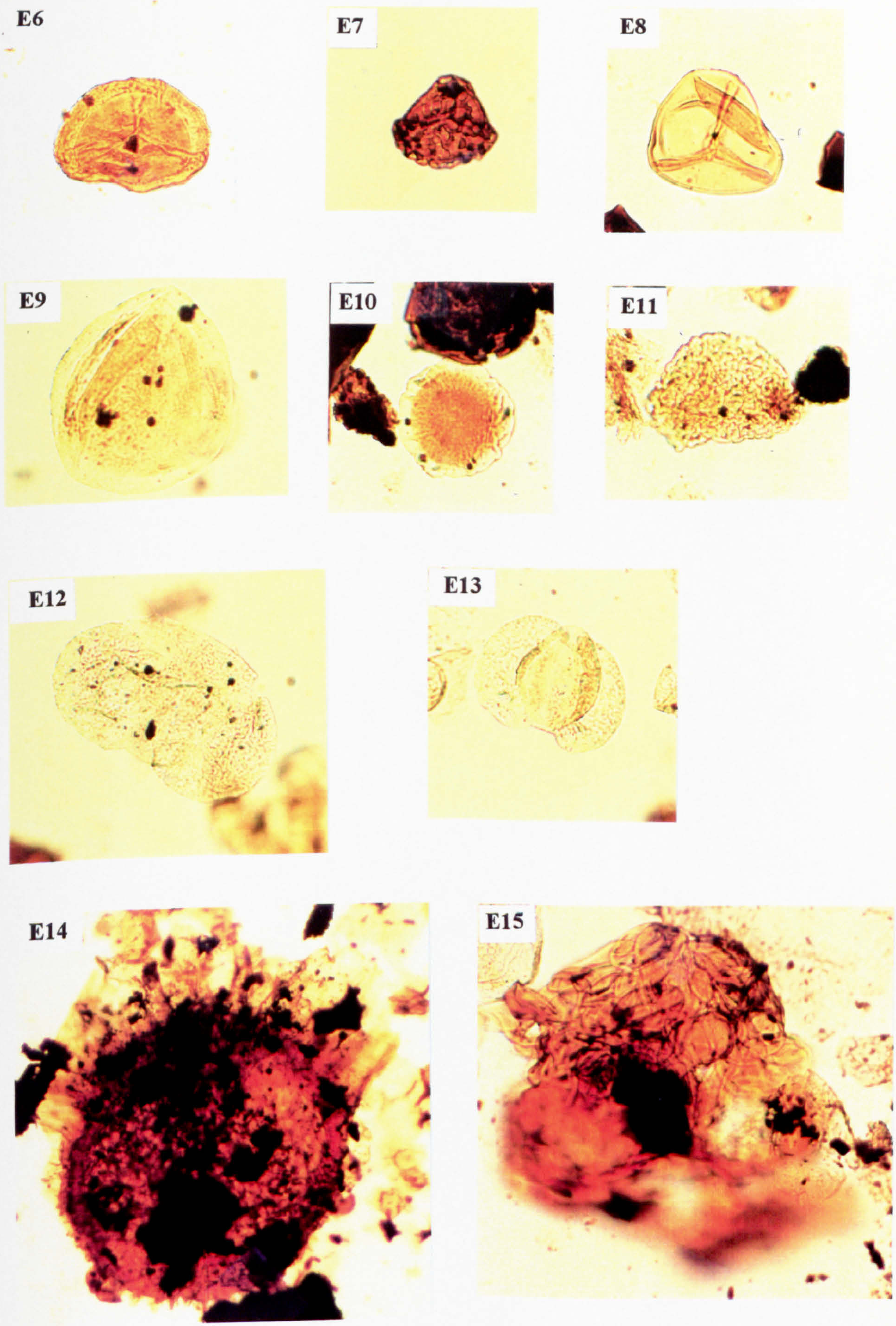
E10. *Callialasporites* pollen grain. Sample UOB15, Upper Ostrea Member, Staffin Bay Formation. Diameter = 40μm.

E11. *Cerebropollenites* pollen grain. Sample UOB18, Upper Ostrea Member, Staffin Bay Formation. Diameter = 50μm.

E12 and **E13**. Bisaccate pollen grains. Both from sample LOK36, Duntulm Formation. Long axes 70 and 60μm respectively.

E14. Megaspore. Sample CGD53, Duntulm Formation. Diameter = 360μm.

E15. Mass of monosulcate pollen grains. Sample CGD53, Duntulm Formation. Long axis = 420μm.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E16. *Pareodinia* spp. dinocyst. Sample LBM5, Duntulm Formation. Long axis = 70μm

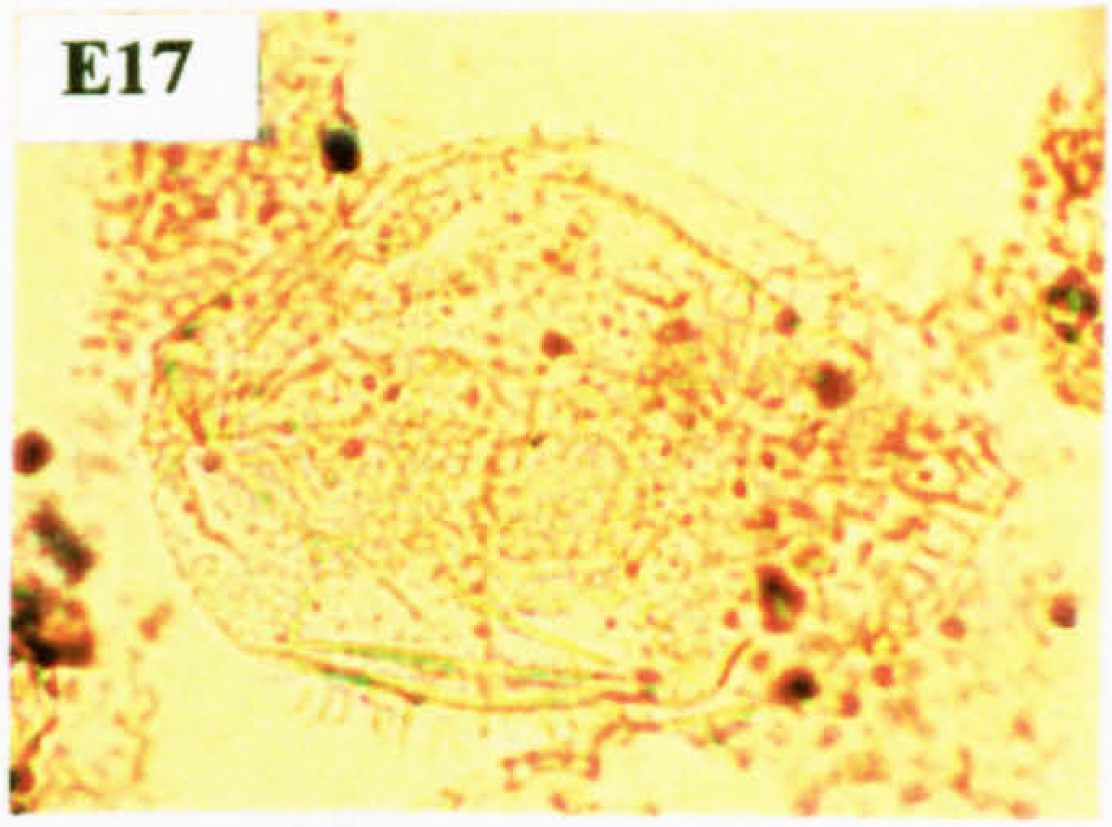
E17. *Ctenidodinium* spp. dinocyst. Sample LOK11, Duntulm Formation. Long axis = 60μm.

E18. *Jansonia manifesta* dinocyst. Sample LOD8, Duntulm Formation. Diameter = 30μm.

E19 and **E20.** Gonyaulacacean dinocyst (*Tubotuberella* spp.) viewed under transmitted white light and incident blue light fluorescence. Sample LBM1, Duntulm Formation. Long axis = 105μm.

E21 and **E22.** Long spined acritarch (*Micrhystridium*) viewed under transmitted white light and incident blue light fluorescence. Sample LOK37, Duntulm Formation. Diameter = 30μm.

E23. Foraminiferal test lining. Sample CGD60, Duntulm Formation. Diameter = 60μm.


E16

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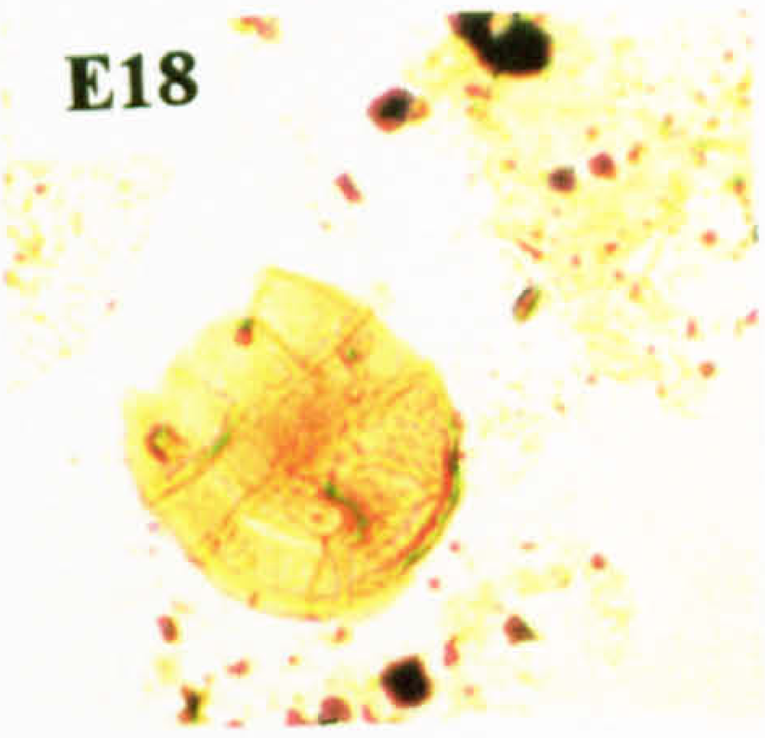
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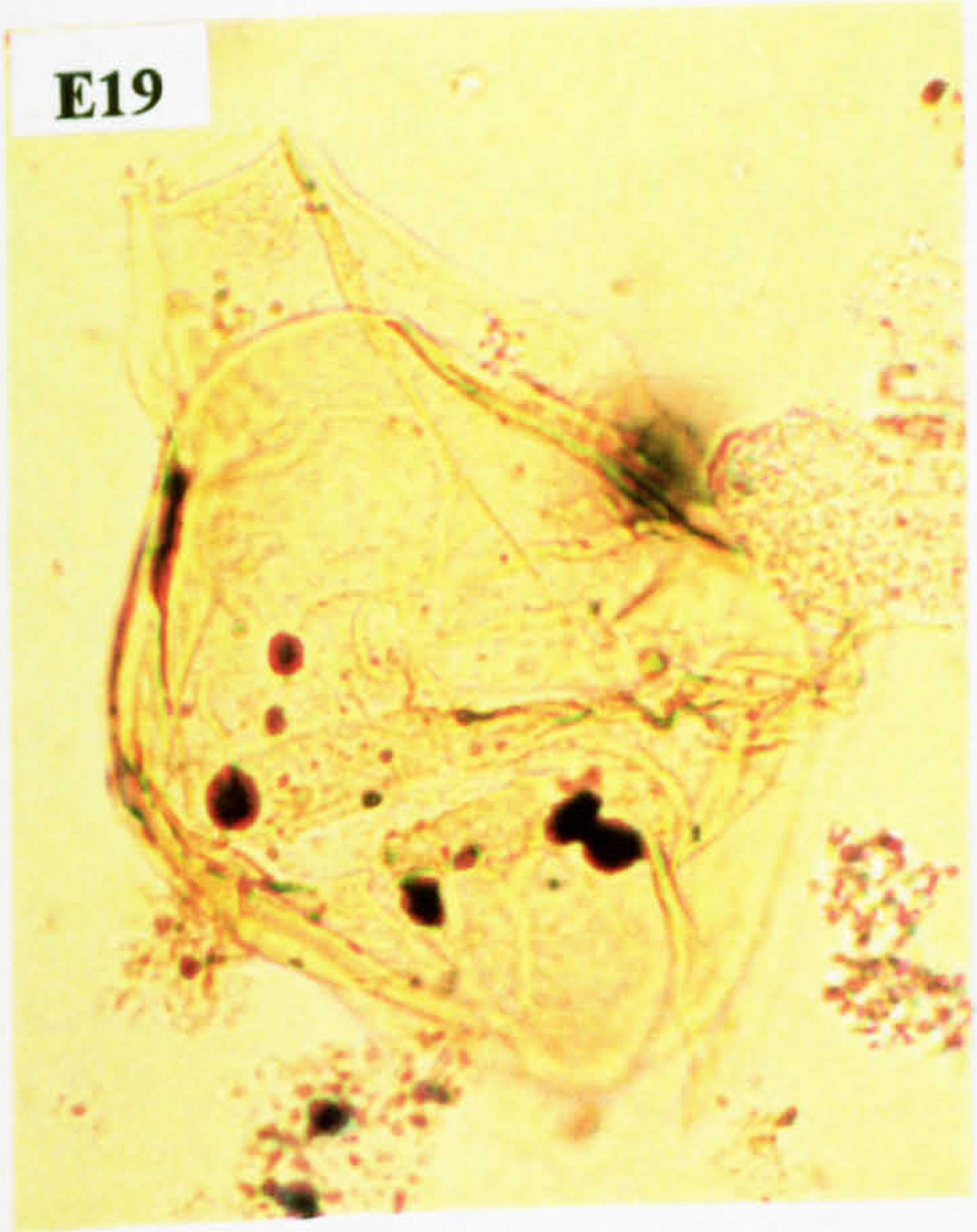
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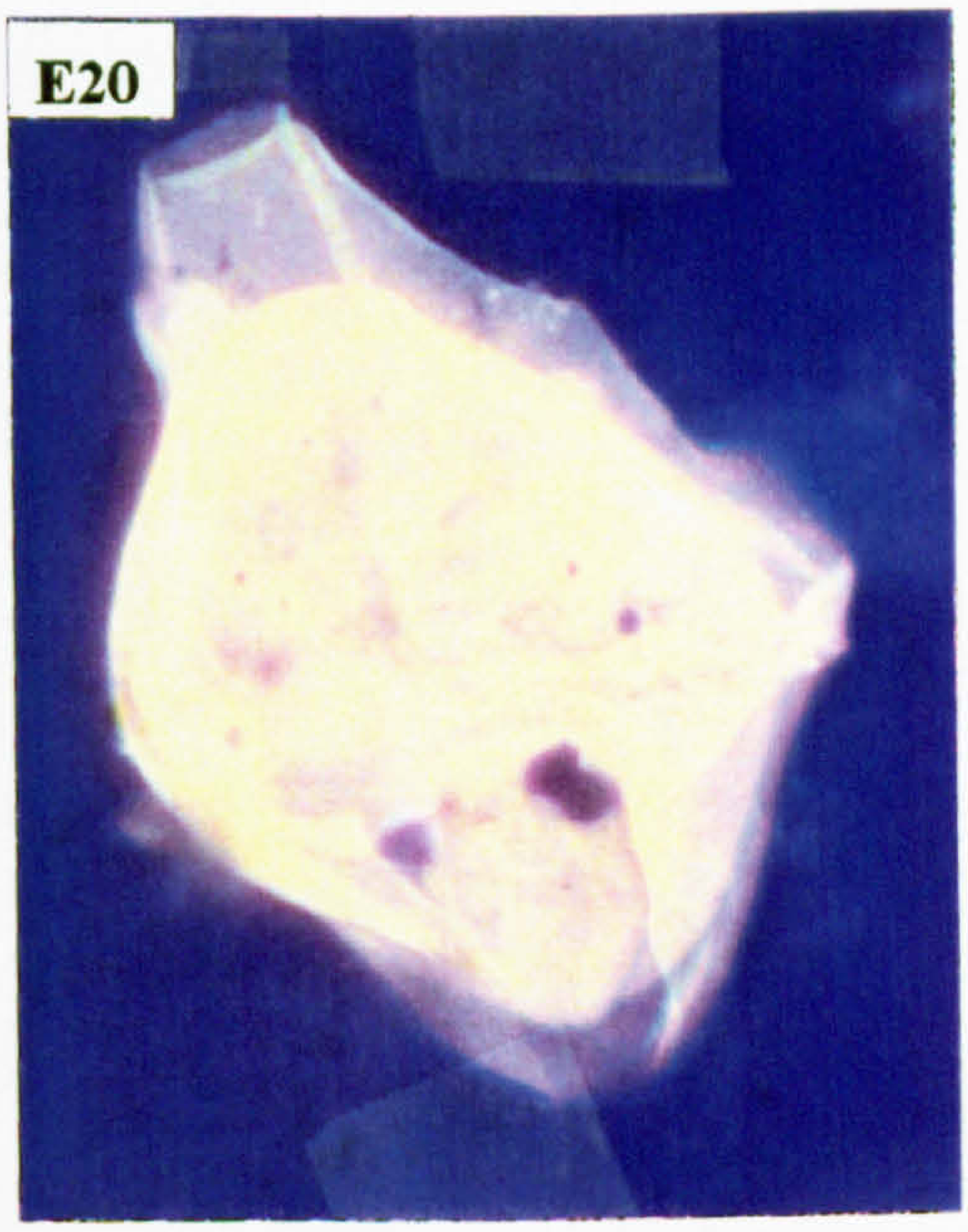
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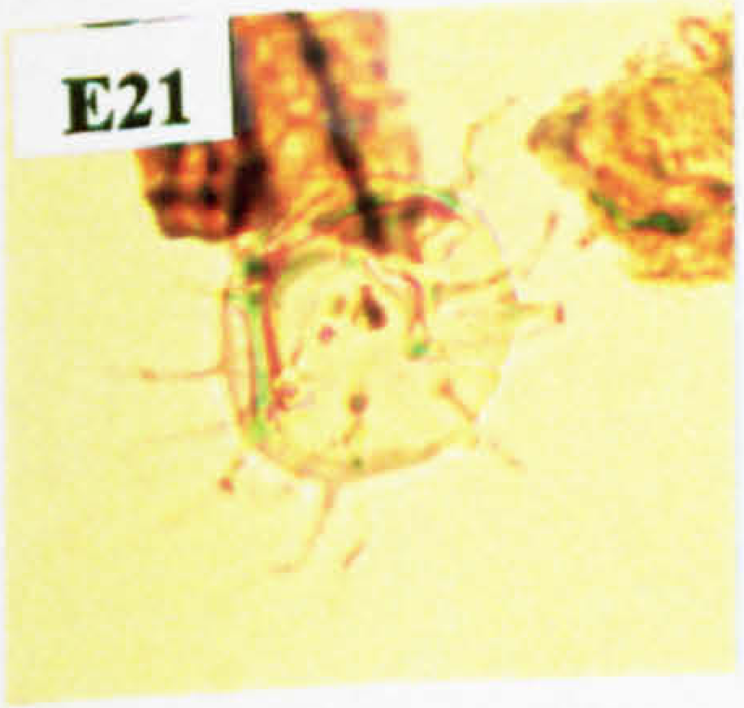
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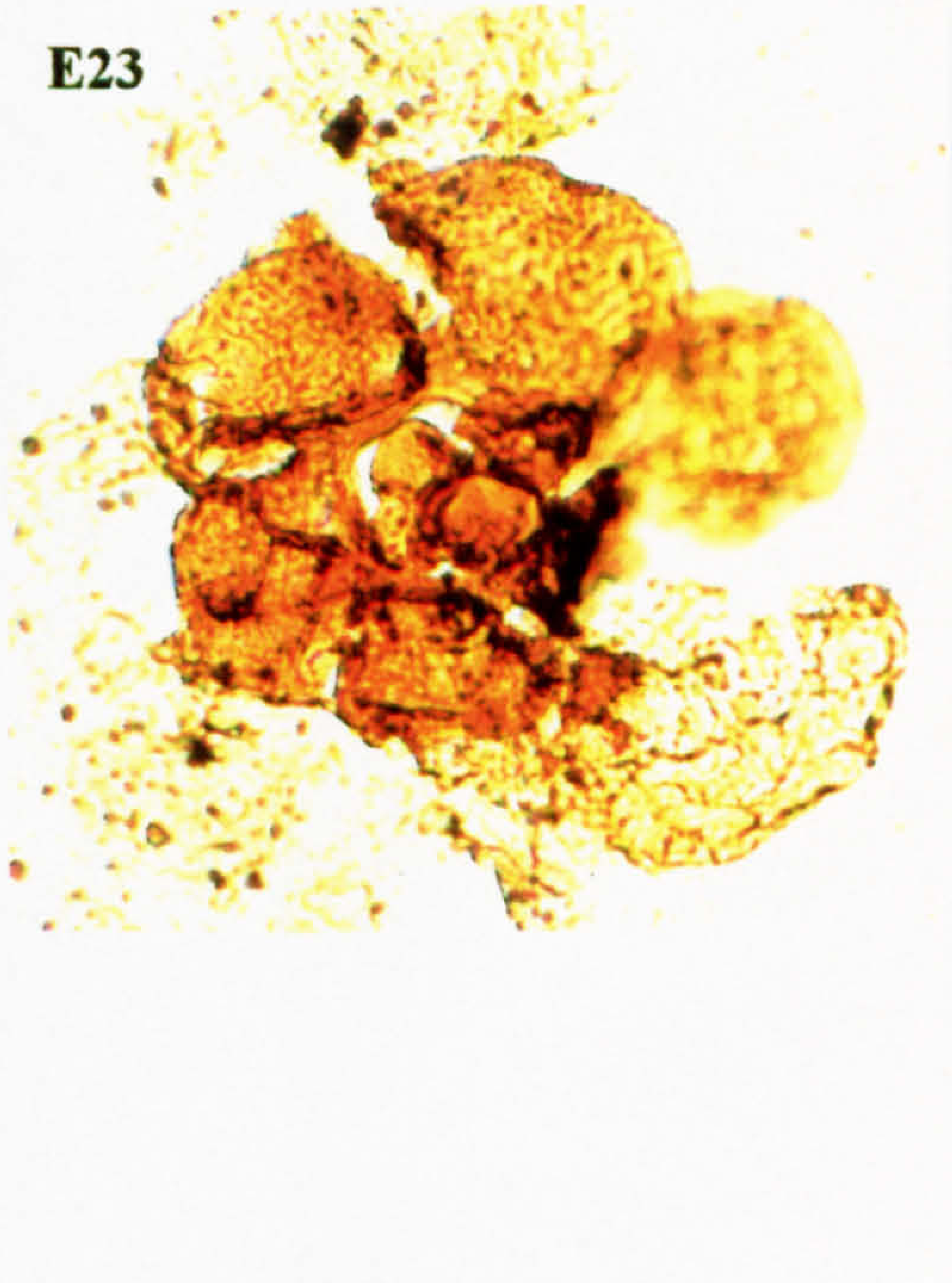
E22

E23

CHAPTER 3.0
STATISTICAL METHODS

3.0 STATISTICAL METHODS

3.1 Introduction

With around 500 samples and over 30 variables this project generated a large amount of data which would have been difficult to interpret fully without the use of multivariate statistical techniques. There are many procedures which can be followed; the major techniques chosen in this case were those that had proved useful in the analysis of similar data and which took different but complementary approaches to data analysis, such as discriminant function analysis and cluster analysis. In practice the choice was somewhat constrained by the options available in the SPSS software package (release 6.0, SPSS inc. 1992) which was used to carry out the majority of the statistical analyses. One statistical procedure (constrained cluster analysis) was carried out using the MVSP (release 2.1, Kovach computing services, 1993) software package. The SPSS package was used primarily because it is a WINDOWS (Microsoft) based version and allows easy import (from Microsoft EXCEL) and export of data and results; MVSP was used because it is the only available package, designed for geological applications, which contains the constrained cluster analysis technique. The current non WINDOWS status of the latter made it less easy to use, but data could be imported by converting conventional EXCEL spreadsheets to LOTUS compatible worksheet files (simply saving the files as .WKS type in EXCEL). The graphics output of MVSP is of lower quality compared to SPSS, and cannot be easily imported into WINDOWS systems.

The methods chosen can be divided into data reduction techniques (Factor Analysis) and those used for classification (Discriminant Function and Cluster Analysis). A brief introduction to each of the techniques used is given below; more thorough treatments of multivariate techniques may be found in Davis (1986), Hair *et al.* (1987), Kovach (1989), Swan and Sandilands (1995) and references therein. Some examples of the palynological application of the techniques are documented in Lenoir and Hart (1988), Kovach and Batten (1994), Hart (1994), and Darby and Hart (1994).

3.2 Factor Analysis

3.2.1 Introduction

The primary purpose of factor analysis is data reduction and summarisation; it is used to analyse the interrelationships between a large number of variables, and to explain any variation in terms of independent common underlying dimensions (factors). It is an interdependence technique, i.e. all the entered variables are considered simultaneously (Hair *et al.,* 1987).

For the purposes of this project component factor analysis has been used, the objective being to summarise most of the original variation in a minimum number of factors. The method is similar to principle components analysis (PCA), but focuses on the correlation between variables rather than the amount of variance (Hair *et al.,* 1987; Kovach & Batten, 1994). This is achieved by first creating a correlation matrix (a complete table of intercorrelation amongst the data), which is then transformed to produce a factor matrix from which the factors are extracted; this technique assumes a certain degree of underlying order exists in the data (Hair *et al.,* 1987).

3.2.2 Interpretation

Before the analysis was performed by the computer the program options were set so that the number of factors extracted was equal to the number of input variables; not all of these factors are relevant. When component factor analysis is being used only factors having eigenvalues (latent roots, a measure of the variance of the dataset accounted for by the factor) of greater than 1.0 are considered significant, as these are the factors that account for at least the variance of a single variable (Hair *et al.,* 1987). In practice, the four factors with the highest eigenvalues were considered, even if their eigenvalues were below 1.0, as the technique was being used in a non-rigorous manner i.e. just to examine the main sources of variation in the dataset. The factor loadings represent the correlations between the original variables and the factors. Hair *et al.* (1987) state that most factor analysts consider loadings of ± 0.3 to be significant, 0.4 to be more important, and 0.5 to be very significant. However, factor analysis was used with the intention of showing only the large scale variations in the data set, thus the procedure was simple in statistical terms (no rotation of factors), and only loadings greater than or equal to ± 0.4 were considered relevant. Attempts were then made to name the factors (i.e. identify their nature) from the variable loadings.

In this study factor analysis was the initial multivariate statistical technique used because it is able to assess and summarise the main sources of variation within the dataset (see Table 3.1 for a worked example). It has only been applied to the total dataset and to those four formations from which over 50 samples have been obtained, and only the 'combined variables group' has been used containing the integrated set of variables derived from both the kerogen and palynomorph counts, the latter substituted for the less detailed palynomorph categories derived from the kerogen counts (section 2.6). The datasets were left in the form of the recalculated percentages.

3.2.3 Limitations

There are many different techniques and no one knows which is best. There are many subjective aspects of factor analysis (e.g. deciding how many factors and which factor loadings are significant, the naming of the factors). Problems of reliability, if the data changes because of changes in the sample, measurement errors, or the data gathering process, these can also produce plausible differences in the results (Hair *et al.*, 1987).

3.3 Discriminant Function Analysis (DFA)

3.3.1 Introduction

In this study DFA has been used to assess the control that different dependent variables (e.g. lithology, lithofacies) have on kerogen and palynomorph assemblages. This technique is used when the dataset contains categorical dependent variables, and several matrix independent variables (e.g. the variables derived from the kerogen and palynomorph counts). The categorical variables usually consist of classifications (e.g. lithofacies or lithologies) into two or more groups (section 2.6). "Discriminant analysis involves deriving a linear combination of two or more independent variables that will discriminate best between the *a priori* defined groups" (Hair *et al.*, 1987, p.75). The equation takes the following form (*ibid.*):

$$Z = W_1X_1 + W_2X_2 + W_3X_3 +.........+ W_nX_n$$

where

Z = discriminant score
W = discriminant weights
X = independent variables

Example of factor loadings from the kerogen variables whole dataset analysis (a); those shown in bold type are considered relevant when factor names are assigned (b).

(a)

Variable	factor1	factor2
Botryo	0.57439	0.19795
Foram lining	-0.09895	-0.07328
AOM	0.18016	0.67972
Phytoclasts	-0.5578	-0.57277
Palynos	0.48375	-0.12031
Striate/strbro	-0.62102	0.13045
Stripe/strbro	0.22931	-0.0081
Band/strbro	0.52913	-0.22907
Pit/strbro	0.27128	0.0232
Lath/black	0.08026	0.801
Equant/blck	-0.08026	-0.801
Blck/phytos	0.46706	-0.3697
Bro/phytos	-0.73843	0.1468
Cor/unstrbro	-0.74759	-0.16978
Undg/unstrb	0.81403	0.0011
Psu/unstrbro	-0.30974	0.54161
Cutic/phytos	0.40383	0.12554
Mem/phytos	0.55372	0.25208
Str/brown	0.69571	0.0488
Ustr/brown	-0.69571	-0.0488
Undg/strbro	0.51504	-0.07614
Deg/strbro	-0.20145	-0.00657
Sporo/palyn	0.46418	-0.30999
Marpl/palyn	-0.24942	0.09891
Undiff/palyn	-0.43193	0.38479

(b)

Variable	factor1
Cor/unstrbro	-0.74759
Bro/phytos	-0.73843
Unstr/bro	-0.69571
Striate/strbr	-0.62102
Phytoclasts	-0.5578
Undiff/palyn	-0.43193
Cutic/phytos	0.40383
Sporo/palyno	0.46418
Black/phyto	0.46706
Palynos	0.48375
Undg/strbr	0.51504
Band/strbro	0.52913
Mem/phyto	0.55372
Botryo	0.57439
Str/brown	0.69571
Undg/ustrbr	0.81403

Variable	factor2
Phytoclasts	-0.57277
Psu/unstrbro	0.54161
AOM	0.67972
Lath/black	0.801
Equant/blck	-0.801

The significant factor loadings are then considered and attempts are made to name the factor. The positively loaded variables commonly associate together and not with the negatively loaded variables group and vice-versa. Interpretation is carried out by comparison with known palynofacies trends (section 2.4), but also considering the inherent sympathetic variation that is expected. In this case the negatively loaded variables from factor 1 suggest a more proximal assemblage than the positively loaded ones, so this factor is named as **Proximal-Distal.** In the case of factor 2 the positively loaded variables suggest enhanced preservation of relatively labile particle types, not associated with phytoclast input, and so this factor is named as **Preservation.**

(c) *Variation accounted for by the first 2 factors examined in the kerogen variables whole dataset analysis.*

Factor	Eigenvalue	Pct of Var	Cum Pct	Factor	Eigenvalue	Pct of Var	Cum Pct
1	6.01071	24	24	2	3.02665	12.1	36.1

Pct of Var refers to the percentage of variation of the dataset accounted for by that factor
Cum Pct is the cumulative sum of the Pct of Var.

Once the factor names had been assigned the amount of variation accounted for by that factor could be examined and compared between factors and formations, etc. For example in the above analysis factor 1, Proximal-Distal effects, accounts for 24% of the variation, around twice as much as factor 2, Preservation, which accounts for 12%. This suggests that in this case Proximal-Distal effects are more important than preservational factors.

Table 3.1. *Factor analysis interpretation.*

Discrimination is achieved by maximising the between group variance relative to within group variance, expressed as the between group to within group variance ratio (Hair *et al.*, 1987).

3.3.2 Assumptions

There are several key assumptions made when using this technique: multivariate normality of distribution; unknown (but equal) dispersion and co-variance for the groups; equal costs of mis-classification; equal *a priori* group probabilities; known dispersion and co-variance structure. However, DFA is known to be a robust technique not sensitive to violations in these assumptions, particularly when sample sizes are large (Hair *et al.*, 1987).

3.3.3 Types of Discriminant Analysis

Simultaneous analysis involves all of the independent variables being considered concurrently, regardless of their discriminating power, the discriminant function being derived from the entire independent variable set. In **stepwise analysis** independent variables are entered into the equation one at a time on the basis of their discriminating power (best first), then paired with each of the other independent variables until the one is found that best improves the discrimination, this process continues until the addition (or omission as independent variables can also be removed from the equation) of any new independent variables is judged as not contributing significantly to further discrimination (Hair *et al.*, 1987).

3.3.4 Classification by Chance

In order to assess the level of accuracy of the prediction of a discriminant function it is necessary to determine the percentage that would be classified correctly by chance. There are two chance classification criteria: the maximum chance and the proportional chance (Hair *et al.*, 1987). The maximum chance criterion is used mainly when the objective of the discriminant function is to maximise the percentage correctly classified (Morrison, 1969 cited *in* Hair *et al.*, 1987). It is the percentage of samples in the largest category of the dependent variable (out of the total number of samples). The proportional chance criterion is used when the intent is to correctly identify the members of two or more groups, as is usually the case (Hair *et al.*, 1987). It is defined as:

$$Cprop = (p_1)^2 + (p_2)^2 + \ldots\ldots (p_n)^2$$

where

Cprop = proportional chance
p_1 = proportion of individuals in group 1
p_2 = proportion of individuals in group 2

3.3.5 Interpretation

For the purposes of this study the main way of interpreting discriminant function analyses has been through the examination and comparison of the classification matrices and the data contained therein. Hair *et al.* (1987) state that in order to be considered significant classification accuracies should be at least 25% higher than those that could be achieved by chance, but as was the case with Factor Analysis, no hard and fast rules were followed and the chance criteria were used only to give an idea of the significance of the accuracies that were found. When the stepwise method was employed Wilks' lambda values were used to identify the relative discriminating power of the independent variables chosen; larger values of this parameter, which varies between 0.0-1.0, indicate a greater contribution to the discriminating power of the equation (Hair *et al.*, 1987), however, the values can only be compared within individual analyses. The mis-classified samples (samples which have been incorrectly classified into the wrong category) have been profiled using data not included in the analysis (e.g. lithology, dominant lithology, lithofacies, bioturbation level, etc.) so that the reason for their mis-classification can be established.

In the example shown in Figure 3.1, comparison of the overall classification accuracies shows that the simultaneous analysis provides only a 5% better accuracy using all 17 variables as opposed to 2 variables in the stepwise analysis. The accuracies of the individual groups show a similar pattern, being reduced somewhat uniformly in the stepwise analysis. Examination of the two variables chosen for this analysis shows that the percentage of *Botryococcus* is the variable that has the best discriminating power, and this is joined by the percentage acritarchs of marine plankton in the stepwise function. In the actual results section this would be followed by the profiling of the mis-classified samples (only for the all variables simultaneous analysis). For all the dependent variables analysed four discriminant function analyses were performed: simultaneous analyses on the kerogen variables group, the palynomorph variables group and the all variables group, and stepwise analysis on the all (combined) variables group only (see section 2.6 for the variables included in each of these groups).

Classification matrix from the simultaneous analysis of the palynomorph variable group from the Lealt Shales Formation, using 'Salinity' as the dependant variable.The groups relate to the three salinity categories, 1 = freshwater-miohaline, 2 = mesohaline, 3 = pliohaline

Classification results -

Actual Group		No. of Cases	Predicted Group Membership 1	2	3
Group	1	34	25 73.5%	1 2.9%	8 23.5%
Group	2	25	4 16.0%	14 56.0%	7 28.0%
Group	3	17	1 5.9%	3 17.6%	13 76.5%

Percent of "grouped" cases correctly classified: 68.42%

Classification processing summary

76 (Unweighted) cases were processed.
0 cases were excluded for missing or out-of-range group codes.
0 cases had at least one missing discriminating variable.
76 (Unweighted) cases were used for printed output.

Classification matrix and summary table from the stepwise analysis of the palynomorph variables group from the Lealt Shales Formation, using 'Salinity' as the dependant variable

Summary Table

Step	Action Entered Removed	Vars in	Wilks' Lambda
1	%BOTRYOCOCCUS/PALYNOMORPHS	1	.68448
2	%ACRI/MARINE PLANKTON	2	.61212

Classification results -

Actual Group		No. of Cases	Predicted Group Membership 1	2	3
Group	1	34	24 70.6%	4 11.8%	6 17.6%
Group	2	25	3 12.0%	12 48.0%	10 40.0%
Group	3	17	0 .0%	5 29.4%	12 70.6%

Percent of "grouped" cases correctly classified: 63.16%

Classification processing summary

76 (Unweighted) cases were processed.
0 cases were excluded for missing or out-of-range group codes.
0 cases had at least one missing discriminating variable.
76 (Unweighted) cases were used for printed output.

In both the simultaneous and stepwise cases the maximum chance criterion (Cmax) is 45% (34/76) and the proportional chance criterion (Cprop) is 36%

Fig. 3.1. *Worked examples of the results of the discriminant function technique.*

3.4 Hierarchical Cluster Analysis

3.4.1 Introduction

This is a technique where individual samples are grouped into clusters so that those in the same cluster have a greater similarity with each other than they do with individuals in other clusters. Clusters therefore exhibit high internal homogeneity and high external heterogeneity (Hair *et al.*, 1987). In this respect the clusters are similar to the groups of discriminant function analysis (section 3.3), but cluster analysis differs in that the classification is according to natural (empirical) relationships not pre-recognised groups. There are many different approaches to cluster analysis, each with a different way of measuring the similarity (or distance) between two objects (samples) and with differences in the clustering algorithms which place objects (samples) into clusters (Tables 3.2 & 3.3). Unfortunately no one method has universal approval; some are briefly examined below.

3.4.2 Similarity Measures

The most commonly used measure is the euclidean distance which is essentially a measure of the length of a straight line drawn between two points (Hair *et al.*, 1987, p.299, their Fig.7.3). The squared euclidean distance uses the sum of the squared distances as the calculation of the square root has no effect on the separation of the points. The Mahalanobis distance is a normalised version of the euclidean distance, whereby responses from data are scaled in terms of standard deviations and adjustments made for any inter-correlations between variables (Hair *et al.*, 1987). The Spearman rank-order correlation coefficient bases correlations on the rank-order of abundances rather than the abundances themselves (Kovach, 1989).

3.4.3 Discussion

Kovach (1989) found that using the squared euclidean distance emphasised the more abundant varieties in his megaspore assemblages, and that using the Spearman rank-correlation coefficient gave the 'best' results as the non-metric approach meant that noise driven variations did not affect the coefficient. Hair *et al.* (1987) state that if the variables are inter-correlated (as is often the case in this project) then the Mahalanobis distance is likely to be the most appropriate as it weights all variables equally. Unfortunately this measure was not available on the SPSS PC package.

Measure	Characteristics
Euclidean distance	Square root of the sum of the squared differences in values for each variable
Squared euclidean distance	Sum of the squared differences in values for each variable
Mahalinobis distance	Normalised version of euclidean distance
Spearman correlation coefficient	Non-metric ranking of distances
Cosine	Cosine between vectors of values
Pearson correlation	Correlation between vectors of values

Table 3.2. *Some popular similarity measures.*

Name	Method of forming clusters
Single Linkage Cluster analysis (nearest neighbour)	Observation joined to a cluster if it has certain similarity with at least one member of that cluster. Clusters based on links between single entities.
Complete Linkage Cluster Analysis (furthest neighbour)	Observation joined to cluster if it has certain level of similarity with all current members of the cluster.
Average linkage cluster analysis (simple average linkage, centroid method)	In all methods the observation is joined to cluster if it has a certain average level of similarity with all current members of the clusters
Minimum variance cluster analysis (Wards' method)	Generates clusters in such a way as to minimise within cluster variance; considered by some to be an average linkage method.

Table 3.3. *Clustering algorithms. (Adapted from Hair et al., 1987).*

3.4.4 Clustering Algorithms

Problems can occur with single linkage (nearest neighbour) clustering as chains of single links can be formed, eventually joining into one long chain in which case the individuals at either end of the chain will be very dissimilar. Complete linkage (furthest neighbour) eliminates this problem, but both methods suffer from the problem that the shortest or longest distance may not represent the true similarity between two groups (Hair *et al.*, 1987). The similarity between groups as a whole is used in average linkage, but these techniques tend to combine clusters with small variances, and be biased towards producing clusters with similar variances. Ward's method tends to combine clusters with a small number of observations and to produce clusters with similar numbers of observations. Centroid clustering suffers from reversals, where the distance between the centroids of one pair can be less than the distance of another pair merged at another time (Hair *et al.*, 1987).

3.4.5 Discussion

Single and complete linkage are problematic because they rely on single extreme points to represent whole clusters; Kovach (1989, p.257) rejects them on theoretical grounds stating that the use of one point is "space-distorting, causing groups to cluster as if they were closer or further apart than they actually are". He similarly rejects centroids as they "are non-monotonic and may contain reversals in which the level where two objects fuse is higher than the next level of fusion" which produces serious flaws in the dendrogram (*ibid.*).

Hair *et al.* (1987) state that average linkage and Wards' minimum variance clustering are probably the best available hierarchical clustering methods, but note that many techniques should be employed and compared if possible. Indeed this seems to exemplify the rationale behind the application of cluster analysis: many different combinations of relevant distance measures and algorithms should be employed to test the strength of the clusters, before any one technique is chosen, and this technique is generally the one which gives the best (unambiguous) results (Kovach, 1989).

3.4.6 Comparison and Choice of Similarity Measures and Algorithms

From the above discussion it was possible to discard many techniques, leaving only two measures of similarity (one metric and one correlation coefficient) and four algorithms (two average linkage techniques, one minimum variance technique and one from single/complete linkage for contrast).

Figure 3.2 shows seven dendrograms resulting from the application of some different similarity measures (squared euclidean distance and the Pearson correlation) and clustering algorithms (average linkage, complete linkage, and Wards' method). To aid ease of comparison the clusters defined have been labelled A to F; the order of the lettering is arbitrarily based on the first dendrogram. Table 3.4 presents a comparison of the results.

3.4.7 Algorithm

Table 3.4 shows that there are no major changes in the cluster memberships using the different algorithms apart from the fact that cluster C is not present when the 'within groups' average linkage, and Wards' method are used (Figs. 3.2 c & f); these two methods show the greatest changes in cluster membership from Figure 3.2a. In terms of the dendrogram characteristics, the two average linkage techniques are characterised by a high number of clustering levels, and in the 'within groups' dendrogram (Fig. 3.2f) clustering generally takes place at a high level on the rescaled distance measure. The complete linkage method (Fig. 3.2b) gives a low number of clustering levels, and a low number of clusters at a rescaled distance value of 10; Wards' method (Fig. 3.2c) shows clusters joining at a low level on the rescaled cluster measure, and is also different in terms of the most distinct clusters present (Table 3.4).

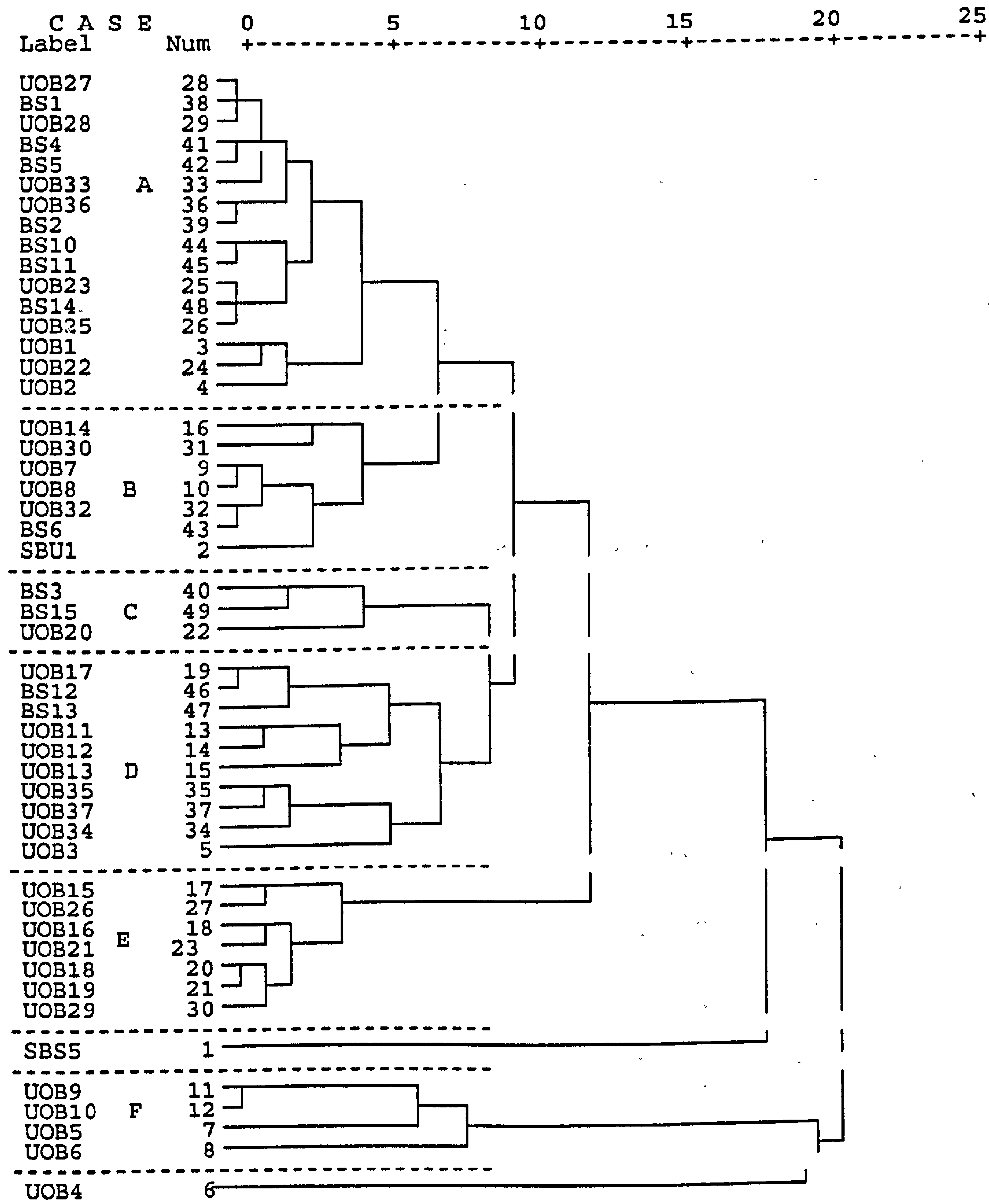
The dendrograms that would be the most easy to interpret are the between groups average linkage (Fig. 3.2a) and Wards' method (Fig. 3.2c)

Fig. 3.2. *Dendrograms from selected combinations of distance measures and clustering algorithms performed on the Staffin Bay Formation palynomorph group variables.*

a)

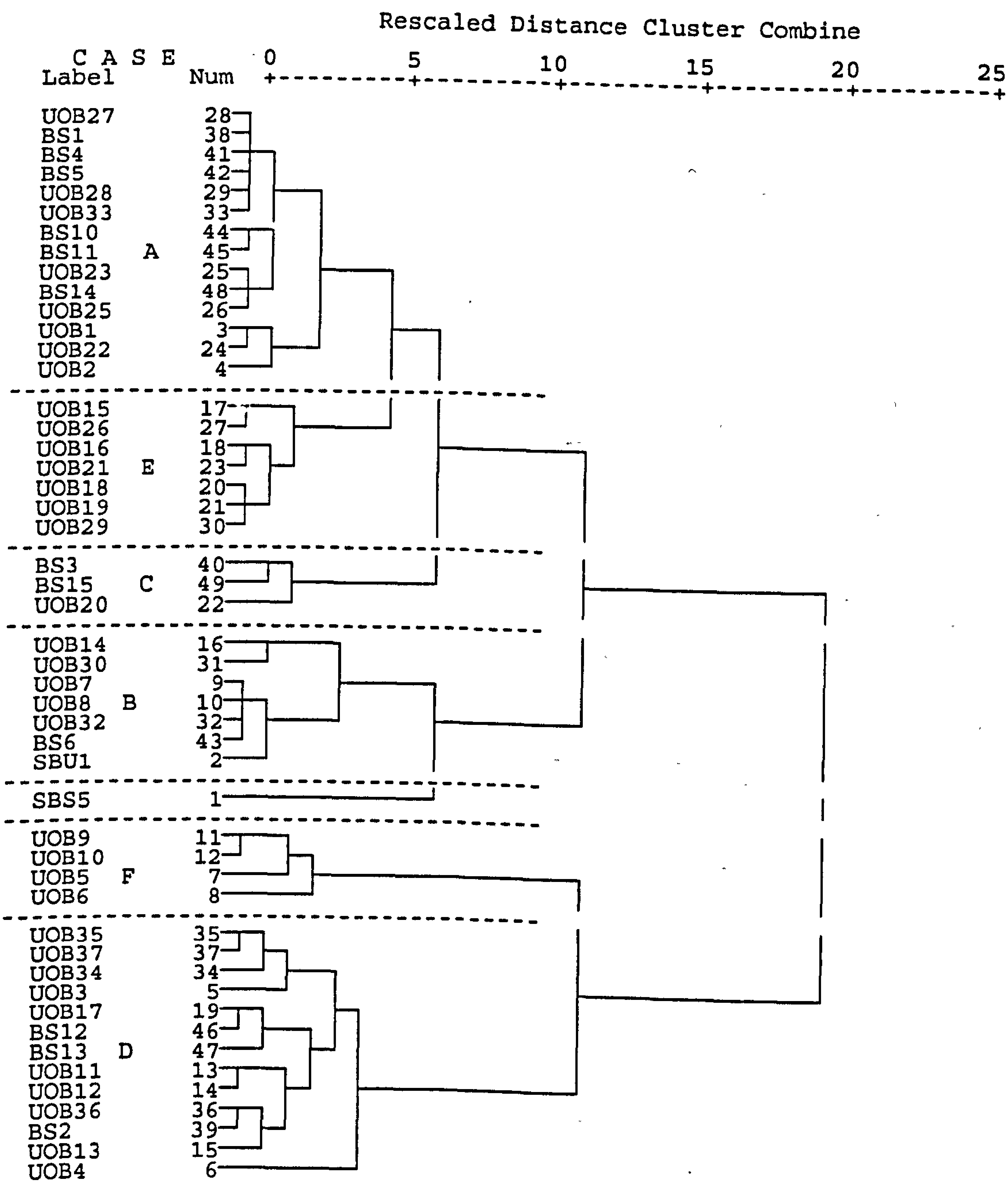
Dendrogram using average linkage (between groups) and squared euclidean measure

Rescaled Distance Cluster Combine



b)

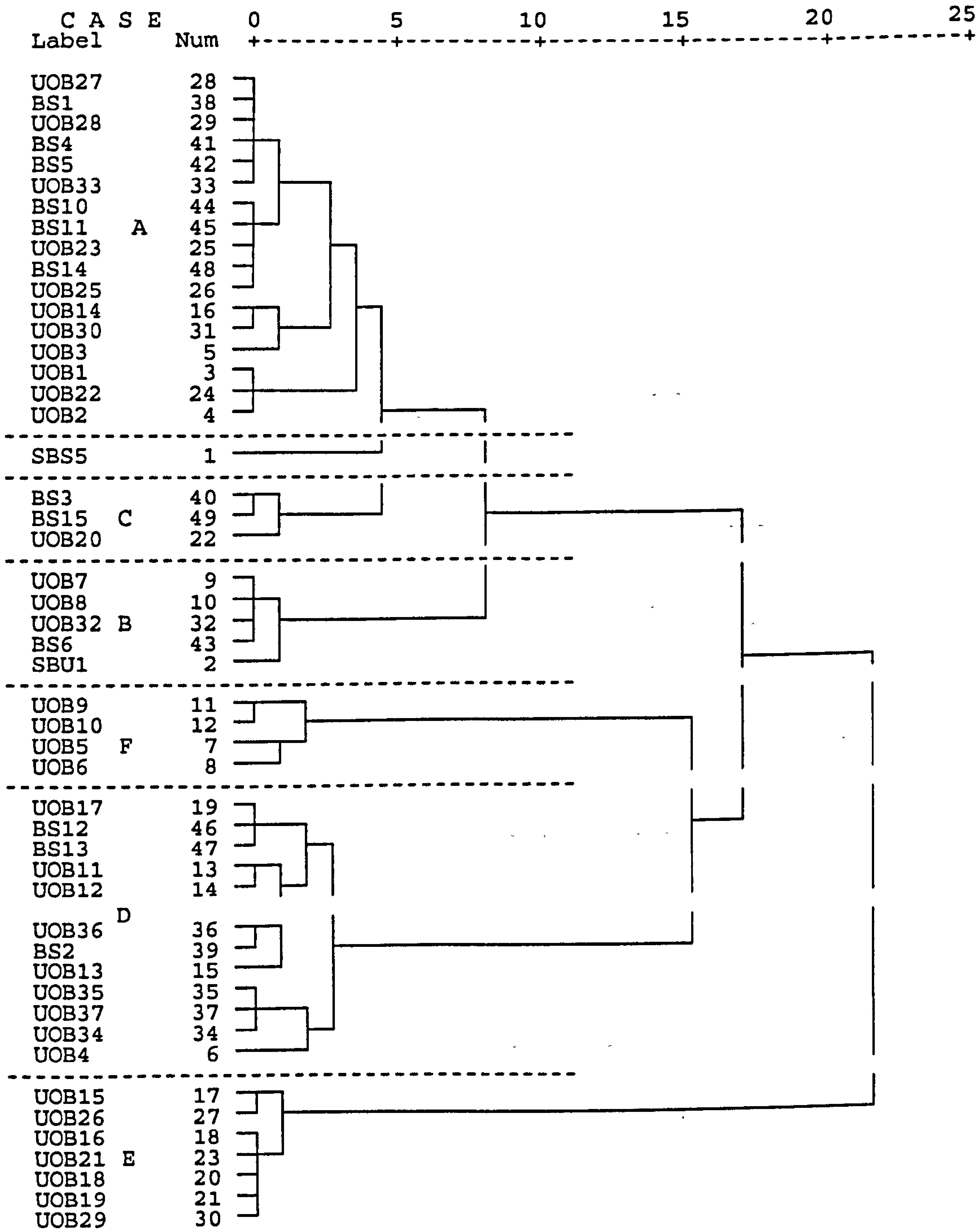
Dendrogram using complete linkage (furthest neighbour) and squared euclidean measure



c)

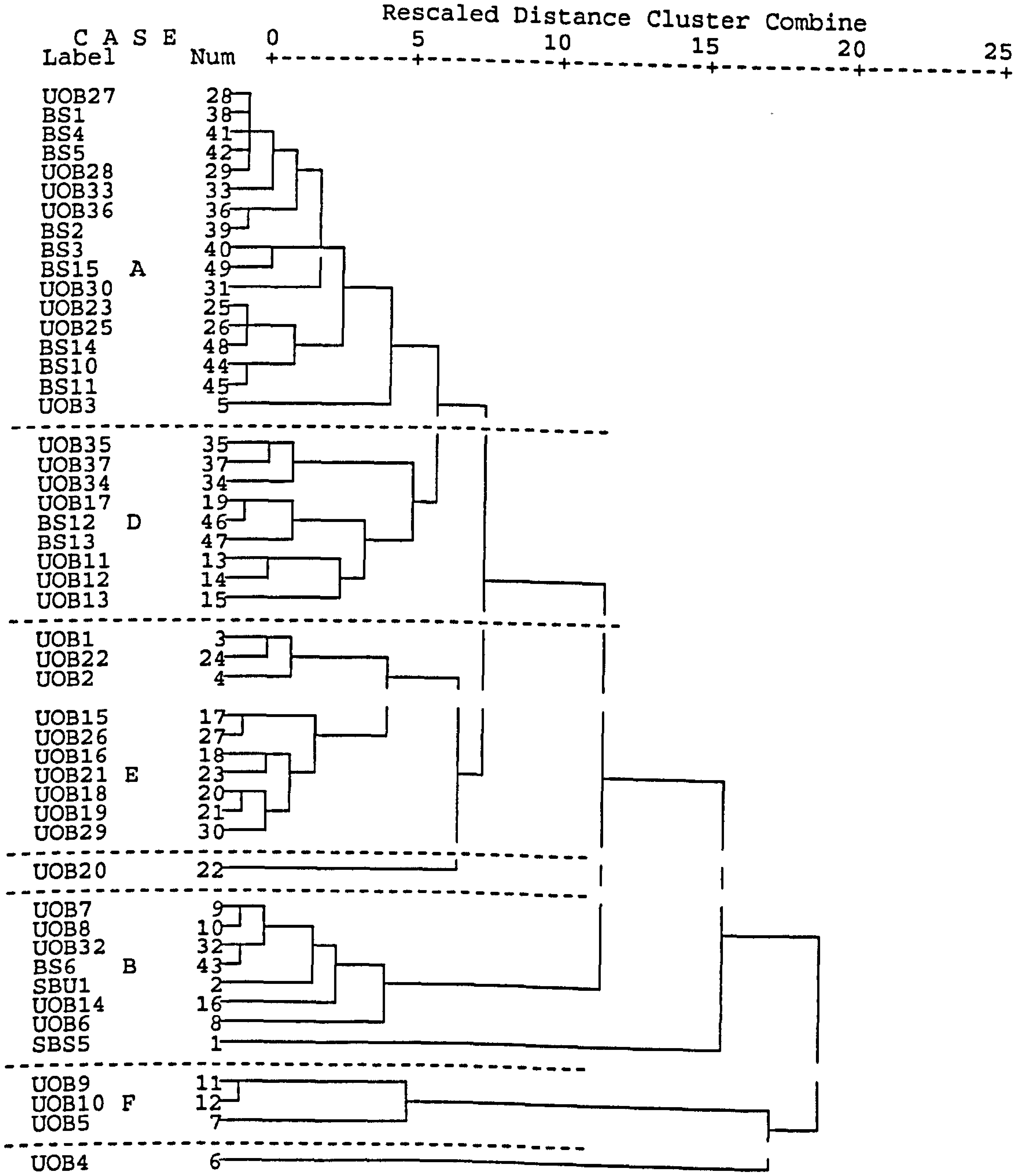
Dendrogram using Wards' method and squared euclidean measure.

Rescaled Distance Cluster Combine



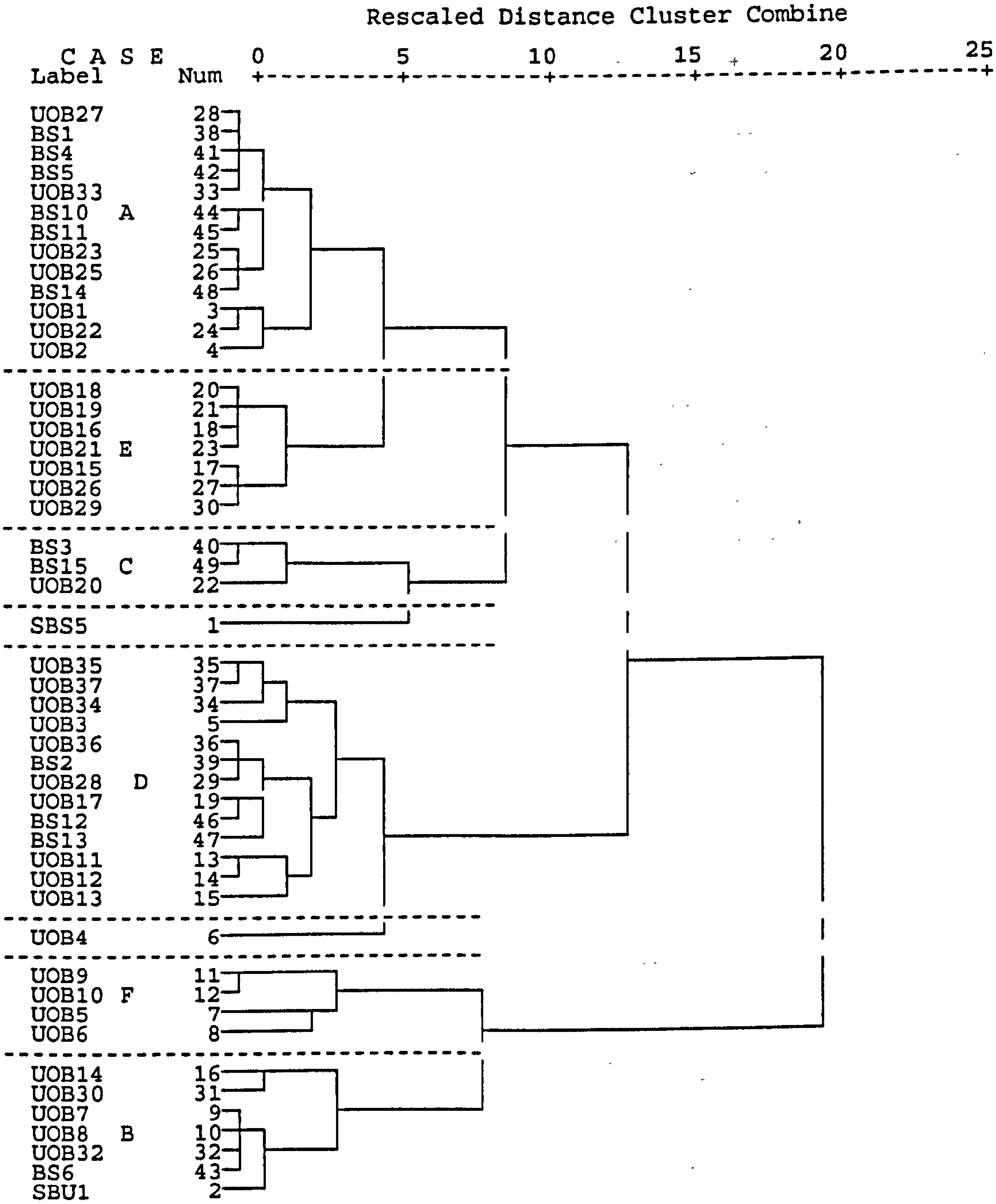
d)

Dendrogram using average linkage (between groups) and Pearson correlation measure



e)

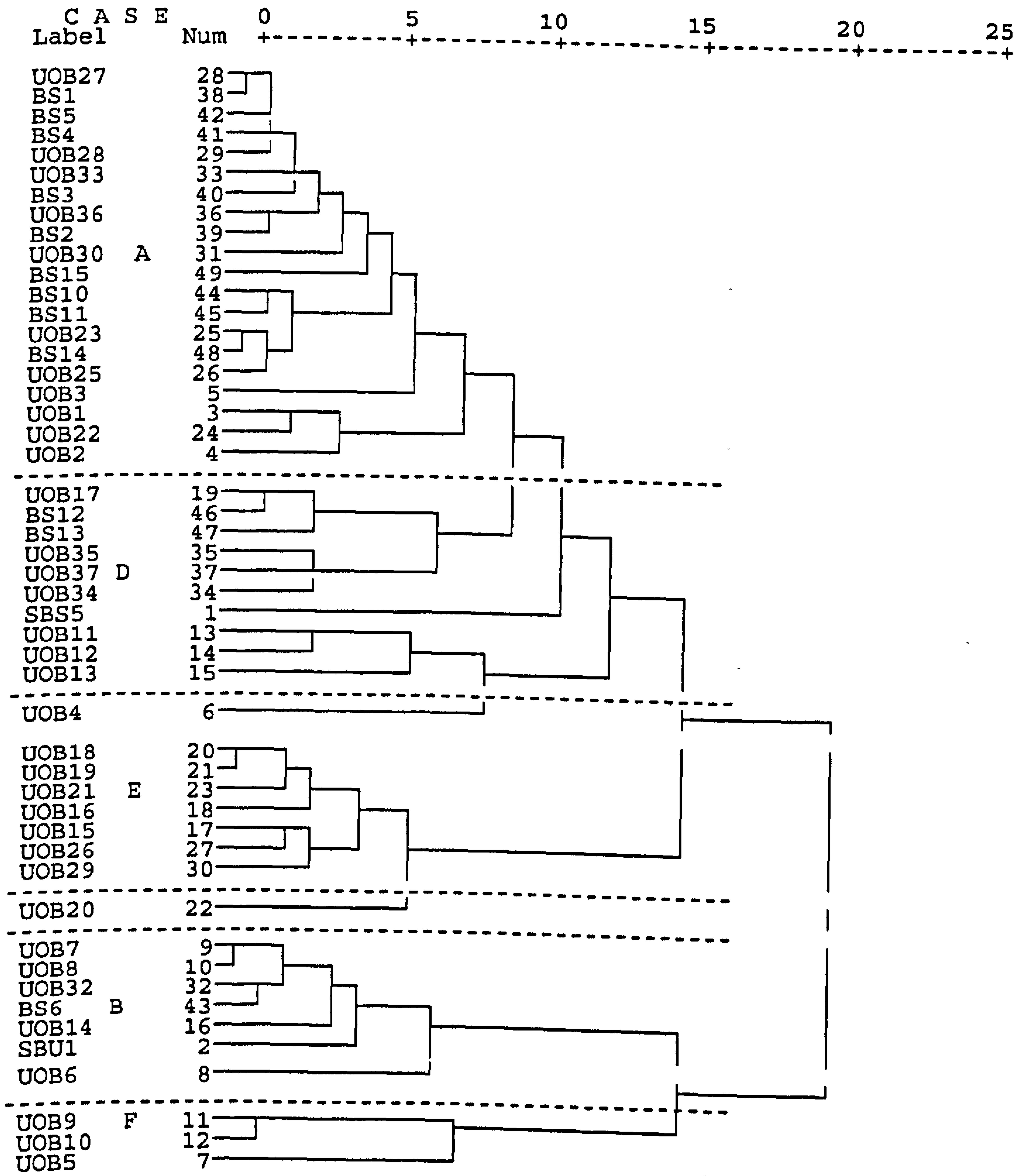
Dendrogram using complete linkage (furthest neighbour) and Pearson correlation measure



f)

Dendrogram using average linkage (within group) and squared euclidean measure

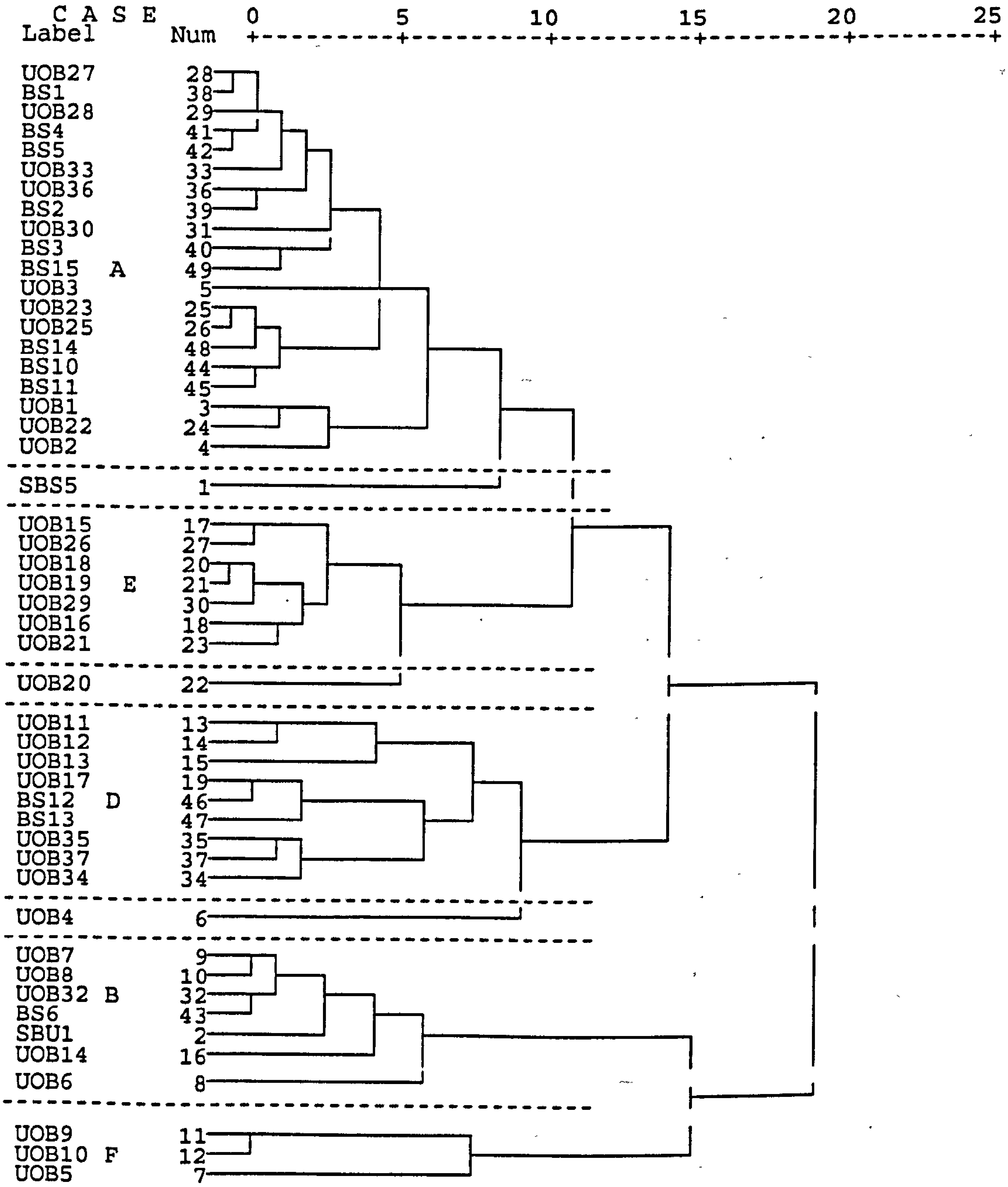
Rescaled Distance Cluster Combine



g)

Dendrogram using average linkage (within group) and Pearson correlation measure

Rescaled Distance Cluster Combine



Dendrogram	ED2 & average linkage (between groups) (a)		ED2 & complete linkage (b)		ED2 & Wards' method (c)		ED2 & average linkage (within group) (f)		Pearson corr. & average linkage (between groups) (d)		Pearson corr. & complete linkage (e)		Pearson corr. & average linkage (within group) (g)	
No. clustering levels	16		10		10		17		15		11		15	
No. clusters at rescaled distance 10	8		4		8		9		6		5		9	
Most distinct clusters	(A, B, C, D, E) vs. (F)		(A, B, C, E) vs. (F, D)		(A, B, C, D, F) vs. (E)		(A, D, E) vs. (B, F)		(A, B, D, E) vs. (F)		(A, C, D, E) vs. (E, B)		(A, E, D) vs. (B, E)	
Most similar clusters	A & B		A & E		A & C		A & D		A & D		A & D		A & E	
Similarity of cluster membership (sample composition) relative to (a)	Cluster	Number	% O	Ch	% O	Ch	% O	Ch	% O	Ch	% O	Ch	% O	Ch
	A	16	87.5	–2 D	87.5	+2 B +1 D –2 D	100	+2 C +1 D +1 C	81	+2 C +1 B +1D –3 E	81	–3 D	100	+2 C +1 B
	B	7	100		71	–2 A	86	+1 F –1 A	86	+2 E –1 A	100		86	+1 F –1 A
	C	3	100		100		0	–2 A –1 S	0	–2 A –1 S	100		0	–2 A –1 S
	D	10	100	+2 A	90	+2 A +1 S –1 A	90	+1 S –1 A	90	–1 A	100	+3 A	90	–1 A
	E	7	100		100		100		100	+3 A	100		100	
	F	4	100		100		75	–1 B	100	+2 B	100		75	–1 B
	Singles	2	100		50	–1 C	50	+1 C	100	+1 C	100		100	+1 C

ED2 = squared euclidean distance; %O = percentage of original cluster membership present: Ch = Changes in cluster membership; S = single samples

Table 3.4. *Comparison of the characteristics of the dendrograms derived from different selected combinations of distance measures and clustering algorithms.*

3.4.8 Similarity Measures

Comparison of the two similarity measures when the algorithms are the same (Table 3.4) shows that all the dendrograms are similar in terms of the number of clustering levels and number of clusters, but that the cluster memberships are only similar in the within groups and complete linkage techniques. However, in the latter cases the most distinct and similar clusters are different. In the between groups dendrograms (Figs. 3.2 a & d) the use of the Pearson correlation measure results in the combination of cluster C with other clusters, and there are also other changes in cluster membership. Also, when the Pearson correlation measure is combined with Wards' method (not shown) the dendrogram produced consists of just one cluster at the lowest level!
It would appear that either of the similarity measures presented here could be used successfully as long as Wards' method is not employed as the algorithm.

A clustering algorithm had to be chosen for this study. The furthest neighbour (and nearest neighbour) techniques were rejected as they rely on one point to represent a cluster. Wards' method produces a relatively simple and easy to interpret dendrogram, but some relatively different clusters may combine at a low level (as was the case when it was combined with the Pearson correlation measure), therefore, the between groups average linkage technique seemed to be the best overall option. This has been combined with the squared euclidean distance similarity measure which seems to be relatively simple and is readily available on SPSS.

3.4.9 Constrained Cluster Analysis

This is a special form of cluster analysis used for analysing sequential data. Clustering proceeds as normal, but the objects to be fused are constrained by having to be adjacent in the data matrix. The dendrogram thus has the objects (samples) in the same order as the input matrix (Kovach, 1993). In the case of this study this has allowed sections to be examined with the samples kept in stratigraphic order. The only problem with this technique is that constraint can cause distortion in the dendrogram such as reversals; these occur "where the distance between two objects is greater than that between the cluster of those two and the next object in the hierarchy" (Kovach, 1993, p.35). In extreme cases this can make the dendrogram uninterpretable (Kovach, *ibid.*). The squared euclidean distance has again been used as the distance measure, combined with the Wards' minimum variance clustering algorithm.

3.4.10 Interpretation

All clustering methods produce dendrograms (e.g. Fig. 3.2), and it from these that interpretations are derived. There is no single rule which determines at which level clusters should be identified, but this process is usually carried out for several different numbers of clusters (Hair *et al.*, 1987). In this project clusters have been analysed using their descriptive statistics, and profiled using characteristics such as lithology, lithofacies, etc.

3.5 Multiple Regression Analysis

3.5.1 Introduction

Multiple regression is not strictly a multivariate technique as only one dependent variable is used (Swan & Sandilands, 1995), but it is included in the multivariate statistics section in this work. It is a technique used to analyse the relationship between a single dependent variable and several independent (predictor) variables. The objective is to use the predictor variables whose values are known to predict the dependent variable value (Hair *et al.*, 1987).

The key assumption made in multiple regression is that the predictor variables are independent; if this is not the case the regression coefficients can be incorrectly estimated, and may have the wrong signs (Hair *et al.*, 1987). The correlation between the independent variables can be measured by correlation coefficients (e.g. Pearson). If two variables are found to be interrelated this is known as collinearity: a correlation coefficient of 1.0 is known as complete collinearity, 0.0 represents a lack of collinearity. If all the independent variables are found to be interrelated this is known as multicollinearity (Hair *et al.*, 1987; Swan & Sandilands, 1995). Unfortunately, in this dataset the predictor variables are likely to be interrelated no matter what procedures are carried out on them (e.g. log transformation); Hair *et al.* (*ibid.*) state that if this is the case, the model should be used for prediction only, and that simple correlations between each predictor and the dependant variables should be used to understand the predictor-dependant variable relationship.

3.5.2 Interpretation

The multiple regression results have been interpreted using the following parameters:

Multiple R: indicates the strength of the association between the dependent and independent variables. The coefficient varies between −1.0 and +1.0 and these would indicate a perfect inverse and normal relationship respectively; however, the magnitude of the coefficient is difficult to interpret (Hair *et al.*, 1987).

R squared (r^2): coefficient of determination, measures the proportion of the variation of the dependent variable about its mean that is explained by the predictor variables. Varies between 0.0 and 1.0 (±); the higher the value of r^2 the greater the explanatory power of the regression equation and the better the prediction of the dependent variable (Hair *et al.*, 1987).

Adjusted r^2: coefficient of multiple determination adjusted for degrees of freedom; increases as the number of regressors increases, provided that the decrease in error sum of squares is enough to compensate for the loss of a degree of freedom (Swan & Sandilands, 1995).

Significance of F: measures the probability that the model is correct by chance; varies between 0.0 and 1.0: values close to 0.0 represent a low probability that the model is a chance occurrence (e.g. a significance of F value of 0.05 would indicate significance at the 95% level; B.Jones pers.comm., 1995).

Regression coefficients (B): the numerical value of any parameter estimate that is directly associated with the independent variables; in multiple regression the regression coefficients are partial as they take into account the relationship between the predictor variables as well with the dependent variable (Hair *et al.*, 1987).

Beta Coefficients: these are regression coefficients resulting from standardised raw data (the data is transformed into new measurement variables with a mean of 0.0 and a standard deviation of 1.0), this eliminates the problem of different measurement units and allows the relative effect of each predictor variable on the dependent variable to be compared (Hair *et al.*, 1987). There are potential problems with using the beta coefficients: Hair *et al.* (*ibid.*) note that they should only be used as a guide when collinearity is minimal, that the values can only be interpreted in the context of the other variables in the equation (not in any absolute sense), and that different variable values can affect the beta value.

Significance of T: a measure of significance that gives the probability that the predictor variables contribution to the regression equation is occurring by chance; again this varies between 0.0 and 1.0, low values representing a low probability of chance occurrence (B.Jones pers.com., 1995).

In the actual interpretation a combination of the beta coefficients and significance of T values has been used to establish the relative effects of the different predictor variables on the dependant variable.

3.5.3 Path Analysis

Path analysis is a graphic explanation of the interrelationships among several variables; both causal relationships and interrelationships can be shown together with numerical measures of the strength of the relationships (Afifi & Clark, 1984). In this study the numerical measures of causal relationship are the beta values from the multiple regression and the interrelationships are the Pearson's correlation coefficient values between the independent variables. A simple example is shown in Fig. 3.3; X and Z are the independent variables, Y is the dependant variable, the figures on the X—Y and Z—Y lines are the beta coefficients from the multiple regression of X and Z on Y, and the figure on the X—Z line is the correlation coefficient (Pearson's) between these two variables. The variable U represents other variables affecting Y that have not been included; the underlined value on the U—Y line is equal to 1.0 minus the coefficient of determination (r^2) for the aforementioned multiple regression. In this case X is exerting more influence on Y than Z, and X and Z are correlated; the underlined value on U—Y (0.4) (= square root of $1-r^2$) is the proportion of the standard deviation of Y not explained by the variables in the regression equation.

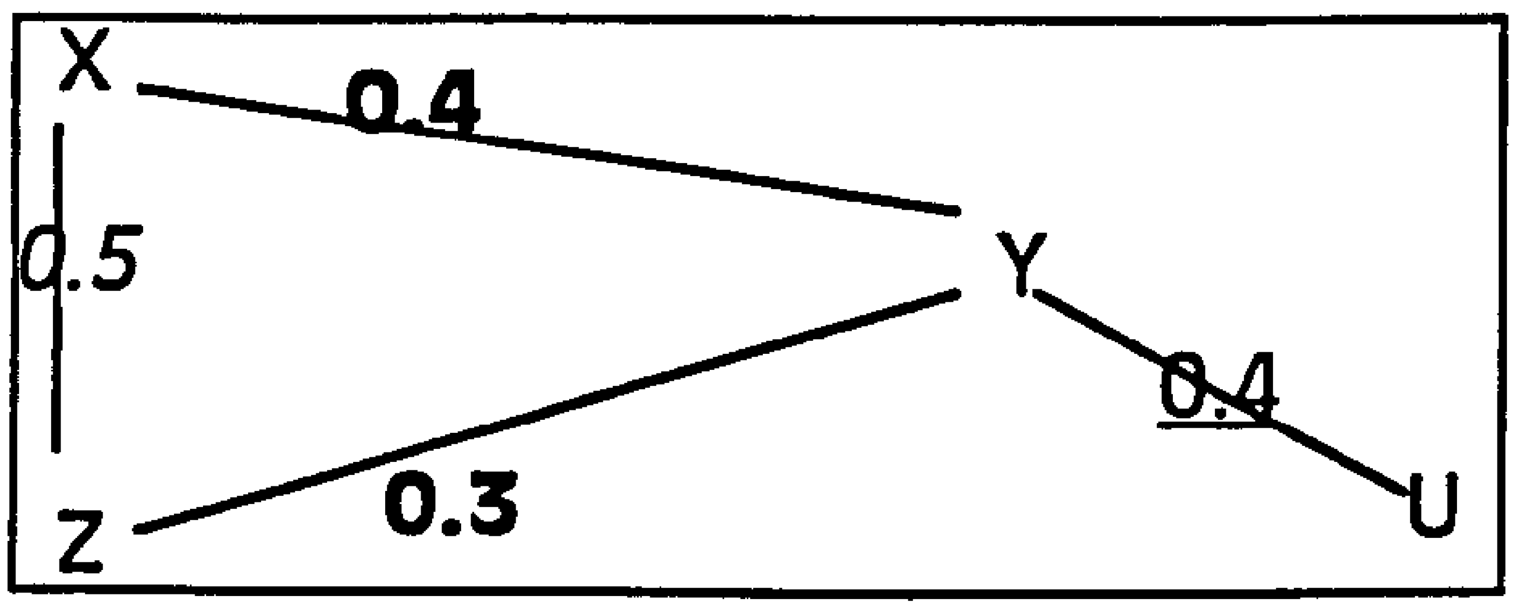


Fig. 3.3. *An example of a path analysis diagram (adapted from Afifi & Clark, 1984).*

3.6 Integration of the Results of Statistical Methods

The three methods used (FA, DFA, Clustering), although different, each produced results that could be compared and contrasted. For example, in naming the factors the variables selected by stepwise DFA could be compared with those on the factor loadings, if they were similar the assigned name would be the same as that of the dependent variable used in the DFA. In such cases the relative importance of the variables on the factors (determined by ranking according to their loading scores) could be compared with the independent variables (and their ranking by Wilks' lambda values) derived from stepwise DFA

The cluster and group memberships from the two classification methods was also compared to assess the strength of the control of pre-recognised factors (e.g. lithofacies). It was possible to 'bias' the clusters towards certain of these factors by only inputting the variables derived from stepwise DFA with that factor as the dependent variable.

CHAPTER 4.0
THE EFFECT OF LITHOLOGY

4.0 THE EFFECT OF LITHOLOGY ON PALYNOFACIES ASSEMBLAGES

4.1 Introduction

Sample lithology and dominant lithology (see below) have an effect on palynofacies assemblages that cannot be ignored, and in order to interpret palynofacies data properly this effect must be assessed, so that changes in the palynofacies assemblage that are simply due to changing sample lithology can be separated from actual facies or proximal-distal variations. For example, sandstones are known to have increased percentages of phytoclasts (due to hydrodynamic equivalence or selective preservation), so when one compares a sandstone and a shale is the increased percentage of phytoclasts simply due to the fact that one is now in a sand, or because the setting is more proximal? The dominant lithology (see below) of a particular part of a section can also have an effect on the kerogen assemblage; one of the more obvious examples of this effect is the case of thin shale beds or partings in sandstone-dominated sections (Tyson, 1989, 1995). The kerogen assemblages of samples from such shales often have characteristics which are closer to sandstones (e.g. rich in spores and phytoclasts), rather than typical shales; if only the sample lithology is recorded this may be interpreted as a facies change.

Lithology or sample lithology (lith) refers to the lithology of the sample taken, defined in the field and in hand specimen. Dominant lithology (dlith) refers to the lithology of the adjacent interval as determined in the field or with reference to published logs; it was assessed over a vertical interval of 0.5-1.0m around the sample horizon. In addition, gross lithology (glith) categories have been defined by combining similar sample lithology categories: shales and silty shales were combined into a 'shales' category; shaley silts, silts and sandy silts were combined as 'silts'; argillaceous, silty and clean sands combined as 'sands' and limestones, shaley limestones, argillaceous limestones and sandy limestones combined as a 'limestones' category. The sample lithology categories not mentioned above (clay-mudstone, shaley sand, and sandy shale; 18 samples in total) were not included in this classification as they could not be easily placed in any of the gross lithology categories. A gross dominant lithology (gdlith) classification was created using the same approach as described for the gross sample lithology.

The assessment of lithologic control has been carried out by the comparison of the differences in the mean values of parameters in different lithologies relative to shale (the palynological 'norm'), and by the use of discriminant function analysis (DFA) to try to establish the extent of the control that lithology has on assemblage characteristics, both overall and in the case of the different lithology types.

4.2 Lithology Types and Proportions

Fifteen different lithologies have been identified; their proportions in the total dataset are shown in Table 4.1; the gross lithology categories and proportions are shown in Table 4.2.

The sample set is heavily skewed towards the finer grained sediments, with shales and silty shales together making up 60% of the rock types present (Tables 4.1 & 4.2). The sample, and to some extent the dominant lithology, classifications contain some categories that have only a small number of samples within them (e.g. shaley sands). Where the number of cases is ≤ 5 the categories are probably too small to be significant in terms of the whole dataset, but they can be used in interpretations by reference to a change between them and the adjacent sample lithologies where they occur. However, these groups are lithologically distinct so have been included in the sample lithology classification.

The four major formations (Bearreraig Sandstone, Lealt Shales, Duntulm, and Staffin Bay) contain ≥ 90% of the samples in the study; the distributions of their sample and dominant lithologies are shown in Figs. 4.1 to 4.4. The sample lithology distributions are all dominated by shales and silty shales, apart from in the Bearreraig Sandstone Formation where silty shale and shaley silt are the most common; the sandstone categories contain the majority of the rest of the samples, apart from in the Lealt Shales Formation where there are no sand sample lithologies. The largest dominant lithology categories are similar to those from the sample lithology classification in each case, although there are some differences. For example, the Lealt Shales Formation dominant lithology classification includes a clean sandstone category.

Type	Code	Lithology Percentage	Lithology No. of cases	Dominant lithology Percentage	Dominant lithology No. of cases
Shale	1	33%	144	27%	119
Silty shale	2	27%	118	32%	140
Shaley silt	3	14%	62	9%	39
Silt	4	1%	5	na	na
Sandy silt	5	0.2%	1	na	na
Silty sand	6	7%	31	6%	25
Arg. sand	7	7%	31	10%	43
Clean sand	8	2%	8	7%	32
Lst.	9	2.5%	10	3%	13
Shaley Lst.	10	2.5%	10	1%	6
Arg. Lst.	11	0.5%	2	1%	3
Sandy Lst.	12	na	na	2%	9
Sandy shale	13	1%	4	na	na
Shaley sand	14	1%	3	na	na
Clay-mud	15	2.5%	11	3%	15

na = no samples in this category

Table 4.1 *Lithology (lith) and dominant lithology (dlith) types and proportions.*

Gross lithology	Code	No. of samples	Percentage
Shales	1	262	60%
Silts	2	68	15%
Sands	3	70	16%
Limestones	4	22	5.5%

Table 4.2 *Gross lithology (glith) types and proportions. Total not equal to 100% due to exclusion of certain sample lithology categories from this classification (see section 4.1).*

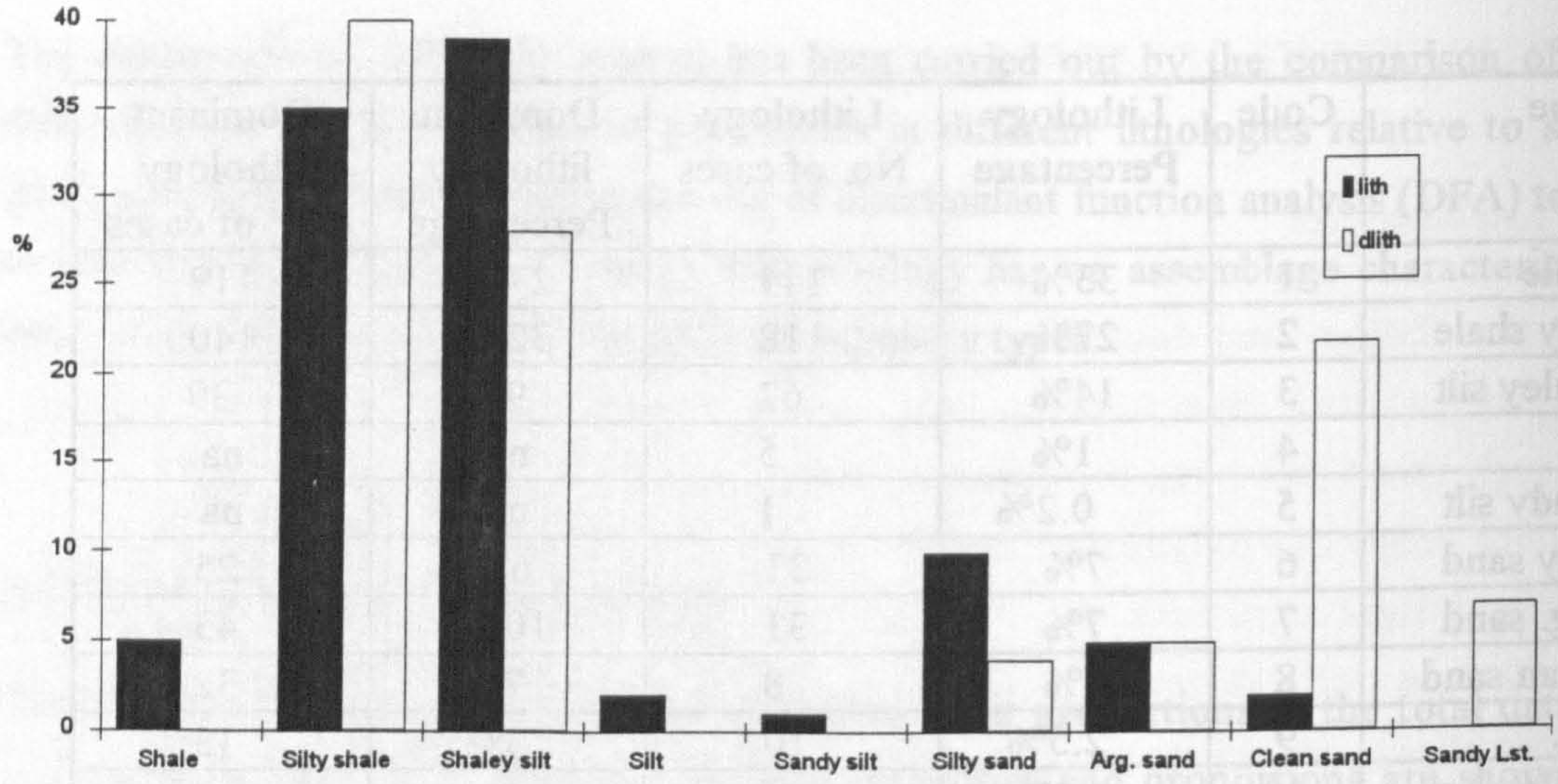


Fig. 4.1 *Bearreraig Sandstone Fm. lithology (lith) and dominant lithology (dlith) percentage distribution. (Total number of cases = 131).*

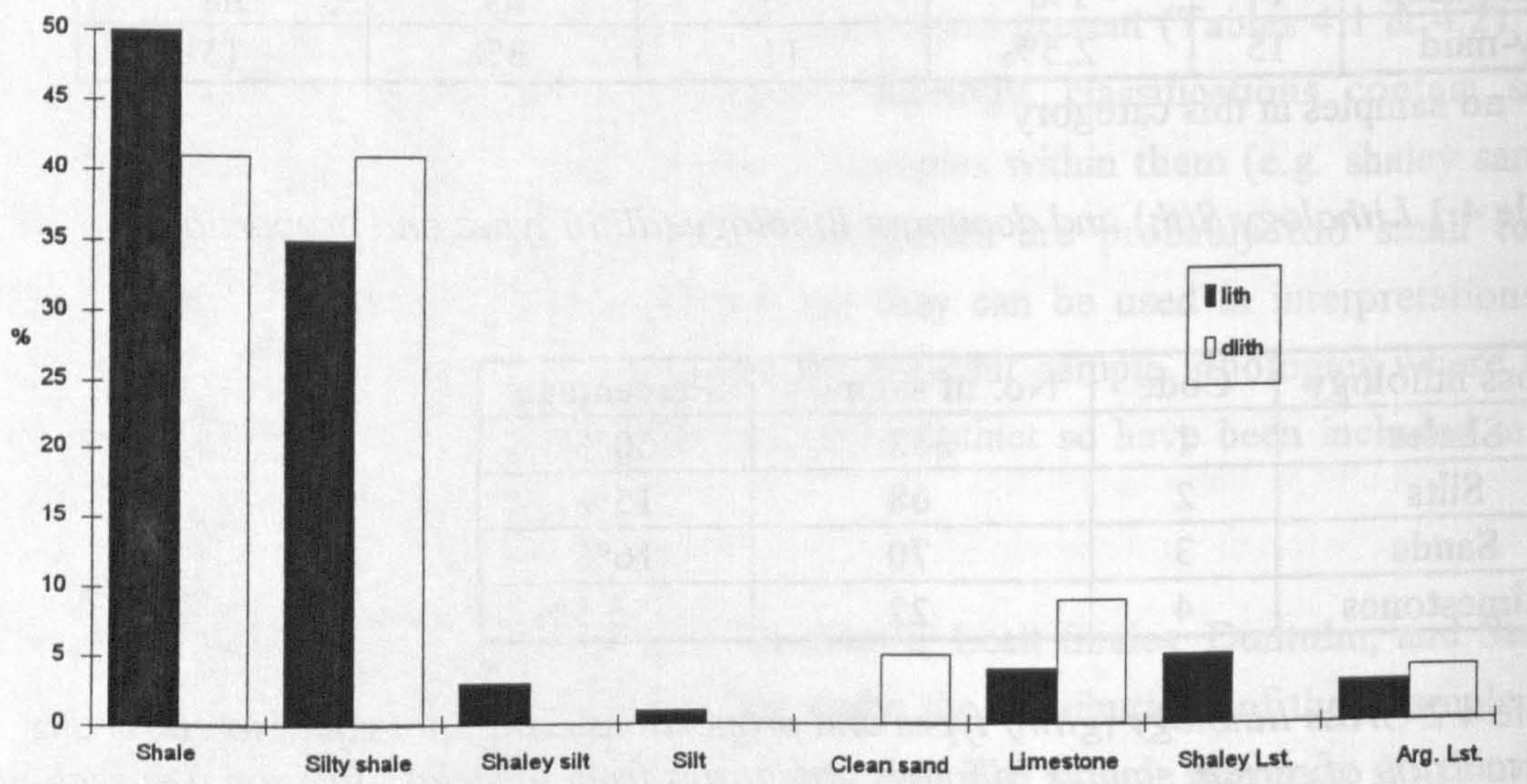


Fig. 4.2. *Lealt Shales Fm. lithology (lith) and dominant lithology (dlith) percentage distribution. (Total number of cases = 78).*

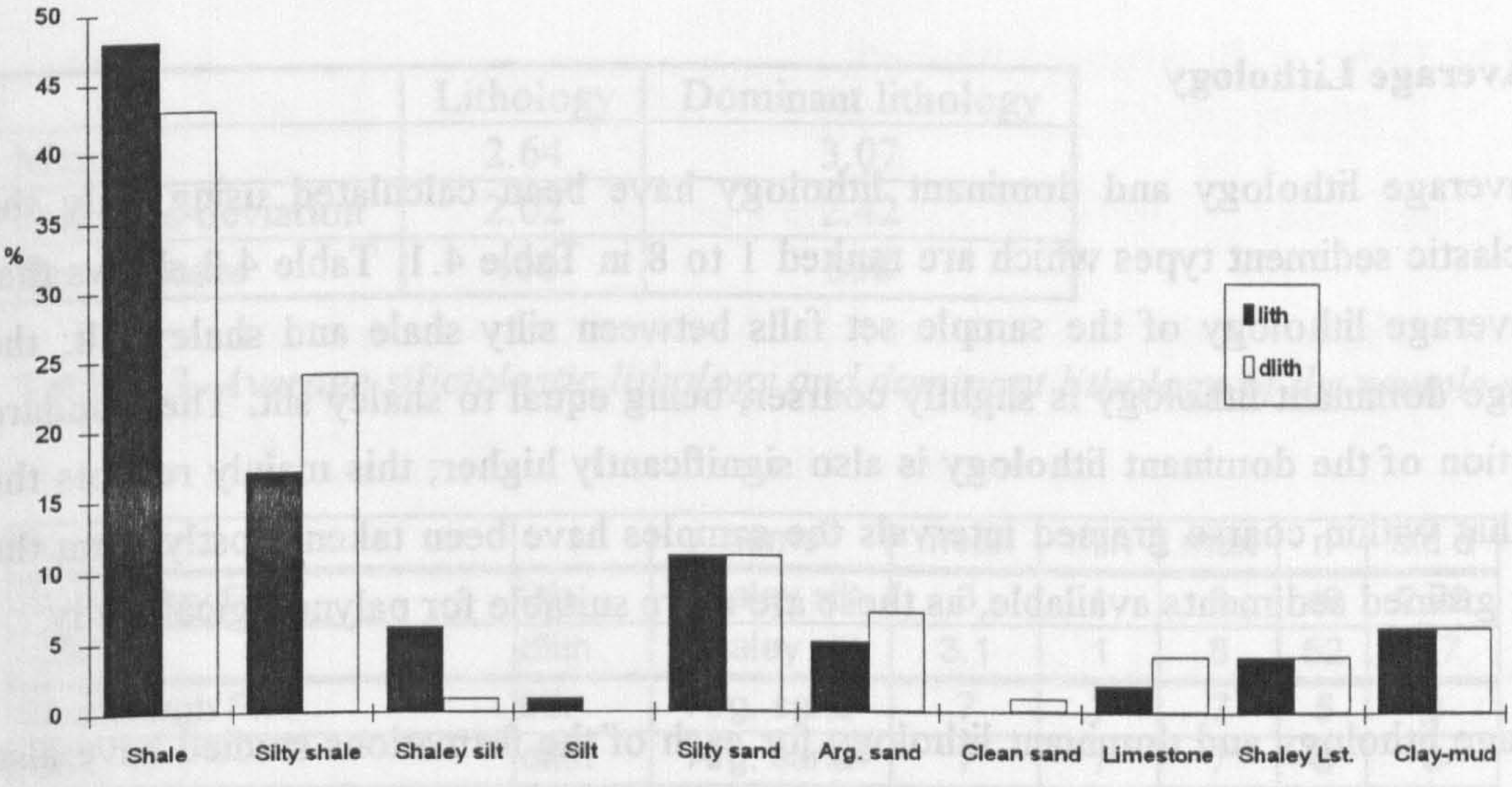


Fig. 4.3. *Duntulm Fm. lithology (lith) and dominant lithology (dlith) percentage distribution. (Total number of samples = 138).*

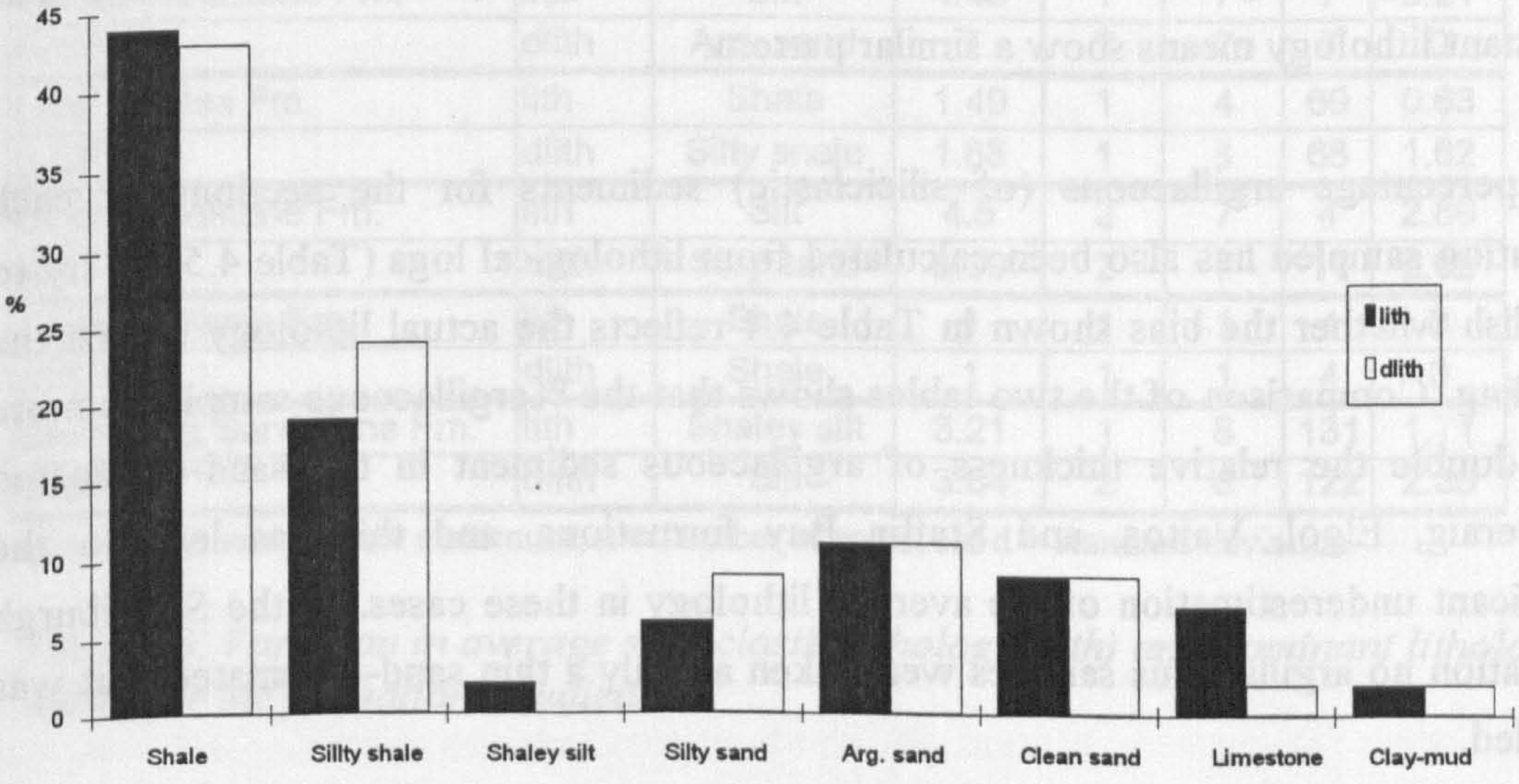


Fig. 4.4. *Staffin Bay Fm. lithology (lith) and dominant lithology (dlith) percentage distribution. (Total number of samples = 54).*

4.3 Average Lithology

An average lithology and dominant lithology have been calculated using only the siliciclastic sediment types which are ranked 1 to 8 in Table 4.1. Table 4.3 shows that the average lithology of the sample set falls between silty shale and shaley silt; the average dominant lithology is slightly coarser, being equal to shaley silt. The standard deviation of the dominant lithology is also significantly higher; this mainly reflects the fact that within coarse grained intervals the samples have been taken mostly from the finest grained sediments available, as these are more suitable for palynological study.

Average lithology and dominant lithology for each of the formations studied have also been calculated; the stratigraphic variations are shown in Table 4.4. As one would expect the average lithology is coarsest in the two sandstone formations, but it is also high in the Skudiburgh and Staffin Bay formations; apart from the Skudiburgh, these formations generally also have the most varied lithologies (standard deviations). The dominant lithology means show a similar pattern.

The percentage argillaceous (of siliciclastic) sediments for the sections of each formation sampled has also been calculated from lithological logs (Table 4.5) to try to establish whether the bias shown in Table 4.4 reflects the actual lithology or just the sampling. Comparison of the two tables shows that the %argillaceous samples is more than double the relative thickness of argillaceous sediment in the sand-dominated Bearreraig, Elgol, Valtos, and Staffin Bay formations, and this has lead to the significant underestimation of the average lithology in these cases. In the Skudiburgh Formation no argillaceous samples were taken as only a thin sand-dominated unit was sampled.

	Lithology	Dominant lithology
Mean	2.64	3.07
Standard deviation	2.02	2.42
No. of cases	400	398

Table 4.3. *Average siliciclastic lithology and dominant lithology of the sample set.*

Formation		name	mean	min	max	n	std d
Staffin Bay Fm.	lith	Shaley silt	3	1	8	49	2.72
(SBF)	dlith	Shaley silt	3.1	1	8	52	2.7
Skudiburgh Fm.	lith	Arg. sand	7	7	7	5	0
(SF)	dlith	Arg. sand	7	7	7	5	0
Kilmaluag Fm.	lith	Silty shale	1.9	1	2	10	0.32
(KF)	dlith	Silty shale	1.9	1	2	10	0.32
Duntulm Fm.	lith	Silty shale	2.32	1	7	121	2
(DF)	dlith	Silty shale	2.45	1	8	119	2.13
Valtos Sandstone Fm.	lith	Silt	4.43	1	7	7	3.21
(VSF)	dlith	Arg. sand	7	7	7	7	0
Lealt Shales Fm.	lith	Shale	1.49	1	4	69	0.63
(LSF)	dlith	Silty shale	1.88	1	8	68	1.62
Elgol Sandstone Fm.	lith	Silt	4.5	2	7	4	2.89
(ESF)	dlith	Silty sand	6.09	2	7	11	2.02
Cullaidh Shale Fm.	lith	Shale	1	1	1	4	0
(CSF)	dlith	Shale	1	1	1	4	0
Bearreraig Sandstone Fm.	lith	Shaley silt	3.21	1	8	131	1.71
(BSF)	dlith	Silt	3.84	2	8	122	2.36

min = minimum; max = maximum; n = number of cases; std d = standard deviation

Table 4.4. *Variation in average siliciclastic lithology (lith) and dominant lithology (dlith) for the formations studied.*

Formation	Percent argillaceous sediment	Percent argillaceous samples
Staffin Bay Fm.	33%	71%
Skudiburgh Fm.	83%	0%
Kilmaluag Fm.	71%	100%
Duntulm Fm.	74%	82%
Valtos Sandstone Fm.	12%	43%
Lealt Shales Fm.	97%	100%
Elgol Sandstone Fm.	4%	50%
Cullaidh Shale Fm.	100%	100%
Bearreraig Sandstone Fm.	37%	82%

Table 4.5. *Percentage of argillaceous sediments of the total thickness of siliciclastics and percentage argillaceous samples of those used in the average lithology calculation for the sections sampled in each formation.*

4.4 The Effect of Dominant Lithology

4.4.1 Gross Lithology and Gross Dominant Lithology

Gross dominant lithology (Gdlith) was combined with the gross lithology (Glith) to calculate sets of mean values for the three major kerogen groups (AOM, phytoclasts, and palynomorphs) for the cases where Glith and Gdlith = shale, and Glith = shale, but Gdlith = sand.

Table 4.6 shows that (for the whole dataset) when the gross dominant lithology is sand, the mean %AOM is lowered by 30%, and the mean %phytoclasts increased by 29% relative to the 'shales in shales' values. The percentage of palynomorphs is similar in both shale and sand gross dominant lithologies.

The distributions of the different percentage values of AOM and total phytoclasts for the two glith/gdlith combinations have been plotted on frequency histograms in Figures 4.5 to 4.8. In both cases the majority of samples have < 10% palynomorphs (of kerogen). In the case of AOM, when the gross dominant lithology is sand 15 out of 17 cases have < 40% AOM, and only one case has > 50%; when the gross dominant lithology is shale there are many cases that have ≥ 60% AOM. When the gross dominant lithology is sand there are no cases which have < 20% phytoclasts, and 11 out of 17 cases have phytoclast values of > 50%. When the gross dominant lithology is shale the majority of cases have 20% to 40% phytoclasts, but there is a wide spread.

Figures 4.9 and 4.10 show the percentages of AOM, phytoclasts, and palynomorphs in the two gross lithology/gross dominant lithology combinations described above in each of the four major formations. In the generally coarser Bearreraig Sandstone Formation there is no difference in values between the two gross dominant lithologies, but the other three finer grained formations show significant differences. The Lealt Shales and Staffin Bay formations show similar patterns, with AOM values decreased by 39% and 90% (respectively), and %palynomorphs increased by 82% and 76% in the shales in sandstones relative to shales in shales. Percentages of phytoclasts are similar. In the Duntulm Formation the %AOM is increased by 51% and %palynomorphs decreased by 75% in the shales in sands category relative to shales in shales. Phytoclast percentages are again similar.

Glith/Gdlith	n	AOM	Phytoclasts	Palynomorphs
Shales/shales	219	33.9	44	19.7
Shales/sands	17	23.5	56.6	17.2

Table 4.6. *Mean percentages of the three major kerogen groups in the shales gross lithology category (Glith) when the gross dominant lithology (Gdlith) is shales or sands. n = number of cases.*

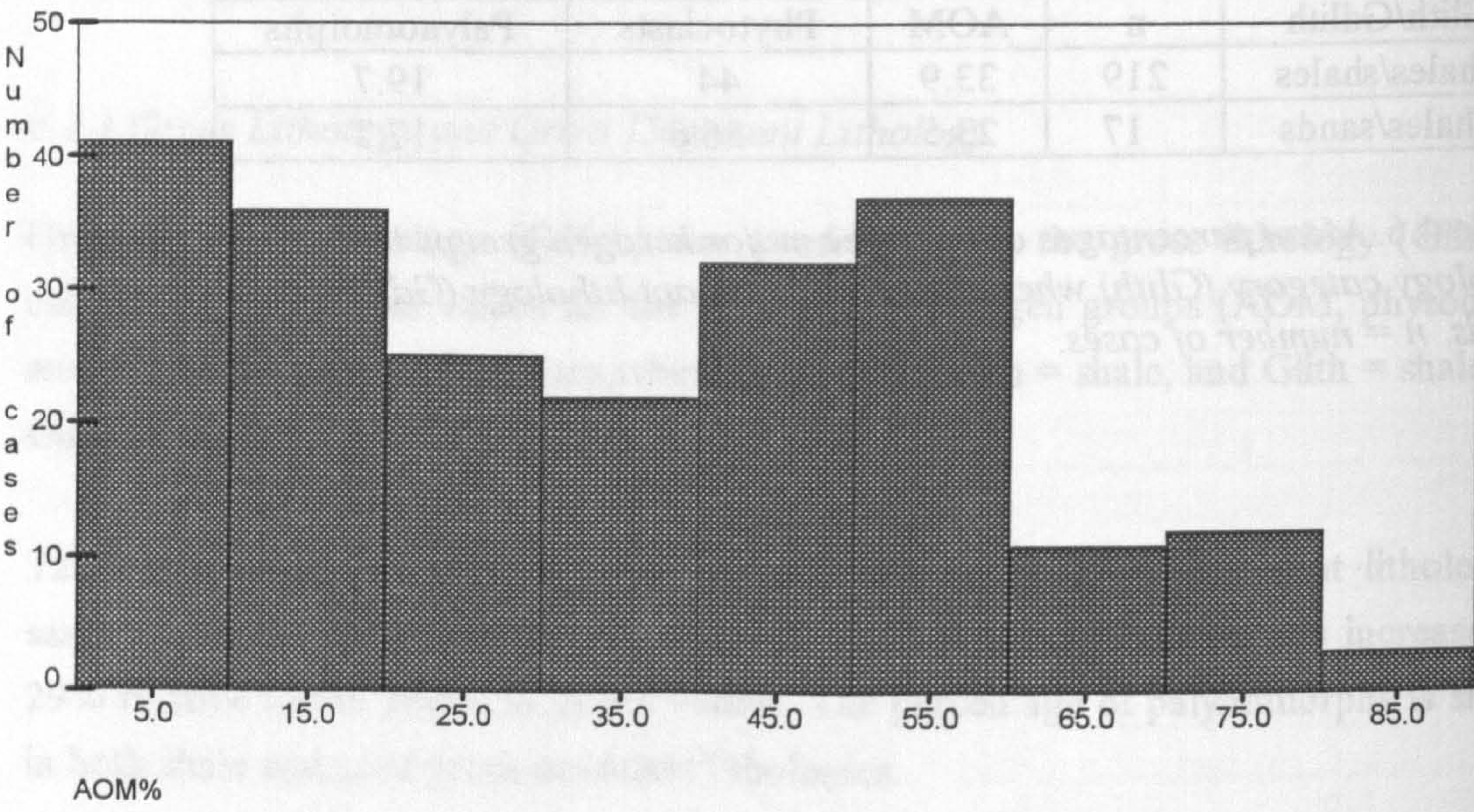


Fig. 4.5. *Distribution of AOM percentage values in the shales gross lithology category when the dominant gross lithology is shales. (Total number of cases = 219).*

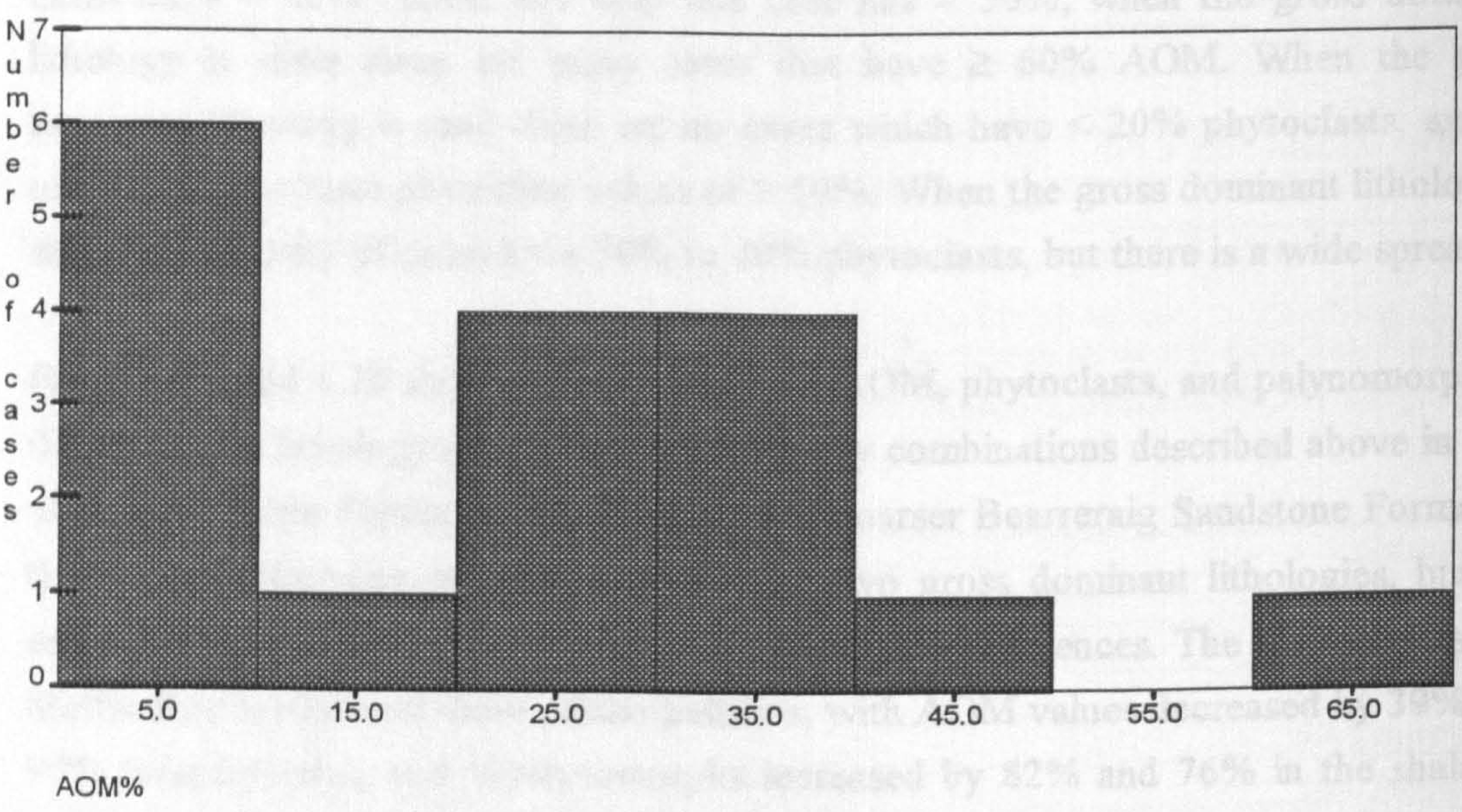


Fig. 4.6. *Distribution of AOM percentage values in the shales gross lithology category when the dominant gross lithology is sands. (Total number of cases = 17). Note different vertical scale to Fig. 4.5.*

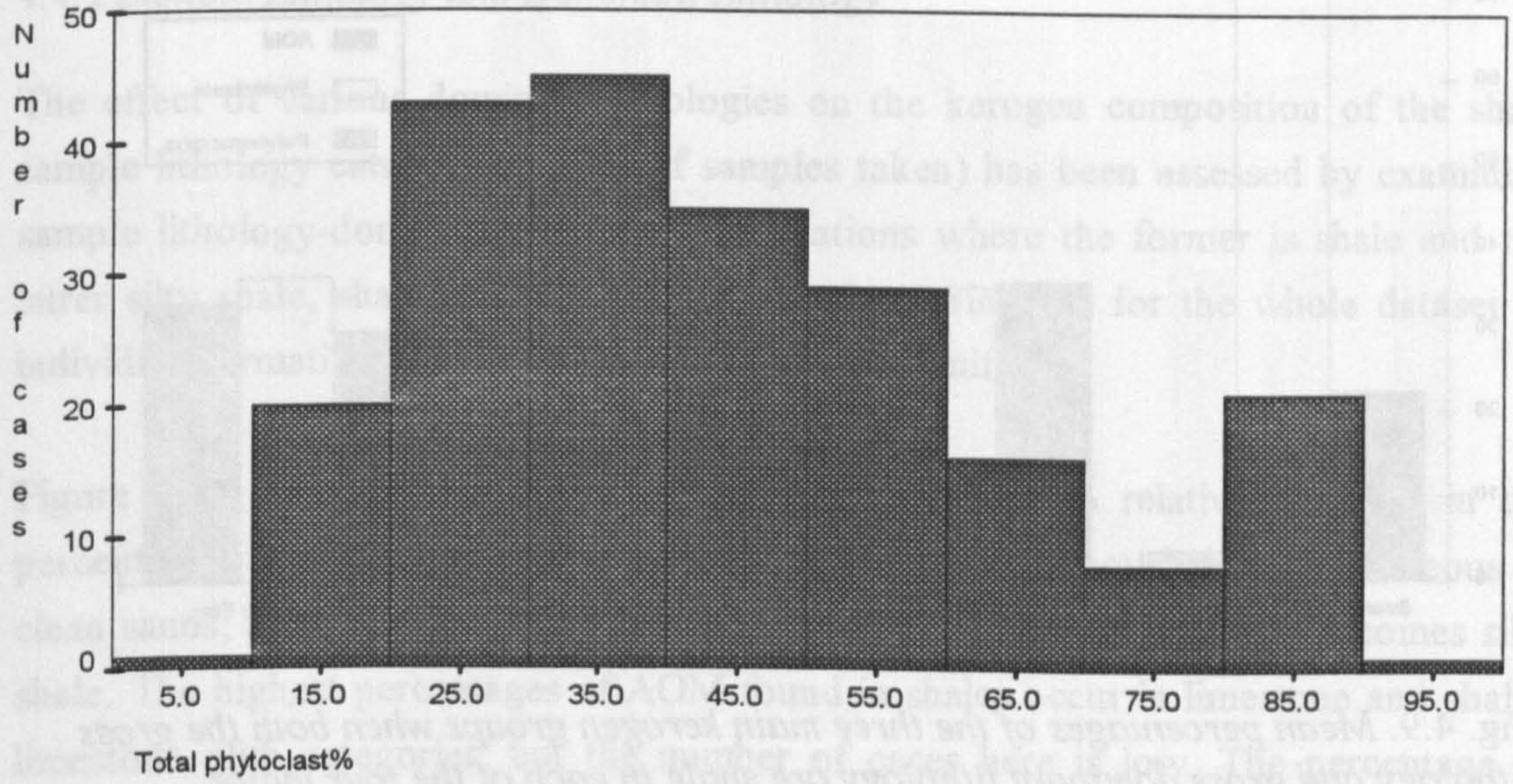


Fig. 4.7. *Distribution of total phytoclast percentage values in the shales gross lithology category when the dominant gross lithology is shales. (Total number of cases = 219).*

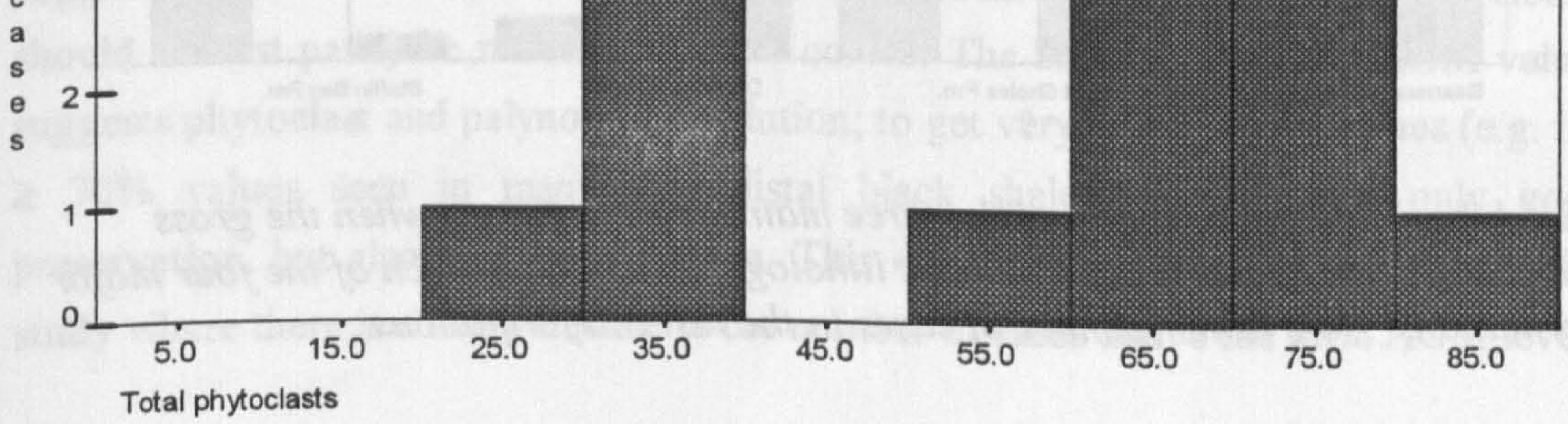


Fig. 4.8. *Distribution of total phytoclast percentage values in the shales gross lithology category when the dominant gross lithology is sands. (Total number of cases = 17). Note different vertical scale to Fig. 4.7.*

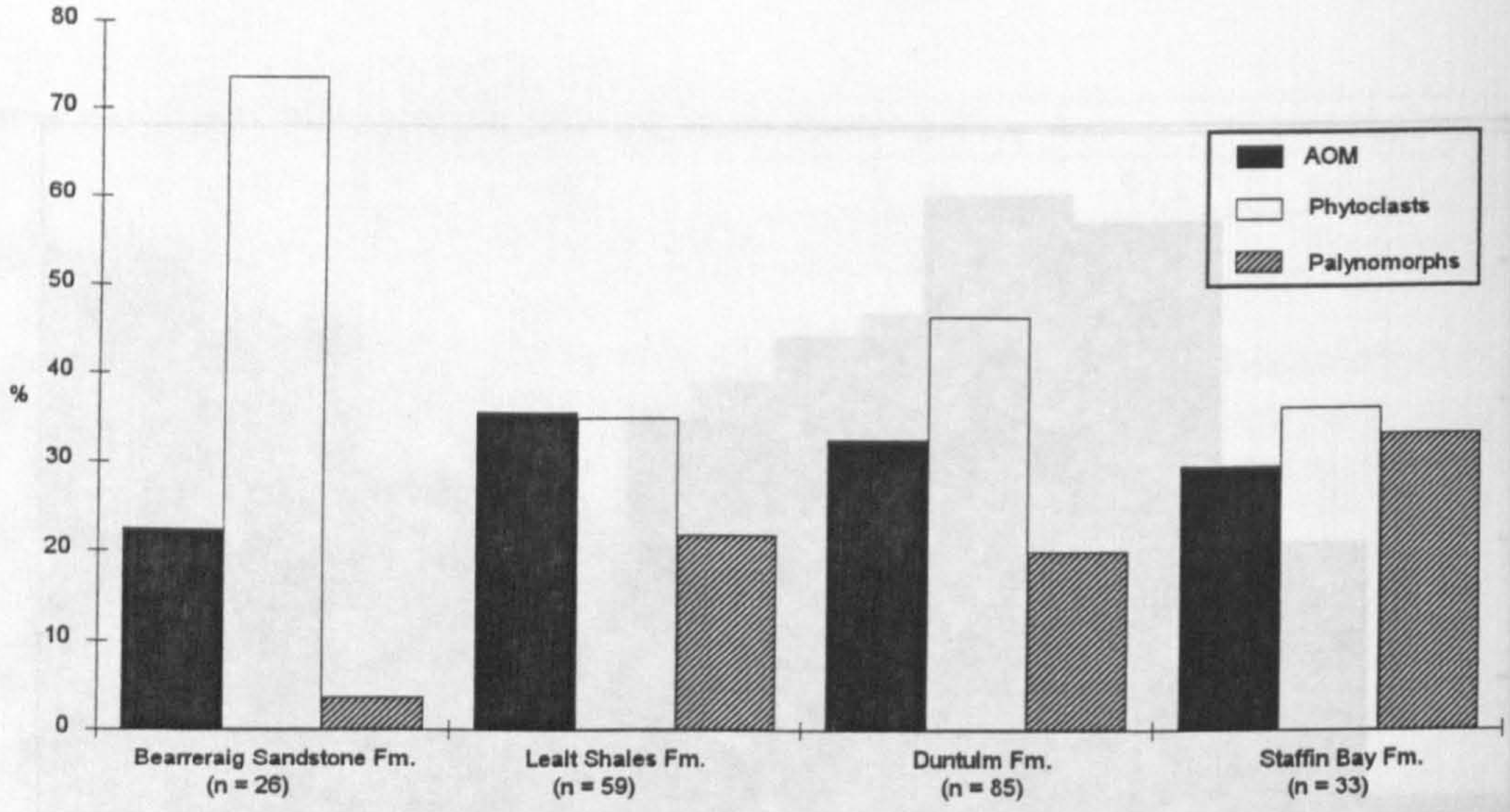


Fig. 4.9. *Mean percentages of the three main kerogen groups when both the gross lithology and gross dominant lithology are shale in each of the four major formations.*

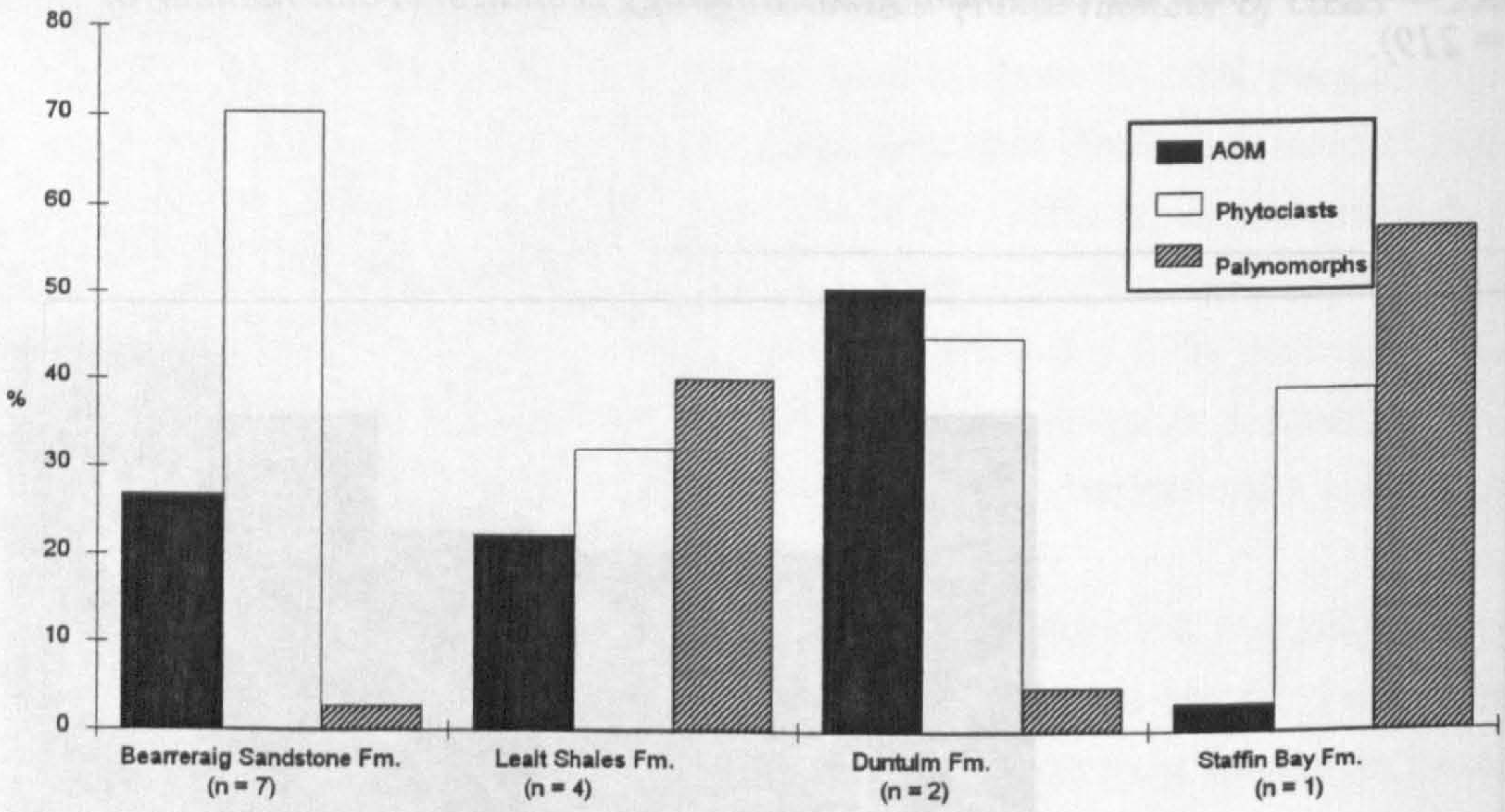


Fig. 4.10. *Mean percentages of the three main kerogen groups when the gross lithology is shale and gross dominant lithology sandstone in each of the four major formations. Note lower number of cases in the last two formations.*

4.4.2 Sample Lithology and Dominant Lithology

The effect of various dominant lithologies on the kerogen composition of the shale sample lithology category (= 33% of samples taken) has been assessed by examining sample lithology-dominant lithology combinations where the former is shale and the latter silty shale, shaley silt, etc. This was only carried out for the whole dataset as individual formations had too few examples to be significant.

Figure 4.11 shows that for shale samples there is a 32% relative decrease in the percentage of AOM when the dominant lithology changes from shale to argillaceous or clean sands; there is also a slight decrease when the dominant lithology becomes silty shale. The highest percentages of AOM found in shales occur in limestone and shaley limestone dlith categories, but the number of cases here is low. The percentage of phytoclasts shows the opposite pattern, with a 52% relative increase as dlith changes from shale to argillaceous sandstone, and a 53% relative decrease from shale to limestone. The percentage of palynomorphs shows a 48% and 30% relative decrease from shale to argillaceous and clean sand respectively; there are also relative decreases of 65% and 50% as it changes from shale to limestone and shaley limestone.

4.5 The Effect of Shale Colour

Figures 4.12 and 4.13 show that within the shale sample lithology category there is a wide distribution of AOM percentages and variable kerogen fluorescence levels; this suggests that redox conditions were not the same in all of the shales and this variability should at least partly be reflected in shale colour. The absence of high %AOM values suggests phytoclast and palynomorph dilution; to get very high %AOM values (e.g. the ≥ 70% values seen in many true distal black shales) requires not only good preservation, but also negligible dilution. This does not appear to be the case in this study where there is a sharp decline in the number of cases above the 60% AOM level.

Figures 4.14 and 4.15 show how the mean percentage AOM and fluorescence values vary in the different shale colour categories. There is a 41% relative decrease in the mean %AOM between the black and medium dark grey colour categories, and a similar 56% relative decrease in levels from brownish black to brownish grey; only the latter decrease is significantly expressed in the mean fluorescence levels. There is a marked peak in mean AOM in the medium grey category (only 18% relatively lower than in the black category) and this correlates with the maximum mean fluorescence

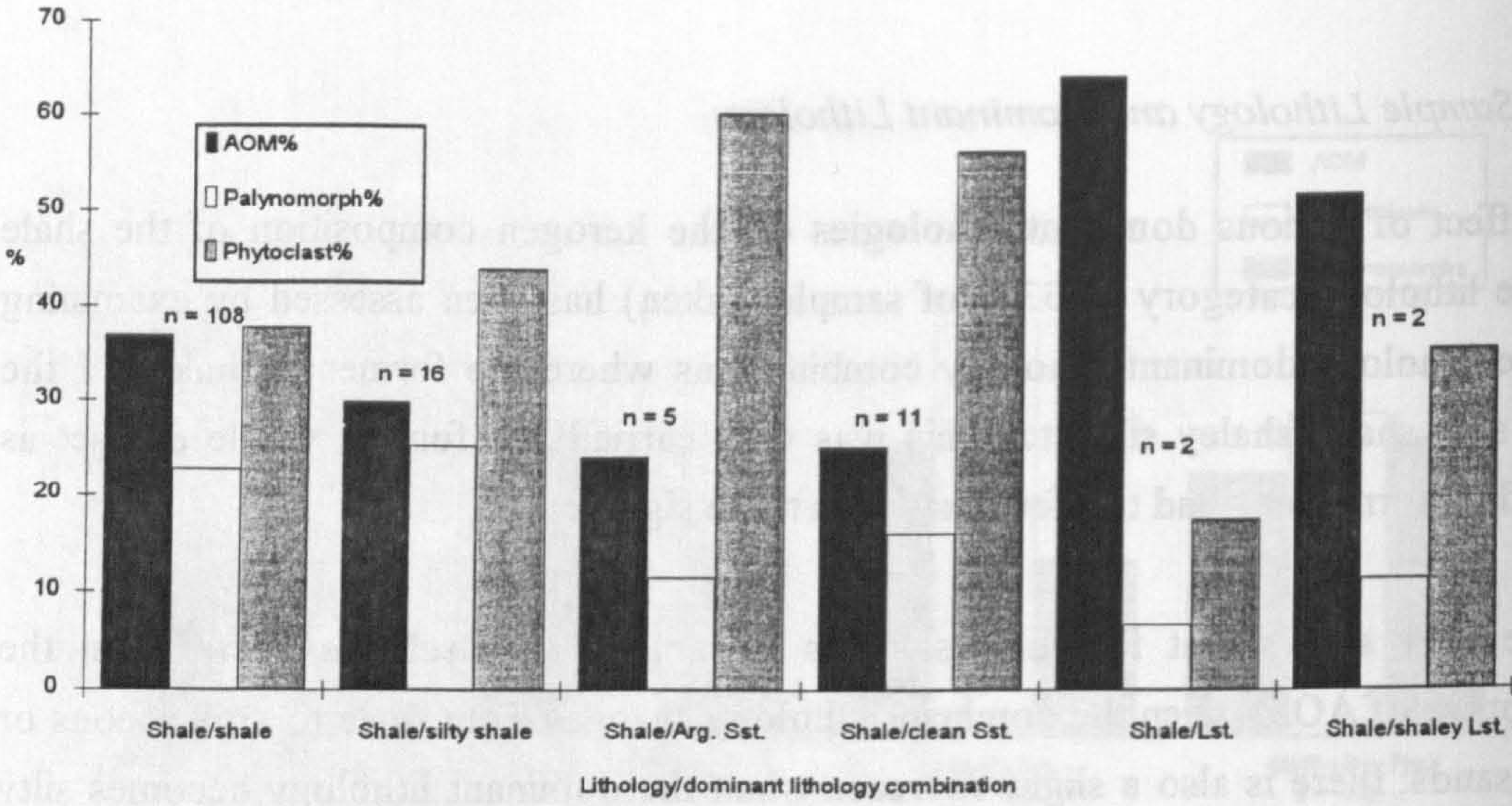


Fig. 4.11. *Mean percentages of AOM, phytoclasts, and palynomorphs in the shale sample lithology category for various dominant lithologies (n = number of samples).*

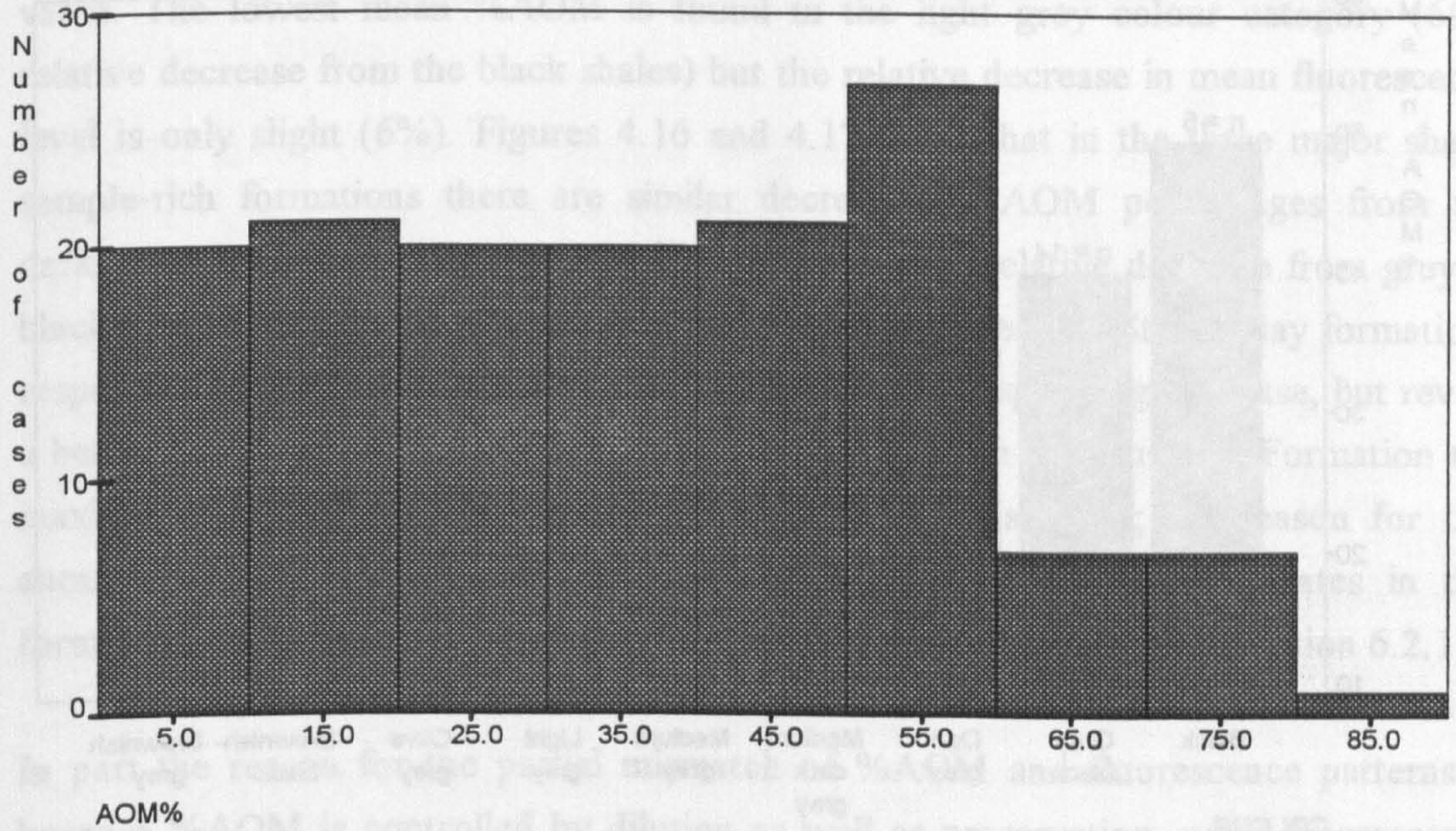


Fig. 4.12. *Frequency histogram for AOM percentage values in shale sample lithology for the whole dataset (see also Fig. 4.5).*

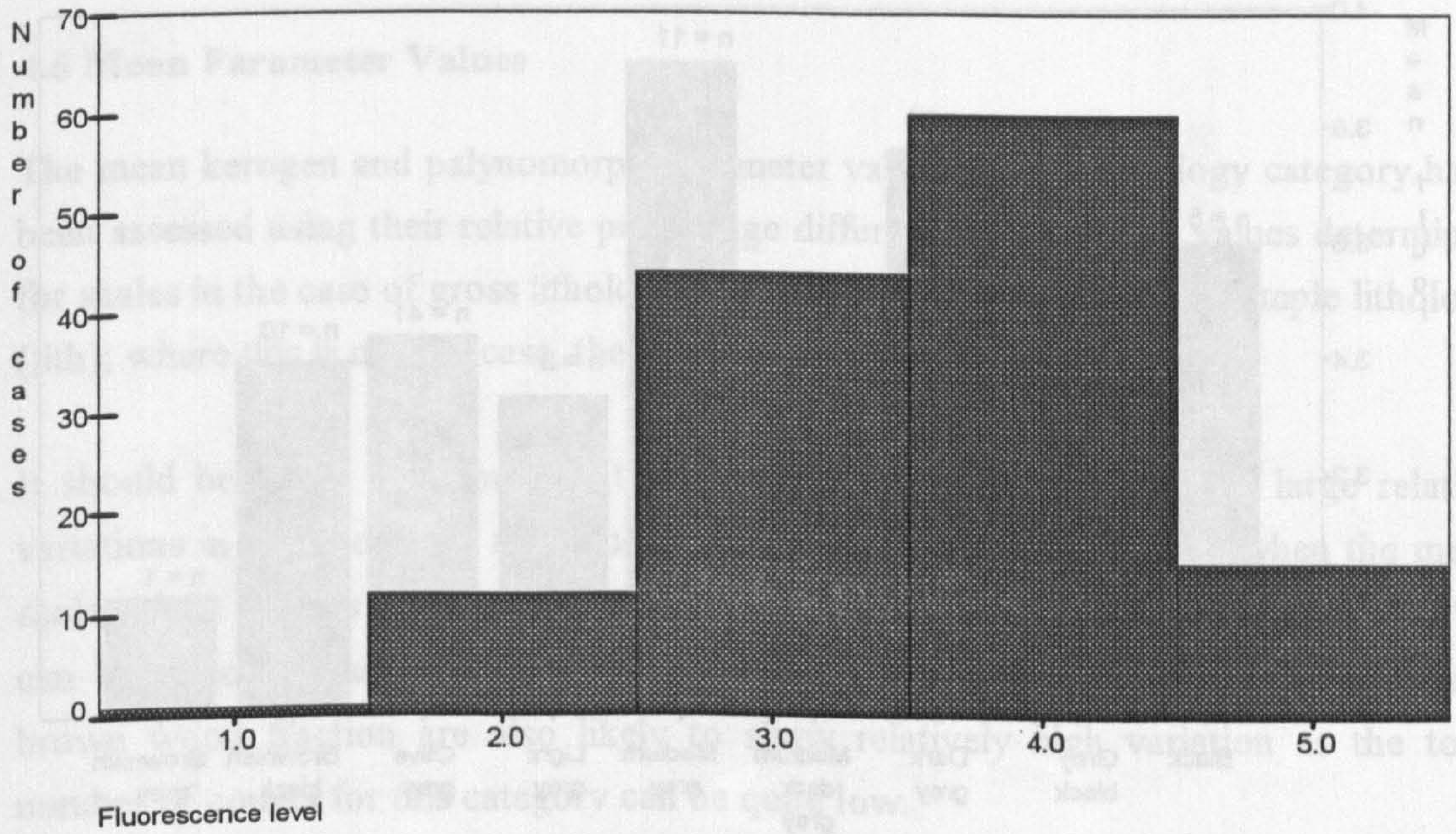


Fig. 4.13. *Frequency histogram for kerogen fluorescence levels in shale sample lithology. For explanation of the fluorescence scale see section 2.2.1.*

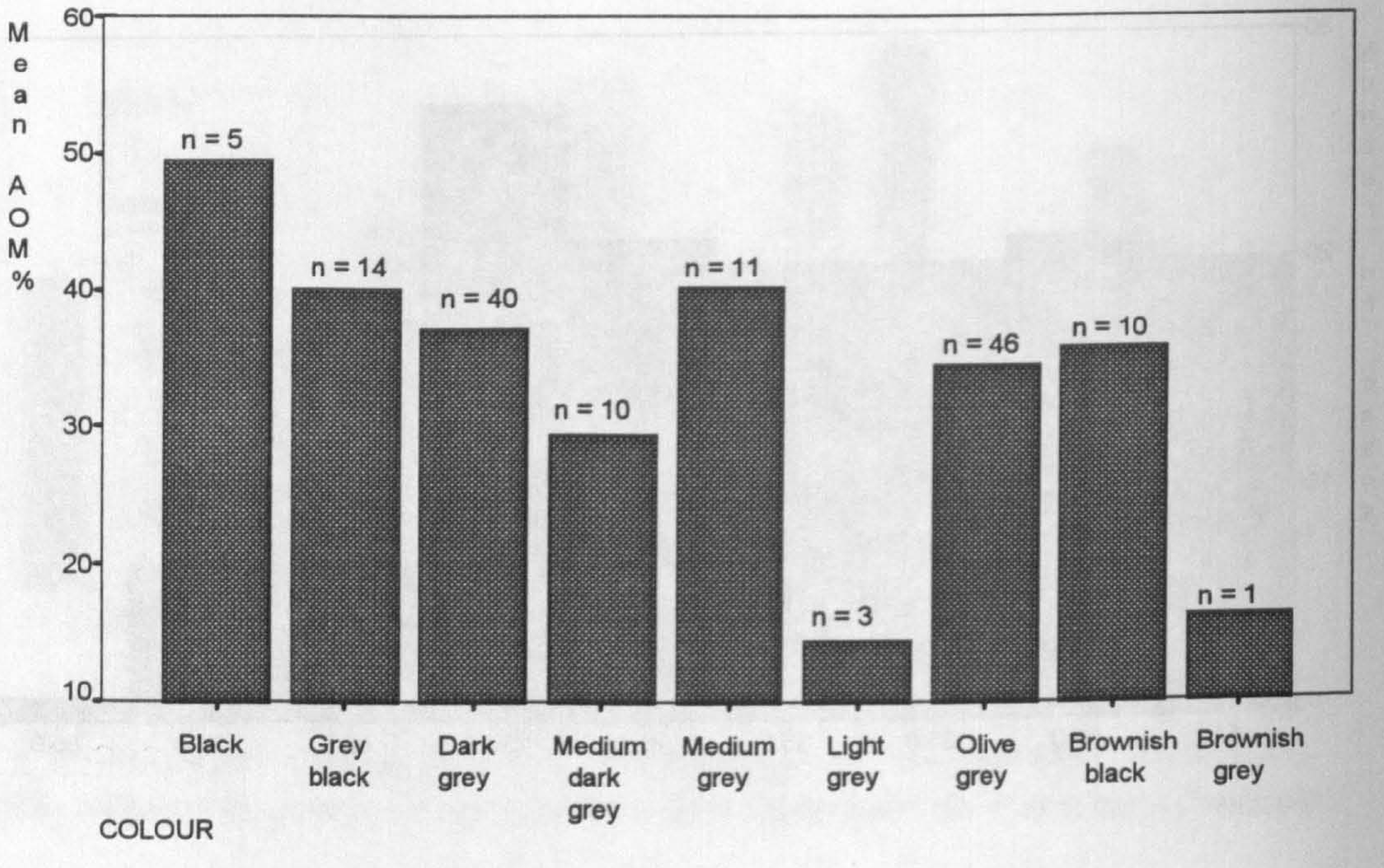


Fig. 4.14. *Mean AOM percentage in each shale colour category, all data (n = number of samples).*

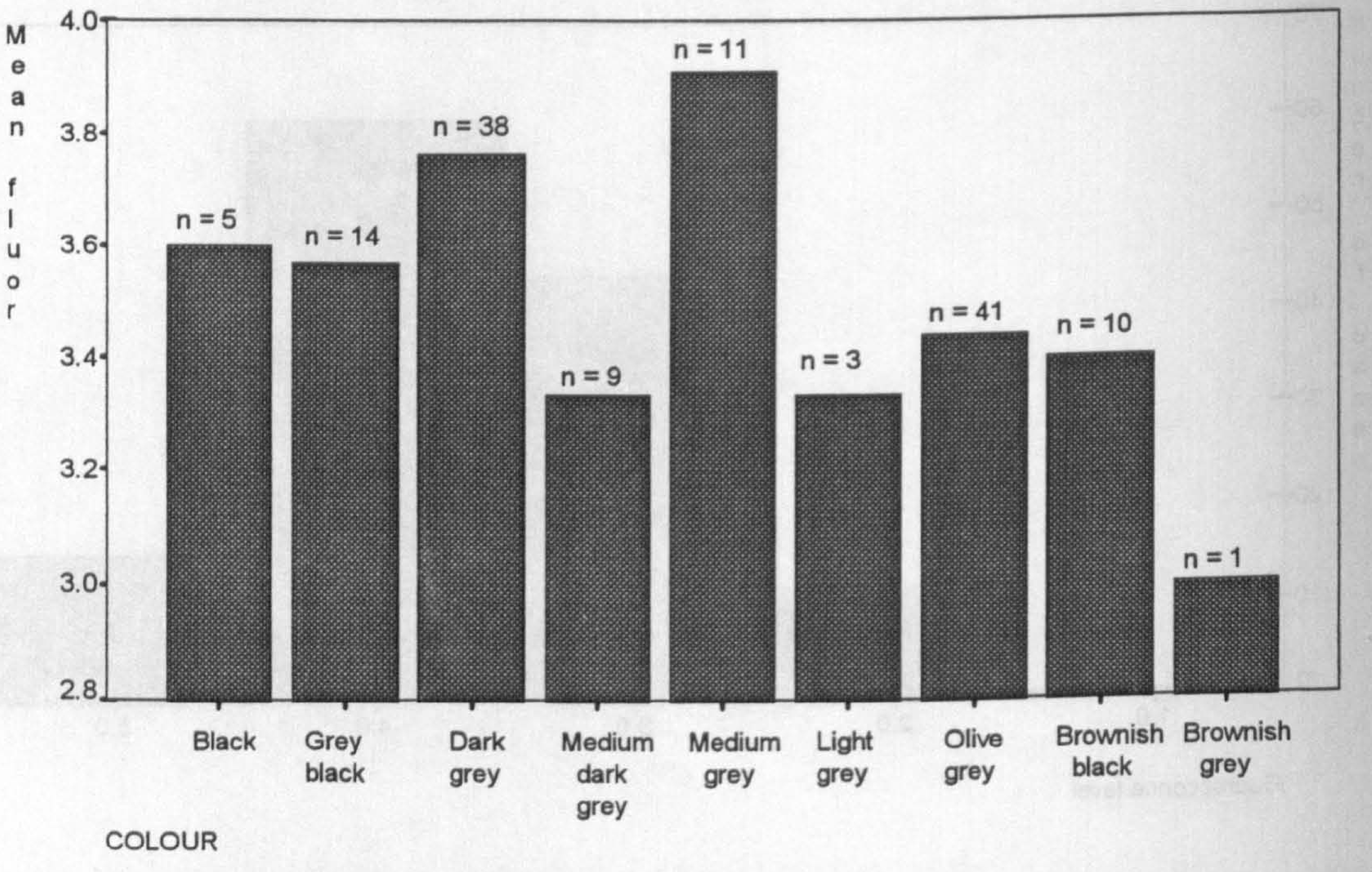


Fig. 4.15. *Mean fluorescence level in each shale colour category, all data (n = number of samples).*

value. The lowest mean %AOM is found in the light grey colour category (69% relative decrease from the black shales) but the relative decrease in mean fluorescence level is only slight (6%). Figures 4.16 and 4.17 show that in the three major shale-sample-rich formations there are similar decreases in AOM percentages from the darkest to the lighter coloured shales, e.g. a 56%-67% relative decrease from greyish black to medium dark grey or dark grey in the Lealt Shales and Staffin Bay formations respectively. The mean fluoresence values show no corresponding decrease, but reveal a better correlation with low mean AOM percentages. In the Duntulm Formation the maximum mean %AOM occurs in the medium grey category; the reason for this anomalous pattern is unclear, but the extensive occurrence of carbonates in this formation may be responsible for lightening of the sediment colour (cf. section 6.2.1).

In part the reason for the partial mismatch of %AOM and fluorescence patterns is because %AOM is controlled by dilution as well as preservation, while fluorescence and shale colour only directly or indirectly record preservation (cf. section 6.3.5). The fluorescence scale is also relative and non-linear.

4.6 Mean Parameter Values

The mean kerogen and palynomorph parameter values in each lithology category have been assessed using their relative percentage difference to the mean values determined for shales in the case of gross lithology (glith), and shale in the case of sample lithology (lith); where this is not the case, the basis for comparison is specified.

It should be noted that some of the parameters can show potentially large relative variations in terms of their reproducibility; this is particularly the case when the mean shale values are less than 5%, where relatively high standard deviations (up to ± 95%) can be expected (section 2.5). The parameters calculated out of the biostructured brown wood fraction are also likely to show relatively high variation as the total number of counts for this category can be quite low.

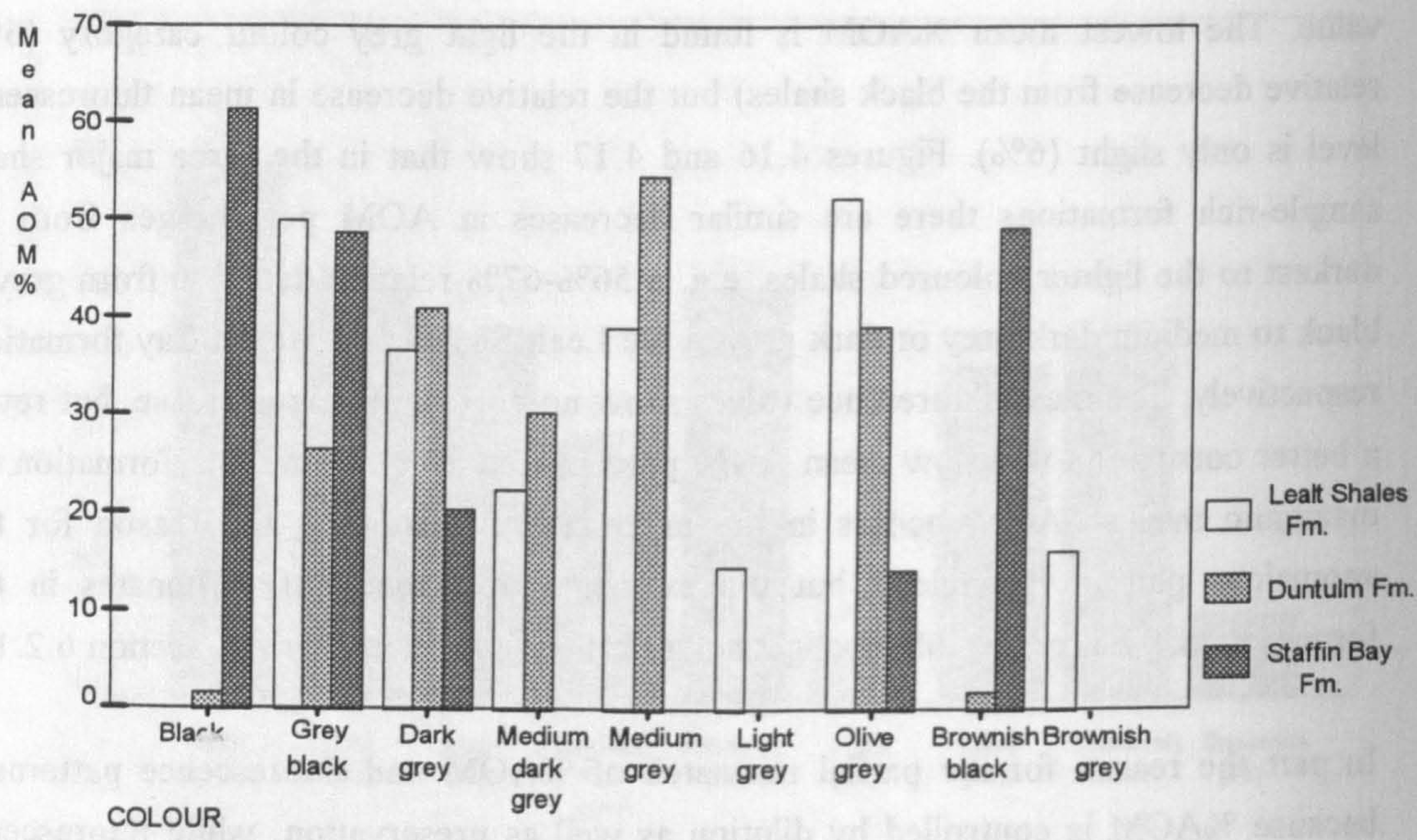


Fig. 4.16. *Mean AOM percentage in each shale colour category of the Lealt, Duntulm, and Staffin Bay formations.*

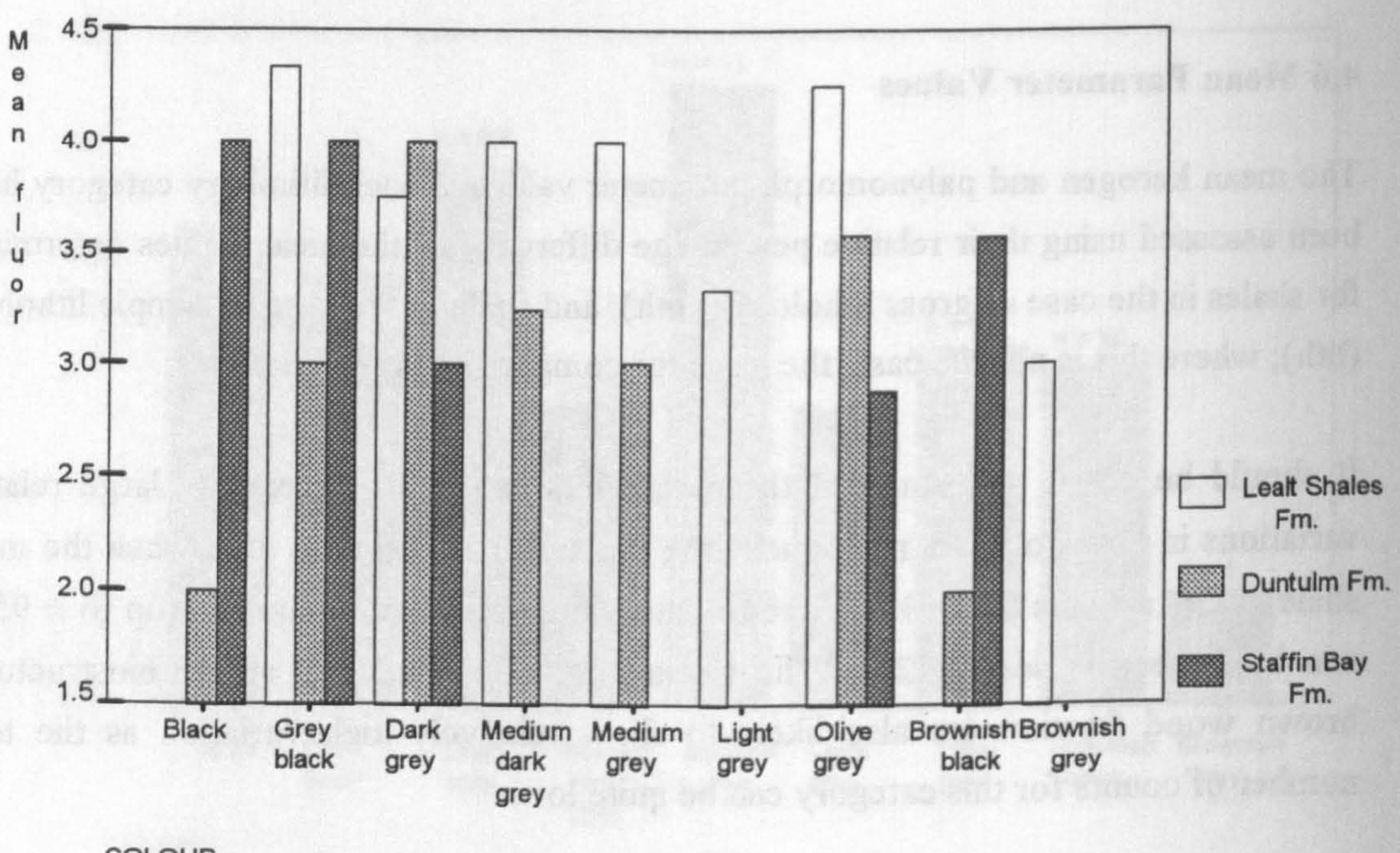


Fig. 4.17. *Mean fluorescence level in each shale colour category of the Lealt, Duntulm, and Staffin Bay formations.*

4.6.1 Gross Lithology

Table 4.7 shows the relative changes in selected parameters for the gross lithology categories (parameters selected so as to provide examples from each particle group of the kerogen and palynomorph assemblage). The highest average changes occur in those parameters likely to show a high relative variation due to the counting technique (section 2.5); these changes often represent only minor absolute differences (e.g. < 5% in the case of membranes/phytoclasts). In terms of the more reliable parameters, the greatest average changes are seen in the %palynomorphs of kerogen, and the %marine plankton and %*Botryococcus* (both of palynomorphs). Comparison of the trends shown from shales to silts and silts to sands shows that 10/17 parameters show the same trend (i.e. increase or decrease), while 7/17 show an opposite relationship. Those parameters showing the same trend seem mostly to relate to the increased proximality of the sands (on average), whilst those showing the opposite trend relate more to selective preservation within, or hydrodynamic equivalence with the sands (e.g. banded/biostructured brown wood, equant/black wood). Where silt and sand show the same trend, limestones show the opposite trend in 6/10 parameters and these parameters are indicative of a more distal environment of deposition for limestones (on average).

4.6.2 Sample Lithology

4.6.2 (a) Whole Dataset

The percentage variation of selected parameters relative to the shale 'norm' are shown for the whole dataset in Tables 4.8 and 4.9. The lithological categories excluded are those containing less than 5 samples, or those where the lithologies are too formation specific.

The greatest average change seen in 'reliable parameters' occurs in the %phytoclasts/kerogen, %undegraded/non-biostructured brown wood, %marine plankton/playnomorphs, and %*Botryococcus*/palynomorphs. Comparison of the sand-dominated categories shows that they all behave reasonably similarly (at least in terms of either increase or decrease relative to shale); any anomalies generally occur in the clean sands category (which has the lowest number of samples, n = 8), and often involve the less reliable parameters (i.e. within the biostructured wood fraction). Within the palynomorph fraction (Table 4.9) there are no anomalous parameters, but

Parameter	Shales (n = 262)	Average change (+ or –)	Silts (n = 68)	Sands (n = 70)	Limestones (n = 22)
AOM/ kerogen	33%	37% -- moderate	–42%	–58%	–12%
Phytoclasts/ kerogen	46%	44% -- moderate	+56%	+65%	–11%
Palynomorphs/ kerogen	18%	54% -- strong	–50%	–44%	+67%
Black wood/ phytoclasts	17%	39% -- moderate	–41%	+53%	+23%
Cuticle/ phytoclasts	3%	61% -- strong	–85%	–85%	–14%
Membrane/ phytoclasts	5%	97% -- v.strong	–60%	–72%	+160%
Equant/ black wood	66%	14% -- weak	+6%	+23%	+12%
Striate/ biostructured brown	20%	90% -- v.strong	+190%	–30%	–50%
Banded/ biostructured brown	26%	50% -- moderate	–69%	+38%	+42%
Undegraded/ non-biostructured brown	19%	40% -- moderate	+42%	–63%	+16%
Corroded/ non-biostructured brown	77%	10% -- weak	–13%	+12%	–4%
Sporomorphs/ palynomorphs	72%	19% -- weak	+24%	+11%	–22%
Marine plankton/ palynomorphs	17%	53% -- strong	–71%	–24%	+65%
Botryococcus/ palynomorphs	9%	55% -- strong	–84%	–71%	+11%
Spores/ sporomorphs	10%	30% -- moderate	–40%	+50%	0%
Thick-walled/ spores	14%	26% -- moderate	–64%	–7%	–7%
Cerebropollenites/ pollen	3%	50% -- moderate	–33%	+50%	–67%

Table 4.7. *Changes in selected parameters for the gross lithology categories relative to the shales mean value. The average changes have been classified as follows: > 75% = very strong, 51-75% = strong, 25-50% = moderate, < 25% = weak.*

Parameter	Shale (n = 144)	Average change (+ or –)	Silty shale (n = 118)	Shaley silt (n = 62)	Arg. sand (n = 31)	Silty sand (n = 31)	Clean sand (n = 8)
AOM/ kerogen	35%	50% -- strong	–11%	–48%	–63%	–57%	–71%
Phytoclasts/ kerogen	40%	78% -- v. strong	+32%	+82%	+87%	+87%	+100%
Palynomorphs/ kerogen	22%	51% -- strong	–36%	–59%	–50%	–54%	–54%
Brown wood/ phytoclasts	74%	6% -- weak	+3%	+19%	–7%	0%	0%
Black wood/ phytoclasts	18%	33% -- moderate	–11%	–39%	+50%	+28%	+39%
Lath/ black wood	33%	26% -- moderate	+6%	–12%	–51%	–39%	–21%
Undegraded/ biostructured brown	12%	53% -- strong	–42%	–75%	–58%	–17%	+75%
Striate/ biostructured brown	17%	80% -- v. strong	+41%	+253%	–65%	+18%	+23%
Banded/ biostructured brown	27%	27% -- moderate	0%	–67%	+15%	+55%	0%
Undegraded/non-biostructured brown	29%	66% -- strong	–21%	–76%	–10%	–59%	+162%
Corroded/ non-biostructured brown	64%	24% -- weak	+12%	+36%	+9%	+31%	–31%

Table 4.8. *Changes in means of selected kerogen parameters relative to shale values for siliciclastic sample lithologies, all data. Classification of average changes as in Table 4.7.*

Parameter	Shale (n = 144)	Average change (+ or –)	Silty shale (n = 118)	Shaley silt (n = 62)	Arg. sand (n = 31)	Silty sand (n = 31)	Clean sand (n = 8)
Sporomorphs/ palynomorphs	65%	26% -- moderate	+25%	+37%	+21%	+23%	+25%
Marine plankton/ palynomorphs	23%	55% -- strong	–65%	–78%	–43%	–48%	–39%
Botryococcus/ palynomorphs	9%	66% -- strong	–11%	–89%	–56%	–78%	–95%
Spores/ sporomorphs	10%	42% -- moderate	0%	–40%	+40%	+30%	+100%
Thick-walled/ spores	17%	45% -- moderate	–47%	–76%	–6%	–23%	–71%
Bisaccates/ pollen	32%	36% -- moderate	–19%	–62%	–19%	–50%	–28%
Unidentified/ pollen	62%	19% -- weak	+11%	+37%	+13%	+26%	+6%
Dinocysts/ marine plankton	79%	13% -- weak	–20%	+6%	+10%	+5%	+23%

Table 4.9. *Changes in means of selected palynomorph parameters relative to shale values for siliciclastic sample lithologies, all data. Classification of average changes as in Table 4.7.*

the %spores/sporomorphs shows a far larger increase in the clean sands as opposed to the other sand-dominated categories.

The silty lithologies also behave similarly, with the differences always being greater in the shaley silts than in the silty shales; in terms of the reliable parameters they are most different in their relative phytoclast, spore, *Botryococcus*, and bisaccate pollen content. There are also large changes within the less reliable biostructured brown wood fraction.

The parameters which highlight the differences between the silt- and sand-dominated sediments are the %black wood/phytoclasts and %spores/sporomorphs; these show opposite trends and reflect selective preservation within, and hydrodynamic equivalence with, the sand fraction.

4.6.2 (b) Comparison with Patterns in Individual Formations

Comparison of the parameter trends shown in each formation shows that the trends are most similar in the finer grained lithological categories (Tables 4.10 & 4.11), and that the differences between the formations are most apparent in the coarser lithologies, particularly the silty and clean sands. The Duntulm Formation lithologies show the most constant trends in the majority of the parameters examined. The Duntulm and Bearreraig Sandstone formations generally show the greatest average differences in parameter values, but the largest magnitude differences (>80%) between individual lithology categories are most common in the Bearreraig and Staffin Bay formations. However, the absolute percentage values are often low in the former, and the parameters showing the high magnitude variations are potentially unreliable. The most variable parameter in terms of the trends shown is the %palynomorphs of kerogen, which may reflect the fact that this parameter is strongly affected by dilution from both AOM and phytoclasts. The %thick-walled/spores also shows variable trends, but this is likely to be partly due to the high relative variability expected in this 'unreliable' category.

Although the magnitude of the changes often shows a large range of variability within the individual lithology categories, probably due partly to local 'facies' differences and partly to variation in the magnitude of the shale mean, the trends seen in each of the formations are relatively similar both to each other and to the whole dataset trends.

Parameter	Formation	Shale	Average change (+ or –)	Silty shale	Shaley silt	Arg. sand	Silty sand	Clean sand
AOM/ kerogen	Bearreraig Sst.	27%	23% – weak	–22%	–37%	–26%	–30%	0%
	Lealt Shales	37%	na	–4%	na	na	na	na
	Duntulm	36%	41% – moderate	–25%	–22%	–55%	–61%	na
	Staffin Bay	36%	89% – v. strong	–64%	na	–97%	–100%	–97%
Phytoclasts/ kerogen	Bearreraig Sst.	70%	5% – weak	+5%	+10%	+6%	+6%	0%
	Lealt Shales	34%	na	0%	na	na	na	na
	Duntulm	41%	66% – strong	+44%	+49%	+85%	+85%	na
	Staffin Bay	33%	113% – v. strong	+36%	na	+127%	+127%	+161%
Palynomorphs/ kerogen	Bearreraig Sst.	3%	93% – v. strong	+100%	+100%	+100%	+130%	+33%
	Lealt Shales	22%	na	0%	na	na	na	na
	Duntulm	21%	51% – strong	–33%	–57%	–57%	–57%	
	Staffin Bay	31%	36% – moderate	+35%	na	–29%	–23%	–58%
Black wood/ phytoclasts	Bearreraig Sst.	14%	18% – weak	–21%	–28%	–14%	–28%	0%
	Lealt Shales	19%	na	0%	na	na	na	na
	Duntulm	15%	48% – moderate	–13%	–33%	+20%	+127%	
	Staffin Bay	25%	27% – moderate	–28%	na	–40%	–16%	+24%
Lath/ black wood	Bearreraig Sst.	40%	24% – weak	–5%	–27%	–42%	–37%	+5%
	Lealt Shales	41%	na	–12%	na	na	na	na
	Duntulm	30%	27% – moderate	0%	–17%	–40%	–53%	na
	Staffin Bay	30%	27% – moderate	–13%	na	–43%	+7%	–47%
Undegraded/ biostructured brown	Bearreraig Sst.	2%	40% – moderate	0%	0%	–100%	+100%	0%
	Lealt Shales	9%	na	0%	na	na	na	na
	Duntulm	6%	54% – strong	–33%	–83%	–50%	+50%	na
	Staffin Bay	35%	22% – weak	–34%	na	–43%	–6%	–6%
Undegraded/ non-biostructured brown	Bearreraig Sst.	7%	56% – strong	–57%	–29%	–86%	–77%	–29%
	Lealt Shales	41%	na	0%	na	na	na	na
	Duntulm	12%	29% – moderate	–33%	–50%	–33%	0%	na
	Staffin Bay	67%	12% – weak	–12%	na	–16%	–12%	+7%
Corroded/ non-biostructured brown	Bearreraig Sst.	64%	39% – moderate	+42%	+39%	+50%	+50%	+12%
	Lealt Shales	54%	na	+6%	na	na	na	na
	Duntulm	81%	6% – weak	+4%	+5%	+12%	+2%	na
	Staffin Bay	30%	28% – moderate	+23%	na	+43%	+37%	–10%

+ relative increase; – relative decrease; na = none or too few samples of this lithology in this formation.

Table 4.10. *Changes in means of selected kerogen parameters relative to shale values for siliciclastic sample lithologies of each formation examined. Classification of average changes as in Table 4.7.*

Parameter	Formation	Shale	Average change (+ or –)	Silty shale	Shaley silt	Arg. sand	Silty sand	Clean sand
Sporomorphs/ palynomorphs	Bearreraig Sst.	92%	1% -- weak	0%	0%	0%	–4%	–3%
	Lealt Shales	66%	na	+15%	na	na	na	na
	Duntulm	56%	36% -- moderate	+33%	+37%	+37%	+39%	na
	Staffin Bay	74%	4% -- weak	+11%	na	0%	+3%	+4%
Marine plankton/ palynomorphs	Bearreraig Sst.	4%	10% -- weak	0%	0%	–50%	0%	0%
	Lealt Shales	5%	na	–40%	na	na	na	na
	Duntulm	40%	60% -- strong	–40%	–77%	–57%	–65%	na
	Staffin Bay	19%	9% -- weak	–26%	na	0%	–11%	0%
Thick-walled/ spores	Bearreraig Sst.	5%	108% -- v. strong	–60%	–60%	–100%	–100%	+220%
	Lealt Shales	18%	na	0%	na	na	na	na
	Duntulm	23%	26% -- moderate	–26%	+26%	+52%	0%	na
	Staffin Bay	4%	0% -- weak	0%	na	0%	0%	0%
Bisaccates/ pollen	Bearreraig Sst.	12%	36% -- moderate	–25%	–25%	–50%	–58%	–20%
	Lealt Shales	46%	na	–9%	na	na	na	na
	Duntulm	26%	27% -- moderate	–19%	–8%	–46%	–35%	na
	Staffin Bay	32%	0% -- weak	0%	na	0%	0%	0%

+ = relative increase, – = relative decrease; na = none or too few samples of this lithology in this formation

Table 4.11. *Changes in means of selected kerogen parameters relative to shale values for siliciclastic sample lithologies of each formation examined. Classification of average changes as in Table 4.7.*

4.6.3 Parameter Dependency on Lithology

The changes shown by the parameters in the previous sections have been used to rank selected particle types in relation to their dependency on lithology; the rankings were compiled by creating an overall average value (Table 4.12) by combining the average differences for each parameter shown in Tables 4.7 to 4.11. These were then assigned ranks as in Table 4.7.

4.7 Discriminant Function Analysis (DFA)

4.7.1 Introduction

The objective of using DFA in this case was to use the palynofacies data to discriminate between lithologies (lith and dlith). Simultaneous DFA was carried out using just the variables derived from the kerogen counts (kerogen group variables), just the variables derived from the palynomorph counts (palynomorph group variables), and both variable groups combined (combined). Stepwise DFA was carried out using only the combined variables group. An introduction to DFA is provided in section 3.3; further DFA analyses are presented in Chapter 8.0.

As some of the lithologic groups have only small numbers of samples or come from restricted stratigraphic ranges and facies, they may show strong evidence of other (non-lithological) controls on assemblages. These small groups may disrupt the classification, so DFA was carried out on both a full sample set and a reduced sample set with the samples from these small groups excluded. The following categories were left in the reduced analyses: shales, silty shales, shaley silts, silty sands, argillaceous sands, and limestones.

Parameter	Dependency on lithology	Range
AOM/kerogen	Moderate	Weak -- V.strong
Phytoclasts/kerogen	Strong	Weak -- V.strong
Palynomorphs/kerogen	Strong	Moderate -- V.strong
Black wood/phytoclasts	Moderate	Weak -- Moderate
Lath/black wood*	Moderate	Weak -- Moderate
Undegraded/biostructured brown wood*	Moderate	Weak -- Strong
Striate/biostructured brown wood+	Strong	na
Banded/biostructured brown wood+	Moderate	na
Undegraded/non-biostructured brown wood	Moderate	Weak -- Strong
Corroded/non-biostructured brown wood	Weak	Weak -- Moderate
Sporomorphs/palynomorphs	Weak	Weak -- Moderate
Marine plankton/palynomorphs	Moderate	Weak -- Strong
Botryococcus/palynomorphs+	Strong	na
Spores/sporomorphs+	Moderate	na
Thick-walled/spores	Moderate	Weak -- V.strong
Bisaccates/pollen+	Weak	na

+ = average calculated out of 2 figures only; * = average calculated out of 4 figures only; na = when only 2 figures available no range has been given.

Table 4.12. *Dependency of selected parameters on lithology. Classification as in Table 4.7.*

4.7.2 Overall Classification Accuracies

The overall accuracies are shown in Tables 4.13 to 4.15. The accuracies have been examined by calculating a percentage better than proportional chance parameter. This allows the comparison of DFA runs where the proportional chance criterion is different. All the analyses in the whole dataset (Table 4.13) show that the combined variables provides the best overall classification accuracy, followed by the kerogen and then the palynomorph runs. In two cases the stepwise accuracies exceed those derived from the palynomorph run. The dominant lithology accuracies are greater than those derived from the sample lithology runs and comparison of the reduced category analyses with those carried out on a full set of lithological categories shows that the combined variables run accuracies are very similar. The greatest difference in accuracy between the kerogen and palynomorph runs occurs in the dominant lithology analyses (74%); the greatest increase in accuracy on combining the variable groups occurs in the lithology analyses, and the least increase in the reduced lithology analyses.

When overall classification accuracies of the four major formations are examined (Tables 4.14 & 4.15) the combined > kerogen > palynomorph ranking of accuracies seen the whole dataset is less consistent. The combined variables group generally gives the best discrimination of lithology, but the kerogen variables give slightly better results in the Duntulm and Staffin Bay formations. Comparison of the maximum accuracies present in each formation shows that dominant lithology is discriminated better than sample lithology in all the formations, and that when ranked according to these maximum accuracies the Lealt Shales and Duntulm formations have the lowest accuracies in both the lithology and dominant lithology analyses (cf. Table 4.10). Apart from the Bearreraig Sandstone Formation, the lithology accuracies derived from the kerogen runs are about twice those derived from the palynomorphs parameters. The Bearreraig Sandstone provides the greatest increase in classification accuracy when the variable groups are combined, partly suggesting that they integrate well in this case, but the increase may also be due to the fact that as the accuracy is low it does not take much change to increase by a higher relative percent (i.e. an arithmetic artefact). However, in the discrimination of dominant lithology the difference in accuracy between the variable groups in the Bearreraig Sandstone Formation is 76%, and the combination of the variable groups results in a reduction in classification accuracy; the accuracies derived from the two variable groups in the other formations are much closer (particularly in the Lealt Shales and Staffin Bay formations). This suggests that the palynomorph variables group is less distinct (relative to the kerogen group) in the dominant lithology classification of the Bearreraig Sandstone.

Whole dataset	Overall classification accuracy (OCA)		Proportional chance (Cprop)	Relative % OCA > Cprop	
Lithology	value	rank		value	rank
kerogen	38	2	21	81	2
palynomorph	36	3	23	57	3
combined	56	1	23	144	1
stepwise	33	4	23	44	4
Lithology reduced*					
kerogen	60	3	26	131	2
palynomorph	54	4	29	86	4
combined	71	1	29	145	1
stepwise	61	2	29	110	3
Dominant lithology					
kerogen	52	3	20	160	2
palynomorph	39	4	21	86	4
combined	64	1	21	205	1
stepwise	54	2	21	157	3
Dominant lithology reduced*					
combined	70	1	23	204	1
stepwise	57	2	23	148	2

* reduced refers to analyses carried out using a reduced number of categories, all those containing fewer than 5 samples were removed.

Table 4.13. *Comparison of percentage classification accuracies based on the whole dataset analyses.*

Formation	Overall classification accuracy (OCA)		Proportional chance (Cprop)	Relative % OCA>Cprop	
Bearreraig Sandstone	value	rank		value	rank
Kerogen	69	2	29	138	2
Palynomorph	62	3	27	130	3
Combined	82	1	27	204	1
Stepwise	47	4	27	74	4
Lealt Shales					
Kerogen	77	2	38	103	2
Palynomorph	54	4	37	46	4
Combined	86	1	37	132	1
Stepwise	57	3	37	54	3
Duntulm					
Kerogen	62	2	28	121	1
Palynomorph	52	4	32	63	4
Combined	68	1	32	113	2
Stepwise	61	3	32	91	3
Staffin Bay					
Kerogen	87	1	26	235	1
Palynomorphs	57	3	26	119	3
Combined	82	2	26	215	2
Stepwise	44	4	26	69	4

Table 4.14. *Overall % classification accuracies for the four formations using lithology as the dependent variable.*

Formation	Overall classification accuracy (OCA)		Proportional chance (Cprop)	Relative % OCA > Cprop	
Bearreraig Sandstone	value	rank		value	rank
Kerogen	82	3	26	215	1
Palynomorph	74	4	31	139	4
Combined	95	1	31	207	2
Stepwise	90	2	31	190	3
Lealt Shales					
Kerogen	76	2	35	117	2
Palynomorph	65	3	35	86	3
Combined	91	1	35	160	1
Stepwise	54	4	35	54	4
Duntulm					
Kerogen	65	2	26	150	2
Palynomorph	56	3	30	87	3
Combined	76	1	30	153	1
Stepwise	38	4	30	27	4
Staffin Bay					
Kerogen	76	2	26	192	2
Palynomorph	67	3	26	158	3
Combined	88	1	26	239	1
Stepwise	67	3	26	158	3

Table 4.15. *Overall percentage classification accuracies for the four formations using dominant lithology as the dependent variable.*

4.7.3 Category (lith and dlith types) Classification Accuracies

In the majority of categories (lith and dlith types) the patterns shown in the classification accuracies are: combined > kerogen > palynomorphs, or kerogen > combined > palynomorphs (Table 4.16); in the latter cases it appears that the relatively low classification accuracies found in the palynomorph run are reducing the accuracy of the kerogen run when the variable groups are combined. This suggests that the variable groups do not integrate well. The only category where the above patterns are not found is the argillaceous sands; in both the lithology and dominant lithology analyses the palynomorph run accuracy exceeds that of the kerogen, suggesting that the palynomorph variables group is more distinct in this lithology (lith and dlith). The greatest increase in accuracy when the two variable groups are combined occurs in the silty shale and clean sandstone categories in both the lithology and dominant lithology analyses; this suggests that it is in these lithologies (lith and dlith) that the variables integrate best.

Ranking of the average increases of the accuracies of each category over the proportional chance parameter shows that the most distinct lithologies are shaley silt, shaley limestone, clay-mudstone, clean sand, and limestone; the least distinct lithologies appear to be silty shale and silty sand. The distinct lithologies are often quite formation specific; the shaley silts category contains a high number of samples from the Udairn Shales Member of the Bearreraig Sandstone Formation (46%), and these are more closely related than the samples in the other lithological categories. Similarly, the majority of the clay-mudstone and shaley limestone samples come from the Duntulm Formation. The limestone and clean sands samples come from a wider range of formations. Examination of the relatively high accuracies in each run, taken together with the rankings derived from the averages, suggests that the most distinct lithologies (lith and dlith) tend to be the coarser and more calcareous ones; this correlates with the patterns described in section 4.6.

Categories	lithology kerogen		lithology palynomorph		lithology combined		lithology stepwise		Dlith kerogen		Dlith palynomorph		Dlith combined		Dlith stepwise		Average acc2
	acc1	acc2	acc1	acc2	acc1	acc2	acc1	acc2	acc1	acc2	acc1	acc2	acc1	acc2	acc1	acc2	
shale	33	57	27	17	55	139	26	13	56	180	34	62	60	186	56	167	103
silty shale	21	0	24	4	42	83	15	–35	34	70	19	–10	58	176	35	67	44
shaley silt	71	238	67	191	72	213	59	157	92	360	90	329	95	352	92	338	272
silt	40*		25*		75*		75*		na		na		na		na		
sandy silt	100*		100*		100*		100*		na		na		na		na		
silty sand	32	52	6	–74	35	52	18	–22	52	160	5	–76	33	57	38	81	29
arg. Sst.	19	-9	47	104	53	130	27	17	49	95	56	167	74	252	59	181	117
clean Sst.	63	200	67	191	100	334	67	191	34	70	50	138	55	162	50	138	178
Lst.	50	138	50	117	60	161	60	161	69	245	39	86	54	157	54	157	153
shaley Lst.	50	138	30	30	40	74	50	117	100	400	67	219	100	376	100	376	216
arg. Lst.	50*		50*		100*		50*		67*		67*		100*		33*		
sandy Lst.	na		na		na		na		78	290	50*		100*		75*		
sandy shale	75*		100*		100*		75*		na		na		na		na		
shaley sand	100*		100*		100*		67*		na		na		na.		na		
clay-mudstone	64	205	67	117	67	117	56	100	82	310	67	219	67	219	67	219	188
Cprop	21		23		23		23		20		21		21		21		

* group containing less than 5 samples; na category not in analysis

Table 4.16. *Percentage classification accuracies of the whole dataset lithology (lith) and dominant lithology (Dlith) categories. Acc1 refers to the original classification accuracy, acc2 represents the increase or decrease (–) relative to the proportional chance criterion (Cprop), and has only been calculated for those categories containing significant sample numbers.*

4.7.4 Profiling of Mis-Classified Samples

Lists of the characteristics of the mis-classified samples from the simultaneous discrimination of lithology by the combined variables were generated via the SPSS PC package. The mis-classified samples are generally of two types: those which come from sections where there is a strong dominant lithologic control, or those from sections where there is a strong facies control. Examples of the first type (Table 4.17) can be seen in the mis-classified shale samples from the Kildonnan Member (KE40-44), and the Valtos Formation (VS3 & 4), where the dominant lithology is sandstone. Probably the best examples of the second type are the samples from the 'freshwater intercalation' of the Duntulm Formation (LOD & LOK), which nearly all classify incorrectly regardless of their lithology. Samples can also classify incorrectly if there is another category present to which they are more strongly related due to stratigraphic position. This is often seen when a lithological category exists which contains the majority of samples from a particular section; other samples from this section that belong to other categories classify into the category that contains the samples from above and below their stratigraphic position rather than into their pre-assigned category. For example, Table 4.17 shows Cullaidh Shale Formation samples (RCS1-3) mis-classifying into lithology category 13 (sandy shale) which includes the samples from directly above them. They are more strongly related to these samples than they are to other shales.

The profiling of mis-classified samples from the simultaneous discrimination of dominant lithology by the combined variables reveals a similar pattern to that from the sample lithology, with many of the mis-classified samples coming from sections with a strong facies control, or having a very different sample lithology to the dominant lithology. For example, the mis-classified shale samples from the Kildonnan Member (KE41-44), which have a sandstone dominant lithology, classify as silty shales not sandstone; it appears that the effect of the dominant sandstone lithology is not enough to have them classify as sandstone, but has enough effect to prevent them from being classified as shales (Table 4.18).

FORMATION	MEMBER	ENVIR	LITHOFAC	SAMNO	DIS_1
2.00	.	3.00	.	RCS1	13.00
2.00	.	3.00	.	RCS2	13.00
2.00	.	3.00	.	RCS3	13.00
4.00	9.00	7.00	.	KE35	2.00
4.00	9.00	9.00	.	KE40	2.00
4.00	9.00	7.00	.	KE41	2.00
4.00	9.00	7.00	.	KE42	2.00
4.00	9.00	7.00	.	KE43	2.00
4.00	9.00	7.00	.	KE44	2.00
5.00	.	7.00	.	VS3	15.00
5.00	.	7.00	.	VS4	15.00
6.00	.	6.00	1.00	LOD8	10.00
6.00	.	5.00	1.00	LOD9	10.00
6.00	.	5.00	1.00	LOD11	10.00
6.00	.	5.00	1.00	LOK11	10.00
6.00	.	8.00	5.00	LOK38	2.00
6.00	.	8.00	5.00	LOK39	2.00

Table 4.17. *Examples of the characteristics of mis-classified samples from the shale category (1), all data sample lithology analysis. Dis-1 refers to the group into which the sample has classified. Key to other characteristics in Tables 2.23 to 2.27.*

FORMATIO	MEMBER	ENVIRONM	LITHOFAC	SAMNO	LITH	DIS_2
1.00	1.00	1.00	.	BBE47	1.00	3.00
4.00	9.00	7.00	.	KE41	1.00	2.00
4.00	9.00	7.00	.	KE42	1.00	2.00
4.00	9.00	7.00	.	KE44	1.00	2.00
1.00	5.00	1.00	.	BBR2	6.00	3.00
1.00	5.00	1.00	.	BBR5	6.00	3.00
1.00	5.00	1.00	.	BBR11	6.00	12.00
9.00	12.00	2.00	4.00	BS10	8.00	6.00
9.00	12.00	2.00	4.00	BS11	8.00	6.00
9.00	12.00	2.00	4.00	BS13	8.00	6.00

Table 4.18. *Mis-classified samples from the Clean Sands (8) dominant lithology category. Dis-2 refers to the group into which the sample has been classified by the DFA. Key to other characteristics in Tables 2.23 to 2.27.*

4.8 Variables Selected by Stepwise DFA (SDFA)

These variables are those which together best discriminate between the lithological (lith and dlith) categories; the Wilks' lambda values provide a measure of the contribution of each variable chosen to the discriminating process.

4.8.1 Whole Dataset

The variables chosen by the SDFA are shown in Table 4.19. Overall, the variables that best distinguish between lithologies and dominant lithologies are quite similar; most of them are kerogen variables, with around 1/3 palynomorph variables. This is reflected in Table 4.20 which shows that in the case of sample lithology the total of the Wilks' lambda values for the kerogen group variables is 2.5 times greater than that for the palynomorph group variables. In the case of dominant lithology the contribution of the kerogen group variables is just over twice that derived from the palynomorph variables selected. This suggests that the palynomorph variables group may be most influenced by dominant lithology (see also Table 4.16). The kerogen variables used tend to include information about each major subdivision of the phytoclast assemblage (e.g. type of biostructured wood, degradation states, phytoclast types), whilst the palynomorph variables contain information on the sporomorph and plankton assemblages. The most obvious difference between the sample lithology and dominant lithology variables is that the %phytoclasts of kerogen (which best distinguishes between lithologies) is the fourth variable chosen in the dominant lithology SDFA. Conversely, the best variable for dominant lithology (percentage total sporomorphs) is the fourth variable chosen in the lithology analysis. Throughout all the analyses the %striate of biostructured brown wood provides the second most significant parameter; this shows that although this is a minor component, it does contain important information This justifies the detailed sudivision of the phytoclasts that has been employed in this study, which is more comprehensive than in most palynofacies studies. The Wilks' lambda values that are associated with the selected variables show a similar pattern in both analyses.

In the reduced sample lithology and dominant lithology analyses the variables chosen are very similar to those from the whole dataset (Table 4.21), but an extra three variables are used in differentiating between the reduced lithology groups. Again the Wilks' lambda values show a similar pattern, but the palynomorph group variables contribute only about 50% less than the kerogen group variables in the reduced sample lithology analysis (Table 4.22).

Lithology	Variable		Wilks' lambda	Dominant lithology	Variable		Wilks' lambda
	Phytoclasts/ kerogen	1	0.62		Sporomorph/ palynomorphs	1	0.61
	Striate/ biostructured brown	2	0.44		Striate/ biostructured brown	2	0.47
	Undifferentiated/ palynomorphs	3	0.36		Pseudoamorphous/ non-biostructured brown	3	0.38
	Banded/ biostructured brown	4	0.31		Phytoclasts/ kerogen	4	0.31
	Sporomorph/ palynomorphs	5	0.26		Membranes/ phytoclast	5	0.27
	Corroded/ non-biostructured brown	6	0.22		Acritarchs/ marine plankton	6	0.23
Classification accuracy	33%	Total	2.21		Black wood/ phytoclasts	7	0.20
					Palynomorphs/ kerogen	8	0.18
					Biostructured/ brown wood	9	0.15
					Undifferentiated/ palynomorphs	10	0.13
					Stripe/ biostructured brown	11	0.12
				Classification accuracy	54%	Total	3.05

Table 4.19. *Variables selected for for stepwise discrimination of lithology and dominant lithology, whole dataset.*

Dependant Variable	Kerogen	Palynomorph
Lithology	1.59	0.62
Dominant lithology	2.08	0.98

Table 4.20. *Total Wilks' lambda values for each variable group (from Table 4.19).*

	Variable		Wilks' lambda		Variable		Wilks' lambda
Lithology (reduced)	Phytoclasts/ kerogen	1	0.65	Dominant lithology (reduced)	Sporomorph/ palynomorphs	1	0.62
	Striate/ biostructured brown	2	0.48		Striate/biostructured brown	2	0.49
	Undifferentiated/ palynomorphs	3	0.40		Pseudoamorphous/ non-biostructured brown	3	0.41
	Sporomorphs/ palynomorphs	4	0.36		Phytoclasts/ kerogen	4	0.35
	Banded/ biostructured brown	5	0.31		Membranes/ phytoclasts	5	0.31
	Membranes/ phytoclasts	6	0.29		Undifferentiated/ palynomorphs	6	0.27
	Acritarchs/ marine plankton	7	0.27		Acritarchs/ marine plankton	7	0.24
	Black wood/ phytoclasts	8	0.25		Black wood/ phytoclasts	8	0.22
	Palynomorphs/ kerogen	9	0.23		Degraded/ biostructured brown	9	0.20
Classification accuracy	61%	Total	3.24		Stripe/biostructured brown	10	0.18
					Callialasporites/ pollen	11	0.17
				Classification accuracy	57%	Total	3.45

Table 4.21. *Variables used for stepwise discrimination of reduced lithology and dominant lithology, whole dataset analysis*

Dependant Variable	Kerogen	Palynomorph
Lithology reduced	2.21	1.03
Dominant lithology reduced	2.15	1.30

Table 4.22. *Total Wilks' lambda values for each variable group (from Table 4.21).*

4.8.2 The Formations

4.8.2 (a) Lithology

The number of variables chosen in each case is similar (Table 4.23), apart from in the Staffin Bay Formation where only two variables are used. In two of the formations the variable that provides the most discrimination is from the palynomorph group; in the other two formations a kerogen group variable is used. In the Bearreraig Sandstone and Duntulm Formations the variables chosen come in equal numbers from the two groups; in the Lealt Shales Formation 2/5 are from the palynomorph group, but in the Staffin Bay Formation only kerogen group variables are chosen. This is reflected in Table 4.24 which shows that the discriminating power of the equation comes mostly (or totally) from the kerogen group variables in the Bearreraig Sandstone and Staffin Bay Formations, but in the Lealt Shales Formation the palynomorph variables group provides twice the discriminating power of the kerogen group. In the Duntulm Formation the discriminating power is distributed quite evenly between the two groups. This suggests that in the coarser grained units, the kerogen character is more distinct than the palynomorphs. In finer sediments the importance of the palynomorphs increases.

4.8.2 (b)Dominant Lithology

The number of variables chosen in the stepwise discrimination of dominant lithology (Table 4.25) is similar, apart from in the Bearreraig Sandstone Formation where twelve variables are chosen. In three out of the four formations the best variable is the same as in the stepwise discrimination of lithology, but additional variables are also used. In all but the Duntulm Formation the majority of the variables selected by DFA come from the kerogen group; this is reflected in Table 4.26 which shows that in the Bearreraig and Staffin Bay Formations the kerogen group variables are the major source of the discriminating power of the equation. In the Lealt Shales Formation there is an increased contribution from the palynomorph group, but the kerogen variables still provide the most discriminating power. The Duntulm Formation shows a more equal contribution from the two groups, with the palynomorph variables slightly predominant. Compared with the values obtained from the lithology analyses the dominant lithology values show a similar pattern, apart from in the Lealt Shales Formation where the palynomorph group variables were strongly predominant in the lithology analysis.

Bearreraig Sst. Fm.	Variable		Wilks' lambda	**Lealt Shales Fm.**	Variable		Wilks' lambda
Lithology	Pitted/ biostructured brown	1	0.19	Lithology	Undifferentiated/ palynomorphs	1	0.51
	Pseudoamorphous/ non-biostructured brown	2	0.04		Marine plankton/ palynomorphs	2	0.31
	Cerebropollenites/ pollen	3	0.03		Membranes/ phytoclasts	3	0.21
	Callialasporites/ pollen	4	0.02		Banded/ biostructured brown	4	0.15
Classification accuracy	47%	Total	0.27		AOM/ kerogen	5	0.11
				Classification accuracy	57%	Total	1.28
Duntulm Fm.	Variable		Wilks' lambda	**Staffin Bay Fm.**	Variable		Wilks' lambda
Lithology	*Botryococcus*/ palynomorphs	1	0.56	Lithology	Phytoclasts/ kerogen	1	0.30
	Phytoclasts/ kerogen	2	0.39		Corroded/ non-biostructured brown	2	0.16
	Membranes /phytoclasts	3	0.28	Classification accuracy	44%	Total	0.46
	Banded/ biostructured brown	4	0.20				
	Dinocysts/ marine plankton	5	0.15				
	Tasmanites type/ marine plankton	6	0.12				
Classification accuracy	61%	Total	1.69				

Table 4.23. *Variables chosen in the combined variables stepwise discrimination of lithology for the four formations.*

Lithology	Kerogen	Palynomorph
Bearreraig Sst. Fm.	0.23	0.05
Lealt Shales Fm.	0.47	0.81
Duntulm Fm.	0.86	0.82
Staffin Bay Fm.	0.46	0

Table 4.24. *Total Wilks' lambda values for the two variable groups used in stepwise discrimination of lithology for the four formations (from Table 4.23).*

Bearreraig Sst. Fm.	Variable		Wilks' lambda
Dominant lithology	Pitted/ biostructured brown	1	0.20
	Black wood/ phytoclasts	2	0.10
	Pseudoamorphous/ non-biostructured brown	3	0.06
	Undegraded/ non-biostructured brown	4	0.04
	Undifferentiated/ palynomorphs	5	0.02
	Striped/ biostructured brown	6	0.02
	Tasmanites type/ marine plankton	7	0.01
	Marine plankton/ palynomorphs	8	0.01
	Unidentified/ pollen	9	0.01
	Cerebropollenites/ pollen	10	0.01
	Phytoclasts/ kerogen	11	0.004
	Undegraded/ biostructured brown	12	0.003
Classification accuracy	90%	Total	0.48

Lealt Shales Fm.	Variable		Wilks' lambda
Dominant lithology	Undifferentiated/ palynomorphs	1	0.70
	Brown wood/ phytoclasts	2	0.50
	Cuticle/ phytoclasts	3	0.39
Classification accuracy	54%	Total	1.59

Duntulm Fm.	Variable		Wilks' lambda
Dominant lithology	Acritarchs/ marine plankton	1	0.008
	Phytoclasts/ kerogen	2	0.005
	AOM/ kerogen	3	0.003
	Dinocysts/ marine plankton	4	0.003
Classification accuracy	38%	Total	0.02

Staffin Bay Fm.	Variable		Wilks' lambda
Dominant lithology	Phytoclasts/ kerogen	1	0.42
	Brown wood/ phytoclasts	2	0.24
Classification accuracy	67%	Total	0.66

Table 4.25. *Variables chosen for the combined variables stepwise discrimination of dominant lithology for the four formations.*

Dominant lithology	Kerogen	Palynomorph
Bearreraig Sst. Fm.	0.42	0.06
Lealt Shales Fm.	0.89	0.70
Duntulm Fm.	0.01	0.01
Staffin Bay Fm.	0.66	0

Table 4.26. *Total Wilks' lambda values for the two variable groups used in stepwise discrimination of dominant lithology for the four formations (from Table 4.25).*

4.9 Summary

The relative variation of the selected parameters in the gross and sample lithology categories shows how different the assemblages in these categories can be relative to the 'palynological norm' of shale. Table 4.13 shows the parameters that can be expected to vary the most due to lithologic bias: these are the %phytoclasts and palynomorphs of kerogen; other parameters show less lithological control, and some (such as the marine plankton subset categories) show variation that is largely independent of lithology.

The effect of dominant lithology on sample lithology assemblages has been shown to be particularly important when sand-dominated lithologies are involved; these give rise to lowered AOM and increased phytoclast mean percentages in shales, and change the distribution frequencies of these variables.

The DFA overall classification accuracies attest to the strong lithologic and dominant lithologic controls on assemblages; the accuracies are higher in the analyses by dominant lithology suggesting a potentially stronger control from this parameter. The individual lithology (lith and dlith) category accuracies suggest varying levels of control, and these lithological categories often show different levels of control in the kerogen and palynomorph runs, suggesting that certain lithologies are better defined by either kerogen or palynomorph variables. There are also cases where the combination of the two groups does not lead to an increase in classification accuracy; this suggests that in these cases the data contained in the groups does not integrate well, reflecting a lack of correlation between total kerogen and palynomorph derived parameters.

The profiles of the mis-classified samples show that these are often affected by strong dominant lithology or facies controls. The mis-classified samples from the Lealt Shales Formation show that the dominant lithology effect on sample lithology can be quite subtle, causing shale samples from a sandstone-dominated unit to classify into the silty shale category.

The variables selected by the stepwise analyses are those which together best discriminate between the lithologic and dominant lithologic categories. It is interesting to note that the first variable chosen in the stepwise discrimination of lithology is the percentage phytoclasts of kerogen, which was rated as having a strong dependence on lithology in section 4.6.3. Many other of the variables rated as being reasonably strongly affected by lithology in the same section also appear in the whole dataset and formation stepwise analyses.

Further comparison of the DFA results will be possible when other dependant variables have been used (see Chapter 8.0).

CHAPTER 5.0
PALYNOFACIES DATA SUMMARY

5.0 PALYNOFACIES DATA SUMMARY

The mean values of the kerogen and palynomorph parameters for the whole dataset and specific subsets are presented in the form of a series of ternary diagrams where the sum of the three components plotted has been normalised to 100% (cf. Tyson, 1993, 1995). Five diagrams are used to summarise different aspects of the kerogen data:

the three major kerogen groups (AOM, phytoclasts, palynomorphs)
the overall nature of the phytoclast population (cuticle+membranes, brown wood, black wood)
the nature of the woody phytoclasts (biostructured and non-biostructured brown wood, black wood)
the nature of the biostructured brown wood (striate, striped, banded+pitted)
the nature of the non-biostructured brown wood (undegraded, corroded, pseudoamorphous)

Another four diagrams are used to summarise the palynomorph assemblage:

the major palynomorph groups (sporomorphs, marine plankton, undifferentiated)
the nature of the sporomorph population (spores, unidentified pollen, bisaccates)
the potential salinity indicators (*Botryococcus*, acritarchs, dinocysts+prasinophytes)
the nature of the marine organic-walled microplankton assemblage (acritarchs, dinocysts, prasinophytes)

Following the convention of Tyson (1993, 1995), all the diagrams are oriented such that the most proximal/terrestrial indicator occurs at the apex, and the parameter in the left lower corner is the one which of the three parameters shows the greatest positive association with distal or reducing environments.

This allows a general overview of the nature of the data, i.e. its variability and the presence of major trends.

5.1 Sample Distribution

The total dataset used in the computation of the mean values and other statistical procedures is based on data from 440 samples. Separate palynomorph counts were only done on 356 samples; it is this figure which determines the number of samples used in the 'combined variables' Discriminant Function and Factor analyses (Chapters 8.0 & 9.0). The distribution of the samples in each subset of the whole dataset and each of the four major formations is shown in Tables 5.1 to 5.5. Some of the environment categories in the whole dataset correspond to stratigraphic units: open marine = Bearreraig Sandstone Formation, bar = Belemnite Sands Member (Staffin Bay Formation), anoxic basin = Cullaidh Shale Formation, and mudflat-alluvial = Skudiburgh Formation.

5.2 Mean Values

5.2.1 Whole Dataset

The overall kerogen assemblage is dominated by the phytoclast group; palynomorphs make up less than 20% (Fig. 5.1). The dominant phytoclast component is brown wood; subdivision of this component shows that it consists mostly of corroded non-biostructured material. The biostructured brown wood fraction is dominated by striped, banded and pitted material (i.e. striate component is $\leq$ 30%).

Sporomorphs are the dominant component of the palynomorph fraction, with marine plankton making up less than 20% of the mean assemblage. The only difference between the palynomorph parameters derived from the kerogen counts and those derived from the separate palynomorph counts is in the level of undifferentiated palynomorphs, which is 225% higher in relative terms in the kerogen count parameters (Fig. 5.2). From the composition of the palynomorph assemblage it is likely that the majority of the undifferentiated palynomorphs are sporomorphs; these were not recognised during the kerogen counts due possibly to AOM masking, or due to the lack of time available for the detailed kind of examination that was possible during the palynomorph counts. The sporomorph assemblage is dominated by pollen, mostly unidentified in form, with bisaccates making up less than 30% of the mean assemblage. Dinocysts dominate the marine plankton assemblage, and prasinophytes are virtually

Formation	%kerogen	%palynomorph
Bearreraig Sst.	30	27
Cullaidh Shale	1	1
Egol Sst.	3	3
Lealt Shales	18	21
Valtos Sst.	2	1
Duntulm	31	32
Kilmaluag	2	1
Skudiburgh	2	0
Staffin Bay	12	14
Total N	440	356

Environment	%kerogen	%paly
Open marine	30	27
Bar	3	3
Anoxic basin	1	1
Supratidal	0.2	0.3
Marine-hypersaline	4	5
Marine-brackish	32	34
Brackish	8	8
Fresh-brackish	15	18
Freshwater	5	4
Mudflat-alluvial	2	0
Total N	440	356

Table 5.1. *Percentage of samples counted for kerogen and palynomorphs in each formation and environment category of the whole dataset (paly = palynomorphs).*

Member	%kerogen	%paly
Dun Caan Shales	37	40
Ollach Sst.	1	0
Udairn Shales	24	34
Holm Sst.	9	12
Rigg Sst.	14	6
Dun Caan Shales (Raasay)	5	2
Bein na Leac Sst. (Raasy)	8	4
?Garantiana Clay (Raasay)	3	2
Total N	131	95

Proximal-distal (Dun Caan Shales Mbr.)	%kerogen	%paly
1	81	76
2	19	24
Total N	48	38
Distal-proximal (Udairn Shales-Holm Sst. Mbrs.)		
1	5	5
2	68	70
3	20	21
4	7	5
Total N	44	43

Table 5.2. *Percentage of samples counted for kerogen and palynomorphs in each category of the Bearreraig Sandstone Formation (paly = palynomorphs).*

Member	%kerogen	%paly
Kildonnan	74	75
Lonfearn	26	25
Total N	78	76
Salinity	%kerogen	%paly
Freshwater-miohaline	45	45
Mesohaline	33	33
Pliohaline	22	22
Total N	78	76

Environment	%kerogen	%paly
Marine-brackish	17	17
Brackish	31	30
Fresh-brackish	49	49
Freshwater	4	4
Total N	78	76

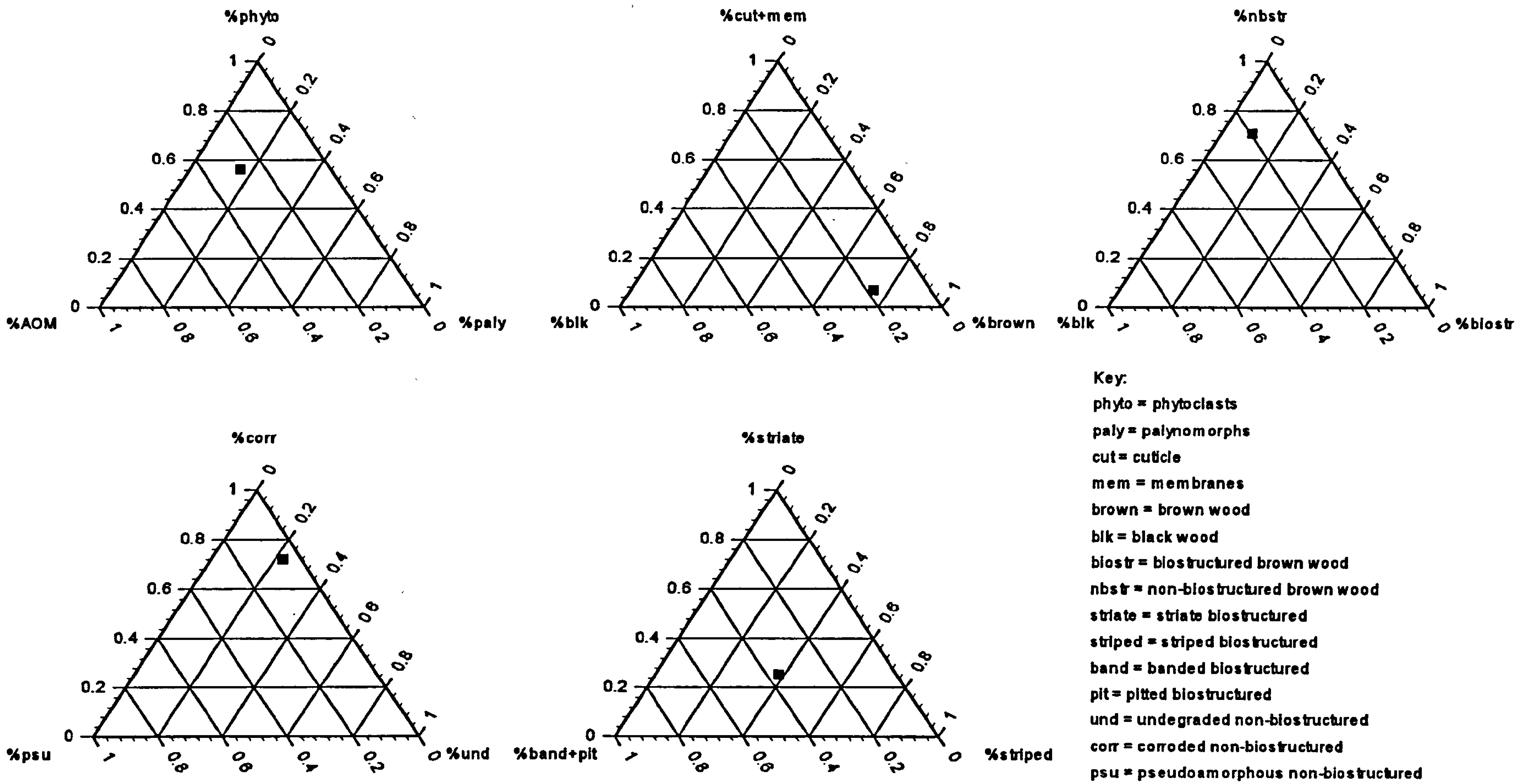
Table 5.3. *Percentage of samples counted for kerogen and palynomorphs in each category of the Lealt Shales Formation (paly = palynomorphs).*

Environment	%kerogen	%paly	Lithofacies	%kerogen	%paly	Biofacies	%kerogen	%paly
Supratidal	1	1	*Praeexogyra* Lst.-shales	46	54	Oyster shell bank	39	46
Marine-hypersaline	13	16	Arg. Lst.	1	2	'Marine' community	8	10
Marine-brackish	59	54	Algal Lst.	2	3	Algal marsh community	7	8
Fresh-brackish	22	23	Cryptalgal-rippled silts	4	5	Sandy lagoon community	21	9
Freshwater	6	7	Sandstone	21	9	Low salinity community	25	27
			Unio-Neomiodon muds & sands	25	27			
Total N	138	114		138	114		138	114

Table 5.4. *Percentage of samples counted for kerogen and palynomorphs in each category of the Duntulm Formation (paly = palynomorphs).*

Member	%kerogen	%paly	Lithofacies	%kerogen	%paly	Biofacies	%kerogen	%paly
Upper Ostrea	72	76	Calc. clay-Lst.	11	12	Monotypic *Neomiodon*	44	45
Belemnite Sands	28	24	Bituminous shales	33	33	*Neomiodon* & others	28	31
Environment			Silt-fine sands	28	31	*Neomiodon-Pleuromya*	24	20
Brackish	4	4	Arg. sands	24	20	*Ctenostrea-Neomiodon*	0	0
Marine-brackish	69	71	Muddy silts	4	4	Abundant *Cylindroteuthis*	4	4
Bar	28	24	Total N	54	49	Total N	54	49
Total N	54	49						

Table 5.5. *Percentage of samples counted for kerogen and palynomorphs in each category of the Staffin Bay Formation (paly = palynomorphs).*



Key:
phyto = phytoclasts
paly = palynomorphs
cut = cuticle
mem = membranes
brown = brown wood
blk = black wood
biostr = biostructured brown wood
nbstr = non-biostructured brown wood
striate = striate biostructured
striped = striped biostructured
band = banded biostructured
pit = pitted biostructured
und = undegraded non-biostructured
corr = corroded non-biostructured
psu = pseudoamorphous non-biostructured

Fig. 5.1. *Mean percentages of the kerogen assemblage, whole dataset.*

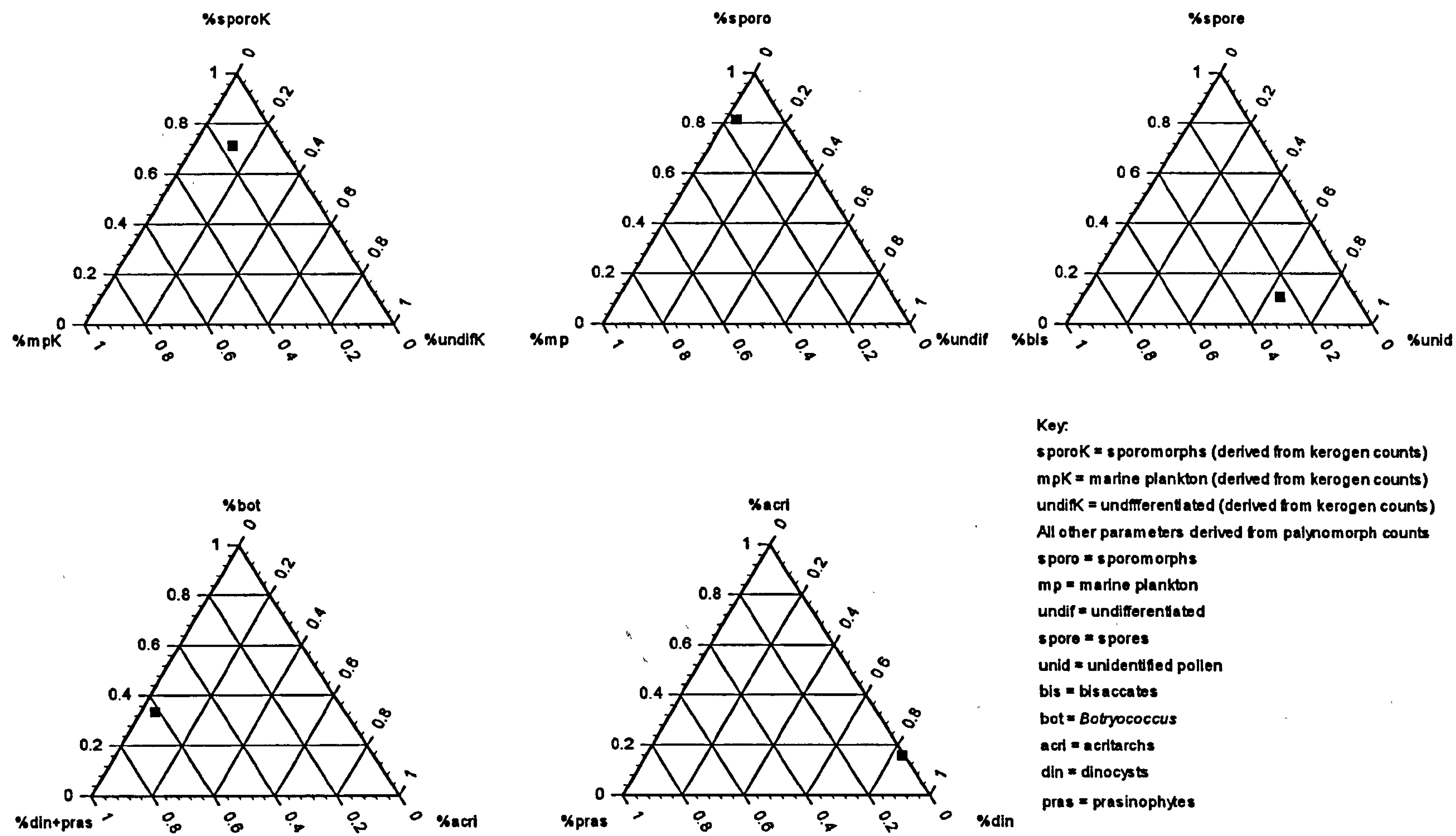


Fig. 5.2. *Mean percentages of the palynomorph assemblage, whole dataset.*

absent; however, the presence of significant levels of *Botryococcus* suggests freshwater influence.

5.2.2 Formations

Within the nine formations the kerogen assemblages are dominated by either phytoclasts (in the sandstone-dominated Bearreraig and Valtos formations, and particularly the mudflat-alluvial Skudiburgh Formation) or AOM (Fig. 5.3). The highest palynomorph contents are found in the lagoonal Duntulm, Lealt and Staffin Bay formations. The phytoclast assemblages are mostly dominated by brown wood, apart from the Skudiburgh Formation where black wood is dominant (reflecting the more oxidising fluvial environment); the underlying Kilmaluag Formation also has increased black wood percentages. The proportion of cuticle and membranes is only significant in the Lealt Shales Formation. The brown wood is dominated by non-biostructured material throughout, and biostructured components are all less than 20%. Within the non-biostructured wood fraction assemblages are dominated by corroded or undegraded material; the former is particularly dominant in the Bearreraig, Cullaidh, Elgol, and Duntulm formations, less so in the Valtos and Skudiburgh formations. Undegraded material dominates the mean assemblage in the Kilmaluag and Staffin Bay Formations. The biostructured brown wood assemblages are dominated by striped, banded and pitted particle types in all cases apart from the Bearreraig Sandstone Formation which is characterised by increased levels of striate wood. Within the other formations increased levels of striped brown wood characterise the Skudiburgh Formation; the two sandstone formations of the Great Estuarine Group (Valtos and Elgol) are dominated by banded and pitted particle types.

The only difference between the kerogen and playnomorph count derived parameters is again the levels of undifferentiated palynomorphs (Fig. 5.4); all the assemblages are sporomorph-dominated, although marine plankton levels are increased in the Duntulm and Staffin Bay formations. Spores represent less than 20% of the assemblage in all cases apart from the Valtos and Staffin Bay formations. The dominant pollen fraction is represented mostly by unidentified forms, particularly in the Bearreraig Sandstone Formation, although bisaccates are present at increased levels in the Cullaidh and Elgol formations.

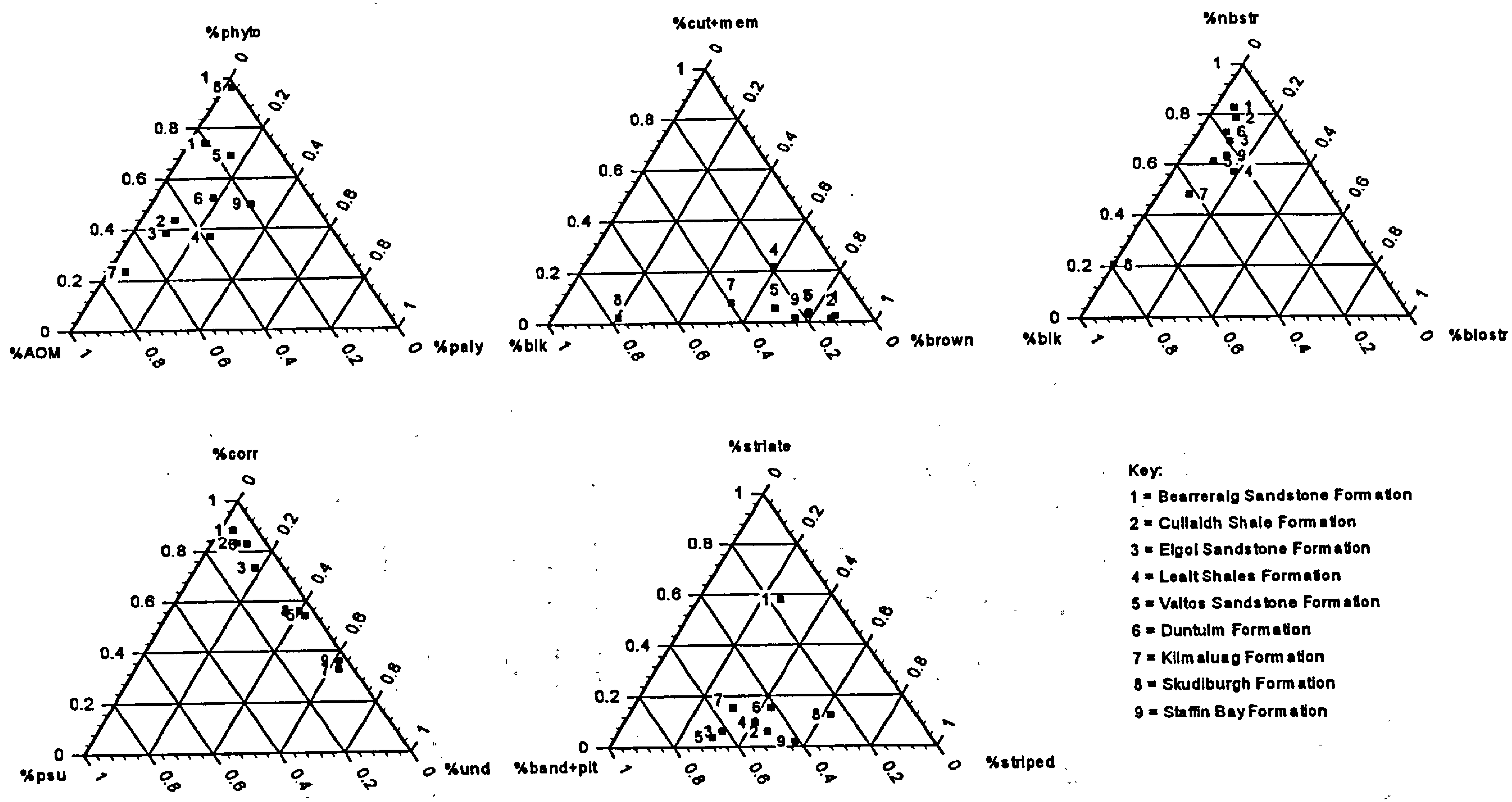


Fig. 5.3. *Mean percentages of the kerogen assemblage in each formation. Key to axes in Fig. 5.1.*

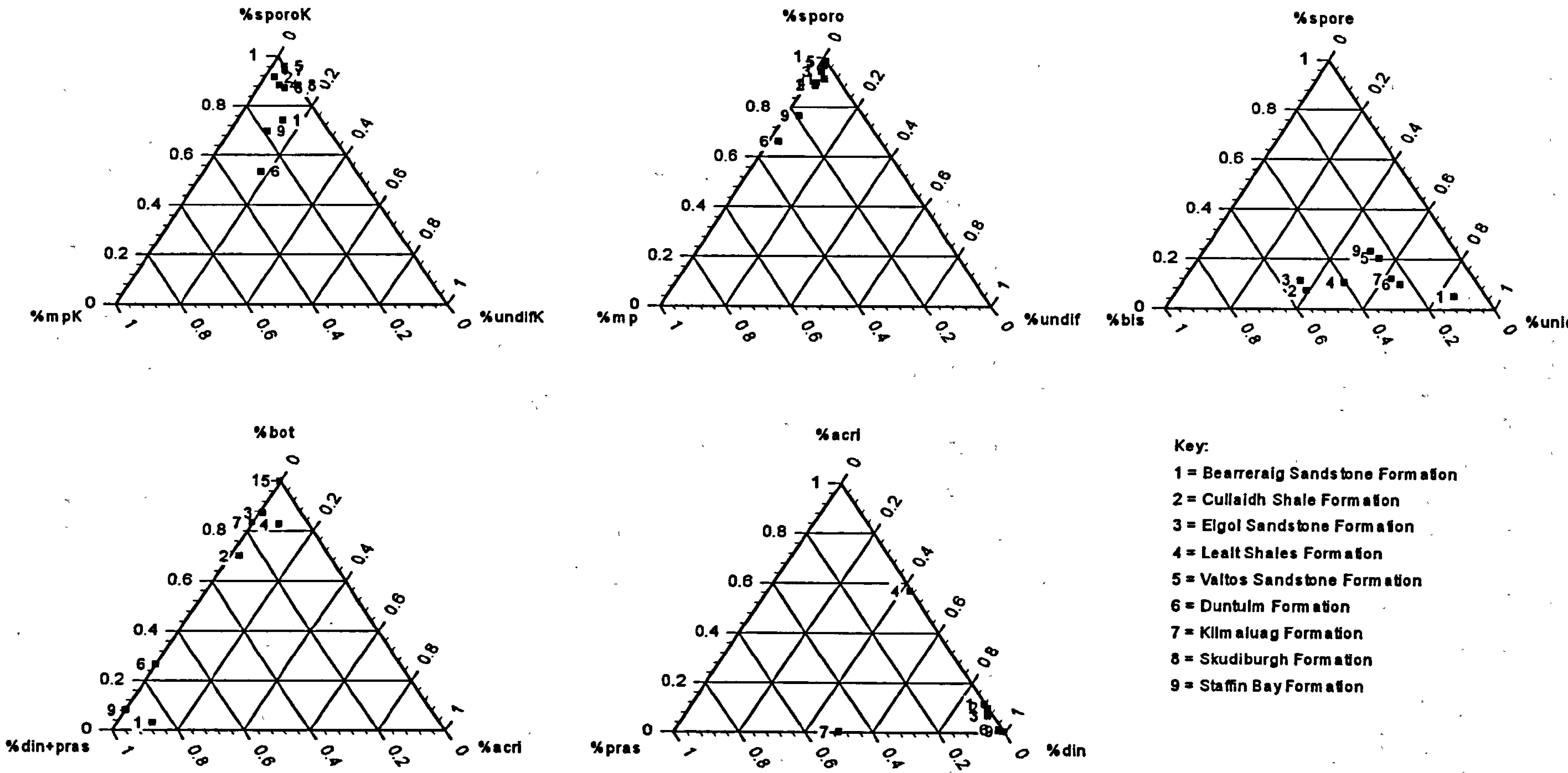


Fig. 5.4. *Mean percentages of the palynomorph assemblage in each formation. Key to axes in Fig. 5.2.*

The formations can be divided into two groups based on their dinocyst and *Botryococcus* levels: the Bearreraig, Duntulm, and Staffin Bay formations are dominated by dinocysts (although the Duntulm Formation does show increased *Botryococcus* levels), and the others are dominated by *Botryococcus*. The marine plankton assemblages are all dominated by dinocysts apart from the Lealt Shales Formation in which acritarch percentages are increased. Prasinophytes represent 50% of the assemblage in the Kilmaluag Formation, but this is misleading as it results from only one prasinophyte occurrence in a formation where marine plankton are generally absent!

5.2.3 Member

The members show most variation in terms of their total kerogen group parameters (Fig. 5.5). All the members of the Bearreraig Sandstone Formation show a similar phytoclast-dominated distribution apart from the ?Garantiana Clay Member which is AOM-dominated. The (upper) Lonfearn Member of the Lealt Shales Formation shows a 47% relative increase in %AOM compared to the (lower) Kildonnan Member. The increased phytoclast content of the Belemnite Sands Member of the Staffin Bay Formation (66% relative to the Upper Ostrea Member) presumably reflects its sandstone-dominated lithology. The constituent members of the Bearreraig Sandstone Formation show most variation in terms of their biostructured brown wood assemblages: the Dun Caan Shales Member is striate-dominated, the Udairn Shales and Holm Sandstone members have increased striped percentages, whilst the Dun Caan Shales (Raasay) and ?Garantiana Clay members are characterised by a dominance of banded and pitted material. The members of the Lealt shales Formation also show differences in terms of their *Botryococcus* and marine plankton content.

5.2.4 Environment and Salinity

In terms of the main kerogen parameters the majority of environment and ostracod-salinity categories are generally similar, being dominated by phytoclasts, but with significant contributions from AOM and palynomorphs (Figs. 5.6 & 5.8). Exceptions are the mudflat-alluvial category where the kerogen is made up almost completely of phytoclasts; phytoclast percentages are also increased in the open marine, supratidal and bar categories. Trends are identifiable in the salinity categories: the %palynomorphs increases (and %AOM decreases) as the salinity becomes more marine, and %AOM increases from the marine to freshwater in the lagoonal environment categories. The phytoclast assemblages are again dominated by brown

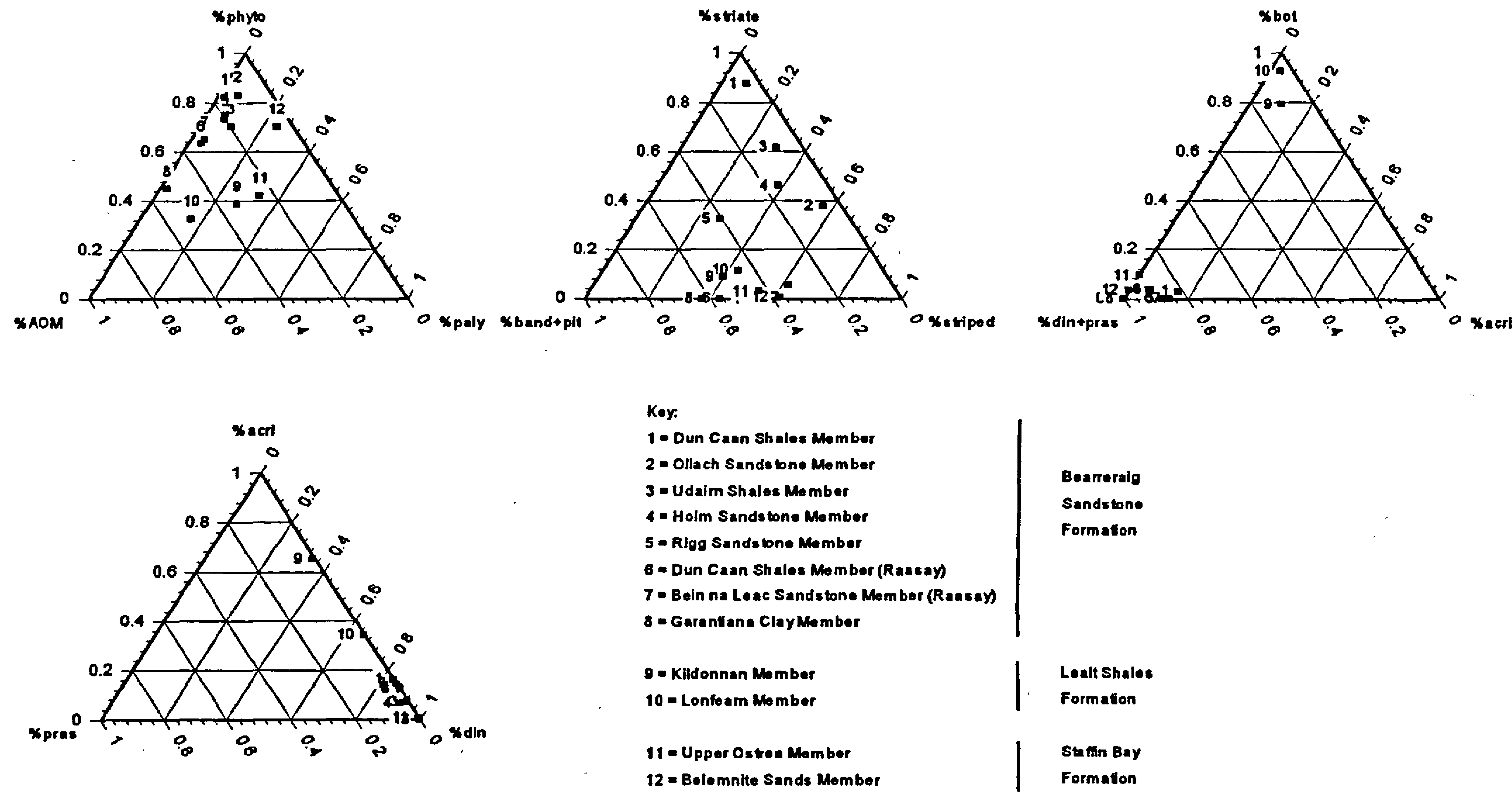


Fig. 5.5. *Mean percentages of selected components of the kerogen and palynomorph assemblages in each member examined. Key to axes in Figs. 5.1 and 5.2.*

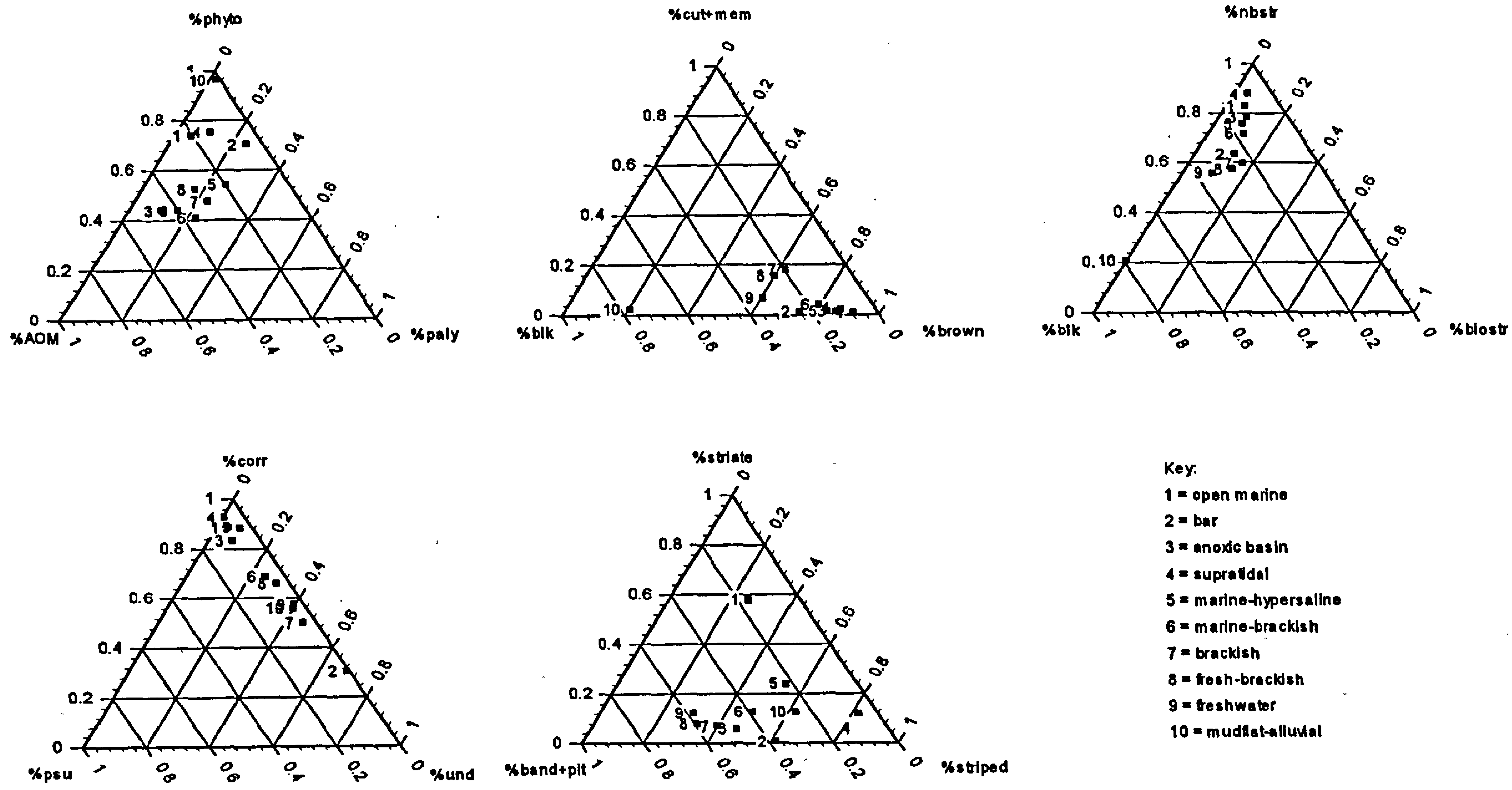


Fig. 5.6. *Mean kerogen percentages in each environment category, whole dataset. Key to axes in Fig. 5.1.*

wood, but the fresh-brackish environment category (and all three ostracod-salinity categories) shows increased %cuticle and membranes. Black wood dominates the mudflat-alluvial category, the mean percentage of this particle type is also somewhat increased in the freshwater environment category. Non-biostructured brown wood is again dominant, but there does appear to be an increase in black wood values from the marine to freshwater environment categories, which continues into the mudflat-alluvial category. Those environments most dominated by non-biostructured brown wood are characterised by particularly high levels of the corroded particles, where as undegraded mean percentages are increased in categories where black wood percentages also appear to be higher (generally). There is considerable variation within the biostructured brown wood fraction; the marine-hypersaline and mudflat-alluvial categories have a similar assemblage characterised by a dominance of striped particles, and there is a trend of increasing banded and pitted mean values as the environment category becomes less saline.

The majority of environments are sporomorph-dominated, but marine plankton are the dominant palynomorph in the marine-hypersaline category (Figs. 5.7 & 5.9). Marine plankton values decrease from this category to the freshwater category, the decrease being particularly marked (55% relative) between the marine-hypersaline and marine-brackish categories. The sporomorphs are dominated by pollen, and spores only exceed 20% in the bar category. Within the lagoonal environment categories the marine-hypersaline and freshwater environments are characterised by relatively high unidentified pollen, while the fresh-brackish and marine-brackish categories show increased bisaccate pollen mean percentages.

The marine-hypersaline and marine-brackish categories are dominated by dinocysts, but there is an increase in *Botryococcus* levels between these two categories of 20% (absolute), a trend which continues into the freshwater category. There is no similar trend in the ostracod-salinity categories. However, when the marine plankton components are compared, %dinocysts *decreases* by 55% in relative terms as the ostracod derived salinity increases, but this parameter decreases as the environment becomes more freshwater. Acritarch percentages are increased in the fresh-brackish environment category.

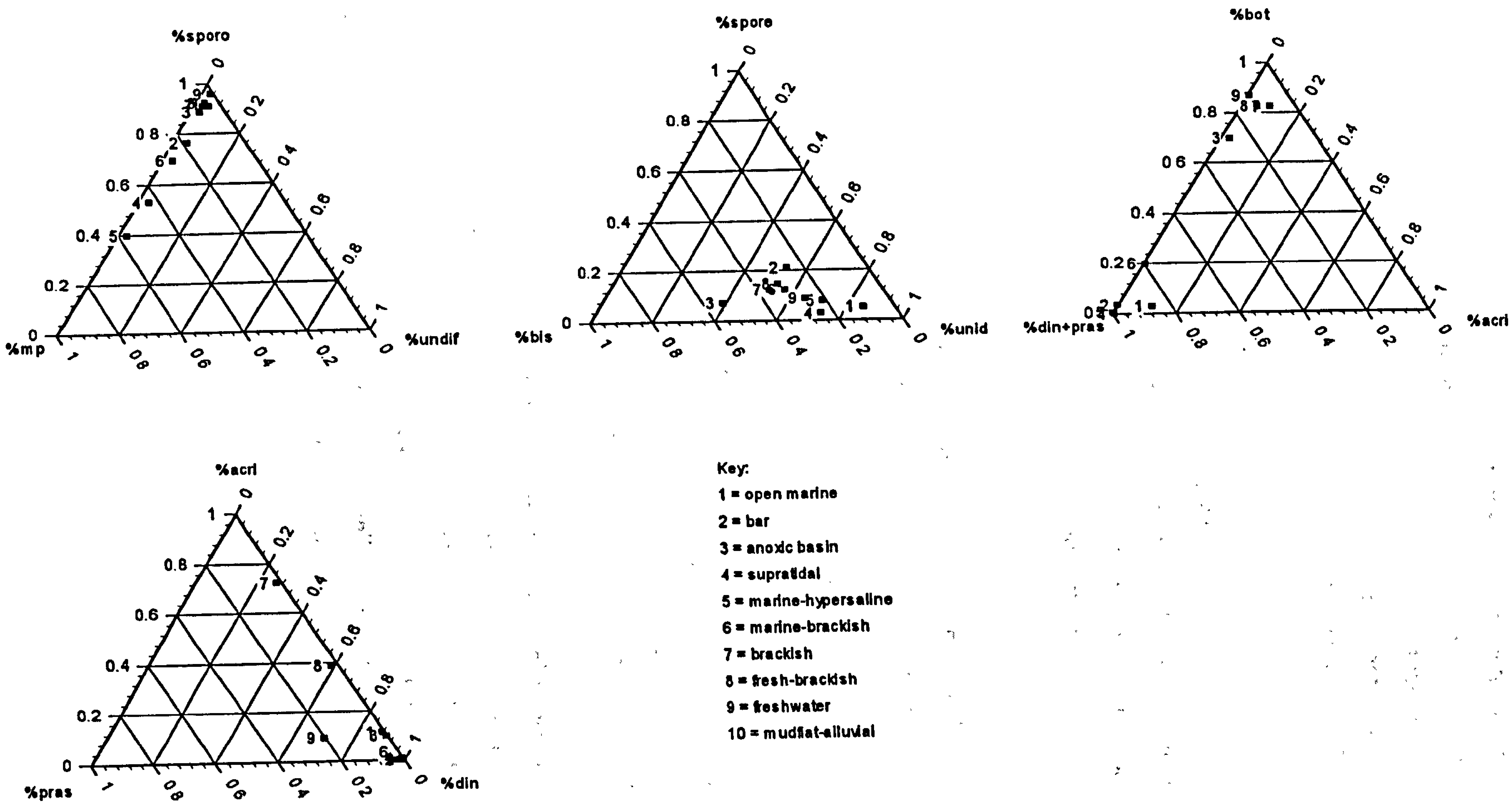


Fig. 5.7. *Mean percentages of the palynomorph assemblage in each environment category, whole dataset. Key to axes in Fig. 5.2.*

5.2.5 Proximal-Distal Trends and Lithofacies

The Bearreraig Sandstone Formation proximal-distal units and Duntulm Formation lithofacies are mostly phytoclast-dominated (Figs. 5.8 & 5.10); however, the argillaceous limestone lithofacies is palynomorph-dominated, and the *Praeexogyra* limestone-shales facies is similar to the majority of the Staffin Bay Formation lithofacies in having increased %AOM values. All the phytoclast assemblages are dominated by brown wood, but the argillaceous limestone lithofacies (Duntulm Formation) is characterised by an increase in %cuticle and membrane. Similarly, the brown wood is dominated by the non-biostructured component, and the argillaceous limestone lithofacies is again distinct, showing an increased mean %black wood. The majority of units are dominated by corroded (non-biostructured brown wood), but the Staffin Bay Formation lithofacies are characterised by increased undegraded percentages, particularly the argillaceous sands and muddy silts. Increased pseudoamorphous percentages characterise the distal unit of the Dun Caan Shales Member (Bearreraig Sandstone Formation). The biostructured brown wood assemblage is reasonably similar in most cases, but the argillaceous limestone and *Unio-Neomiodon* muds and sands lithofacies (both Duntulm Formation) show increased percentages of striate and banded and pitted particles respectively. Trends are visible in the proximal-distal subdivisions of the Bearreraig Sandstone Formation: increasing striped particles in the Dun Caan Shales Member, and increasing striped, banded and pitted particles in the Udairn Shales-Holm Sandstone members type section.

The majority of the units are sporomorph-dominated, but increased marine plankton percentages are found in the argillaceous limestone and *Praeexogyra* limestone-shales lithofacies (both Duntulm Formation; Figs. 5.9 & 5.11). The only other differences seen in the palynomorph assemblages are the increased spores contents of the Staffin Bay Formation lithofacies, and the increased *Botryococcus* percentages in the *Unio-Neomiodon* muds and sands lithofacies of the Duntulm Formation.

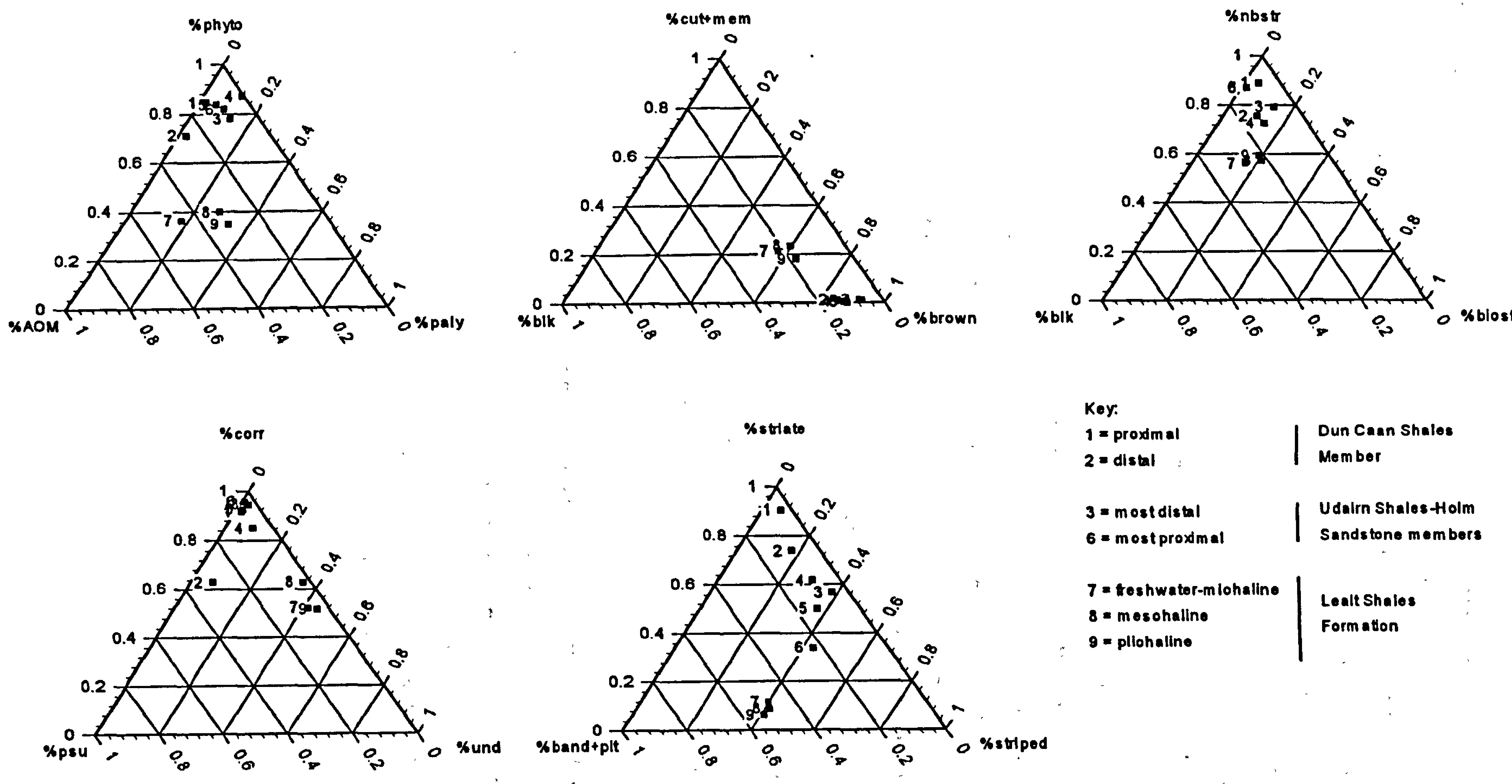


Fig. 5.8. *Mean percentages of the kerogen assemblage in the proximal-distal units of the Bearreraig Sandstone Formation, and the salinity units of the Lealt Shales Formation. Key to axes in Fig. 5.1.*

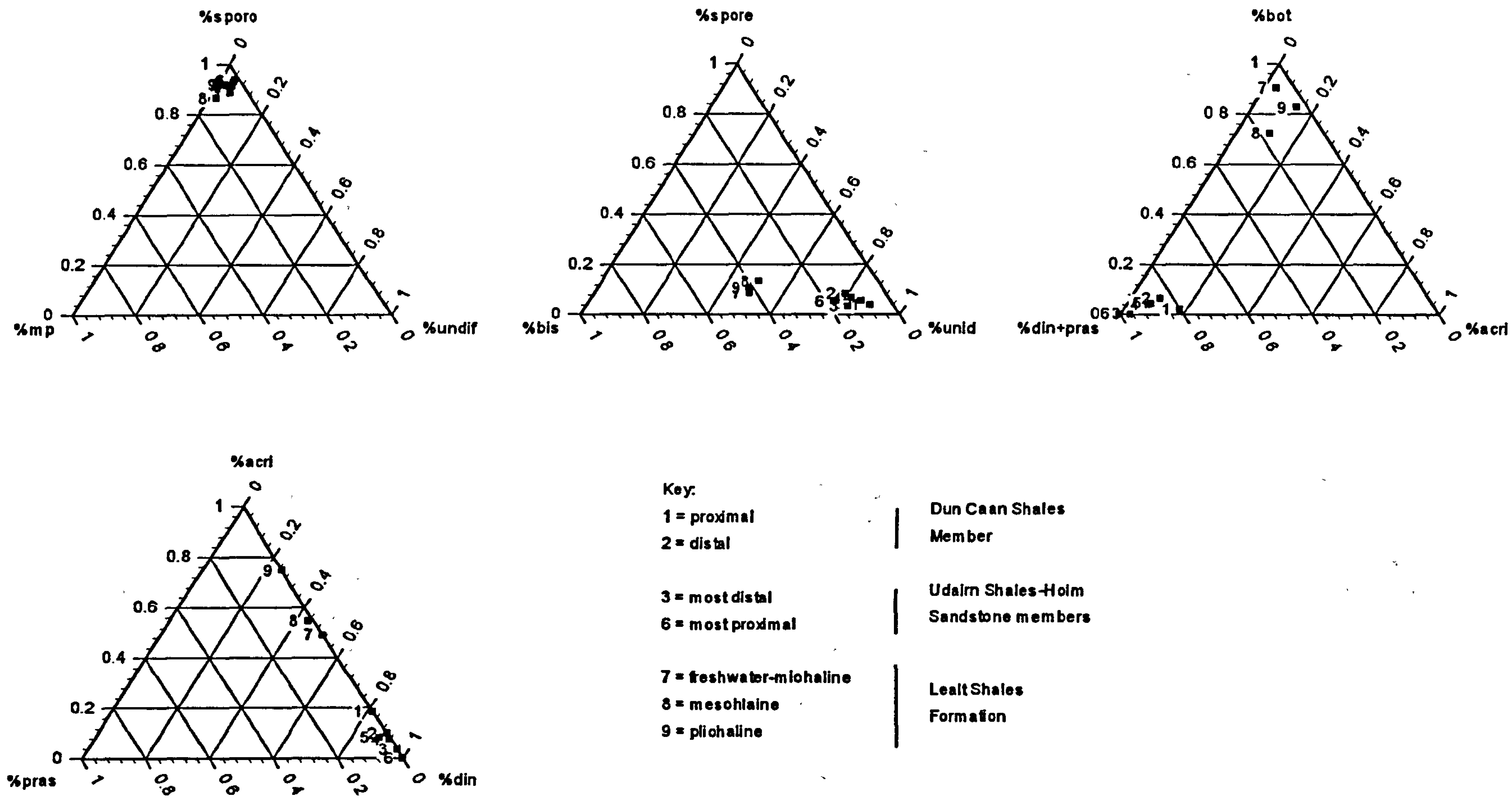


Fig. 5.9. *Mean percentages of the palynomorph assemblage in each proximal-distal unit of the Bearreraig Sandstone Formation, and each salinity unit of the Lealt Shales Formation. Key to axes in Fig. 5.2.*

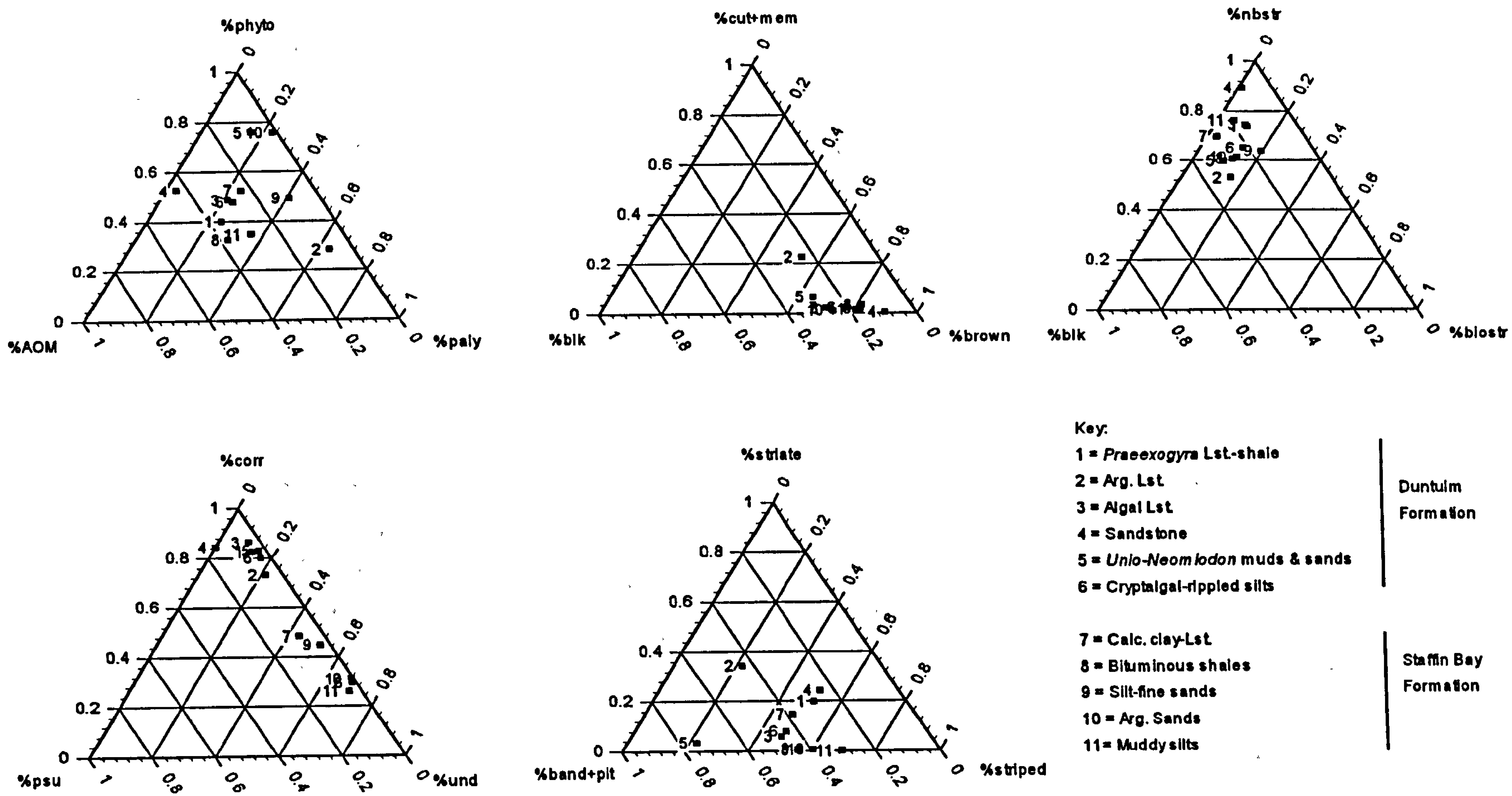


Fig. 5.10. *Mean percentages of the kerogen assemblage in each lithofacies of the Duntulm and Staffin Bay formations. Key to axes in Fig. 5.1.*

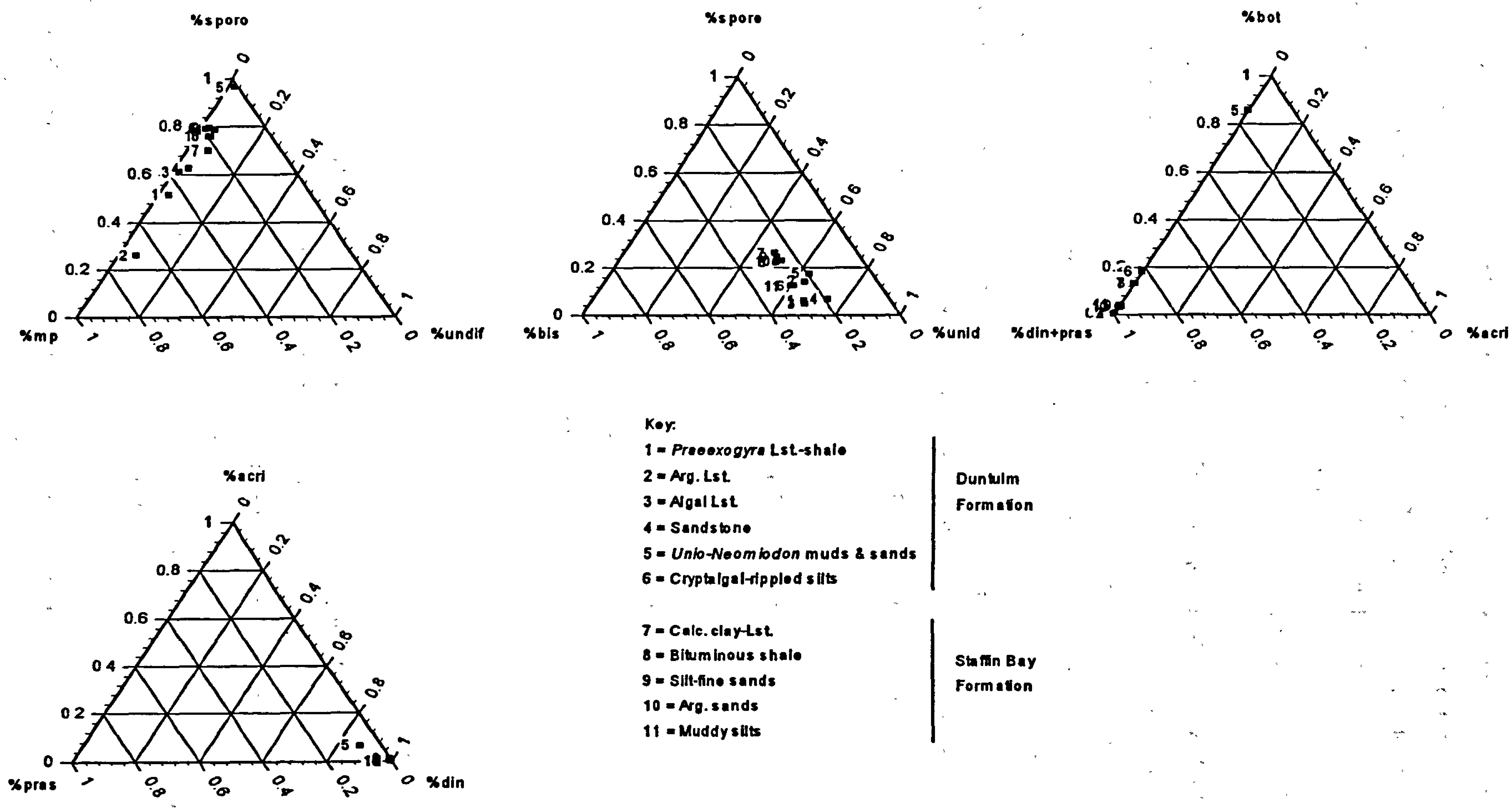


Fig. 5.11. *Mean percentages of the palynomorph assemblage in each lithofacies of the Duntulm and Staffin Bay formations. Key to axes in Fig. 5.2.*

5.2.6 Dinocyst Distributions in the Lagoonal Environments and Biofacies

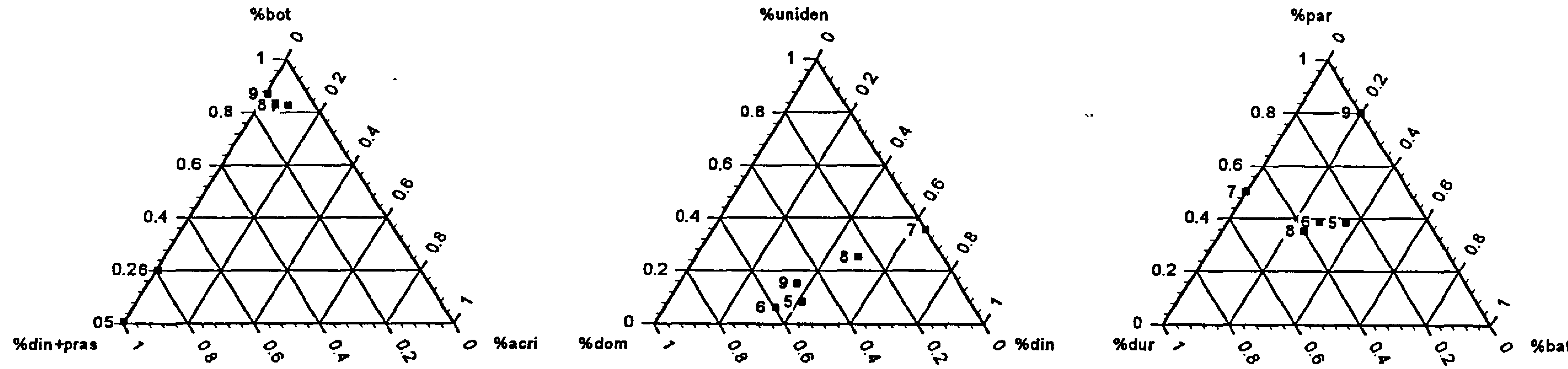
The lagoonal environment categories show similar dinocyst dominance values apart from the fresh-brackish and brackish categories which have significantly lower dominance values (Fig. 5.12). The diagram of the dinocyst taxa common to the lagoonal environments shows that the brackish category is characterised by a lack of *Batiacasphaera*; the freshwater category also shows a low value for this genus, and is instead dominated by *Pareodinia*.

Within the biofacies classification of the Duntulm Formation the 'oyster shell bank' and 'marine' communities are dominated by dinocysts; the 'algal marsh' community is also dominated by dinocysts, but shows slightly increased levels of *Botryococcus* (Fig. 5.13). The low salinity community is dominated by *Botryococcus*. Within the dinocyst taxa the major difference between the 'oyster shell bank' and 'marine' communities lies in the level of *Ctenidodinium*, which is 50% lower in relative terms in the latter compared to the former; the 'algal marsh' community is characterised by slightly increased levels of *Sentusidinium* and *Ctenidodinium*. The 'sandy lagoon' community is characterised by low levels of *Dissiliodinium*.

The biofacies of the Staffin Bay Formation are all almost completely dominated by dinocysts (Fig. 5.14). The percentage of *Batiacasphaera* is generally low, and this taxa is completely absent in the 'abundant *Cylindroteuthis*' biofacies, which is dominated by other gonyaulacacean dinocysts. The main difference between the 'monotypic *Neomiodon*' and '*Neomiodon* and others' biofacies lies in the proportion of *Adnatosphaeridium* and *Rhychodiniopsis* which is 12% (absolute) higher in the latter.

5.3 Summary

The whole dataset means suggest a phytoclast-dominated setting, with the phytoclast assemblage dominated by corroded non-biostructured brown wood. The palynomorph assemblage is dominated by the sporomorph component, which is in turn dominated by pollen. Comparison of the formations shows that all are mostly phytoclast-dominated, particularly those with sandstone-dominated lithologies; only the Kilmaluag Formation is characterised by increased %AOM. Palynomorph mean percentages are increased in the three main lagoonal formations; two of these, the Duntulm and Staffin Bay formations, contain significant mean percentages of marine plankton, while the Lealt Shales Formation is characterised by high mean percentages of *Botryococcus*.

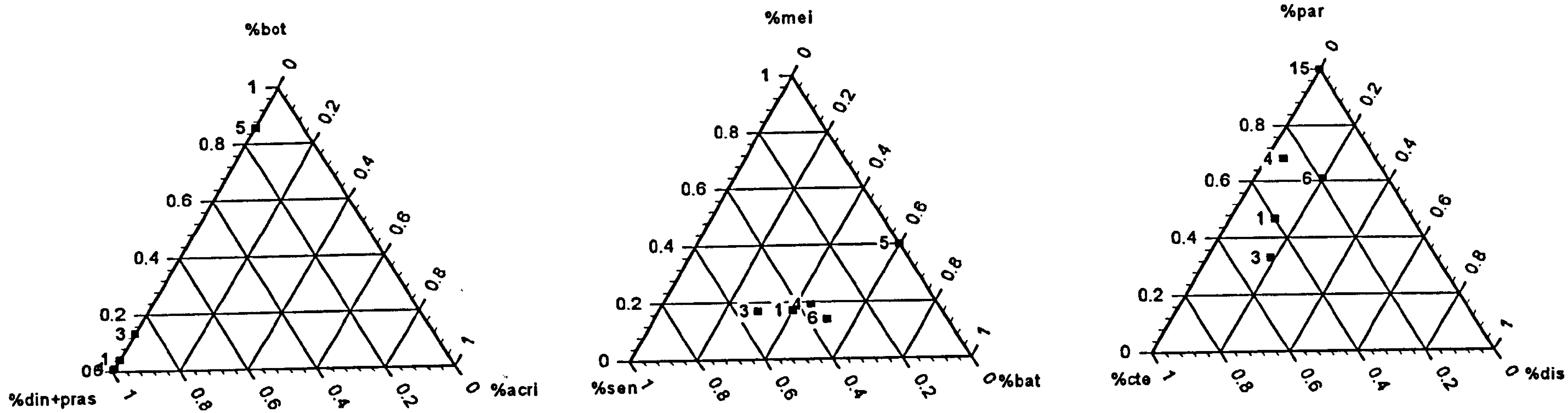


Key:

5 = marine-hypersaline
6 = marine-brackish
7 = brackish
8 = fresh-brackish
9 = freshwater

acri = acritarchs
din = dinocysts
pras = prasinophytes
bot = *Botryococcus*
dom = dinocyst dominance
unident = unidentified dinocysts
bat = *Batiacasphaera*
dur = *Durotrigia*
par = *Pareodinia*

Fig. 5.12. *Mean percentages of the dinocyst taxa in each lagoonal environment category of the whole dataset.*

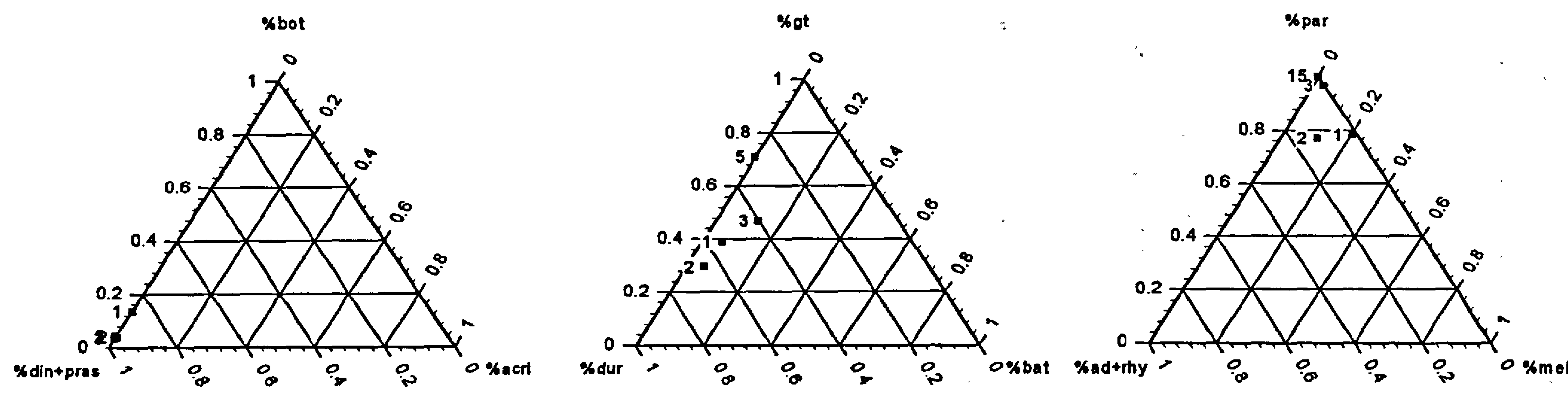


Key:

1 = oyster shell bank
3 = algal marsh community
4 = sandy lagoon community
5 = low salinity community
6 = marine community

acri = acritarchs
din = dinocysts
pras = prasinophytes
bot = *Botryococcus*
bat = *Batiacasphaera*
sen = *Sentusidinium*
mei = *Meiurogonyaulax*
par = *Pareodinia*
dis = *Dissiliodinium*
cte = *Ctenidodinium*

Fig. 5.13. *Mean percentages of the dinocyst taxa in each biofacies of the Duntulm Formation.*



Key:

1 = Monotypic *Neomiodon*
2 = *Neomiodon* and others
3 = *Neomiodon-Pleuromya*
5 = abundant *Cylindroteuthis*

acri = acritarchs
din = dinocysts
pras = prasinophytes
bot = *Botryococcus*
bat = *Batiacasphaera*
dur = *Durotrigia*
gt = other gonyaulacacean type
par = *Pareodinia*
mel = *Meiurogonyaulax*
ad = *Adnatosphaeridium*
rhy = *Rhychodiniopsis*

Fig. 5.14. *Mean percentages of the dinocyst taxa in each biofacies of the Staffin Bay Formation.*

The environment categories are again mostly dominated by phytoclasts, but there is an increase in the %AOM from the more marine to the more freshwater categories. In general the palynomorph distributions reflect the palaeosalinity variations suggested by the environments: the marine-hypersaline and marine-brackish categories being dominated by dinocysts, and the freshwater categories being characterised by increased mean *Botrycoccus* percentages.

The kerogen distributions in the lithofacies and proximal-distal units generally reflect the differences in the mean values of the formations in which they occur, although there are differences. For example, the argillaceous limestone lithofacies of the Duntulm Formation is characterised by high cuticle and membrane percentages, and the distal unit of the Dun Caan Shales Member by an increased mean pseudoamorphous percentage.

The dinocyst distributions within the environment and biofacies classifications show significant differences in the occurrence of the dinocysts. The dinocyst taxa may be used to distinguish between the biofacies units.

CHAPTER 6.0
ORGANIC GEOCHEMISTRY

6.0 ORGANIC GEOCHEMISTRY

6.1 Methods

6.1.1 Total Organic Carbon

Total Organic Carbon (TOC) was determined on a LECO WR12 device using the decarbonated residue of 100mg of powdered sample. The analytical error of each measurement is ± 0.05% absolute; the reproducibility of each measurement is ± 0.1% of the %TOC value (B.Jones, pers. comm. 1995).

6.1.1 (a) Introauction

The abundance of organic matter in sediments is usually expressed as the relative percentage of organic carbon on a dry weight basis; the value for ancient shelf shales generally falls between 0.7 and 2.2% (Tyson, 1995). This technique provides a simple measure of the organic matter content of sediments, but there are problems with the interpretation of TOC data which need to be considered. The main problem is that of dilution; because TOC is expressed as a relative percentage, it depends not only on the supply and preservation of organic matter but also on the supply and preservation of siliciclastic and biogenic material (Tyson, 1995). Also, geochemically significant changes in the organic matter may not be represented by a change in the TOC, particularly in phytoclast-dominated settings where the metabolisable fraction represents only a minor constituent (Tyson, 1995). However, despite these problems TOC% is widely used as the analyses are simple and fast to carry out and give a good starting point for further organic geochemical methods, and can also provide an extra element of quantification to palynofacies studies when combined with percentage abundance data (section 6.1.1 d).

6.1.1 (b) TOC and Sediment Granulometry

The organic content of sediments correlates best with the percentage 'mud' (silt and clay), and has an inverse correlation with the sand:mud ratio. This is partly due to hydrodynamic effects (most organic matter equates with clay-silt) but also may be because of the increased oxidation potential of organic matter in porous and permeable material. Post-depositional oxidation potential is reduced dramatically in argillaceous and silty sands due to the finer grains blocking the pores (Tyson, 1995).

6.1.1 (c) TOC and Organic Matter Type

Correlation between TOC and grain size depends partly on the organic matter type and the hydrodynamic equivalence of the particles (Tyson, 1995). Hennessee *et al.* cited *in* Tyson (1995) show that in those areas of Chesapeake Bay where terrestrial organic matter is dominant TOC has a positive relationship with the silt content of the sediment, but where phytoplankton derived marine organic matter is dominant, TOC is correlated with clay content. A similar relationship is reported by Frank and Tyson (1995) who found that the positive relationship between silt and TOC content was presumably due to the hydrodynamic equivalence (and common fluvial source) of phytoclasts and silt particles. In coarser grained sediments with high relative percentages of large phytoclasts the TOC content reflects the low absolute abundance of refractory organic matter (Tyson, 1995).

In siliciclastic shelf settings TOC values of less than 2-3% are usually associated with phytoclast-dominated kerogen assemblages, where the TOC content is largely determined by variations in absolute phytoclast abundance (input + dilution). Sediments with TOC > 2-3% are often dominated by phytoplankton-derived AOM, with the TOC determined by a combination of dilution, productivity and preservational factors (Table 6.1). Maximum TOC values usually occur in lagoonal/estuarine settings on the inner shelf, and on the upper slope of the outer shelf, and do not usually exceed 5% or 3% respectively, unless anoxic conditions have been developed (Tyson, 1995).

6.1.1 (d) The 'Phytoc' Parameter

This parameter, first described by Tyson (1989), can be used to give an idea ot absolute abundance trends in phytoclast abundance on a whole rock basis by combining TOC and the percentage of phytoclasts in the kerogen assemblage. It is defined as:

Phytoc = %TOC x (%relative numeric frequency of phytoclast materials/100)

It should be noted that the parameter is not corrected for particle size or density, and that different kerogen types contain different percentages of carbon, e.g. black wood is very carbonaceous, so relatively small amounts can give relatively high TOC% values (Tyson, 1989). Also the parameter is affected by dilution-dependent variations in TOC.

1)	Sediment Texture
2)	Water Depth
3)	Primary Productivity
4)	Rate of Terrestrial vs. Marine Organic Matter Supply
5)	Rate of Sediment Accumulation
6)	Bottom Water Oxygenation

Table 6.1. *Controls on TOC (adapted from Tyson 1987, 1995 and references therein).*

The absolute amount of woody material input into a system is related to the proximality of the fluvial source; Mesozoic distal shelf facies thus have relatively low phytoc values, typically <1.0, but values can exceed 4.0 in anoxic facies (Tyson, 1989; Dybkjær, 1991).

6.1.2 Rock-Eval Pyrolysis

Whole rock pyrolysis analyses were made by programmed ('Rock-Eval') pyrolysis using a LECO THA200 device; for more details on the technique see Peters (1986) and Bordenave *et al.* (1993).

6.1.2 (a) Pyrolysis Parameters

S_1 — Free hydrocarbons, oil and gas originally present in the organic matter, expressed as mg HC/g of rock; analytical error ± 10% (Bordenave *et al.*, 1993).
S_2 — Hydrocarbons derived mostly from primary cracking of the kerogen (also heavy hydrocarbons, resins and asphaltenes), the total amount of oil and gas produced during complete thermal maturation in an open system, expressed as mg HC/g rock; analytical error ± 10% (Bordenave *et al.*, 1993). Values > 5 and > 10 mgHC/g rock are considered to represent good and very good source rock potential respectively (Peters, 1986).
T_{max} — Temperature corresponding to the maximum of the S_2 peak, expressed in °C, analytical error ± 1°C (Bordenave *et al.*, 1993). Reflects maturity and organic matter type.
Hydrogen Index — (S_2 / %TOC) x 100, expressed as mg HC/gTOC; used to determine kerogen Type, source and preservation state (Table 6.2).
Production Index — $S_1/(S_1+S_2)$ x 100. Increases due to cracking of kerogen, and to a lesser extent to both thermal vaporisation and cracking of asphaltenes causing the S_2 peak to be transformed to S_1; ranges from 5% to a maximum of 60%, when almost all hydrocarbons have been transformed (Bordenave *et al.*, 1993).

Kerogen Type	Hydrogen Index	Character and source
Type I	700-900	Selective accumulation of algal or cyanobacterial material, sometimes recognisable (e.g. *Botryococcus*, *Tasmanites*) but dominated by AOM.
Type II	250-700	Mixed autochthonous organic matter (derived from phyto-, zooplankton, and micro-organisms) deposited under reducing conditions (Tissot & Welte, 1984). Kerogen assemblages characterised by well preserved AOM with a variable terrestrial component (Tyson, 1995).
Type III	25-250	Derived from macrophyte plants; kerogen assemblages typically dominated by phytoclast material, but can also be degraded AOM.
Type IV	0-50	Derived from macrophyte plants, kerogen assemblages characterised by large amounts of oxidised opaque phytoclasts, together with some identifiable higher plant remains.

Table 6.2. *Kerogen Type characteristics (modified after Tyson, 1995). The Hydrogen Index ranges are approximate only, and are strongly influenced by maturity and preservation. The values indicated are for well to moderately preserved immature kerogens.*

6.1.2 (b) Introduction

Rock-Eval pyrolysis is the one of the standard petroleum industry organic geochemical screening methods; when combined with TOC data it allows the identification of potential source rocks and gives an idea of their quality. As is the case with TOC analyses, Rock-Eval pyrolysis is quick and easy to carry out, but there are also problems which must be addressed when interpreting the data. Peters (1986, p.321) states that 'Proper interpretation of Rock-Eval and TOC data requires information on lithologies, the relative abundances of OM and the mineral matrix, well conditions, the presence or lack of generated hydrocarbons, pyrograms, and geochemical logs'. The main problem with Rock-Eval analyses performed on whole rock material is the 'mineral matrix effect', whereby kerogen-derived hydrocarbons are adsorbed onto the surfaces of clay minerals, reducing the S_1 and S_2 values (and consequently the Hydrogen Index) and increasing the T_{max} (Orr, 1981; Katz, 1983; Peters, 1986; Tyson, 1995; cf. Bordenave *et al.*, 1993, p.244, their Fig. 2-16). Problems can also occur when the rock is particularly organic lean (e.g. $\leq$ 0.3% TOC) as the values of the parameters can approach the potential analytical errors, i.e. at 0.3% TOC the T_{max} becomes unreliable, 0.3 mg HC/g rock for the S_2 (Bordenave *et al.*, 1993).

6.1.2 (c) Kerogen Type

The number of variables involved in the determination of natural kerogen assemblages (e.g. variations in source, maturation, weathering) means that there is a gradational relationship between the four kerogen Types that were defined using atypically pure end member compositions as clear groups (Tyson, 1995; Table 6.2). In this study the kerogen Type has been defined by the Hydrogen Index and cross-plots of the S_2 parameter with TOC using the approach of Langford and Blanc-Valleron (1990). The kerogen Type is defined by plotting Type I/II and II/III lines on the graph which correspond to HI's of 700 and 200 respectively, this allows a more certain assignation of kerogen type than with other methods where the natural mix of components results in uncertain Type I/II or II/III boundaries (Langford & Blanc-Valleron, 1990). Rock matrix adsorption, and/or a 'dead carbon effect' (due to H-poor, TOC-rich inertinitic organic matter) is indicated by a positive intercept of the regression line on the *x*-axis, the larger the intercept value the greater the effect (Langford & Blanc-Valleron, 1990). The true average HI is given by the slope of the S2 vs. TOC regression line.

6.1.3 Organic Facies

The organic facies approach defined by Jones (1987) is probably more realistic than kerogen Type in attempting to classify different kerogen assemblages as it takes into account the fact that the assemblages are controlled by preservational factors as well as their source, and that changes between assemblages are often gradational (Tyson, 1995; Table 6.3). It takes an integrated approach combining bulk organic geochemical (elemental analysis or Rock-Eval pyrolysis) and microscopical techniques (transmitted and reflected light). Tuweni and Tyson (1994) consider that TOC and pyrolysis combined with palynofacies analyses provides an excellent means of characterising organic facies.

The three main divisions are into anoxic-dysoxic (A, AB, B, BC), proximal fluvio-deltaic to prodeltaic-oxic shelf (C, CD), and distal slowly deposited, oxic facies (D) (Tyson, 1995).

Organic Facies (immature)	Description	Palynofacies characteristics
A HI > 850 TOC 5-20%	Rare; well laminated; organic-rich; usually lacustrine; persistant bottom water anoxia; recognisable terrestrial OM input negligible.	AOM dominant; phytoclasts low; black:brown ratio high; often rich in prasinophytes if marine or chloroccocales if lacustrine.
AB HI 650-850 TOC 3-10%	Laminated; organic-rich; OM almost all algal/bacterial; persistent anoxic water column.	As above.
B HI 400-650 TOC 3-10%	Laminated-well bedded; higher percentage of terrestrial and residual OM than AB; often fluctuating bottom water anoxia; often interbedded with less oil-prone facies.	As above, but, dinocysts dominant planktonic organic-walled microplankton.
BC HI 250-400 TOC 3+/-1	Oxic water column; rapid deposition creates post-depositional anoxia; OM mixed partially biodegraded terrestrial and algal material.	Moderate AOM; moderate phytoclasts; black:brown ratio usually low; dinocysts dominant planktonic organic-walled microplankton.
C HI 125-250 TOC 3+/-1	OM dominated by variously oxidised terrestrial OM.	AOM low/absent; phytoclasts dominant; black:brown ratio usually low; this facies can also be dominated by partly oxidised (non-fluorescent) AOM.
CD HI 50-125 TOC<0.5	Moderate-well oxidised terrestrial OM; substantial residual OM	AOM low/absent; phytoclasts dominant; increasing black:brown ratio; this facies can also be dominated by partly oxidised (non-fluorescent) AOM.
D HI < 50 TOC<0.5	Highly oxidised or redeposited residual OM	As above

Table 6.3. *Organic facies (after Jones, 1987 and Tyson, 1995).*

6.2 TOC and Phytoc Results

The mean TOC value for the whole dataset is 1.5%, but, the modal value is 0.5-1.0%. The vast majority of cases have TOC values of less than 3%; less than twenty samples exceed this value (Fig. 6.1).

6.2.1 Lithology

6.2.1 (a) Gross Lithology

The mean TOC value (Fig. 6.2) shows a progressive decrease of 70% in relative terms from shales to limestones; the mean phytoc value is at its maximum in the silts category, then shows a progressive decrease to the limestones.

6.2.1 (b) Sample Lithology

Figure 6.3 shows that within the sample lithology classification the mean TOC and Phytoc values show a similar pattern to that indicated for gross lithology.

6.2.1 (c) The Effect of Organic Matter Type

When only those samples dominated by AOM (≥50%) are included (Fig. 6.4) the highest mean TOC value is found in the shale category (40% greater in relative terms than the silty shales), and the mean value in the other lithologies is less than 0.5%. When only the phytoclast-dominated samples are included (Fig. 6.5) the silt category shows the maximum TOC (1.7%) and relatively increased TOC values are found in all the sand- and silt- dominated categories; the value for silty shale is 14% greater in relative terms than that for shale. This suggests that when AOM is dominant increased TOC values are correlated with clay-rich lithologies (shale), but when phytoclasts are dominant, increased TOC values are correlated with silt- and sand-rich lithologies (cf. Hennessee *et al.*, 1986 *in* Tyson, 1995). The higher mean TOC found in phytoclast-dominated silty shales may be partly due to autochthonous organic matter, as the potential for preserving this material is still relatively high in this category.

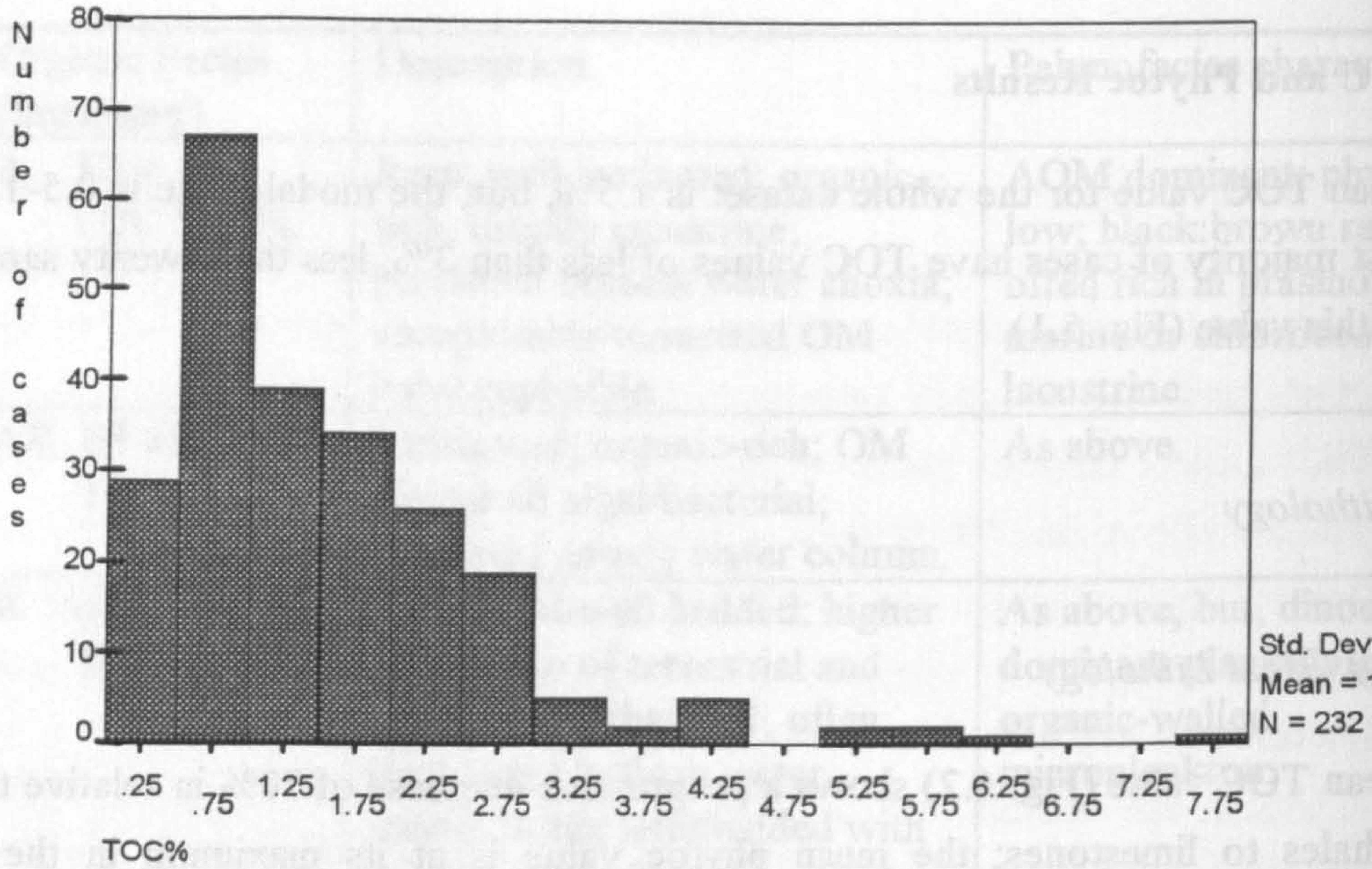


Fig. 6.1. *TOC frequency histogram for the whole dataset.*

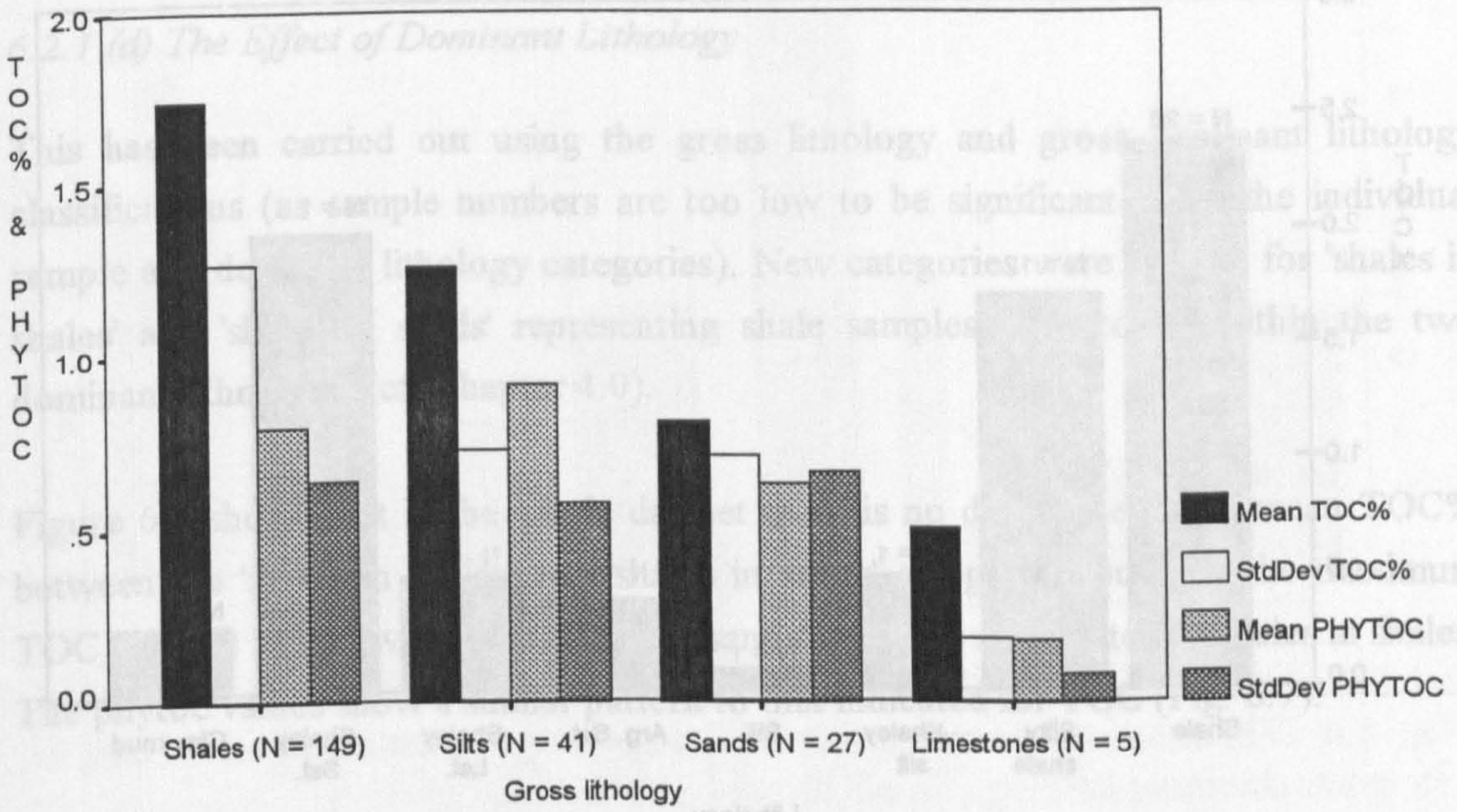


Fig. 6.2. *Mean TOC and phytoc values in each gross lithology category of the whole dataset. (N = number of samples).*

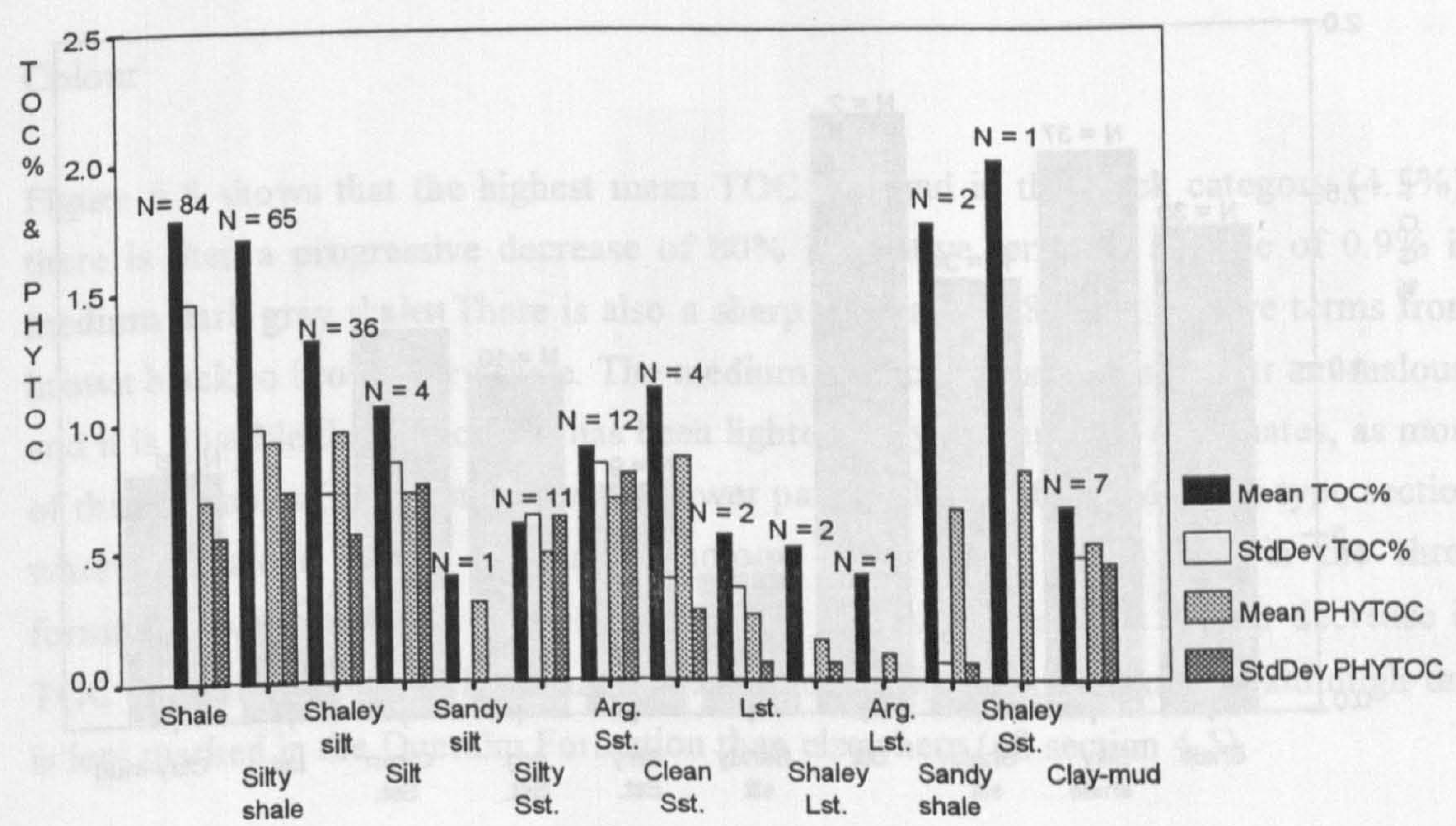


Fig. 6.3. *Mean TOC and phytoc values in each sample lithology category of the whole dataset. (N = number of samples).*

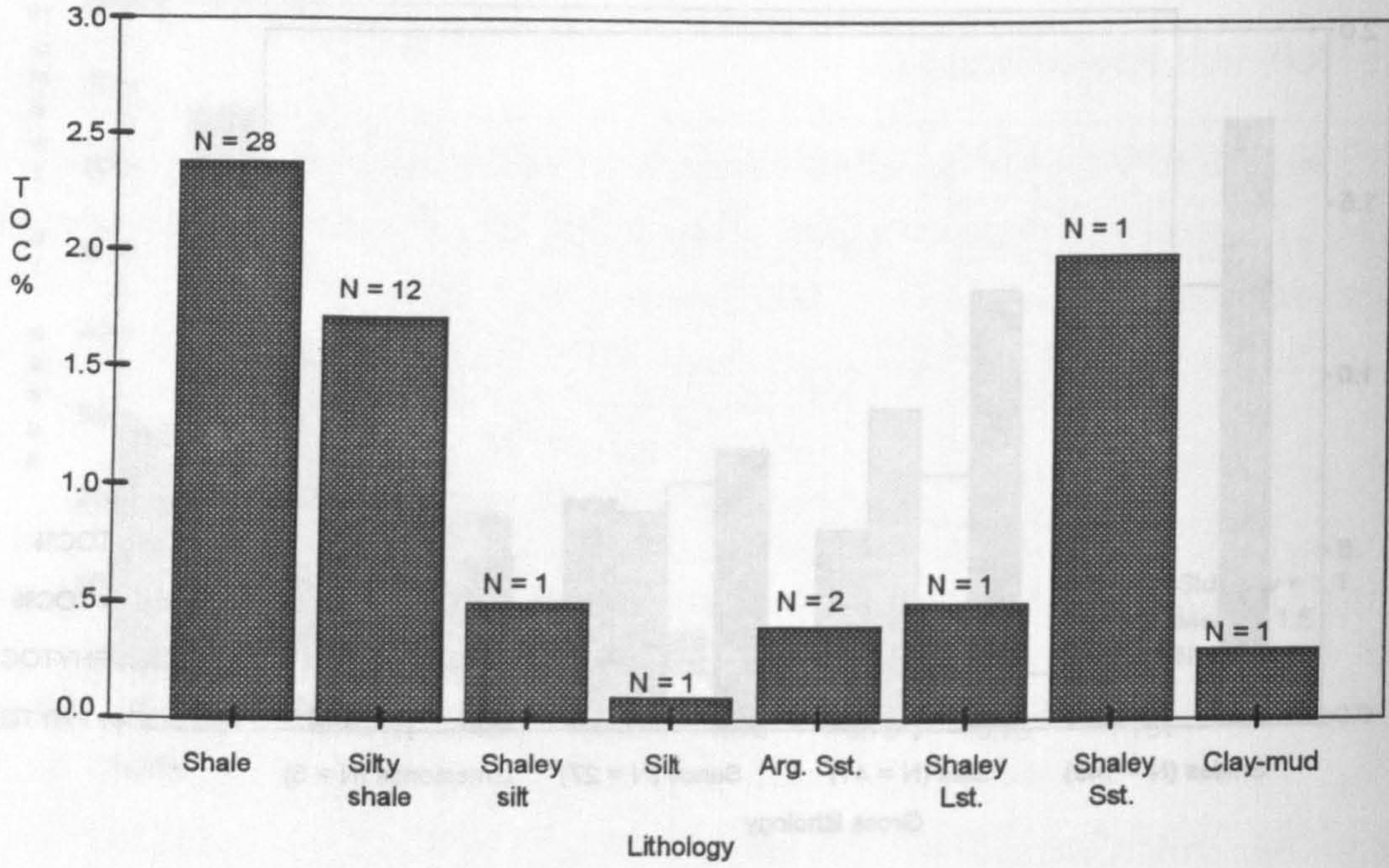


Fig. 6.4. *Mean TOC value in each lithology category of the whole dataset when only those samples with > 50% AOM are included. (N = number of samples).*

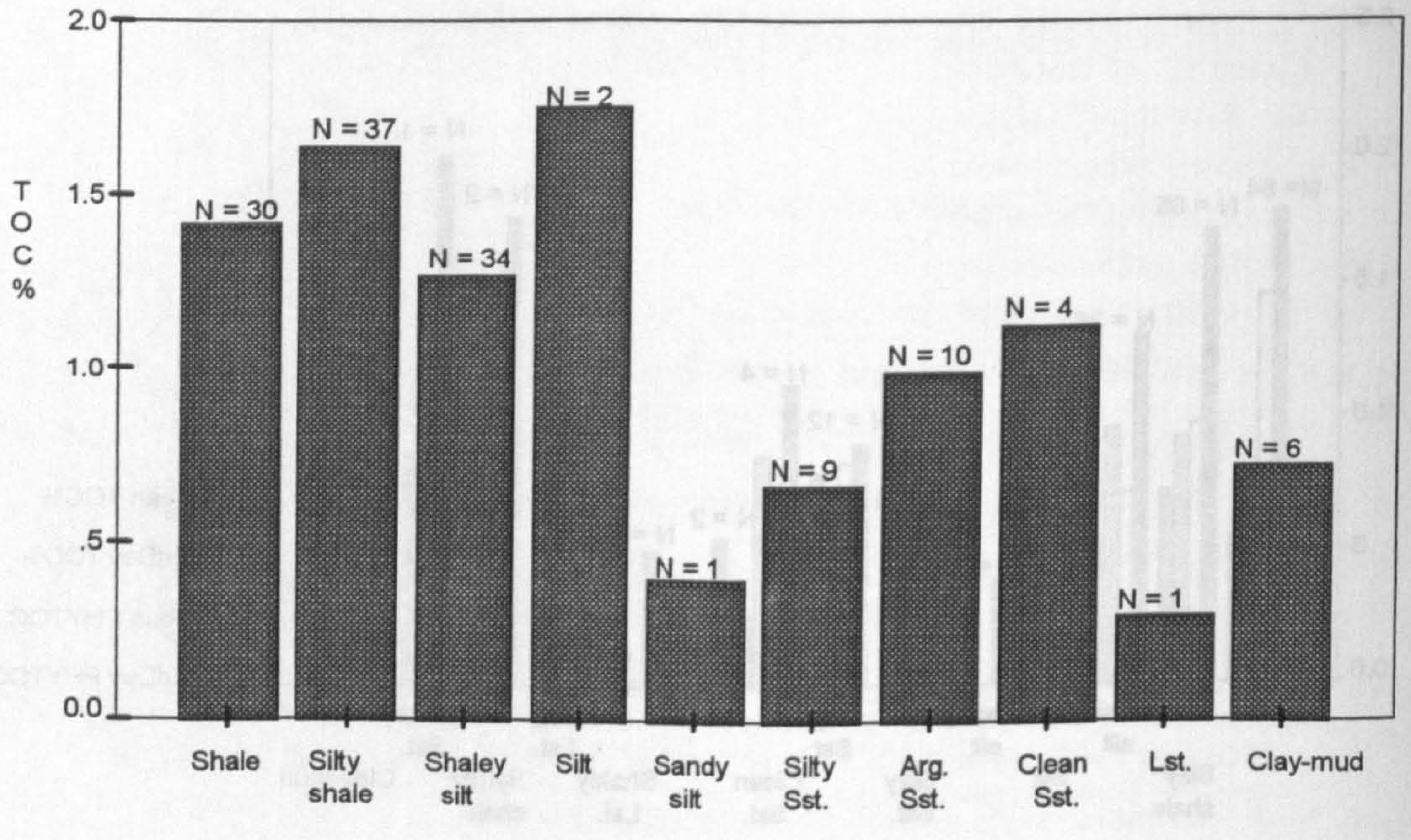


Fig. 6.5. *Mean TOC value in each lithology category of the whole dataset when only those samples with > 50% phytoclasts are included.*

6.2.1 (d) The Effect of Dominant Lithology

This has been carried out using the gross lithology and gross dominant lithology classifications (as sample numbers are too low to be significant using the individual sample and dominant lithology categories). New categories were created for 'shales in shales' and 'shales in sands' representing shale samples interbedded within the two dominant lithologies (cf. Chapter 4.0).

Figure 6.6 shows that in the whole dataset there is no difference in the mean TOC% between the 'shales in shales' and 'shales in sands' categories, but that the maximum TOC value is 30% lower in the 'shales in sands' category relative to the shales in shales. The phytoc values show a similar pattern to that indicated for TOC (Fig. 6.7).

6.2.1 (e) The Effect of Shale Characteristics

These analyses have been carried out using only those samples which have a shale sample lithology.

Colour

Figure 6.8 shows that the highest mean TOC is found in the black category (4.5%); there is then a progressive decrease of 80% in relative terms to a value of 0.9% in medium dark grey shale. There is also a sharp decrease of 87% in relative terms from brown black to brown grey shale. The medium grey colour samples appear anomalous, and it is possible that the colour has been lightened by mixing with carbonates, as most of these samples (3/4) come from the lower part of the Lonfearn Member type section where limestone is the dominant lithology. Figure 6.9 shows that in the three formations which contain significant numbers of shales, there is a similar decrease in TOC from the darkest colour shales present to the lighter grey samples, although this is less marked in the Duntulm Formation than elsewhere (cf. section 4.5).

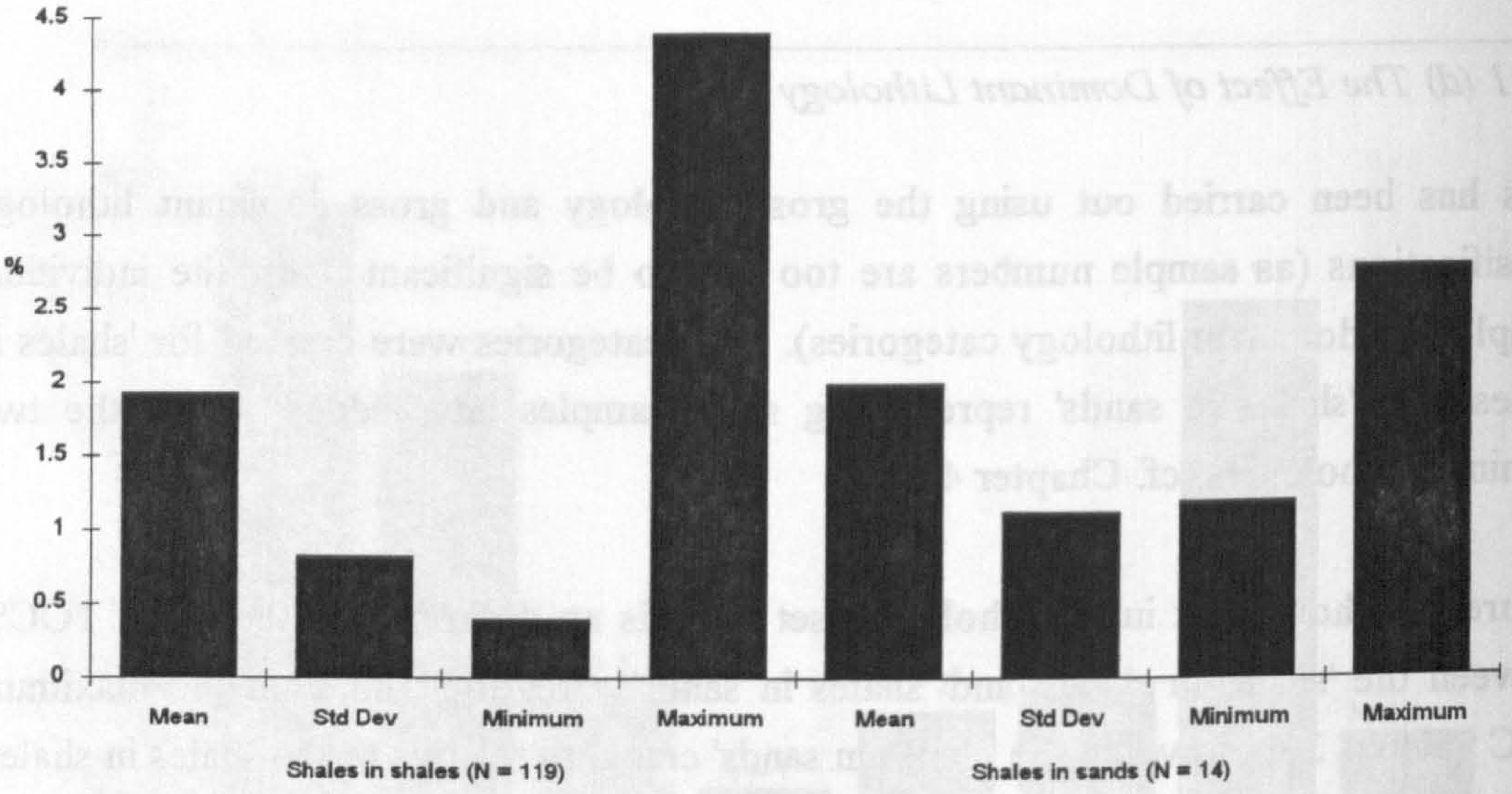


Fig. 6.6. *TOC values in the shales gross lithology category subdivided according to the gross dominant lithology, whole dataset. (N = number of cases).*

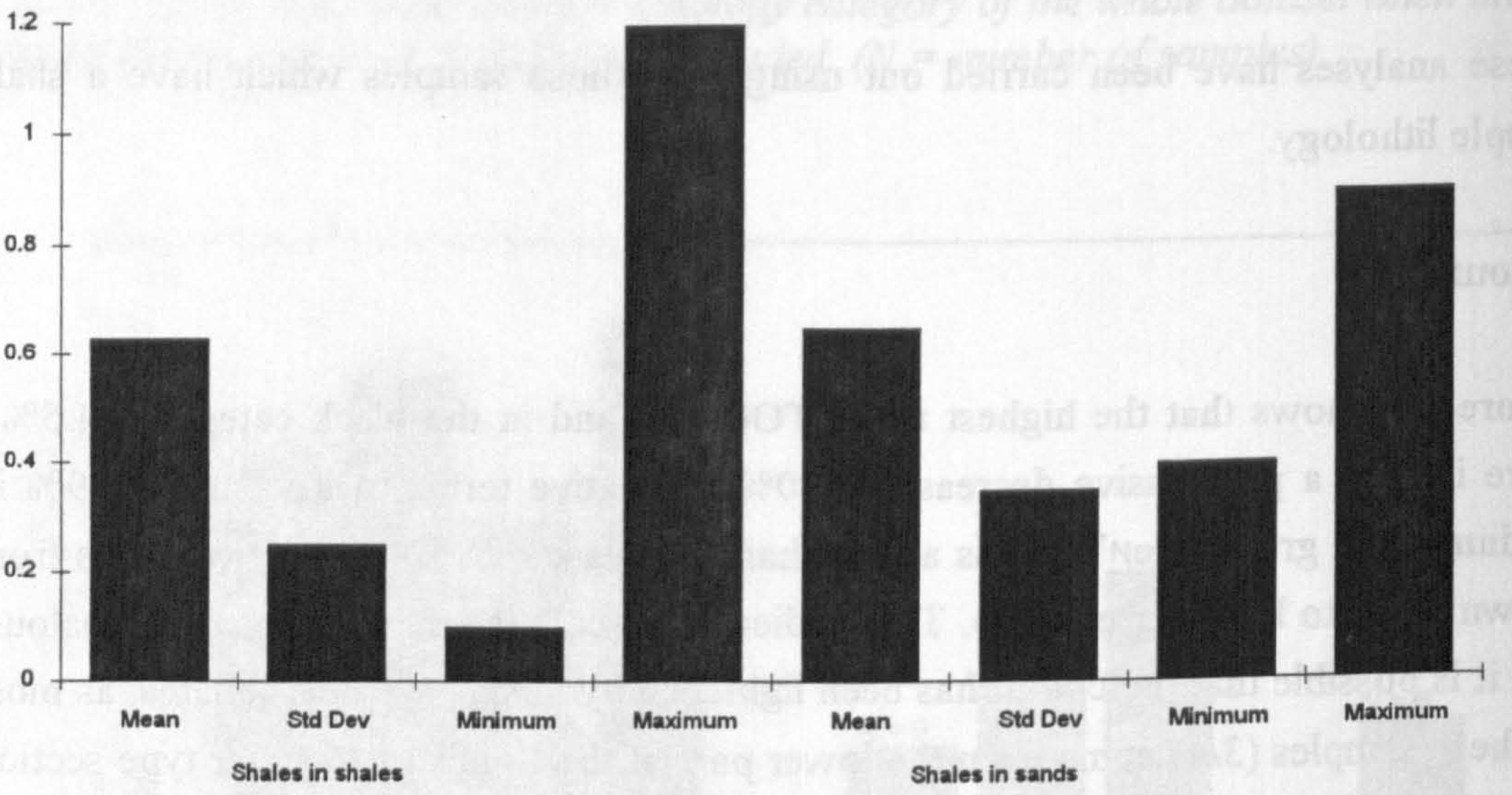


Fig. 6.7. *Phytoc values in the shales gross lithology category subdivided according to the gross dominant lithology, whole dataset. Number of cases as in Fig. 6.6.*

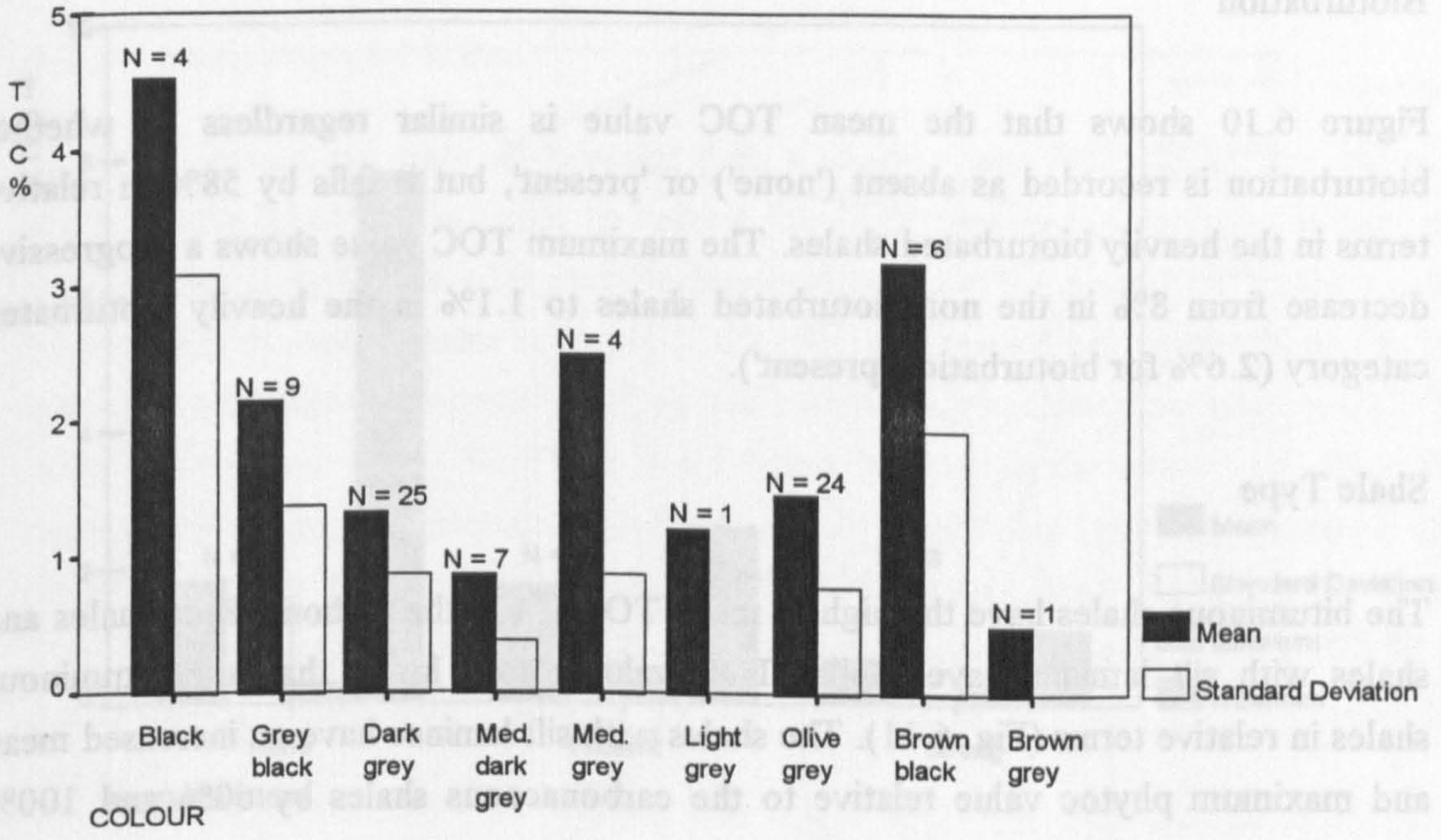


Fig. 6.8. *Mean TOC values in each shale colour category of the whole dataset. (N = number of cases).*

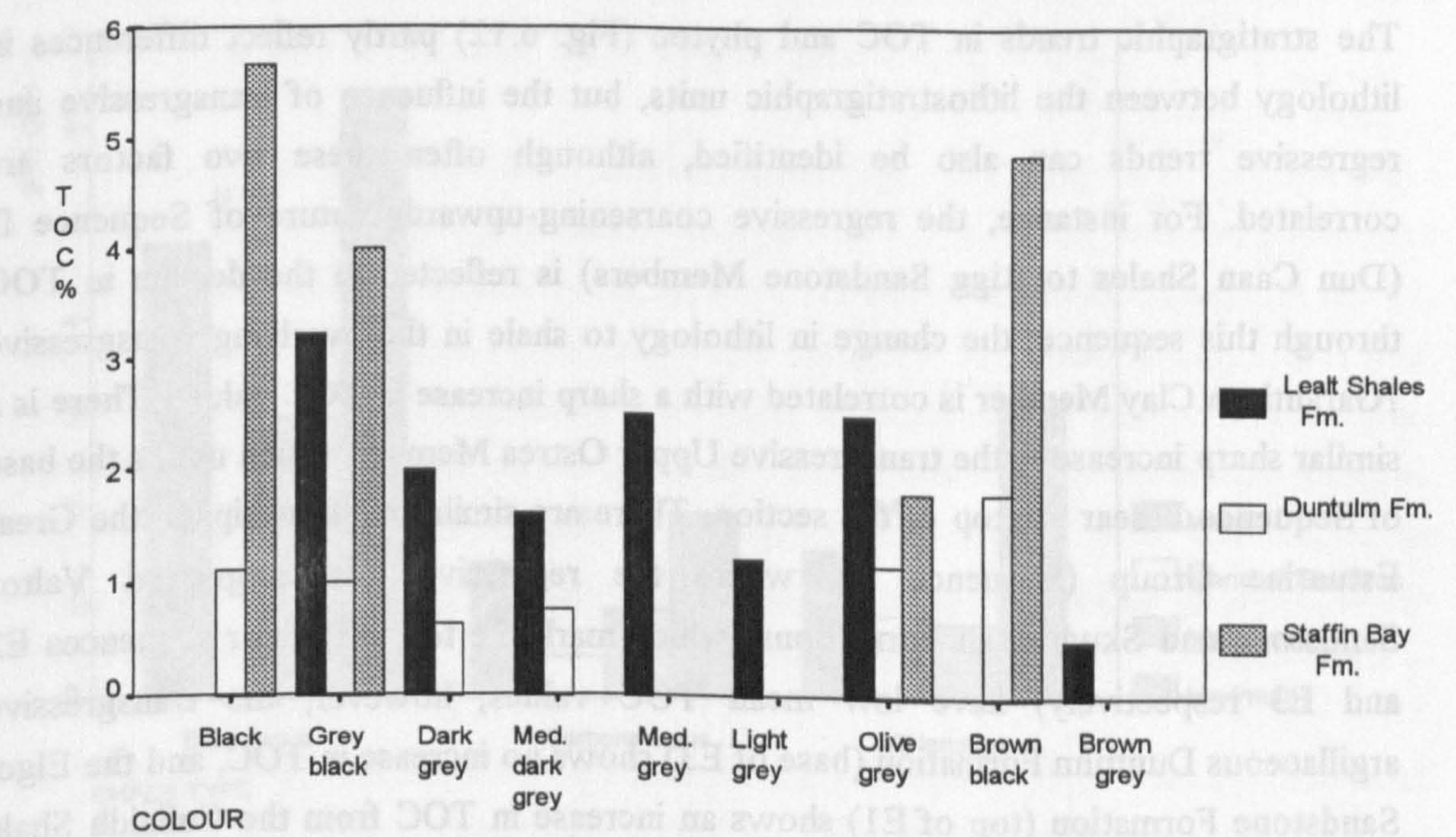


Fig. 6.9. *Mean TOC values in each shale colour category of the three argillaceous formations examined.*

Bioturbation

Figure 6.10 shows that the mean TOC value is similar regardless of whether bioturbation is recorded as absent ('none') or 'present', but it falls by 58% in relative terms in the heavily bioturbated shales. The maximum TOC value shows a progressive decrease from 8% in the non-bioturbated shales to 1.1% in the heavily bioturbated category (2.6% for bioturbation 'present').

Shale Type

The bituminous shales have the highest mean TOC (5%); the carbonaceous shales and shales with silt laminae have similar TOC values, 70% lower than the bituminous shales in relative terms (Fig. 6.11). The shales with silt laminae have an increased mean and maximum phytoc value relative to the carbonaceous shales by 60% and 100% respectively.

6.2.2 Stratigraphic Trends in Mean Values

The stratigraphic trends in TOC and phytoc (Fig. 6.12) partly reflect differences in lithology between the lithostratigraphic units, but the influence of transgressive and regressive trends can also be identified, although often these two factors are correlated. For instance, the regressive coarsening-upwards nature of Sequence D (Dun Caan Shales to Rigg Sandstone Members) is reflected in the decline in TOC through this sequence; the change in lithology to shale in the overlying transgressive ?Garantiana Clay Member is correlated with a sharp increase in TOC values. There is a similar sharp increase in the transgressive Upper Ostrea Member, which marks the base of Sequence F near the top of the section. There are similar relationships in the Great Estuarine Group (Sequence E), where the regressive, coarser-grained Valtos Sandstone and Skudiburgh Formations (which mark the tops of minor sequences E2 and E3 respectively) have low mean TOC values; however, the transgressive argillaceous Duntulm Formation (base of E3) shows no increase in TOC, and the Elgol Sandstone Formation (top of E1) shows an increase in TOC from the Cullaidh Shale below. The latter result is due to the unrepresentative nature of the samples taken from these formations.

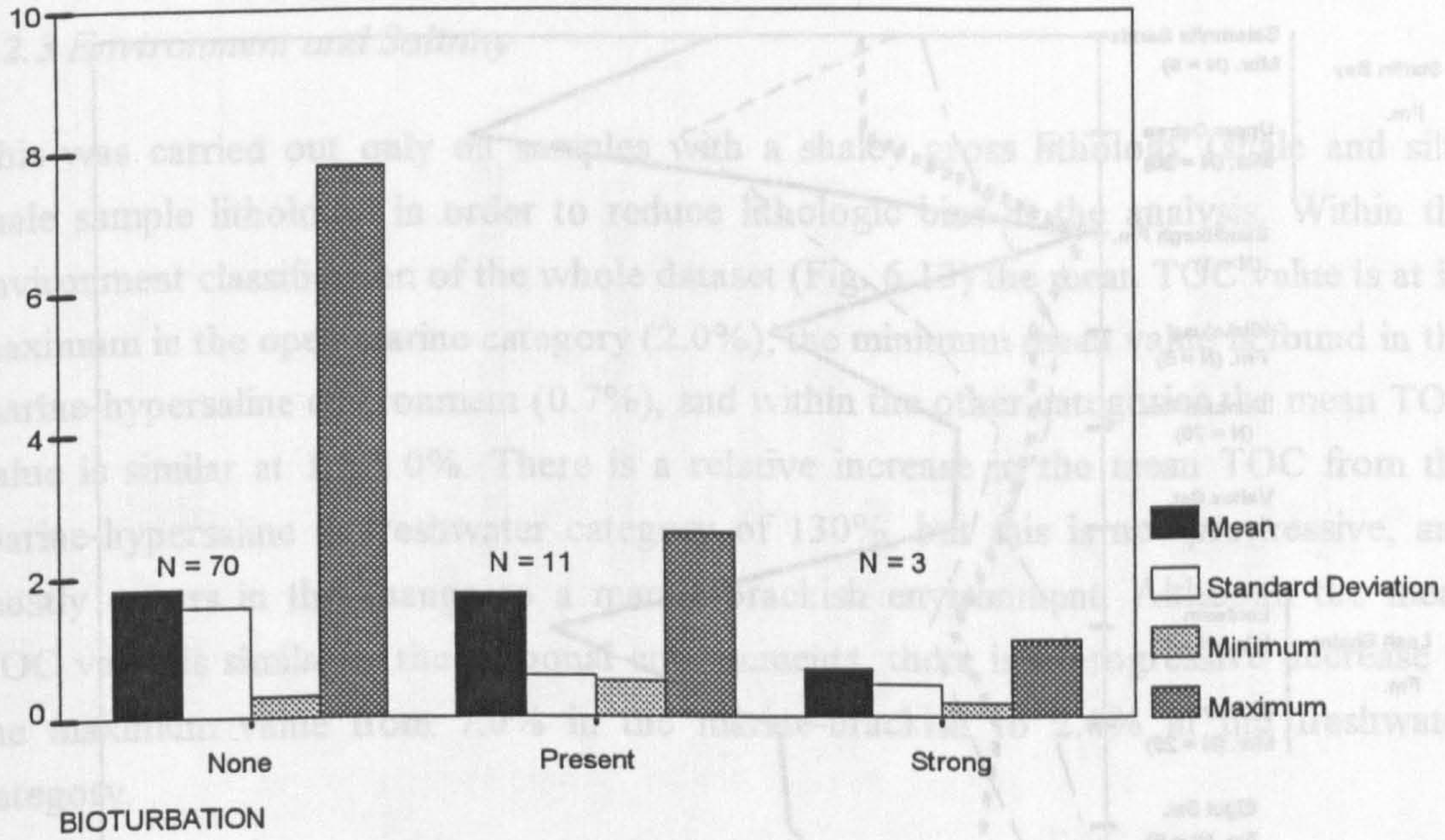


Fig. 6.10. *Summary of TOC data for each shale bioturbation level category, whole dataset. (N = number of samples).*

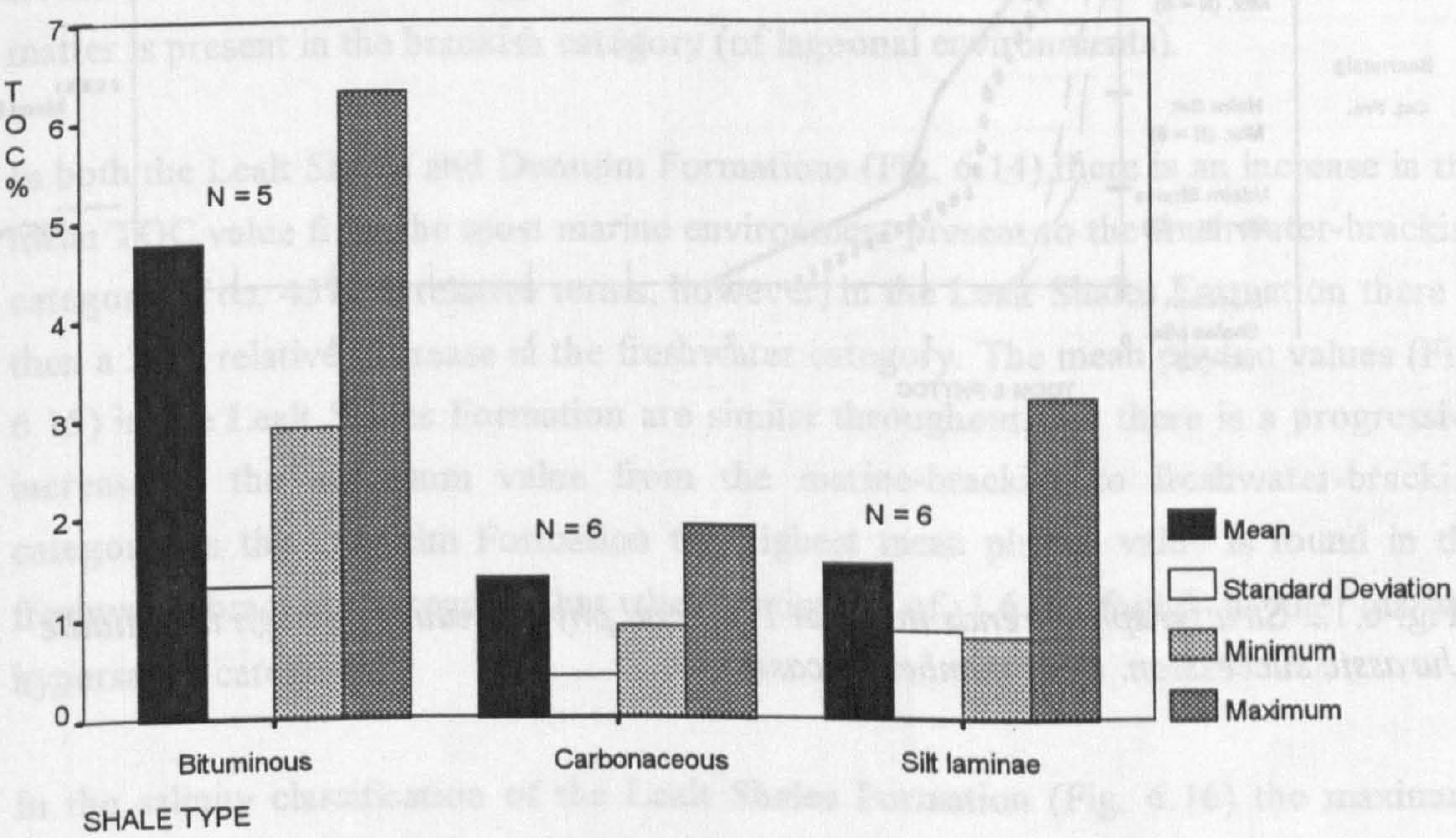


Fig. 6.11. *Summary of TOC data for each shale type category, whole dataset. (N = number of cases).*

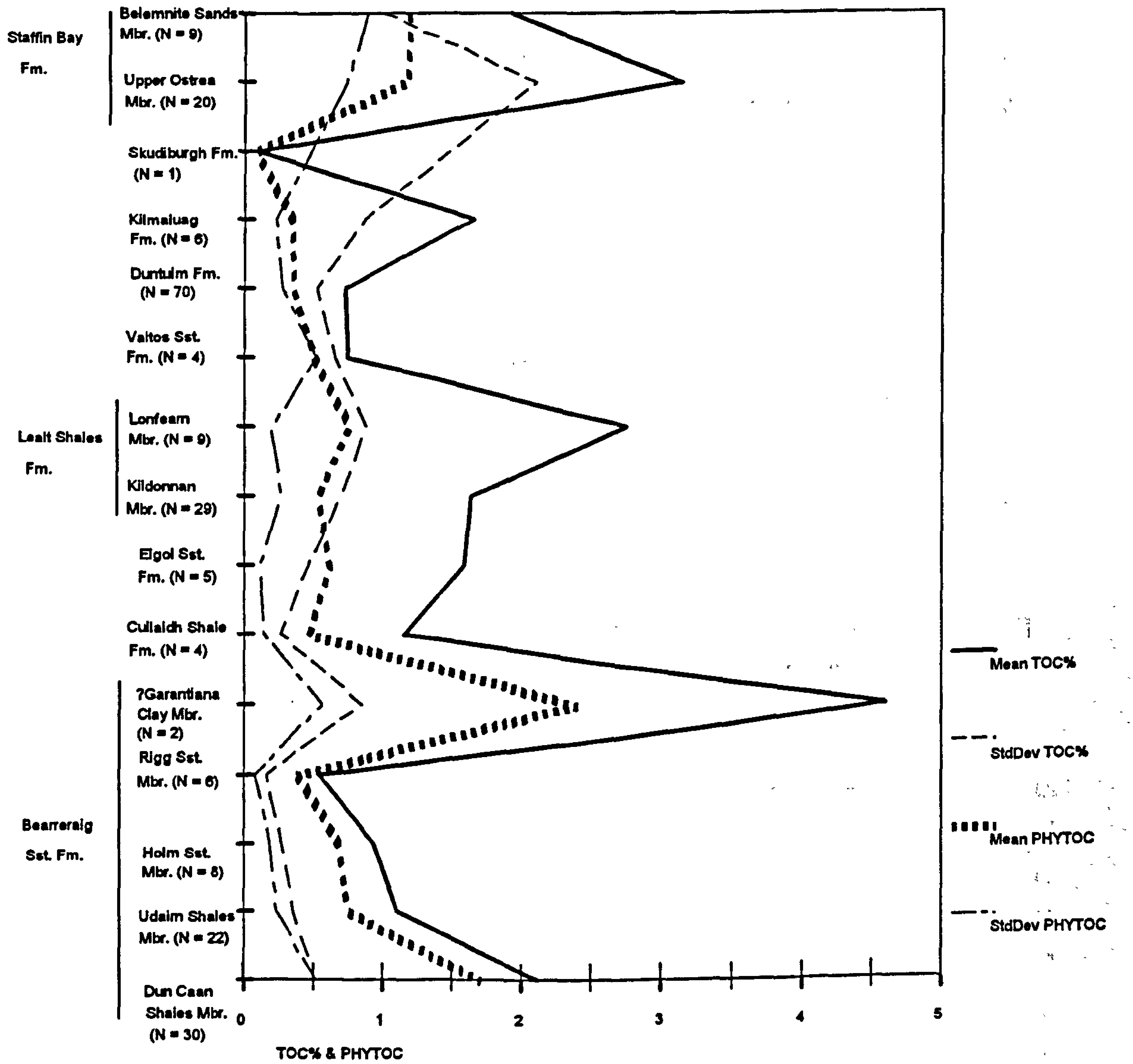


Fig. 6.12. *Stratigraphic trends in mean TOC and phytoc values through the Middle Jurassic succession. (N = number of cases).*

6.2.3 Environment and Salinity

This was carried out only on samples with a shaley gross lithology (shale and silty shale sample lithology) in order to reduce lithologic bias in the analysis. Within the environment classification of the whole dataset (Fig. 6.13) the mean TOC value is at its maximum in the open marine category (2.0%); the minimum mean value is found in the marine-hypersaline environment (0.7%), and within the other categories the mean TOC value is similar at 1.5-2.0%. There is a relative increase in the mean TOC from the marine-hypersaline to freshwater category of 130%, but this is not progressive, and mostly occurs in the change to a marine-brackish environment. Although the mean TOC value is similar in the lagoonal environments, there is a progressive decrease in the maximum value from 7.0% in the marine-brackish to 2.6% in the freshwater category.

The mean phytoc values exceed 1.0 only in the open marine category; in the lagoonal environments there is a relative increase of over 100% from the marine-hypersaline to brackish categories and then a relative decrease of 50% from the brackish to freshwater environments, suggesting that the maximum amount of terrestrial organic matter is present in the brackish category (of lagoonal environments).

In both the Lealt Shales and Duntulm Formations (Fig. 6.14) there is an increase in the mean TOC value from the most marine environment present to the freshwater-brackish category of *ca.* 45% in relative terms; however, in the Lealt Shales Formation there is then a 32% relative decrease in the freshwater category. The mean phytoc values (Fig. 6.15) in the Lealt Shales Formation are similar throughout, but there is a progressive increase in the maximum value from the marine-brackish to freshwater-brackish category. In the Duntulm Formation the highest mean phytoc value is found in the freshwater-brackish category, but the maximum of 1.6 is found in the marine-hypersaline category.

In the salinity classification of the Lealt Shales Formation (Fig. 6.16) the maximum mean TOC and phytoc values are found in the freshwater-miohaline category; the mean values in the other categories are similar, but there is a progressive decrease in the maximum TOC value of over 50% in relative terms from this freshwater-miohaline to the pliohaline category.

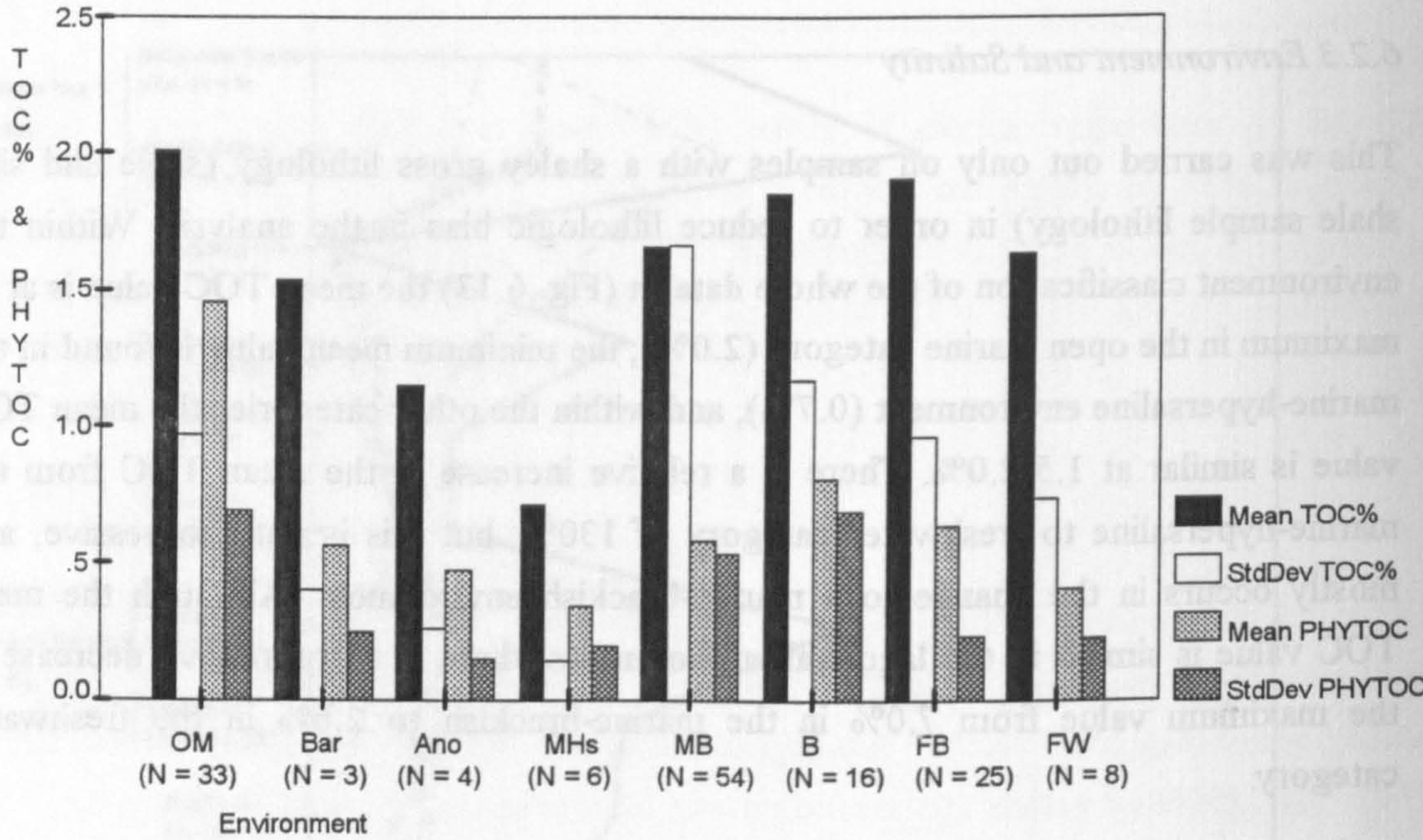


Fig. 6.13. *Mean TOC and phytoc values for each environment of the shales gross lithology category, whole dataset. (N = number of samples). Key to abbreviations in Table 6.4.*

Environment	Abbreviation
Open marine	OM
Bar	Bar
Anoxic basin	Ano
Supra-tidal	SpT
Marine-hypersaline	MHs
Brackish-marine	BM
Brackish	B
Freshwater-brackish	FB
Freshwater	FW
Mudflat-alluvial	MfA

Table 6.4. *Environment classification and abbreviations.*

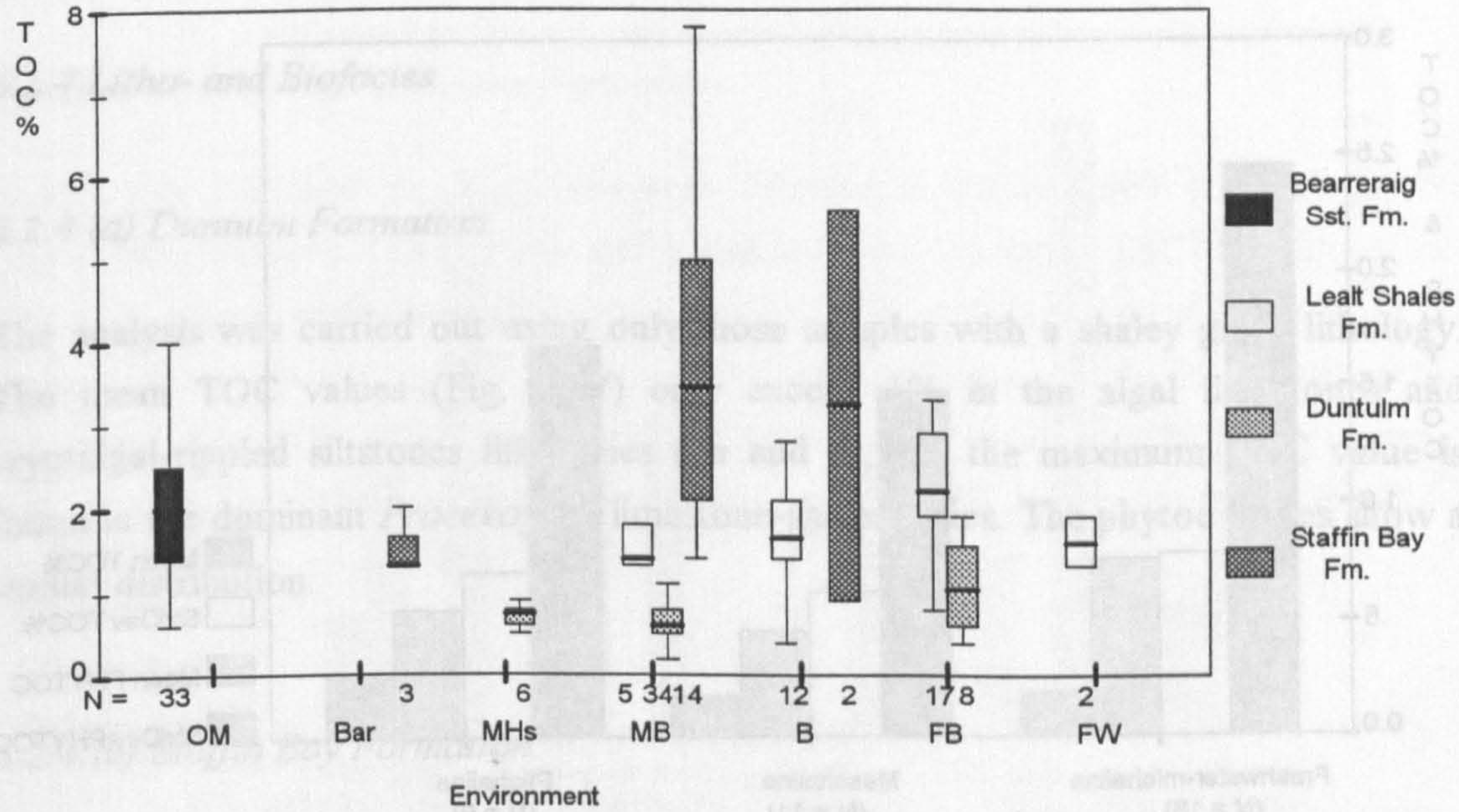


Fig. 6.14. *Boxplot of the distribution of TOC values in the environments of the shales gross lithology category in the four major formations. The boxes contain all the values between the upper and lower quartiles, the thick black line represents the mean value; the whisker lines represent the maximum and minimum values. Key to environments in Table 6.4. (N = number of samples).*

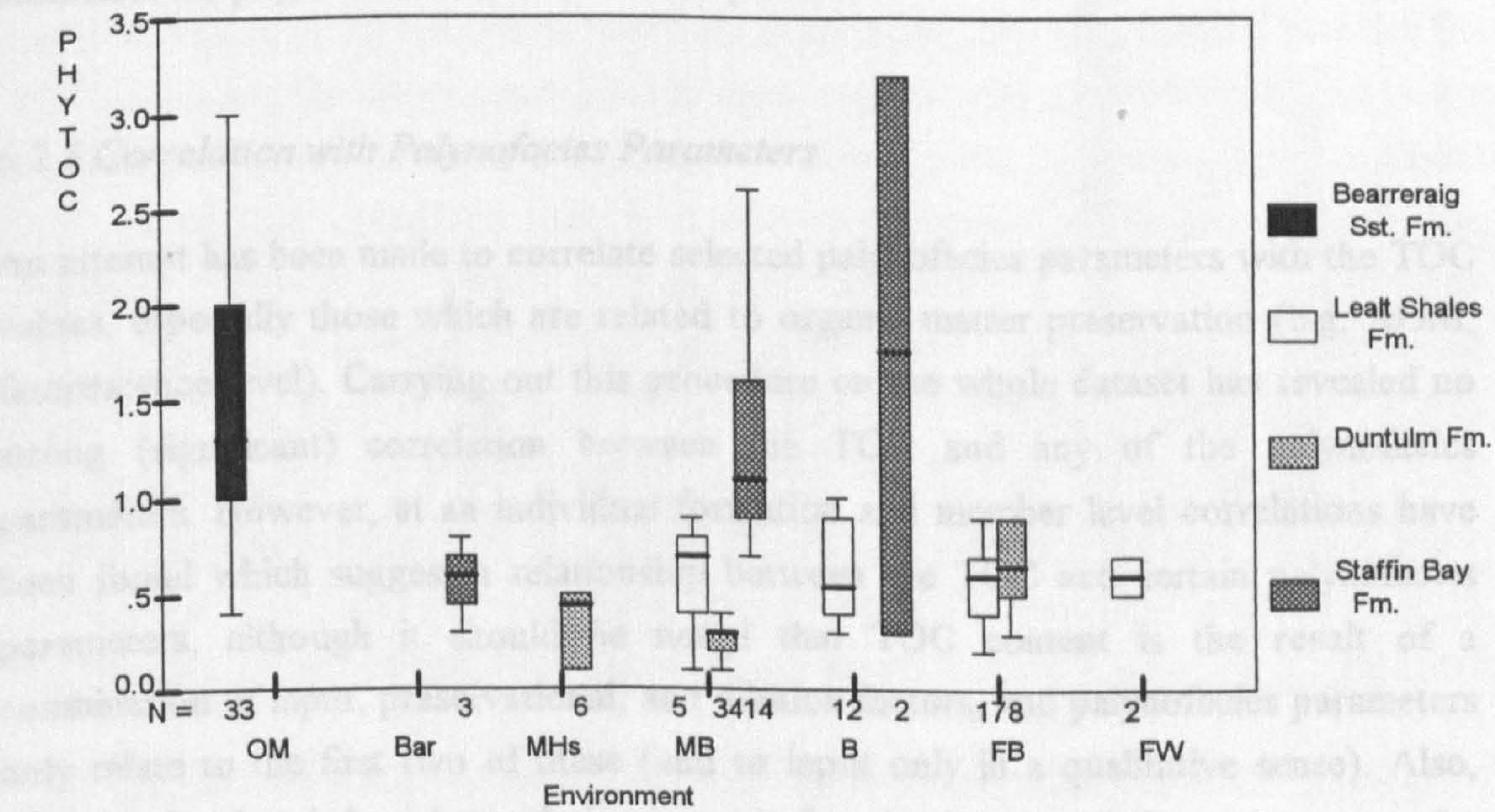


Fig. 6.15. *Boxplot of the distribution of phytoc values in each environment of the shales gross lithology category of the four major formations. N = number of samples, key to definitions in Fig. 6.14, key to environments in Table 6.4.*

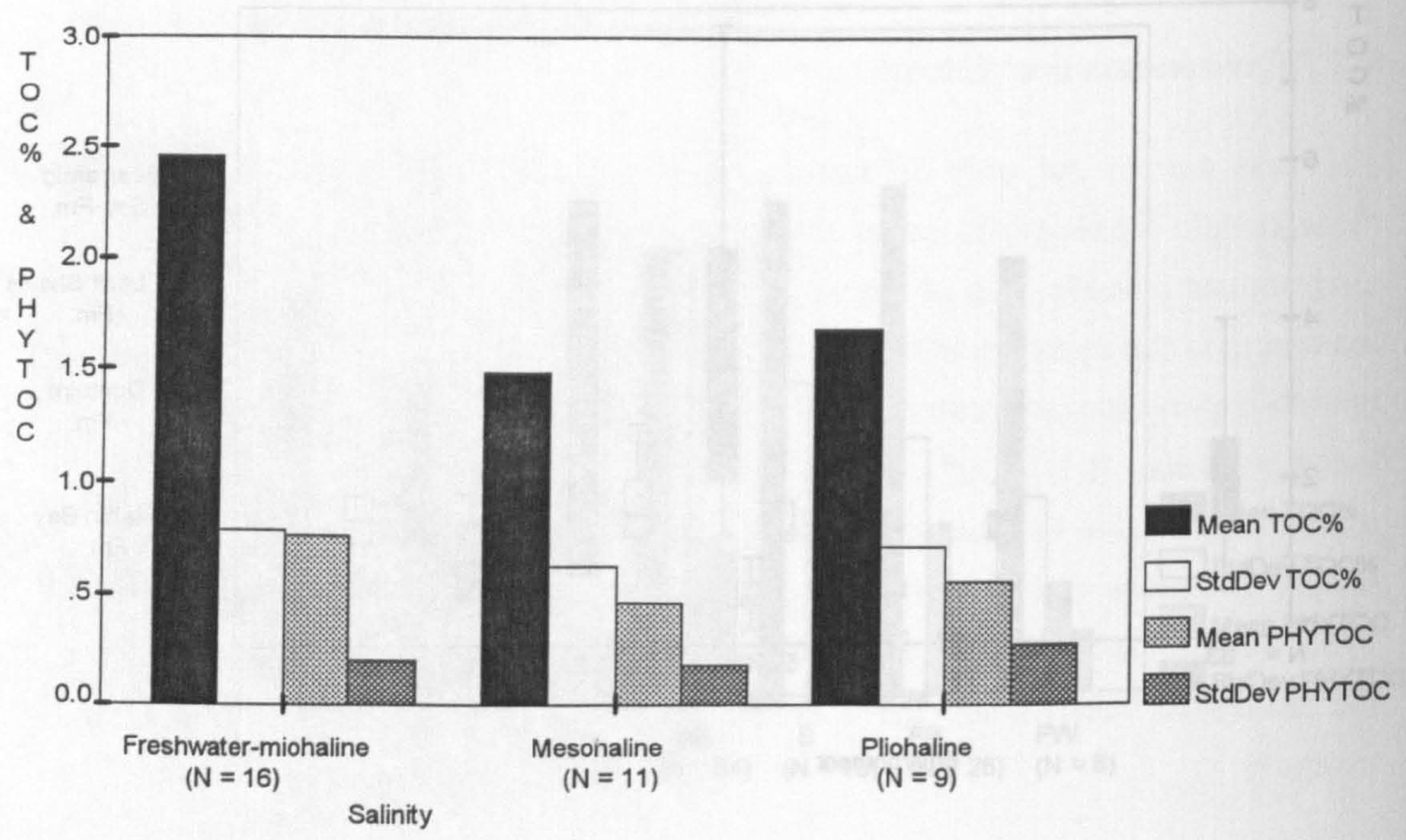


Fig. 6.16. *Mean TOC and phytoc values in the salinity classes of the shales gross lithology category of the Lealt Shales Formation. (N = number of samples).*

6.2.4 Litho- and Biofacies

6.2.4 (a) Duntulm Formation

The analysis was carried out using only those samples with a shaley gross lithology. The mean TOC values (Fig. 6.17) only exceed 1% in the algal limestones and cryptalgal-rippled siltstones lithofacies (3a and b), but the maximum TOC value is found in the dominant *Praeexogyra* limestone-shales facies. The phytoc values show a similar distribution.

6.2.4.(b) Staffin Bay Formation

The mean TOC value (Fig. 6.18) shows a progressive relative decrease of 70% from the bituminous shales lithofacies to the muddy silts which characterises the top of the formation. The phytoc values show a decrease from the calcareous clay-limestones at the base of the formation to the muddy silts, suggesting a decline in the absolute amount of terrestrial organic matter through the formation, or increased sediment dilution. Within the biofacies classification the mean TOC value is 70% greater in the monotypic *Neomiodon* category relative to the more diverse *Neomiodon* and others biofacies; the phytoc values show a similar pattern.

6.2.5 Correlation with Palynofacies Parameters

An attempt has been made to correlate selected palynofacies parameters with the TOC values, especially those which are related to organic matter preservation (e.g. AOM, fluorescence level). Carrying out this procedure on the whole dataset has revealed no strong (significant) correlation between the TOC and any of the palynofacies parameters. However, at an individual formation and member level correlations have been found which suggest a relationship between the TOC and certain palynofacies parameters, although it should be noted that TOC content is the result of a combination of input, preservational, and dilution factors, and palynofacies parameters only relate to the first two of these (and to input only in a qualitative sense). Also, palynofacies data is based on relative numeric frequencies not relative volumes, so the correlation with geochemical mass-balanced data is unlikely to be perfect.

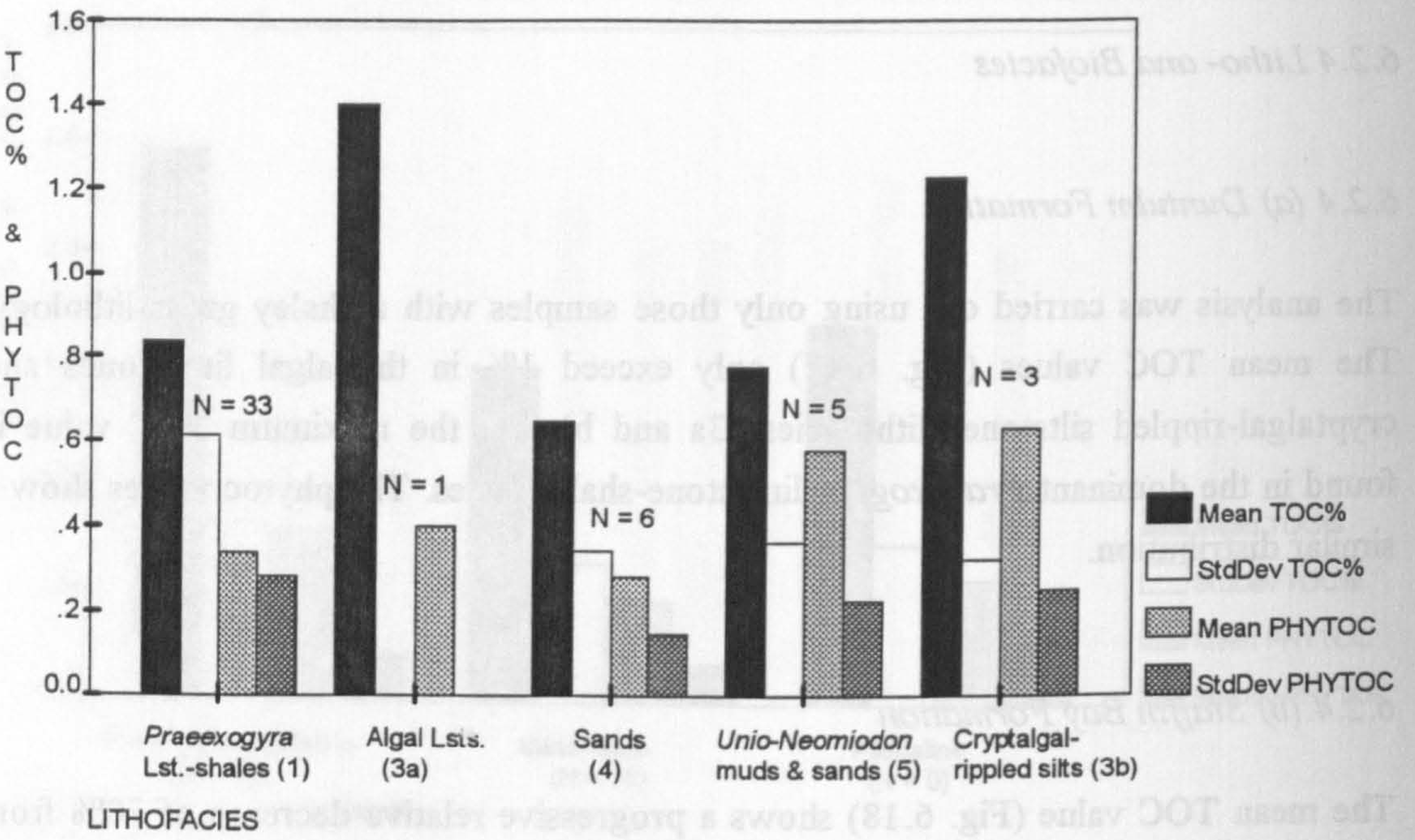


Fig. 6.17. *Mean TOC and phytoc values in each lithofacies within the shales gross lithology category of the Duntulm Fm. (N = number of cases).*

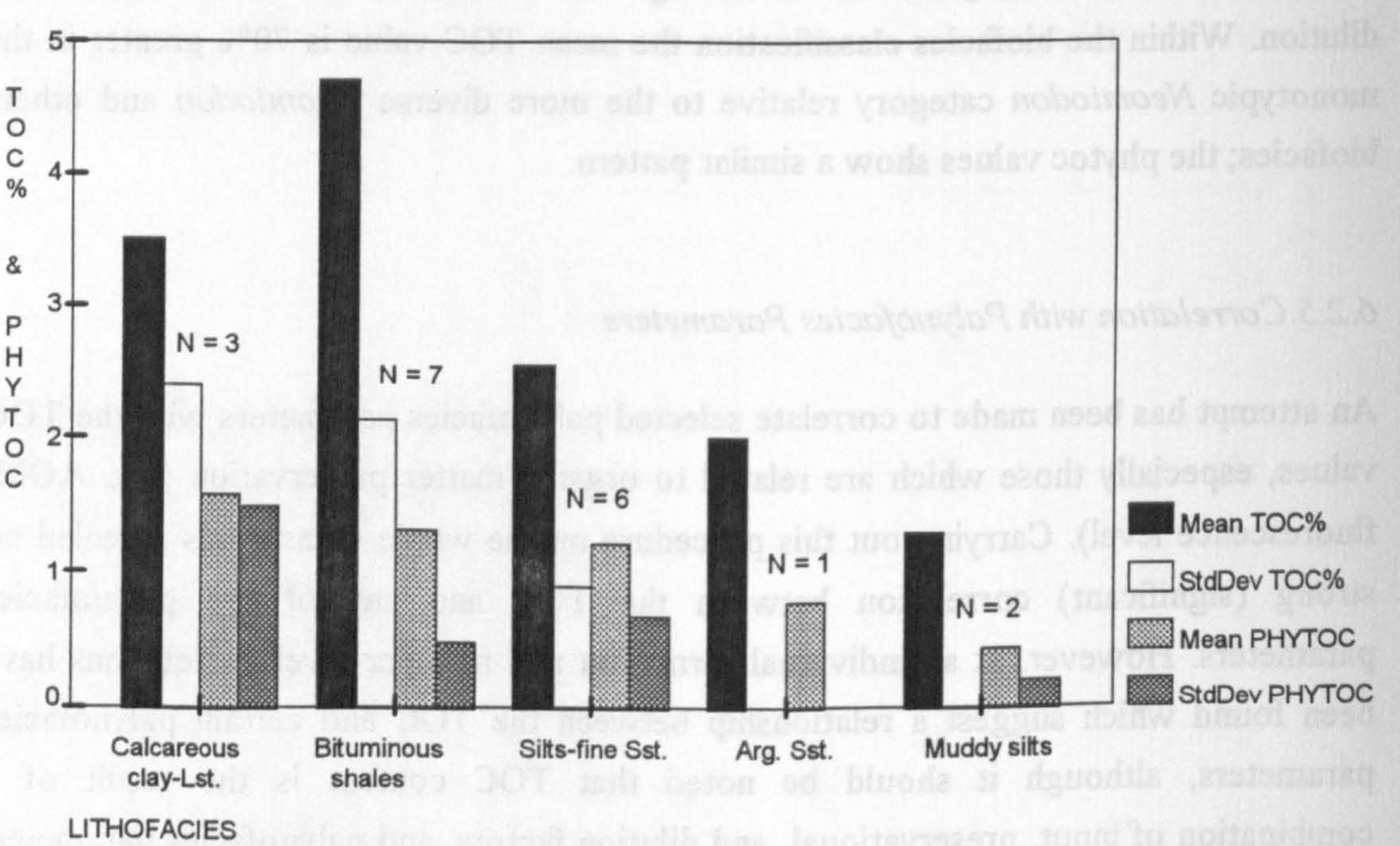


Fig. 6.18. *Mean TOC and phytoc values in each lithofacies within the shales gross lithology category of the Staffin Bay Fm. (N = number of cases).*

6.2.5 (a) Bearreraig Sandstone Formation

Within this formation the Rigg Sandstone Member is the only unit in which there is correlation between TOC values and a palynofacies parameter (AOM). Figure 6.19 shows a strong positive relationship between TOC and %AOM of kerogen in the samples from this member ($r^2 = 0.9$, regression significant at 99% level), suggesting that the higher TOC values may be related to increased production or preservation of this material. No other significant correlations were found in any of the other units in this formation.

6.2.5 (b) Lealt Shales Formation

Cross plots of TOC values with palynofacies parameters in this formation have revealed particularly strong (significant) correlations in the Lonfearn Member and lesser correlations in the Kildonnan Member and whole formation dataset. Figure 6.20 shows a strong positive correlation ($r^2 = 0.9$) between TOC values and %AOM in the Lonfearn Member; in the Kildonnan Member and whole formation the correlations are lower ($r^2 < 0.4$), but the plot still shows a positive relationship between the two variables. This suggests that whilst the TOC of the Lonfearn Member is potentially controlled mostly by fluctuations in %AOM (preservation), other factors also control the TOC values in the Kildonnan Member. There is no strong correlation between the TOC values and the fluorescence level of the kerogen in either member (Fig. 6.21), but a positive trend does exist in the whole formation dataset suggesting that the higher TOC values may indeed be related to increased organic matter preservation. The difference between the two members does not seem to be due to lithological differences as it still exists to virtually the same extent when only shale samples are included in the analysis (Lonfearn Member $r^2 = 0.9$, Kildonnan Member $r^2 = 0.4$). Figure 6.22 shows the positive relationship ($r^2 = 0.5$) that exists between the TOC values and the %*Botryococcus* within the palynomorph assemblage in the whole formation dataset; this may represent a correlation of TOC with ?productivity (organic matter input), although *Botryococcus* is usually most common in oligotrophic settings.

6.2.5 (c) Duntulm Formation

No significant correlation between TOC and palynofacies parameters were found in this formation, suggesting that relationships with TOC are complex.

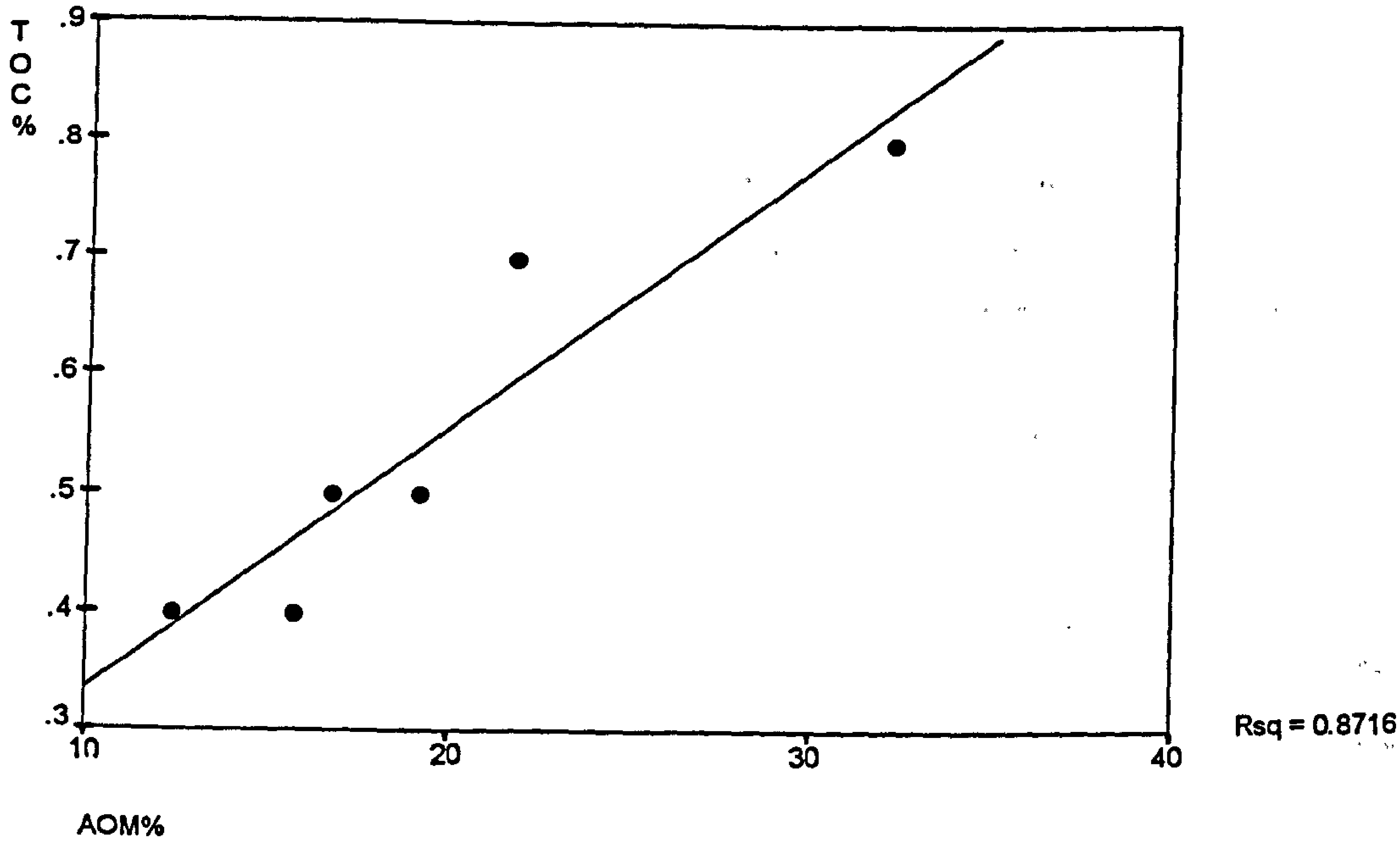


Fig. 6.19. *Crossplot of AOM and TOC in the Rigg Sandstone Member of the Bearreraig Sandstone Formation.*

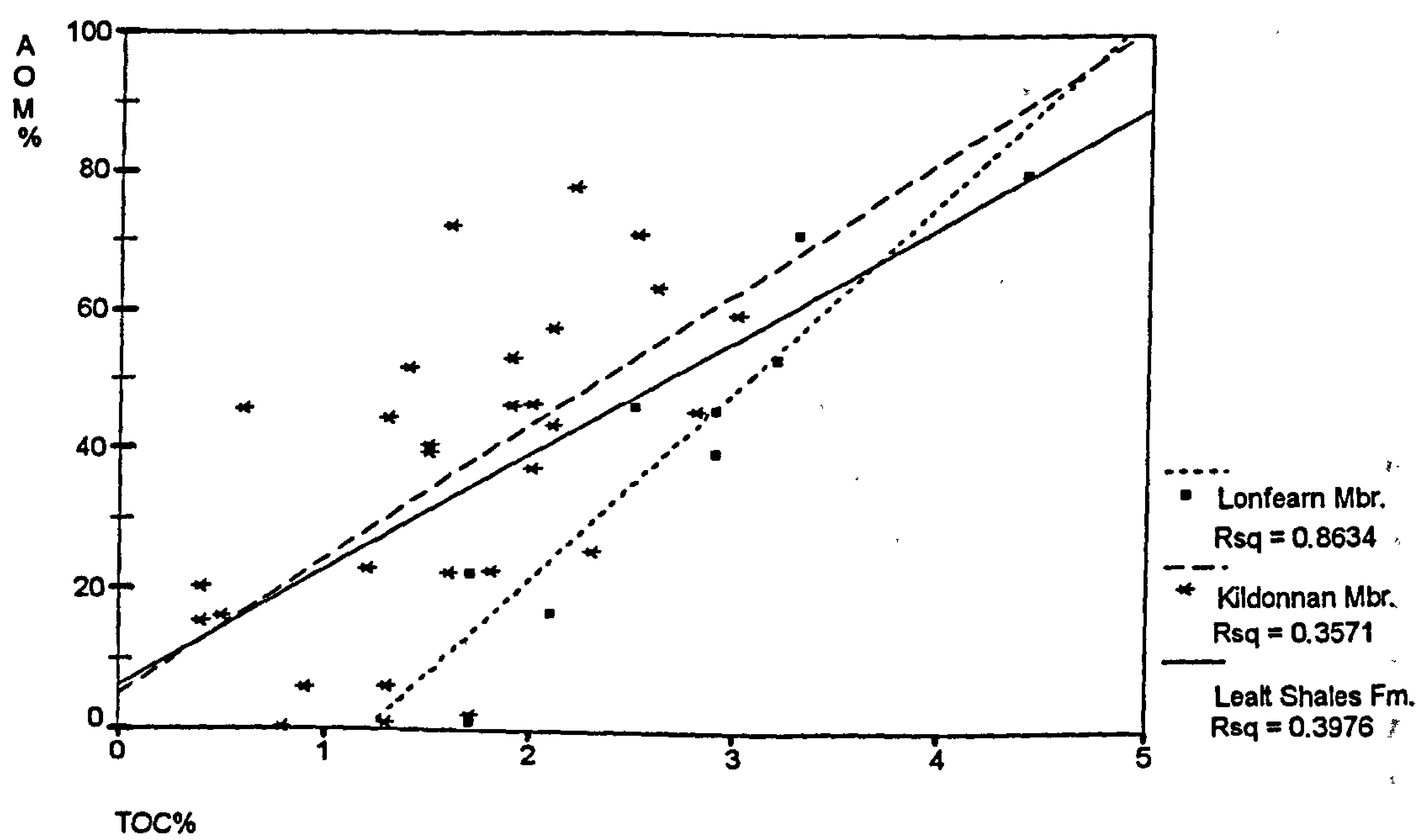


Fig. 6.20. *Crossplot of AOM and TOC in the Lealt Shales Formation.*

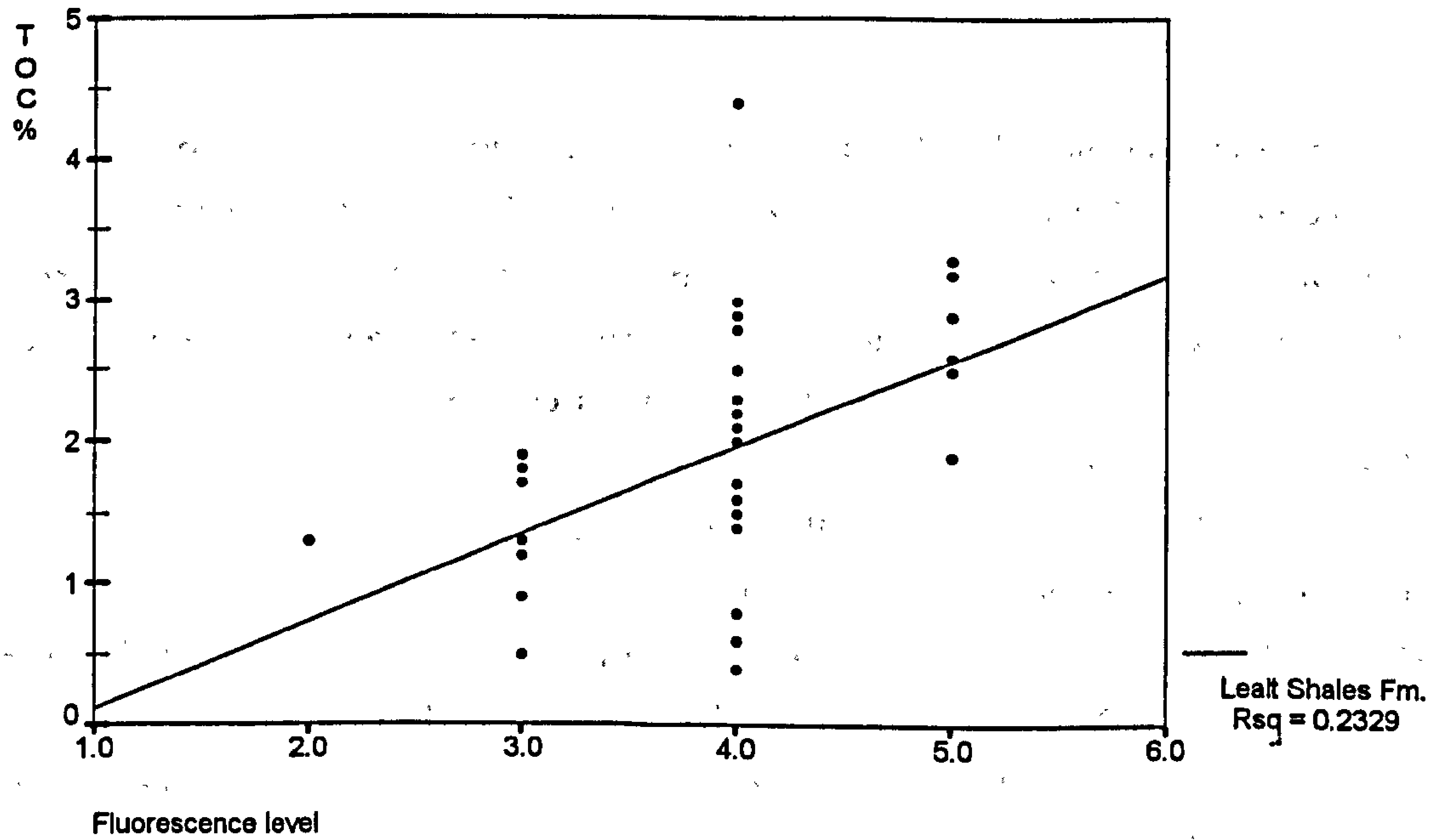


Fig. 6.21. *Crossplot of TOC and fluorescence scale point in the Lealt Shales Formation.*

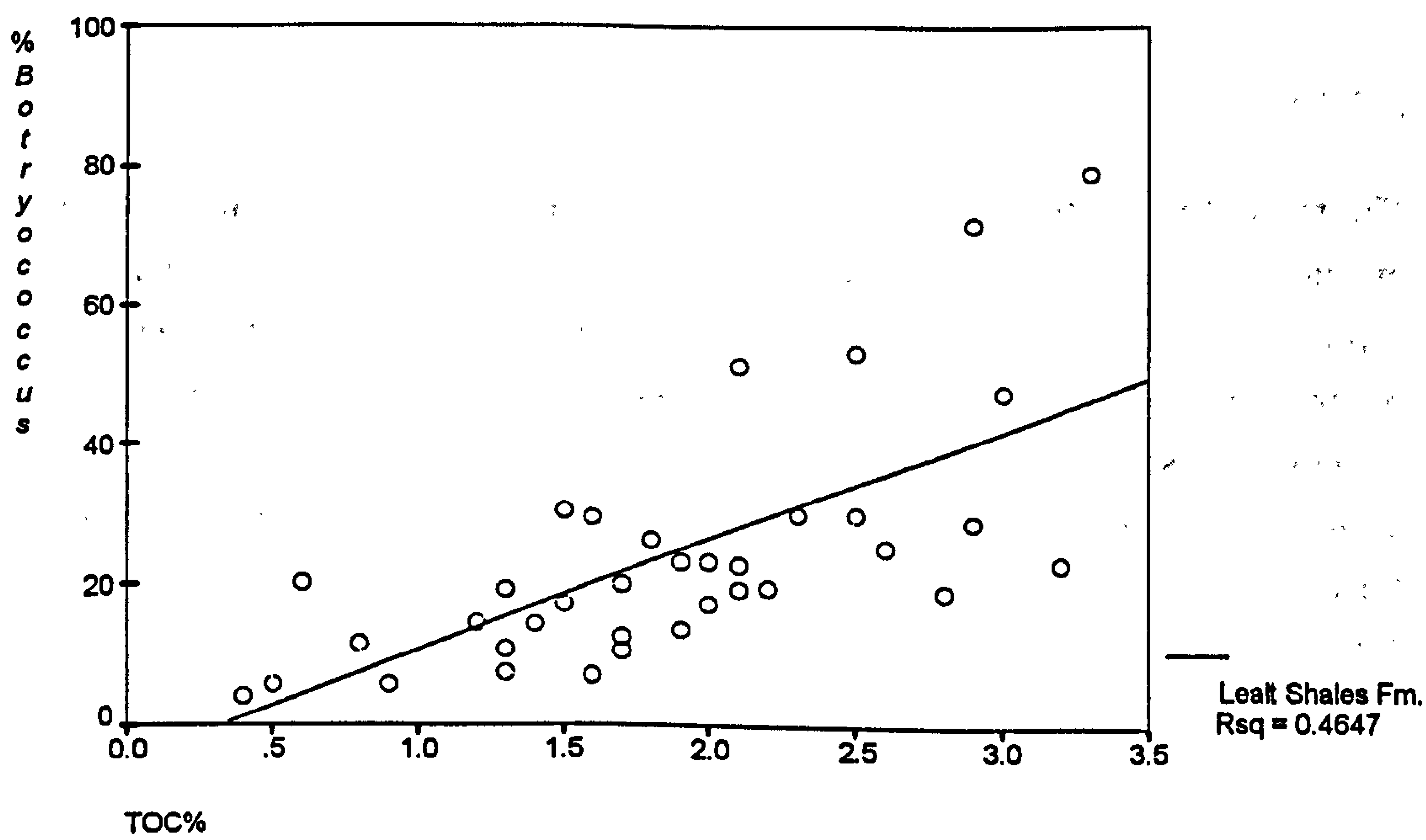


Fig. 6.22. *Crossplot of TOC and the percentage* Botryococcus *(of palynomorphs) in the Lealt Shales Formation.*

6.2.5 (d) Staffin Bay Formation

In this formation only the Upper Ostrea Member shows a positive correlation ($r^2 = 0.6$) between TOC values and the %AOM (Fig. 6.23). This suggests that the primary control on TOC is AOM content (i.e. preservation, cf. section 6.3.5), but the level of the correlation coefficient suggests that other factors are probably also important. Detailed examination of the bituminous shales lithofacies category of this member shows that there is a strong positive correlation ($r^2 = 0.8$, regression significant at 99% level) between the TOC values and %AOM (Fig. 6.24), and a lesser positive correlation ($r^2 = 0.5$, regression significant at 97% level) between TOC values and fluorescence levels (Fig. 6.25). This suggests that in this lithofacies the TOC content is primarily controlled by AOM preservation. This is also expressed in the colour of the shales: those with low AOM, fluorescence, and TOC levels are olive grey, whilst those with high levels of all three parameters are black or black-brown.

6.3 Fluorescence Results

6.3.1 Mean Fluorescence

Fluorescence observations were carried out on 359 samples; those samples not included are from the Bearreraig Sandstone Formation where slides were made using glycerol as the mounting medium. As the latter medium is itself fluorescent, no reliable observations of the organic matter fluorescence were possible; for this reason a selection of slides from this formation were re-mounted using the non-fluorescent elvacite mounting medium used in the rest of the study. The mean fluorescence value for the whole dataset is 3.4. The fluorescence scale (Tyson, 1995) is shown in Table 2.4.

6.3.2 Lithology

6.3.2 (a) Gross Lithology

Within this classification the mean fluorescence values are relatively uniform, but they are somewhat lower in the sands category.

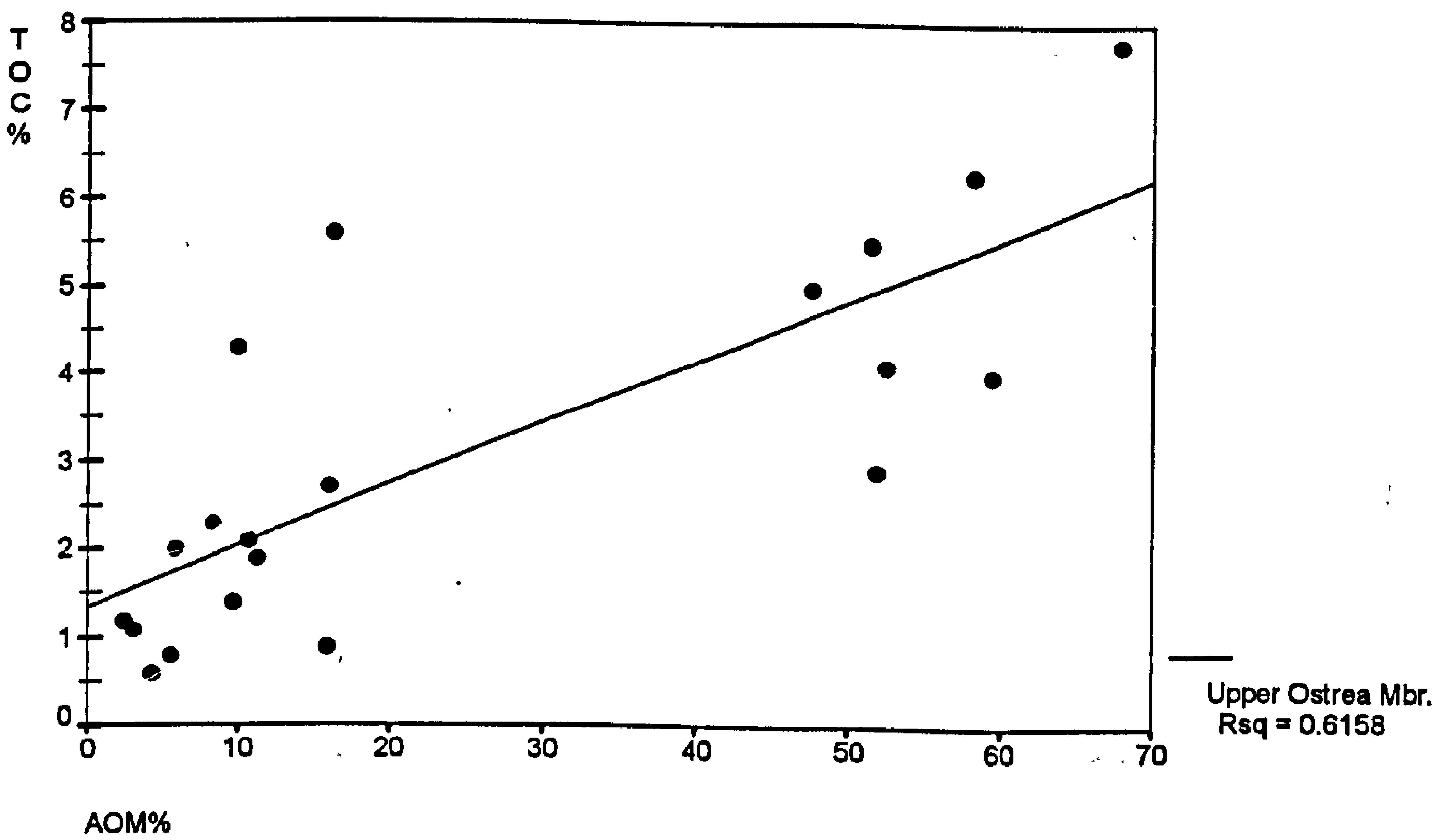


Fig. 6.23. *Crossplot of TOC and AOM in the Upper Ostrea Member of the Staffin Bay Formation. Note that the r^2 value is probably artificially high due to the samples plotting as two distinct groups.*

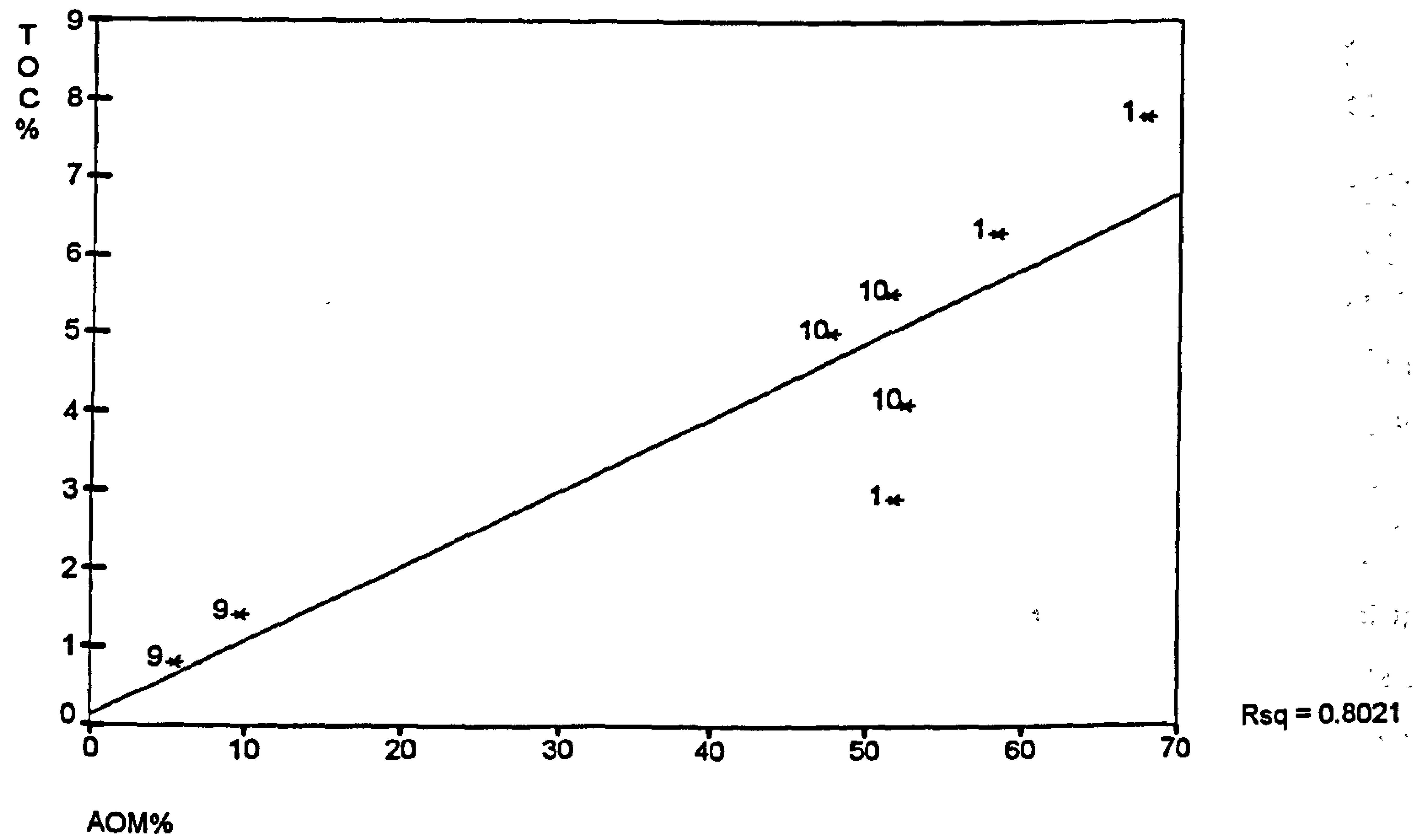


Fig. 6.24. *Crossplot of TOC and AOM in the bituminous shales lithofacies of the Staffin Bay Fm. The number next to each data point represents its colour: 1 = black, 9 = olive grey, 10 = brown black.*

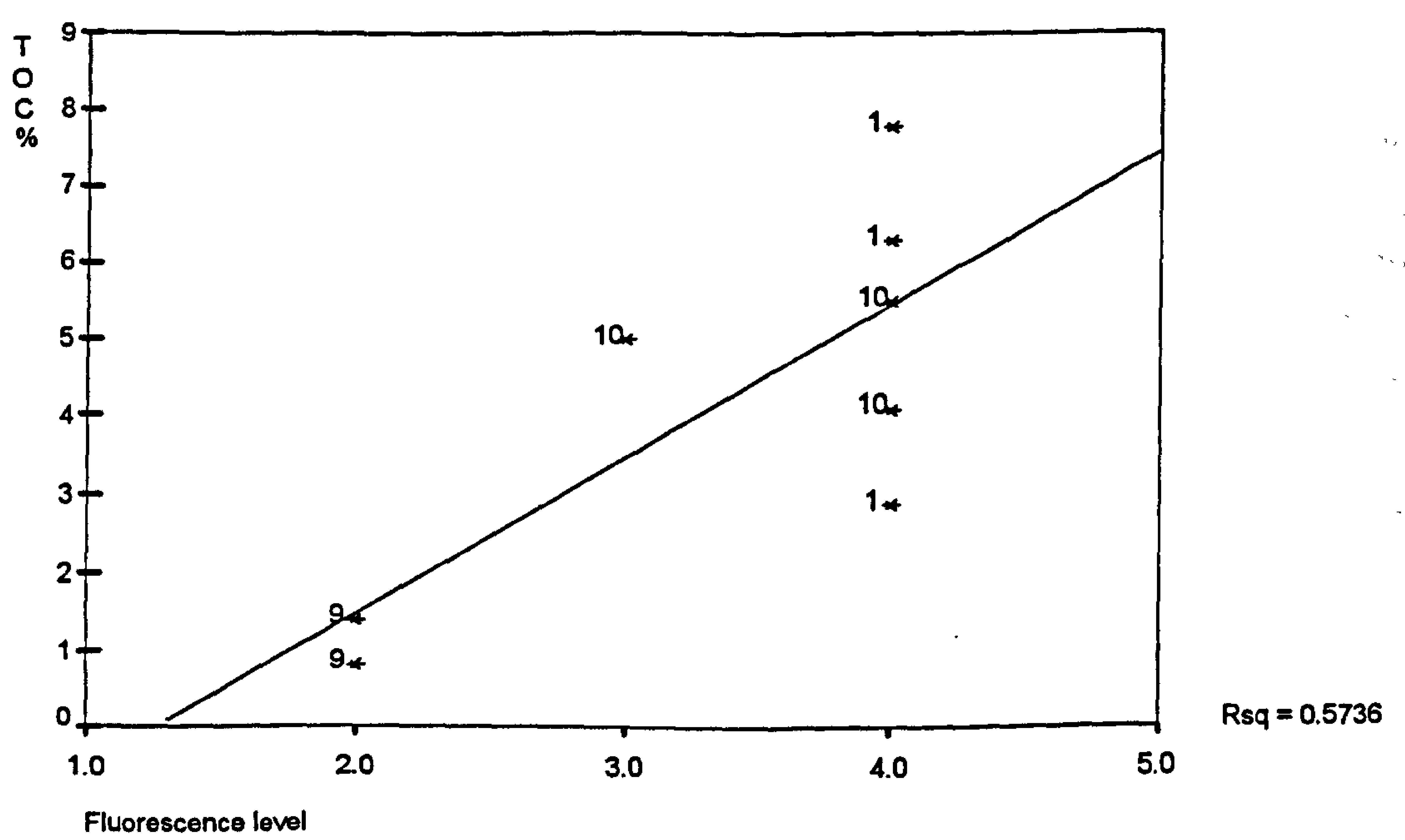


Fig. 6.25. *Crossplot of TOC and fluorescence level in the bituminous shales lithofacies of the Staffin Bay Fm. The number next to each datapoint represents its colour: 1 = black, 9 = olive grey, 10 = brown black.*

6.3.2 (b) The Effect of Dominant Lithology

This was carried out using the gross lithology and gross dominant lithology classification (Chapter 4.0). In the whole dataset the mean fluorescence values in the 'shales in shales' and 'shales in sands' categories are similar, but the maximum fluorescence level is lower (4) in the latter category than in the former (5). In the Bearreraig Sandstone Formation there is a 20% reduction in the mean fluorescence value in the 'shales in sands' relative to the 'shales in shales', the maximum fluorescence value is also lower than in the 'shales in shales' category (3 vs. 5). A similar pattern can be seen in the maximum values exhibited by the Lealt Shales Formation.

6.3.2 (c) The Effect of Shale Characteristics

Colour

The effect of shale colour on fluorescence values is discussed in section 4.5.

Bioturbation

Figure 6.26 shows that the modal and maximum fluorescence values have been reduced in the bioturbated relative to the non-bioturbated shales by 1.0 (absolute).

Shale Type

The fluorescence values show no relationship with this parameter.

6.3.3 Formation

There is very little variation in the mean fluorescence levels of the shales (gross lithology) in each of the formations (Fig. 6.27): they generally fall between 3 and 4 and only exceed the latter value in the Kilmaluag Formation. Similarly, the maximum values show little variation, although they are somewhat reduced (4 rather than 5) in the two sandstone formations of the Great Estuarine Group.

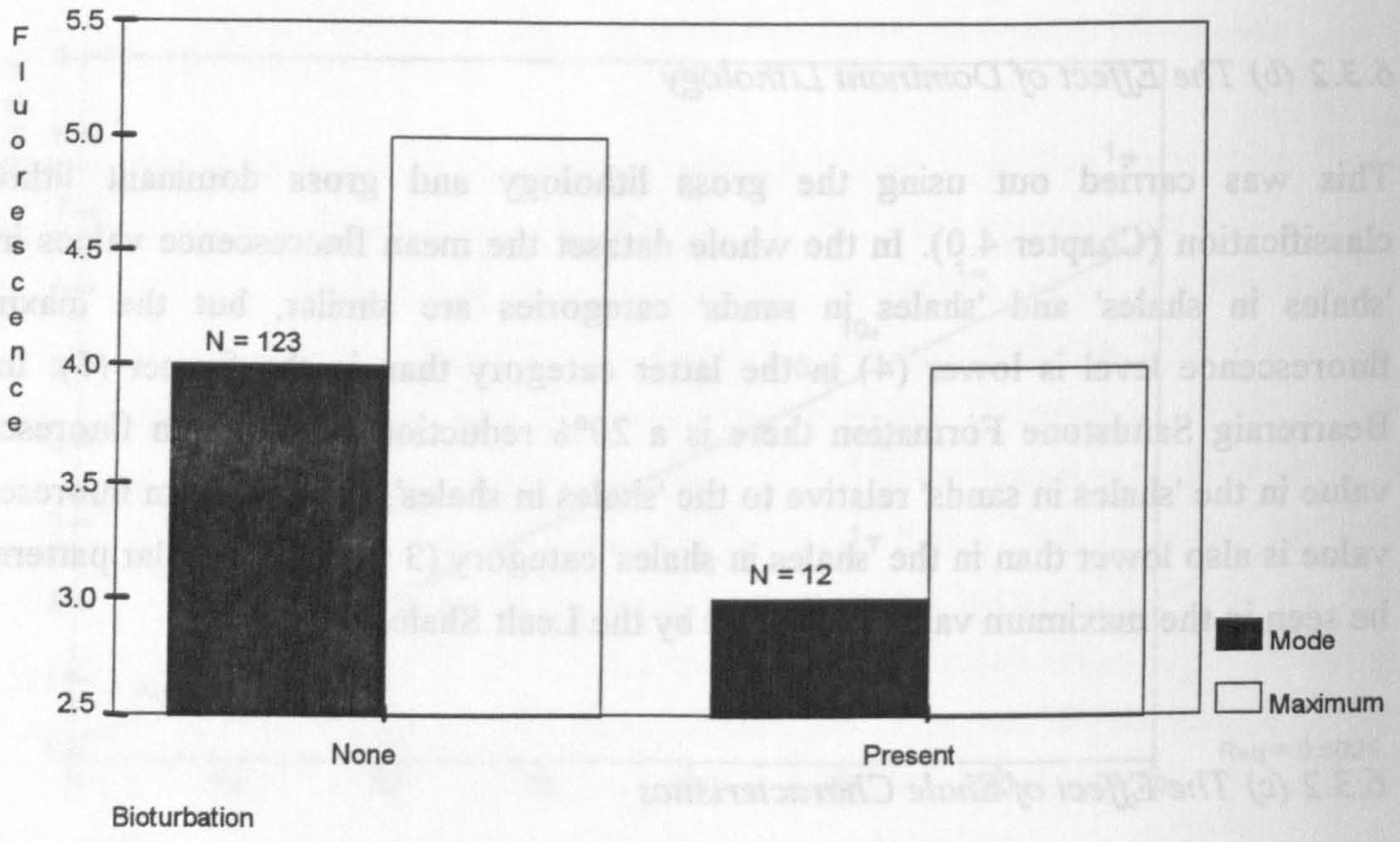


Fig. 6.26. *Mean fluorescence scale points for bioturbated and nonbioturbated shale lithologies, whole dataset. (N = number of cases).*

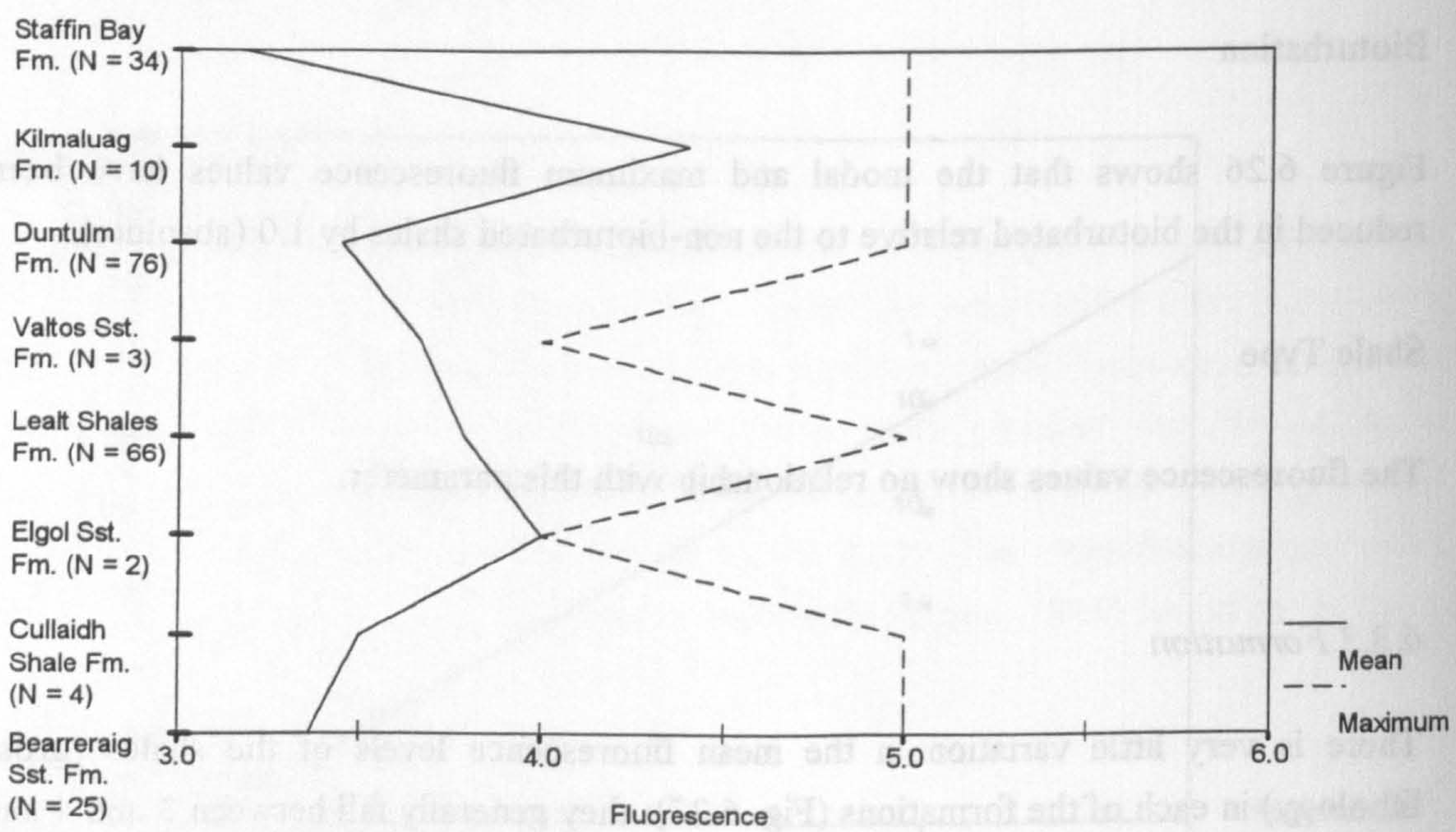


Fig. 6.27. *Mean fluorescence scale points of samples in the shales gross lithology category from each formation examined. (N = number of cases).*

6.3.4 Environment

The mean shale fluorescence values of the whole dataset also show little variation within the environment classification; they all fall between 3 and 4, apart from in the sandstone-dominated bar category where the mean value is 2, and in the freshwater category where the mean value is 4.3. The maximum values are all 5, apart from in the bar and marine-hypersaline categories.

6.3.5 Percent AOM and Fluorescence

Figure 6.28 shows that in the whole dataset there is an increase in the mean %AOM through fluorescence categories 2 to 5 of nearly 600% in relative terms. The value for scale point 1 is anomalous (only three samples); any AOM in this category is likely to be very degraded and the sediment containing these samples is relatively light in colour. In three out of the four major formations there is a similar increase in %AOM from fluorescence categories 2 to 5, these increases are *ca.* 700% in relative terms in the Duntulm and Staffin Bay Formations, and 1000% in the Lealt Shales Formation (Fig. 6.29); in the Bearreraig Sandstone Formation %AOM levels are relatively low and constant.

6.4 Rock-Eval Pyrolysis Results

In this section the pyrolysis results will be examined, particularly the hydrogen index, and any correlation between this and the optical data. The hydrogen index and kerogen type have been calculated using two approaches: the usual method of calculating the hydrogen index from the measured values (S_2/TOC x 100), and calculation by the S_2-TOC regression method of Langford and Blanc-Valleron (1990).

6.4.1 T_{max} and Maturity

T_{max} for the majority of the samples is less than 430°C (i.e. 417°C to 430°C), equivalent to $R_o < 0.5\%$ (cf. Langford & Blanc-Valleron, 1990). This T_{max} figure is only significantly exceeded by samples from the Kilmaluag Formation, where values range between 436 and 451°C (R_o = 0.6-1.0%), and from the Lealt Shales Formation where samples from the Kildonnan Member have T_{max} values between 439 and 445°C (R_o = 0.75%). The Lonfearn Member samples have T_{max} values which are lower,

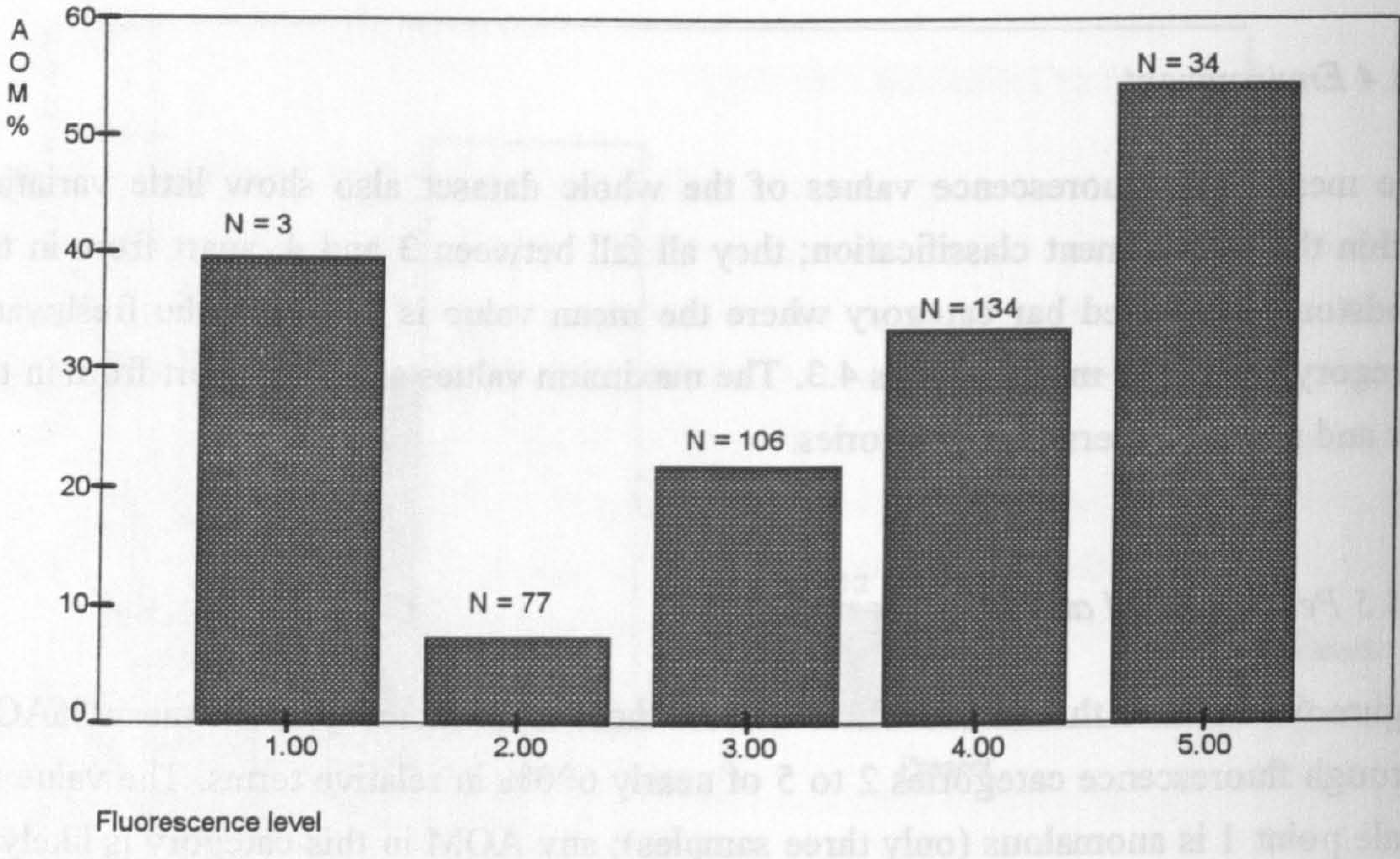


Fig. 6.28. *Mean percentage of AOM for each fluorescence scale point, whole dataset. (N = number of samples).*

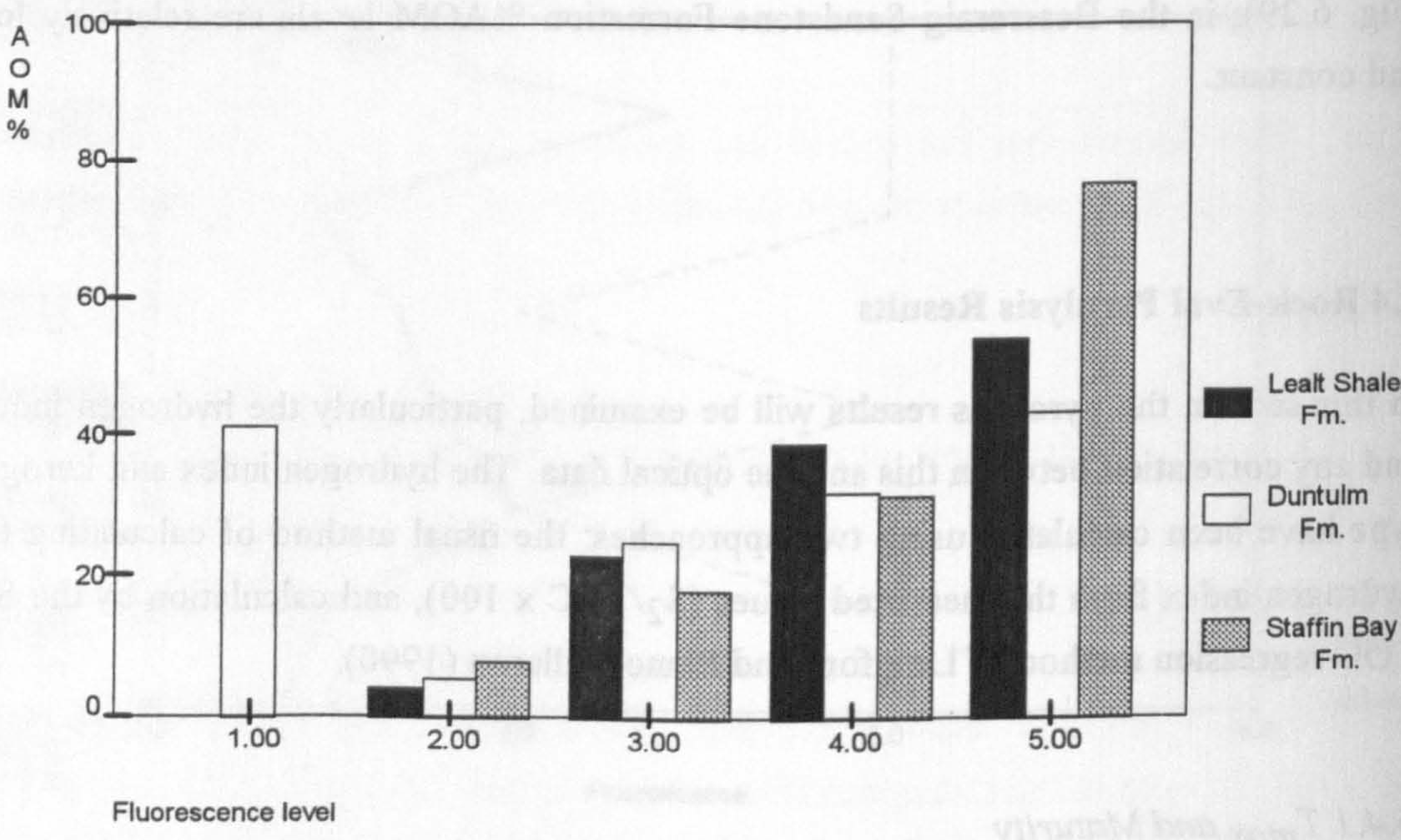


Fig. 6.29. *Mean percentage of AOM for samples of each fluorescence scale point in the Lealt, Duntulm, and Staffin Bay formations.*

between 432 and 438°C (R_0 = 0.5-0.6%). It should be noted that T_{max} values are also affected by kerogen type and TOC levels; the mean T_{max} value is increased in the higher fluorescence categories which reflect well preserved organic matter and dysoxic-anoxic conditions (Fig. 6.30).

6.4.2 Measured Hydrogen Index

In total 57 analyses were performed. The mean measured hydrogen index (HI) is 220 mg HC/g TOC; there is a high standard deviation (176). The distribution of HI values is shown in Fig. 6.31. The number of cases decreases with increasing HI: 29/57 samples have a HI of less than 175, and only 3/57 have a HI of greater than 500. There are two modal ranges, 25-75 and 75-125, each of which contain 11 samples.

6.4.2 (a) Stratigraphic Trends

Within the formations the highest mean HI (equivalent to Type I/II kerogen) is found in the Kilmaluag Formation, the lowest in the Valtos Sandstone Formation (Type III/IV). It exceeds 200 (equivalent to Type II/III kerogen) in all the other formations apart from in parts of the Bearreraig Sandstone and Duntulm formations which fall into Type III/II (Fig. 6.32). Within the Bearreraig Sandstone Formation there is considerable variation in HI between the members, with the Dun Caan Shales and ?Garantiana Clay members (which have better preserved AOM, and define the bases of regressive sequences D1 and E1) having Type II/III kerogen. Subdivision of the former member into its two proximal-distal categories (Fig. 6.33) shows that the more distal, upper section has a reduced mean HI (by 75% in relative terms) and equates to a Type III/IV kerogen. This is correlated with lower kerogen fluorescence levels, the more disseminated nature of the AOM, and a sandstone-dominated lithology, compared to the more proximal division which has Type II/III kerogen and better preserved AOM. There is also an increase in the mean HI from the Udairn Shales at the base of minor sequence D1 to the Rigg Sandstone which marks its top (100% in relative terms). There are relative increases in HI of 70% and 200% through the Elgol Sandstone-Lealt Shales and Valtos Sandstone-Duntulm transgressions respectively, the latter increase continuing into the regressive Kilmaluag Formation. In the transgressive Staffin Bay Formation the mean HI decreases by 80% in relative terms from the argillaceous Upper Ostrea Member to the overlying clastic Belemnite Sands Member.

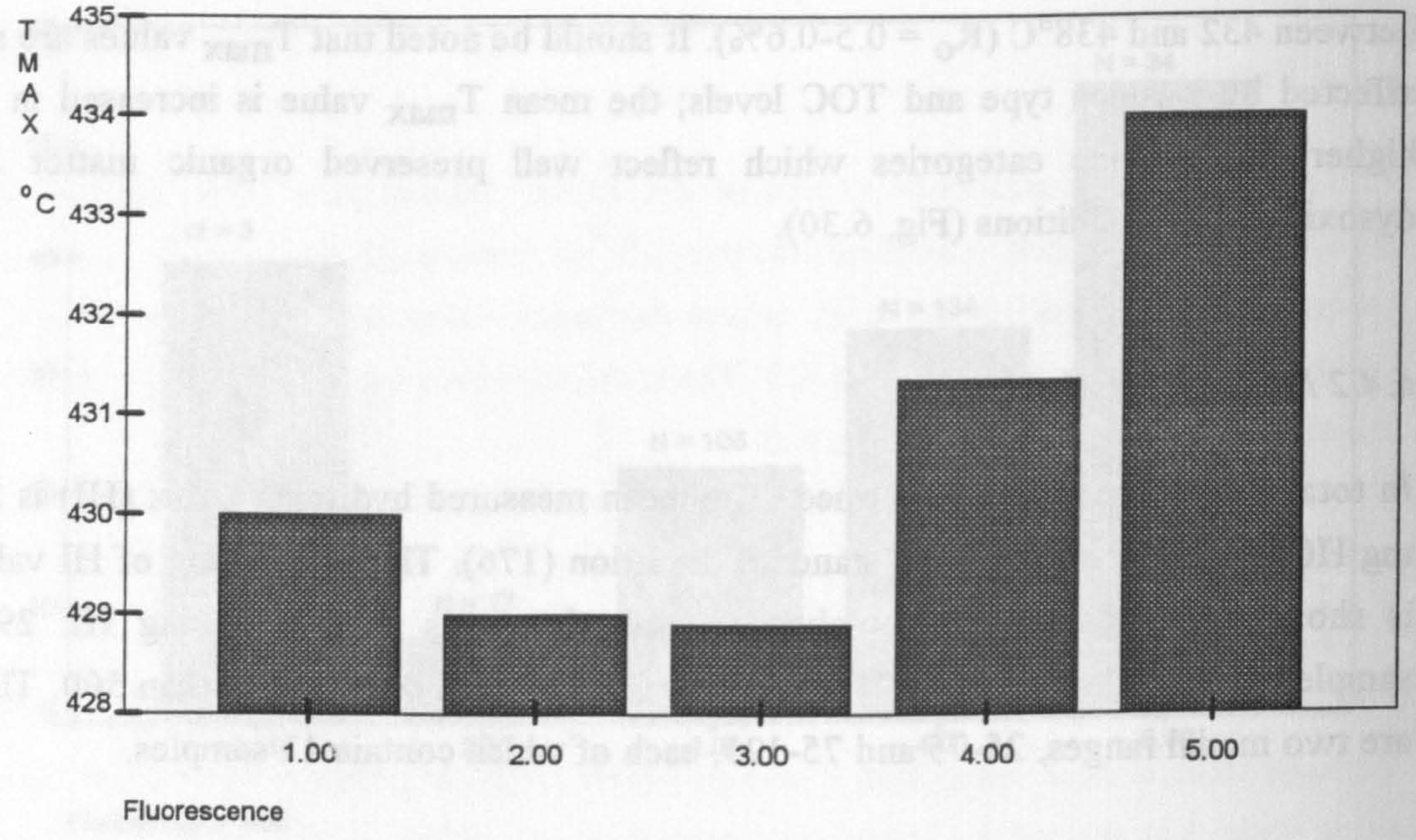


Fig. 6.30. *Mean T_{max} value for samples of each fluorescence scale point in the whole dataset.*

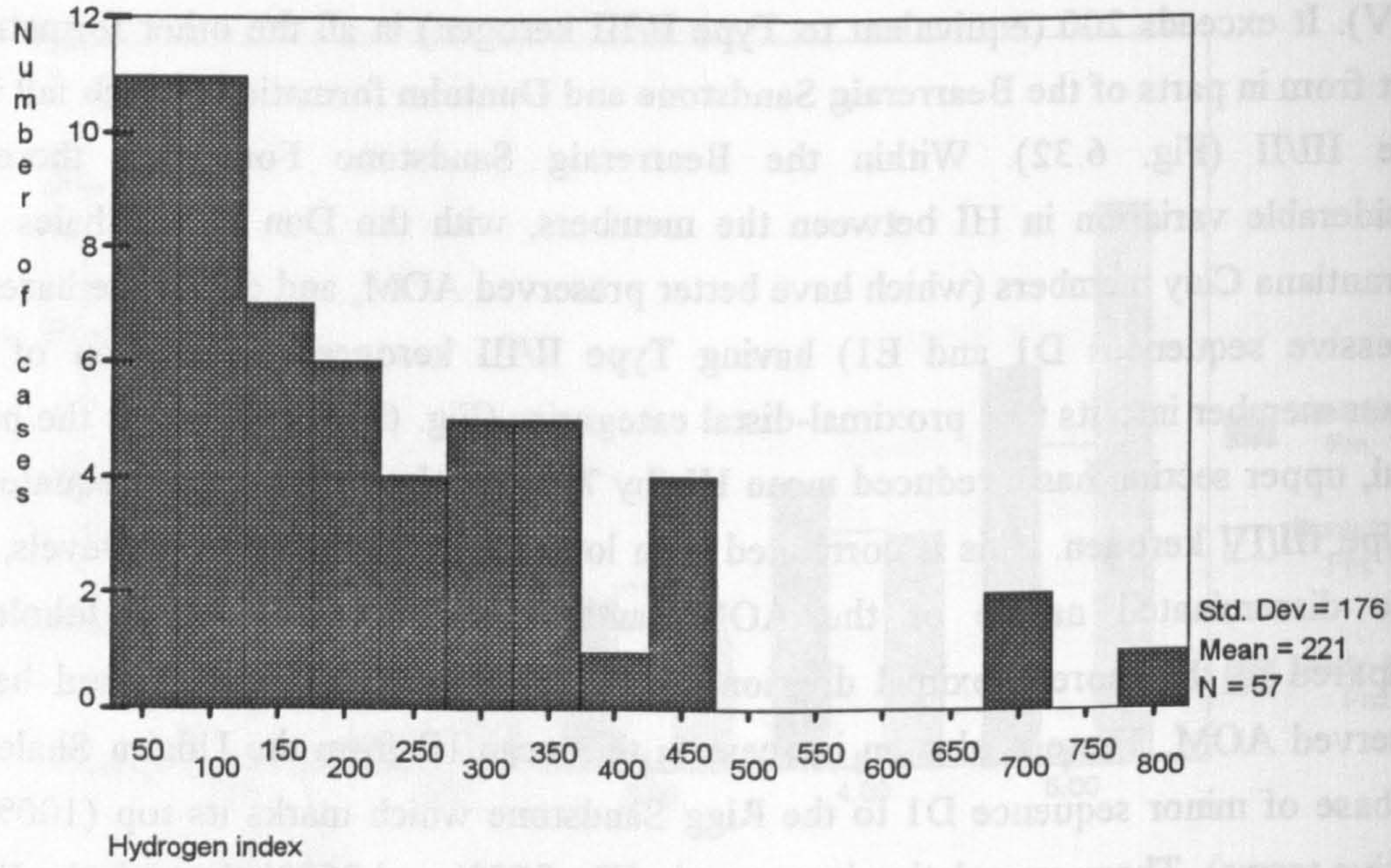


Fig. 6.31. *Frequency histogram of measured hydrogen index distribution in the whole dataset.*

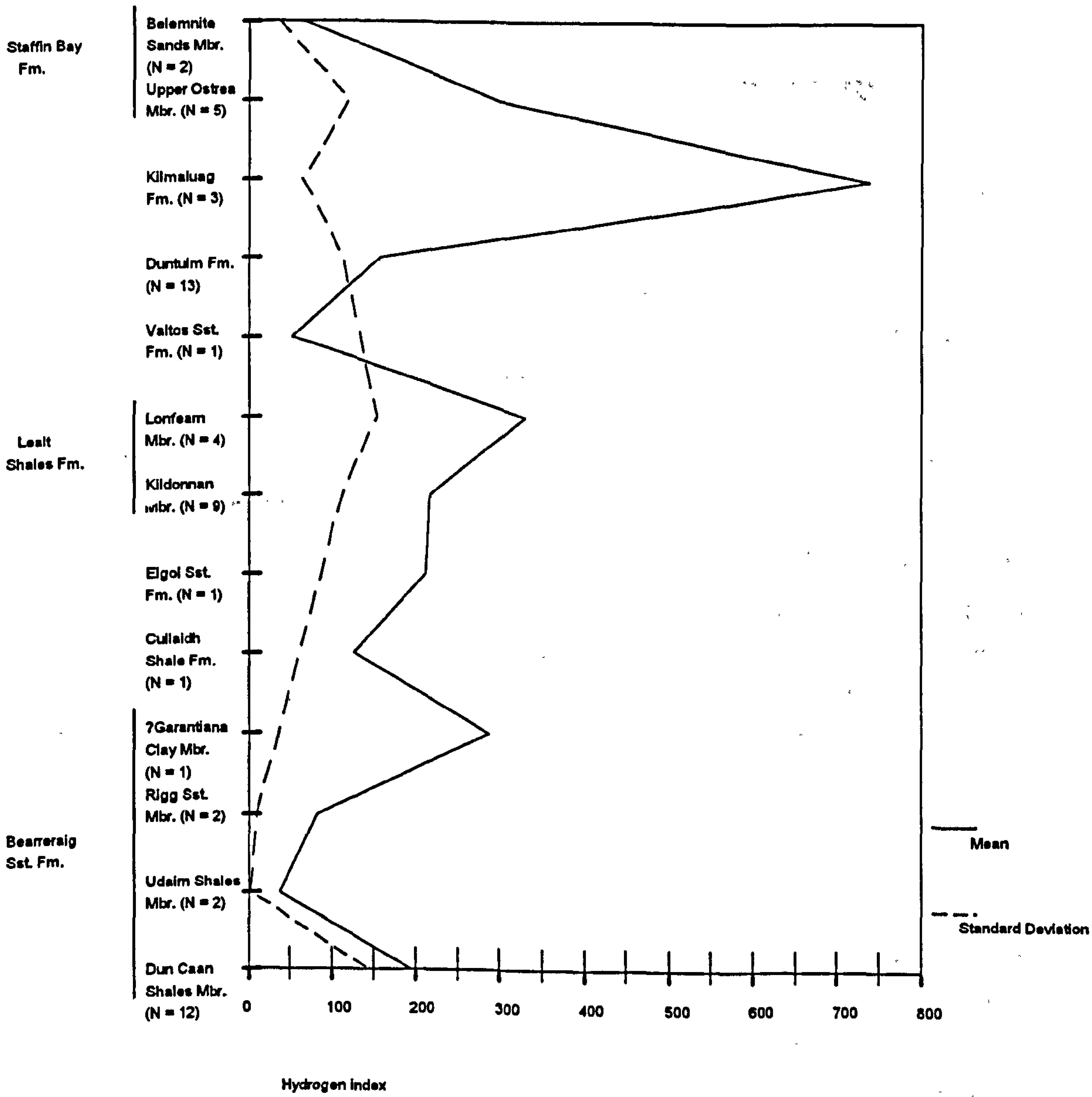


Fig. 6.32. *Mean measured hydrogen index in each lithostratigraphic unit of the Middle Jurassic succession. (N = number of cases).*

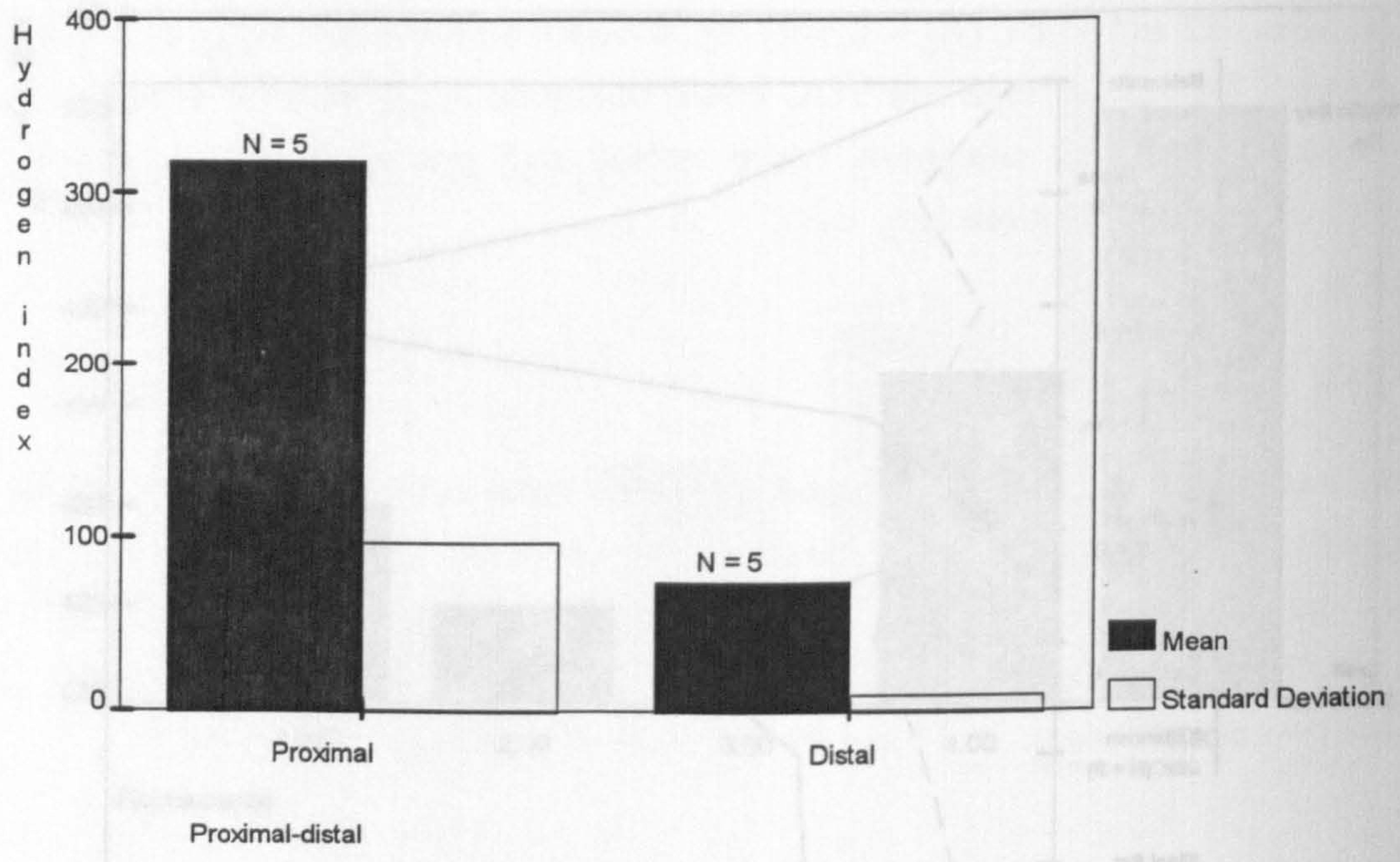


Fig. 6.33. *Mean hydrogen index in each proximal-distal unit of the Dun Caan Shales Member of the Bearreraig Sandstone Formation. (N = number of cases).*

6.4.2 (b) Environment, Salinity and Lithofacies

Within the environment classification of the whole dataset (Fig. 6.34) the mean HI shows a general increase from 96 in the marine-hypersaline environment to just under 577 in the freshwater category (this increase is progressive apart from an anomalous result in the brackish environment). The high value found in the freshwater category is due to the Kilmaluag Formation samples which dominate this category (3/4). The lowest mean HI value, for the bar category, is because it represents sand-dominated lithologies from the Belemnite Sands Member of the Staffin Bay Formation.

In the Lealt Shales and Duntulm Formations (Fig. 6.35) there is a similar general trend of increasing mean HI from the more marine to the more freshwater environments. In the Lealt Shales Formation the mean HI increases by *ca.* 100% in relative terms from 160 in the marine-brackish to 317 in the freshwater-brackish category; it then falls dramatically (> 70% in relative terms) to less than 100 in the freshwater category, but the latter is represented by only one sample. The Duntulm Formation shows a progressive relative increase in mean HI of 200% from the marine-hypersaline to freshwater-brackish categories. In the ostracod-salinity classification of the Lealt Shales Formation (Fig. 6.36) there is a similar trend of the mean HI increasing as salinity falls.

In the lithofacies classification of the Duntulm Formation the mean HI in the dominant *Praeexogyra* limestone-shales facies is just over 200; in the other lithofacies the mean HI does not exceed 100, but there are too few samples for confident conclusions. There is a similar problem in the Staffin Bay Formation where the lithofacies mean HI values (Fig. 6.37) suggest a reduction in HI through the formation correlated with the overall coarsening-upwards nature, but sample numbers are only significant in the bituminous shales facies where the mean HI is 260.

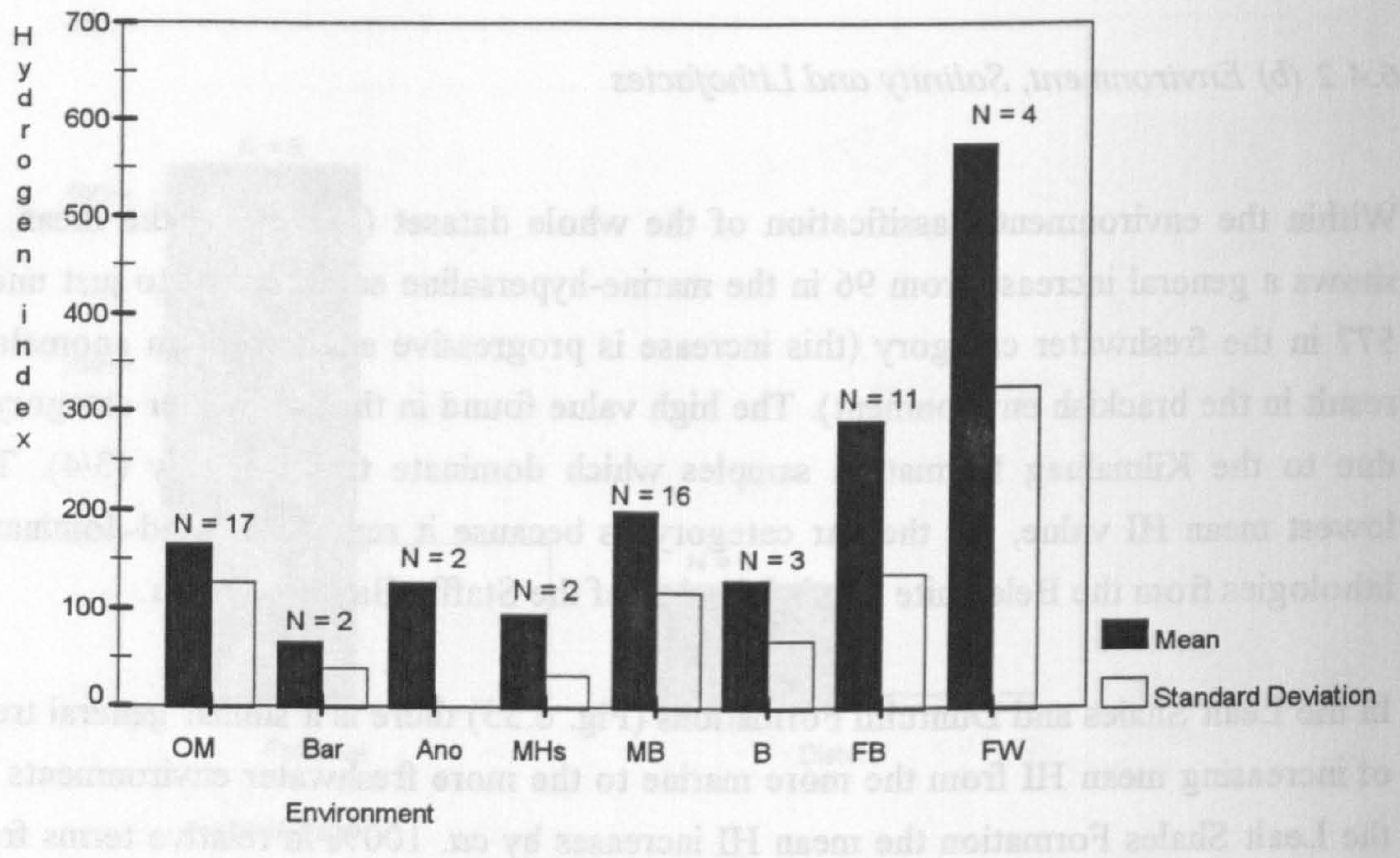


Fig. 6.34. *Mean hydrogen index in each environment category of the whole dataset. Key to abbreviations in Table 6.4. (N = number of cases).*

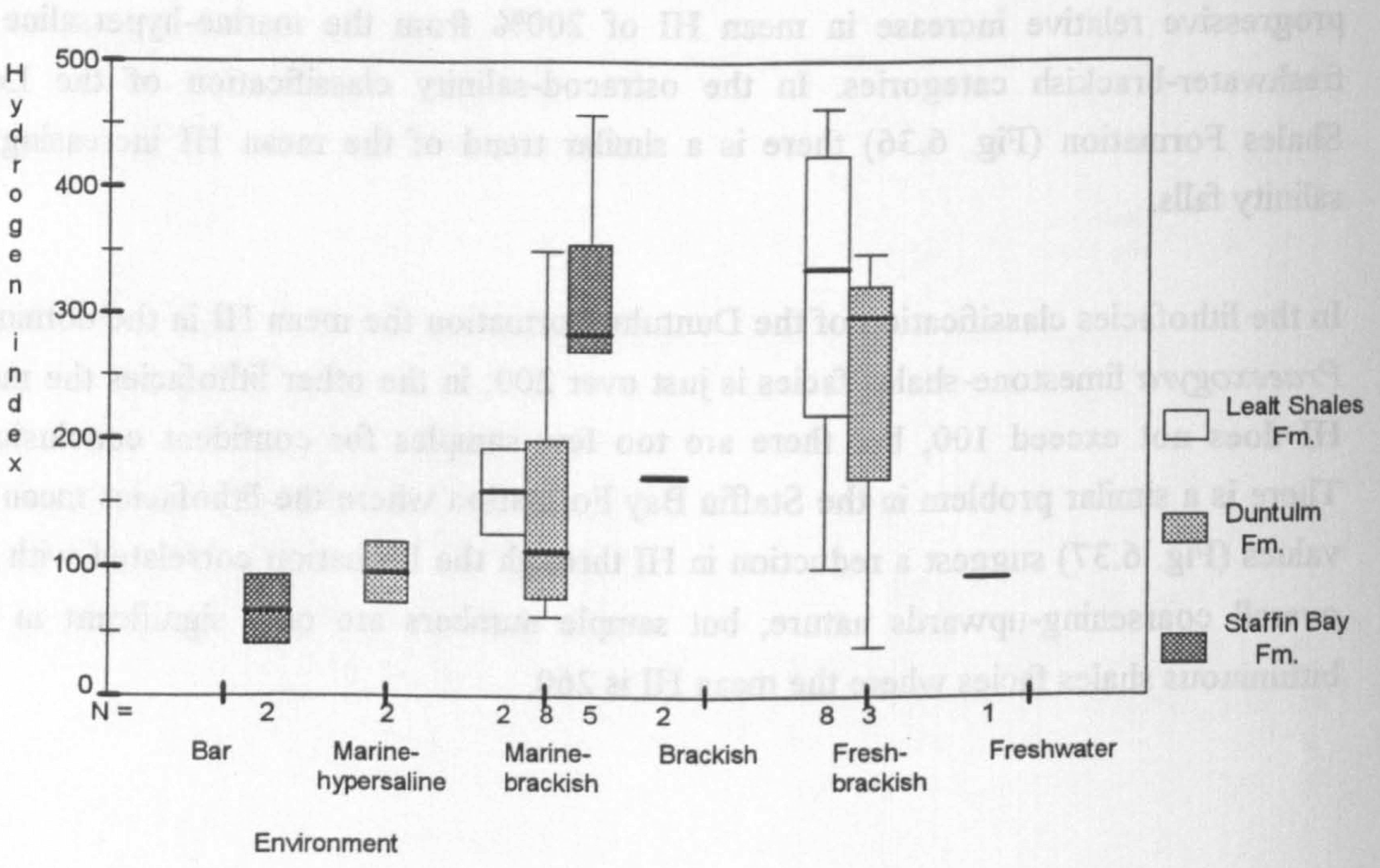


Fig. 6.35. *Boxplot of the hydrogen index values in the lagoonal environment categories of the three main lagoonal formations. The boxes contain all the values between the upper and lower quartiles, the thick black line represents the mean value; the whisker lines represent the maximum and minimum values. (N = number of cases).*

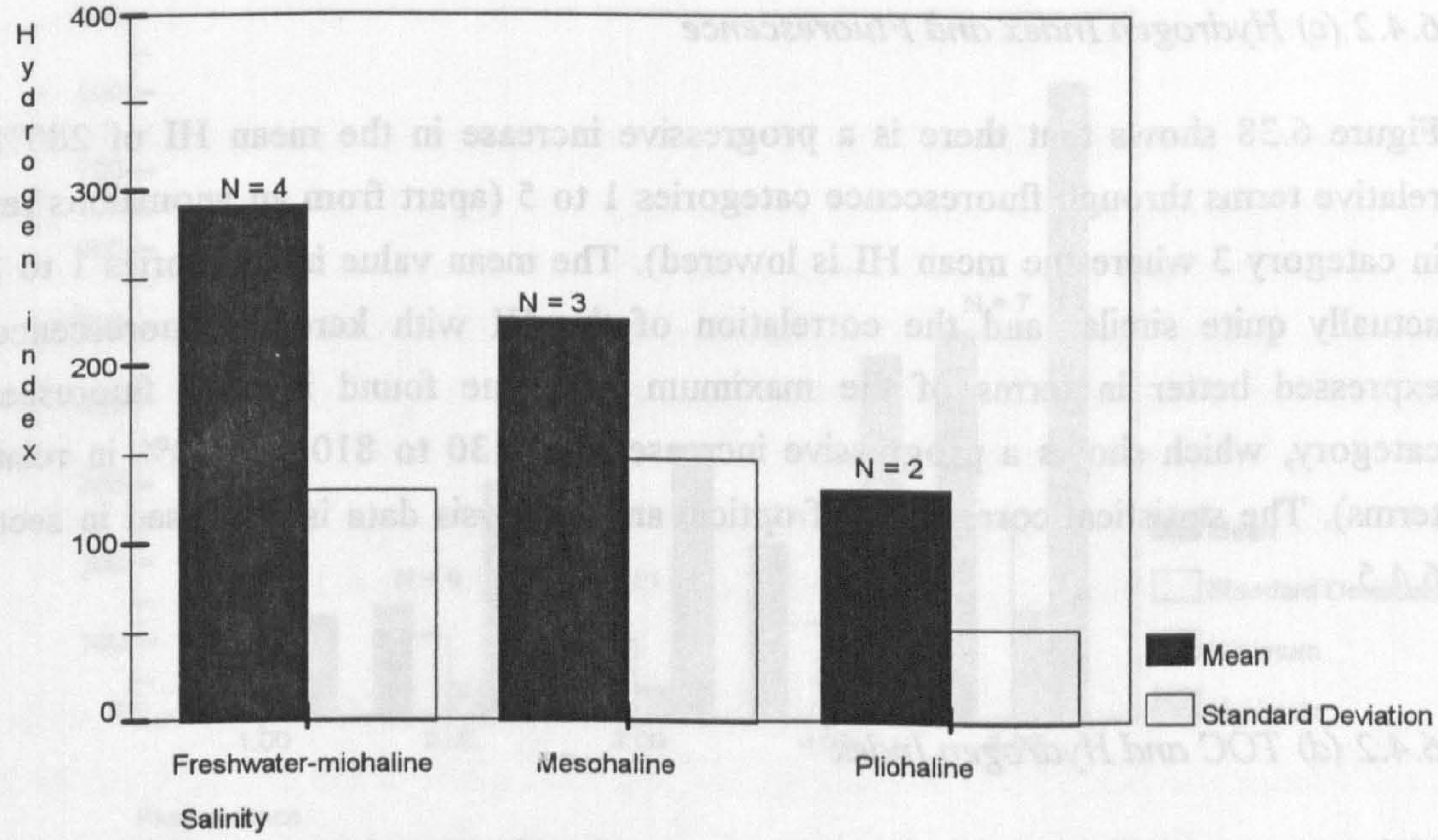


Fig. 6.36. *Mean hydrogen index in each ostracod-salinity category of the Lealt Shales Formation. (N = number of cases).*

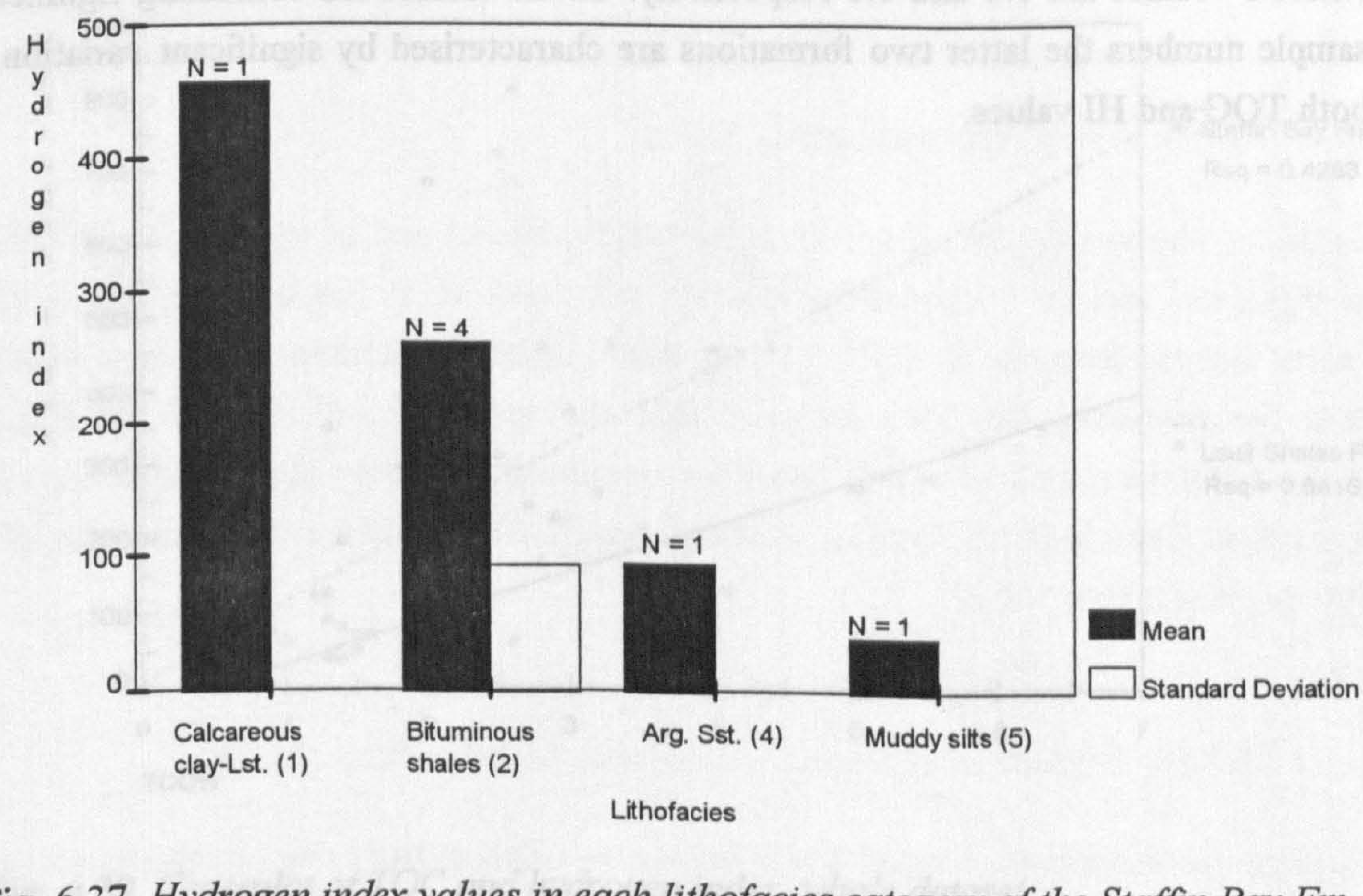


Fig. 6.37. *Hydrogen index values in each lithofacies category of the Staffin Bay Fm. (N = number of cases).*

6.4.2 (c) Hydrogen Index and Fluorescence

Figure 6.38 shows that there is a progressive increase in the mean HI of 280% in relative terms through fluorescence categories 1 to 5 (apart from an anomalous result in category 3 where the mean HI is lowered). The mean value in categories 1 to 3 is actually quite similar and the correlation of the HI with kerogen fluorescence is expressed better in terms of the maximum HI value found in each fluorescence category, which shows a progressive increase from 130 to 810 (> 500% in relative terms). The statistical correlation of optical and pyrolysis data is discussed in section 6.4.5.

6.4.2 (d) TOC and Hydrogen Index

If these two variables are correlated it suggests that the quantity and quality of organic matter are related; the cross plot (Fig. 6.39) of the whole dataset shows no general correlation ($r^2 < 0.2$), but within the different formations significant positive correlations can be found. In the Lealt Shales and Staffin Bay formations, for example, where r^2 values are 0.4 and 0.6 respectively. Of the formations containing significant sample numbers the latter two formations are characterised by significant variation in both TOC and HI values.

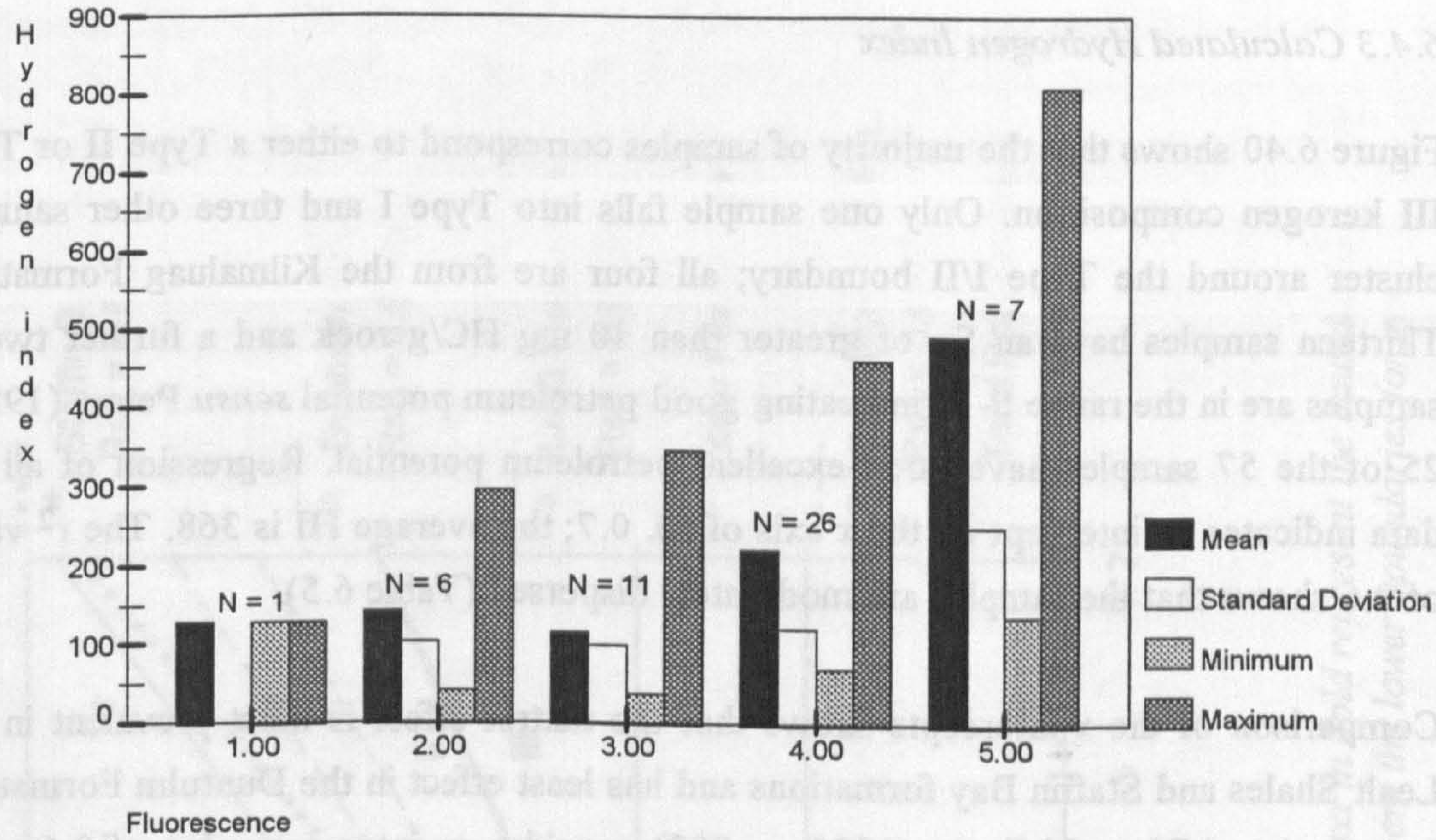


Fig. 6.38. *Hydrogen index values for samples with each fluorescence scale point, whole dataset. (N = number of cases).*

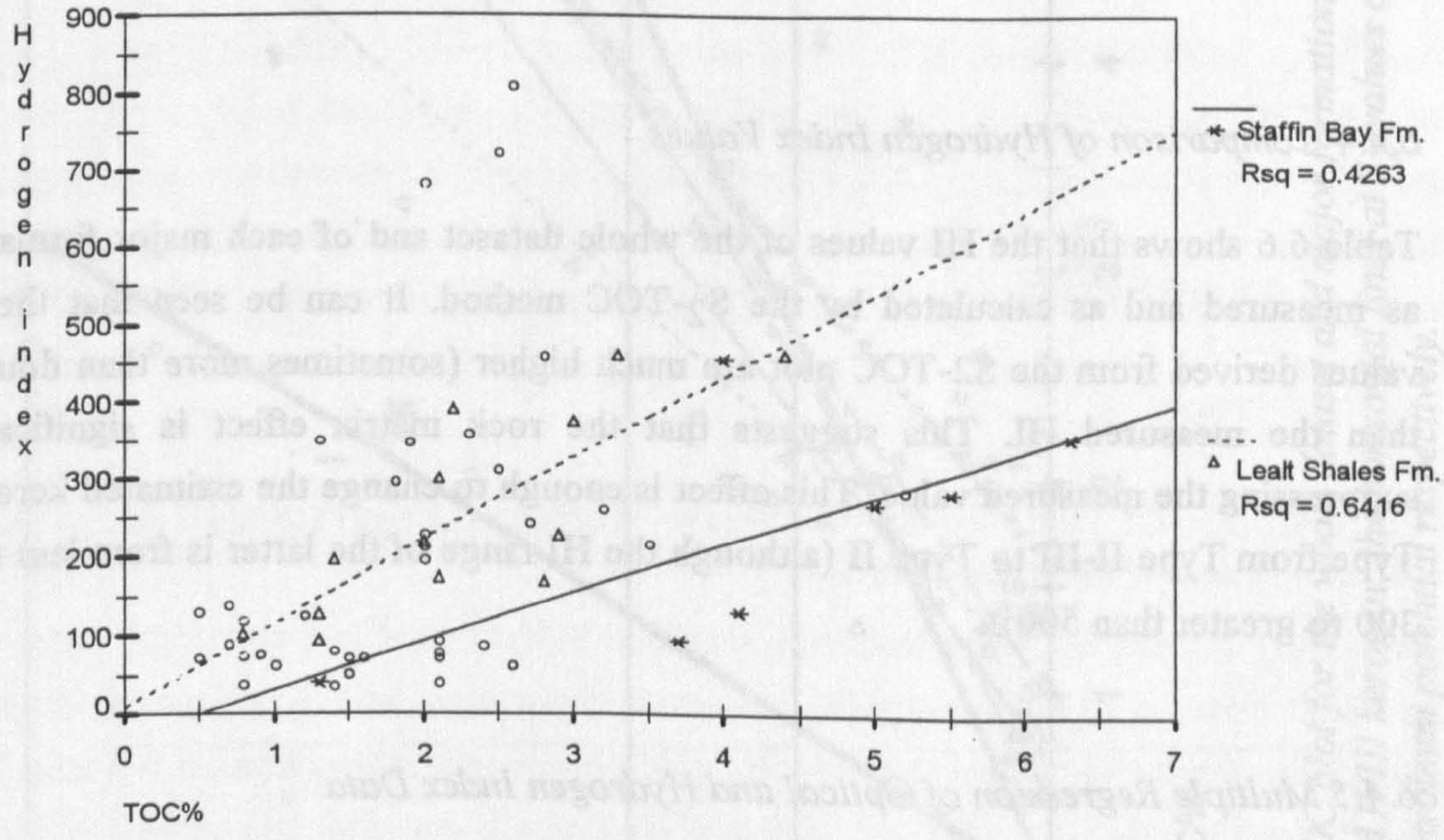


Fig. 6.39. *Crossplot of TOC and hydrogen index, whole dataset.*

6.4.3 Calculated Hydrogen Index

Figure 6.40 shows that the majority of samples correspond to either a Type II or Type III kerogen composition. Only one sample falls into Type I and two other samples cluster around the Type I/II boundary; all three are from the Kilmaluag Formation. Thirteen samples have an S_2 of greater than 10 mg HC/g rock and a further twelve samples are in the range 5-10 indicating good petroleum potential *sensu* Peters (1986); 25 of the 57 samples have good-excellent petroleum potential. Regression of all the data indicates an intercept on the *x* axis of *ca.* 0.7; the average HI is 368. The r^2 value of 0.6 shows that the samples are moderately dispersed (Table 6.5).

Comparison of the *x*-intercepts shows that the matrix effect is most prevalent in the Lealt Shales and Staffin Bay formations and has least effect in the Duntulm Formation. Langford and Blanc-Valleron (1990, p. 803) consider an intercept value of 0.6 to be 'fairly high'. Figure 6.41 shows that in part the *x*-intercept may also reflect the black wood (= 'dead carbon') content of the kerogen; the *x*-intercept of the regression line for those samples with a higher black wood content (11-20%) is some 0.2 higher than for those containing less than 10% black wood.

6.4.4 Comparison of Hydrogen Index Values

Table 6.6 shows the HI values of the whole dataset and of each major formation as measured and as calculated by the S_2-TOC method. It can be seen that the HI values derived from the S2-TOC plot are much higher (sometimes more than double) than the measured HI. This suggests that the rock matrix effect is significantly suppressing the measured value. This effect is enough to change the estimated kerogen Type from Type II-III to Type II (although the HI range of the latter is from less than 300 to greater than 500).

6.4.5 Multiple Regression of Optical and Hydrogen Index Data

Multiple regression has been used to analyse the relationship between HI and parameters from the optical data that are considered most likely to influence it. These parameters are the fluorescent liptinitic fraction of the assemblage (Hartman-Stroup, 1987; Tyson, 1989, 1995 & refs. therein), and the brown/black wood ratio (which can be particularly important at low HI values; cf. Frank & Tyson 1995). The parameters used as predictor variables were thus: %AOM of kerogen (AOM), %palynomorphs of

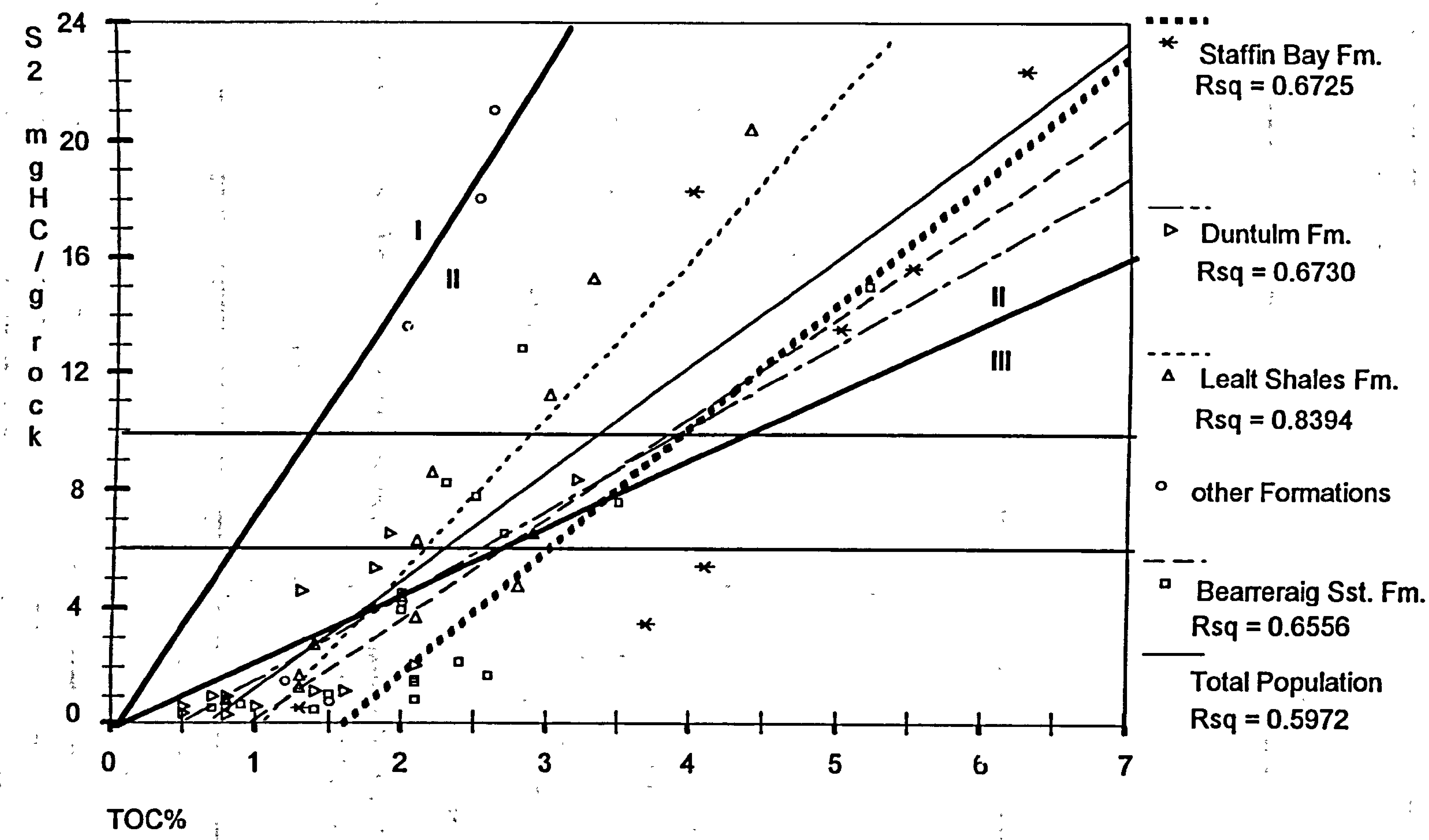


Fig. 6.40. *S_2-TOC plot for the whole dataset and major formations; the lines and text in bold represent the boundaries for Type I/II and II/III kerogen; the horizontal lines at S_2 values of 5 and 10 represent the lower boundaries for good and excellent petroleum potential respectively.*

Unit	N	S_2-TOC equation	x-intercept	r^2
All data	57	y = -2.397 + 3.681x	0.7	0.6
Bearreraig Sandstone Fm.	17	y = -3.242 + 3.432x	0.9	0.5
Lealt Shales Fm.	13	y = -5.605 + 5.405x	1.0	0.8
Duntulm Fm.	13	y = -1.356 + 2.877x	0.5	0.7
Staffin Bay Fm.	7	y = -6.689 + 4.220x	1.6	0.7

N = number of samples; r^2 = coefficient of correlation.

Table 6.5. *S_2 vs. TOC regression equations for the whole dataset and each major formation.*

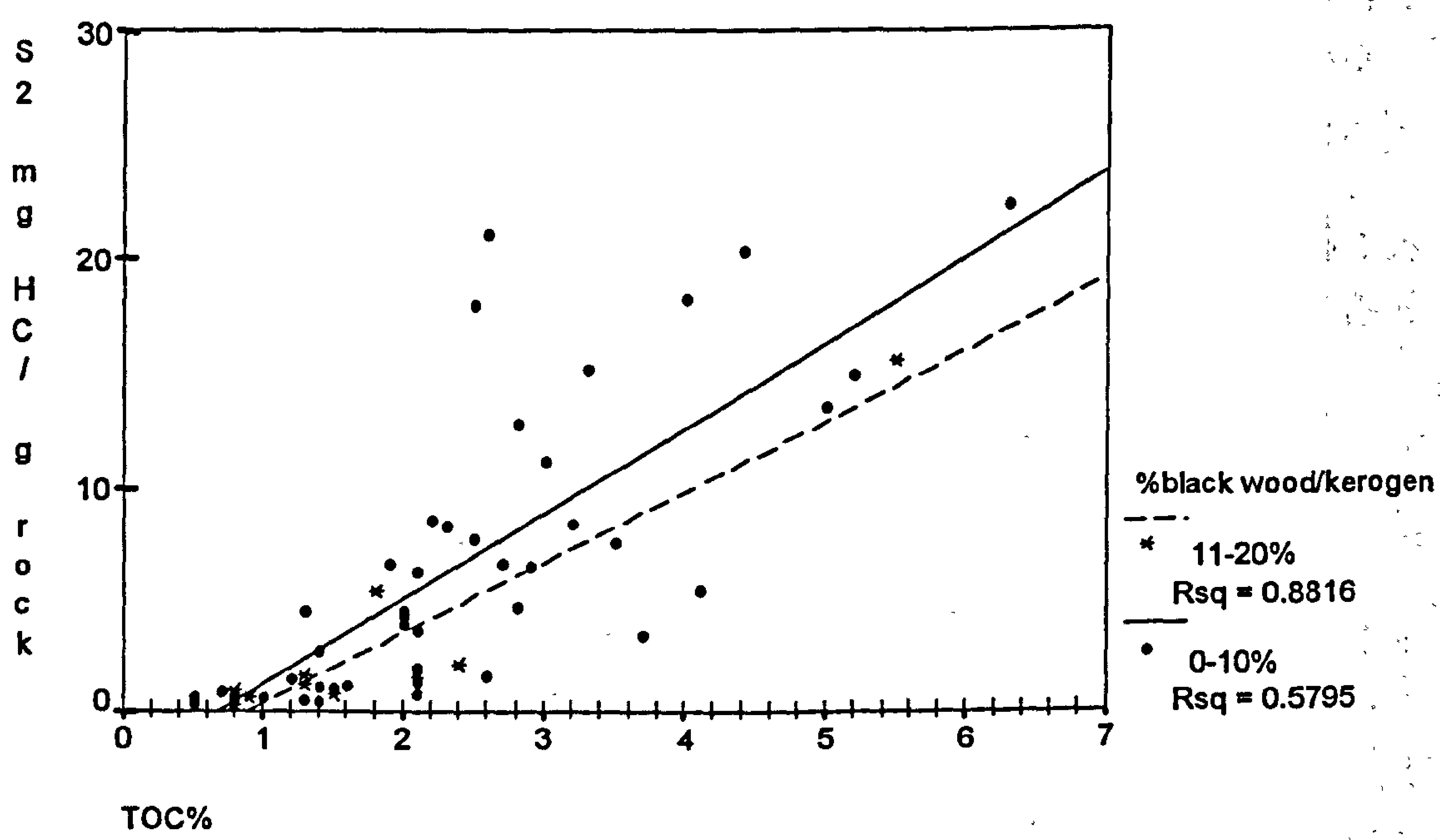


Fig. 6.41. *S2-TOC plot showing the effect of black wood ('dead carbon') content on the x-intercept of the regression line.*

Samples	Measured HI & Type	S_2-TOC HI & Type
All data	220 (II/III)	368 (II)
Bearreraig Sandstone Fm.	160 (III/II)	343 (II)
Lealt Shales Fm.	250 (II/III)	540 (II)
Duntulm Fm.	160 (III/II)	287 (II)
Staffin Bay Fm.	235 (II/III)	420 (II)

Table 6.6. *Mean hydrogen index and kerogen Type derived from different methods.*

kerogen (Tpaly), %cuticle of phytoclasts (Cu/Tphy), brown:black wood ratio (Bro/blk), %*Botryococcus* of palynomorphs (Bot/Tpaly), and fluorescence level from the scale described in section 2.2.1 (Fluor). Although only some of these parameters are expressed as percentage values the standardisation procedure carried out in multiple regression allows all these variables to be included.

6.4.5 (a) Whole Dataset

The multiple R value shows a positive relationship between the independent variables and dependent variable (Table 6.7a), but the r^2 value is relatively low, suggesting that there is much variation about the mean HI that is not explained by the regression equation. The low significance of F value shows that the regression is significant at the 99% level.

Examination of Table 6.7b shows that AOM, the brown:black ratio, and *Botryococcus* have relatively high beta values and low significance of T values; this suggests that it is these variables that are having the greatest effect on the HI.

The path analysis diagram (Fig. 6.42) shows that AOM, the brown:black ratio, and *Botryococcus* have the greatest causal effect on the HI. However, AOM and *Botryococcus* are correlated at the 0.4 level, and AOM and fluorescence are the most strongly correlated pair of variables (0.6). The U value of 0.76 shows that a significant proportion of the standard deviation of the HI is not explained by the six independent variables.

6.4.5 (b) High vs. Low Salinity

Multiple regression has been carried out on a combination of the marine-hypersaline and marine-brackish (high salinity) environment categories, and on a combination of the freshwater-brackish and freshwater (low salinity) categories. Both analyses show a positive relationship between the independent and dependant variables (Table 6.8a); the r^2 value in the low salinity data is double that in the high salinity data, showing better explanatory power for the regression equation and good prediction of the HI in the former. The significance of F value in this data shows that the equation is significant at the 95% level; the higher figure obtained for the high salinity data suggests that this equation is only significant at the 68% confidence level.

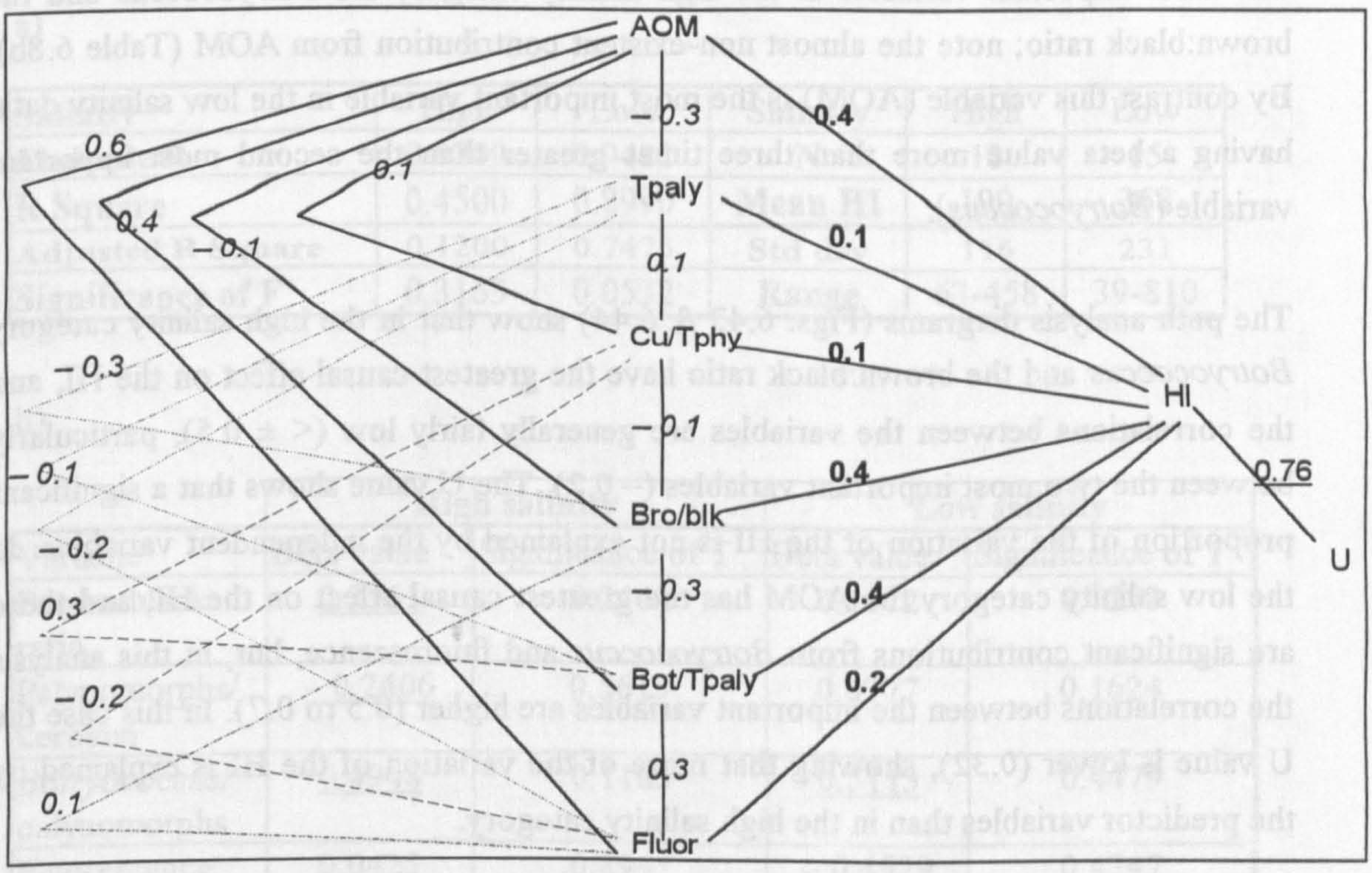
a)

Multiple R	0.6447	N	57
R Square	0.4157	Mean HI	221
Adjusted R Square	0.3209	Std Dev	176
Significance of F	0.0019	HI range	36-810

b)

Variable	Beta value	Significance of T
Brown/black ratio	0.4244	0.0147
Fluorescence level	0.1725	0.2902
Cuticle/ phytoclasts	0.0619	0.6642
Botryococcus/ palynomorphs	0.3780	0.0136
Palynomorphs/ kerogen	0.1478	0.3784
AOM/ kerogen	0.4407	0.0138

Table 6.7. *Results of the multiple regression analysis of hydrogen index and optical data, whole datset. The three highest beta values are underlined.*



Key: AOM, etc. = independant variables
HI = dependant variable
U = other variables
Figures in **bold** (e.g. **0.4**) = Beta coefficients from multiple regression
Figures in *italics* (e.g. *0.1*) = Pearson's correlation coefficient
Figure underlined (e.g. 0.76) = square root of $1-r^2$

Fig. 6.42. *Path analysis diagram for the whole dataset hydrogen index multiple regression.*

The most important variables in the high salinity category are *Botryococcus* and the brown:black ratio; note the almost non-existent contribution from AOM (Table 6.8b). By contrast this variable (AOM) is the most important variable in the low salinity data, having a beta value more than three times greater than the second most important variable (*Botryococcus*).

The path analysis diagrams (Figs. 6.43 & 6.44) show that in the high salinity category *Botryococcus* and the brown:black ratio have the greatest causal effect on the HI, and the correlations between the variables are generally fairly low ($< \pm 0.5$), particularly between the two most important variables (– 0.2). The U value shows that a significant proportion of the variation of the HI is not explained by the independent variables. In the low salinity category the AOM has the greatest causal effect on the HI, and there are significant contributions from *Botryococcus* and fluorescence, but, in this analysis the correlations between the important variables are higher (0.5 to 0.7). In this case the U value is lower (0.32), showing that more of the variation of the HI is explained by the predictor variables than in the high salinity category.

6.4.5 (c) In the Four Major Formations

Multiple regression was carried out separately for the four formations (Bearreraig Sandstone, Lealt Shales, Duntulm, and Staffin Bay); however, due to the existence of multicollinearity the correlation of HI and optical parameters in the Staffin Bay Formation could only be carried out using simple cross plots.

The multiple R values in all three analyses show that there is a positive relationship between the independent and dependant variables (Table 6.9a), and in the Bearreraig Sandstone Formation this relationship is near perfect (multiple R = 0.99). The r^2 values in the Bearreraig Sandstone and Lealt Shales formations analyses are both greater than 0.9 showing a good explanatory power for the regression equations and good prediction of the HI (particularly in the former formation where $r^2 = 0.99$). In the Duntulm Formation the lower r^2 value suggests that there is significant variation in the HI that is not explained by the regression equation. The significance of F values show that the Bearreraig and Lealt formation regression equations are significant at the 99% and 98% levels respectively; the Duntulm Formation equation is only significant at the 70% level.

a)

Salinity	High	Low	Salinity	High	Low
Multiple R	0.6709	0.9482	**N**	18	15
R Square	0.4500	0.8990	**Mean HI**	190	368
Adjusted R Square	0.1200	0.7475	**Std dev**	116	231
Significance of F	0.3163	0.0532	**Range**	63-458	39-810

b)

	High salinity		**Low salinity**	
Variable	Beta value	Significance of T	Beta value	Significance of T
Brown:black ratio	0.3561	0.2461	0.1472	0.7273
Palynomorphs/ kerogen	– 0.2406	0.5619	0.0777	0.1624
Botryococcus/ palynomorphs	0.4948	0.1183	0.5113	0.4479
Fluorescence level	0.0425	0.8941	– 0.4529	0.4347
Cuticle/ phytoclasts	– 0.0877	0.8128	– 0.2089	0.4312
AOM/ kerogen	0.0022	0.9961	1.6013	0.0615

Table 6.8. *Results of the multiple regression analysis of hydrogen index and optical data for the high and low salinity environments (defined in text). The three highest beta values in each analysis are underlined.*

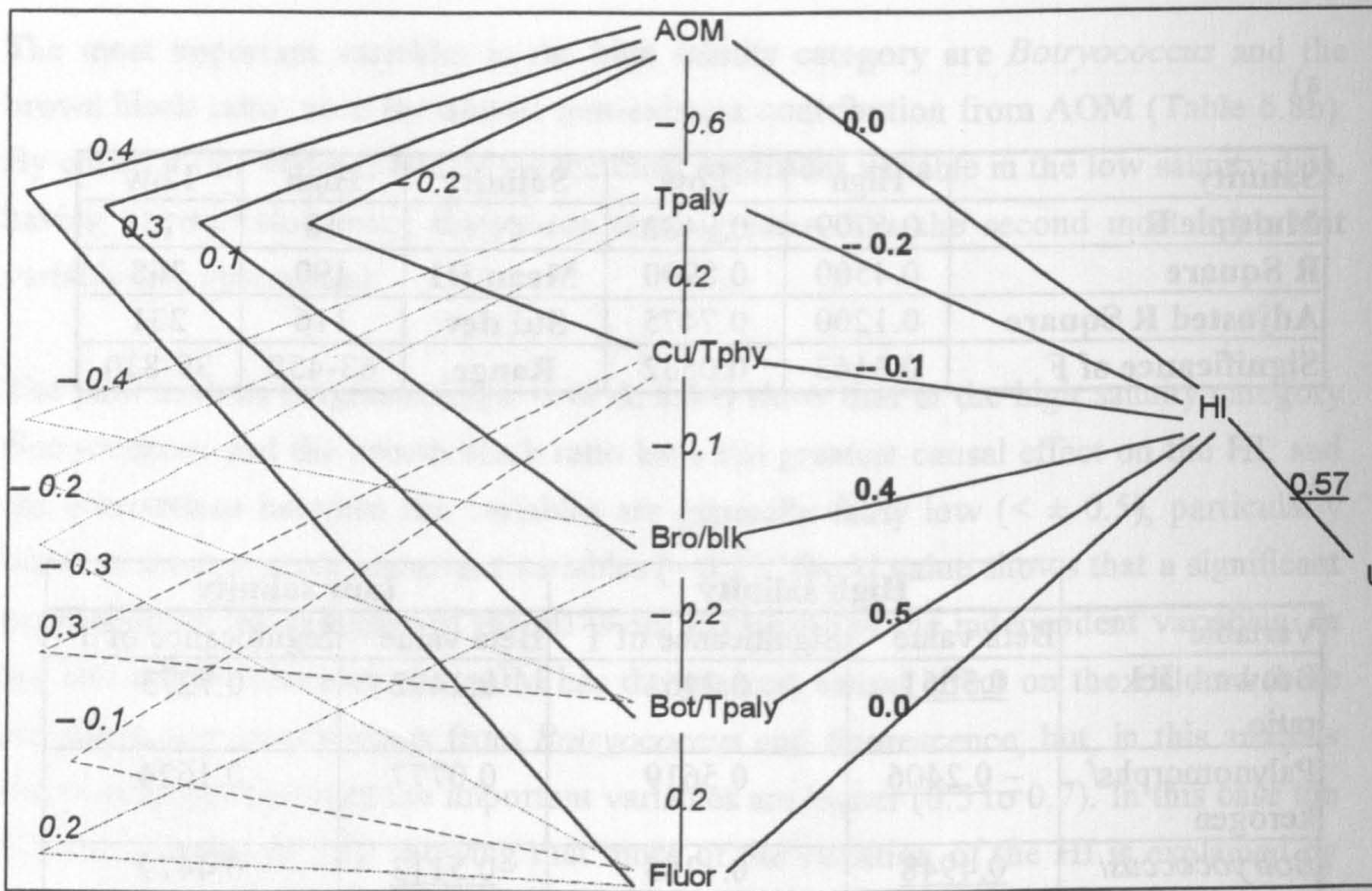


Fig. 6.43. *Path analysis diagram for the high salinity environments. Key in Fig. 6.42.*

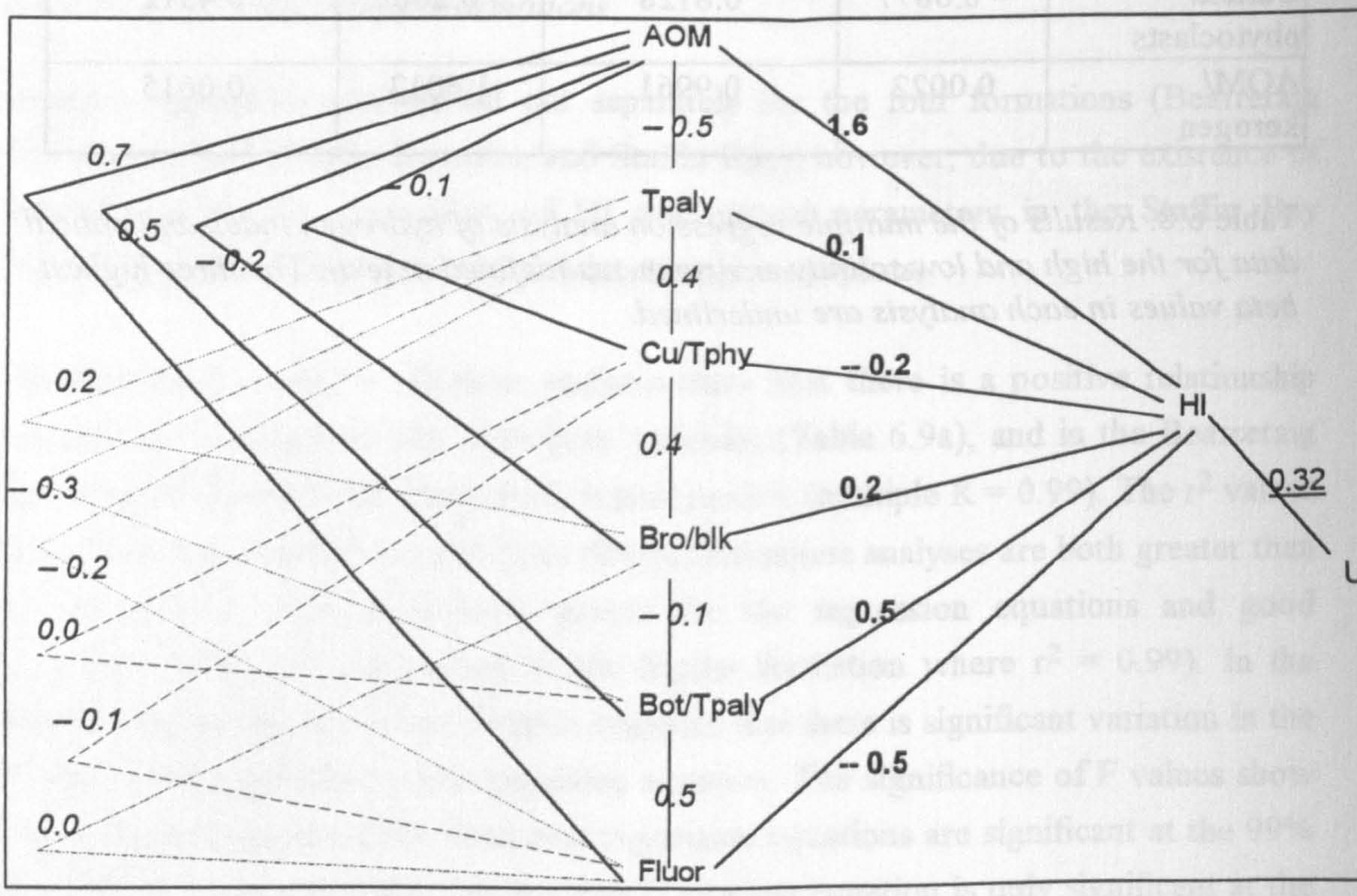


Fig. 6.44. *Path analysis diagram for the low salinity environments. Key as in Fig. 6.42.*

Examination of Table 6.9b shows that in the Bearreraig Sandstone Formation palynomorphs and *Botryococcus* are the only two variables which do not have a significant effect on the HI; the most important two variables are the brown:black wood ratio and cuticle. In the Lealt Shales Formation the beta and significance of T values suggest that the most important variable is AOM, followed by the brown:black ratio; the very low beta value for *Botryococcus* suggests that this variable is having little effect on the HI, but the significance of T values are somewhat increased throughout this analysis suggesting that there is potential for the effects observed on the HI to be chance occurrences. In the Duntulm Formation the beta values are markedly increased (and the significance of T values particularly low) for cuticle and *Botryococcus* suggesting that these variables have the greatest effect on the HI.

The path analysis diagrams show that in the Bearreraig Sandstone Formation (Fig. 6.45) the brown:black wood ratio and cuticle are having the greatest causal effect on the HI, but there are also significant contributions from AOM and fluorescence. The correlations between the variables are generally low ($< \pm 0.5$), particularly between the two most important variables ($-$ 0.2), suggesting that there are few problems with collinearity in the analysis. The U value of 0.11 is the lowest seen in any of the analyses, suggesting that there is little variation in the standard deviation of the HI that is not explained by the independent variables. The U value in the Lealt Shales Formation analysis (Fig. 6.46) is *ca.* three times this figure, suggesting that in this case there is variation about the mean HI that is not explained by the independent variables. Of these, AOM has the greatest causal effect on the HI, with significant contributions also from the brown:black ratio and fluorescence level. In this formation the correlations between the variables are somewhat higher than in the Bearreraig Sandstone Formation with values of up to $-$ 0.8 (AOM and palynomorphs); the highest correlation occurs between AOM and fluorescence (0.5). These two variables are correlated at a similar level in the Duntulm Formation (Fig. 6.47), where there is also a correlation of 0.5 between the two variables that are having the greatest causal effect on the HI (cuticle and *Botryococcus*); there is also a contribution at a lower level from AOM. In this case the U value of 0.5 shows that a significant proportion of the variation of the HI is not explained by the independent variables.

a)

Unit	Bearreraig Sst. Fm.	Lealt Shales Fm.	Duntulm Fm.
Multiple R	0.9936	0.9500	0.8138
R Square	0.9872	0.9026	0.6622
Adjusted R Square	0.9616	0.7856	0.3570
Significance of F	0.0062	0.0202	0.3032
Number of samples	18	13	13
Mean HI	166	252	159
Standard deviation	126	131	113
Range	36-460	93-469	39-350

b)

	Bearreraig Sst. Formation		**Lealt Shales Formation**		**Duntulm Formation**	
Variable	Beta value	Sig. T	Beta value	Sig. T	Beta value	Sig. T
AOM/ kerogen	– 0.2722	0.0933	<u>0.8584</u>	0.3760	<u>– 0.5717</u>	0.3223
Palynomorphs/ kerogen	– 0.1040	0.3960	<u>0.2903</u>	0.9822	0.1767	0.9744
Cuticle/ phytoclasts	<u>0.5670</u>	0.0103	– 0.1060	0.5692	<u>– 7.4230</u>	0.0623
Brown:black ratio	<u>0.7021</u>	0.0077	<u>– 0.3875</u>	0.3606	0.2003	0.5799
Botryococcus/ palynomorphs	– 0.1290	0.2044	– 0.0252	0.9711	<u>6.8624</u>	0.0773
Fluorescence level	<u>0.3247</u>	0.0402	0.2592	0.5513	– 0.0927	0.8093

Sig. T = significance of T value

Table 6.9. *Results of the multiple regression analysis of hydrogen index and optical data in the Bearreraig, Lealt, and Duntulm formations. The three highest beta values in each analysis are underlined.*

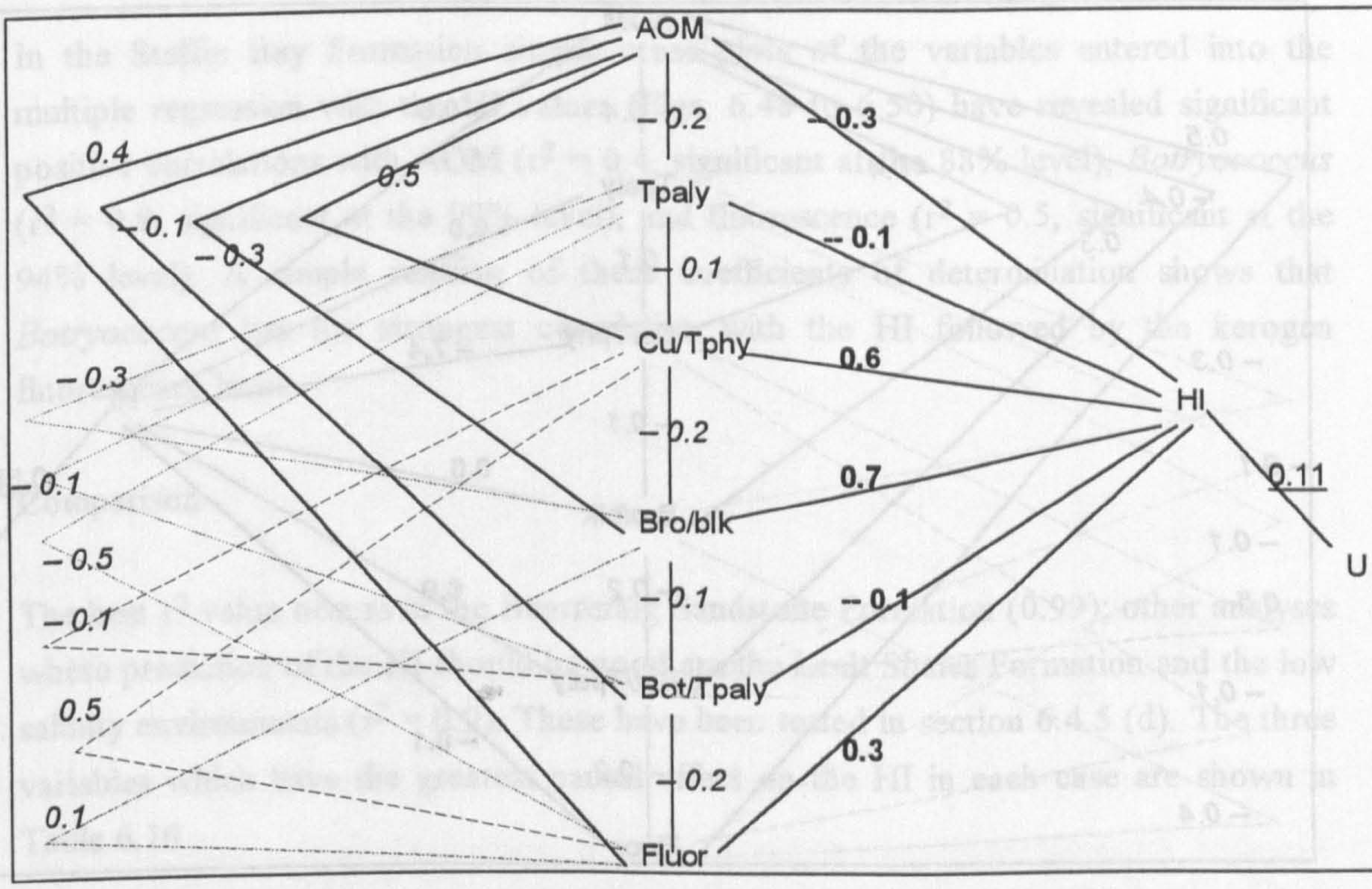


Fig. 6.45. *Path analysis diagram for the Bearreraig Sandstone Formation. Key as for Fig. 6.42.*

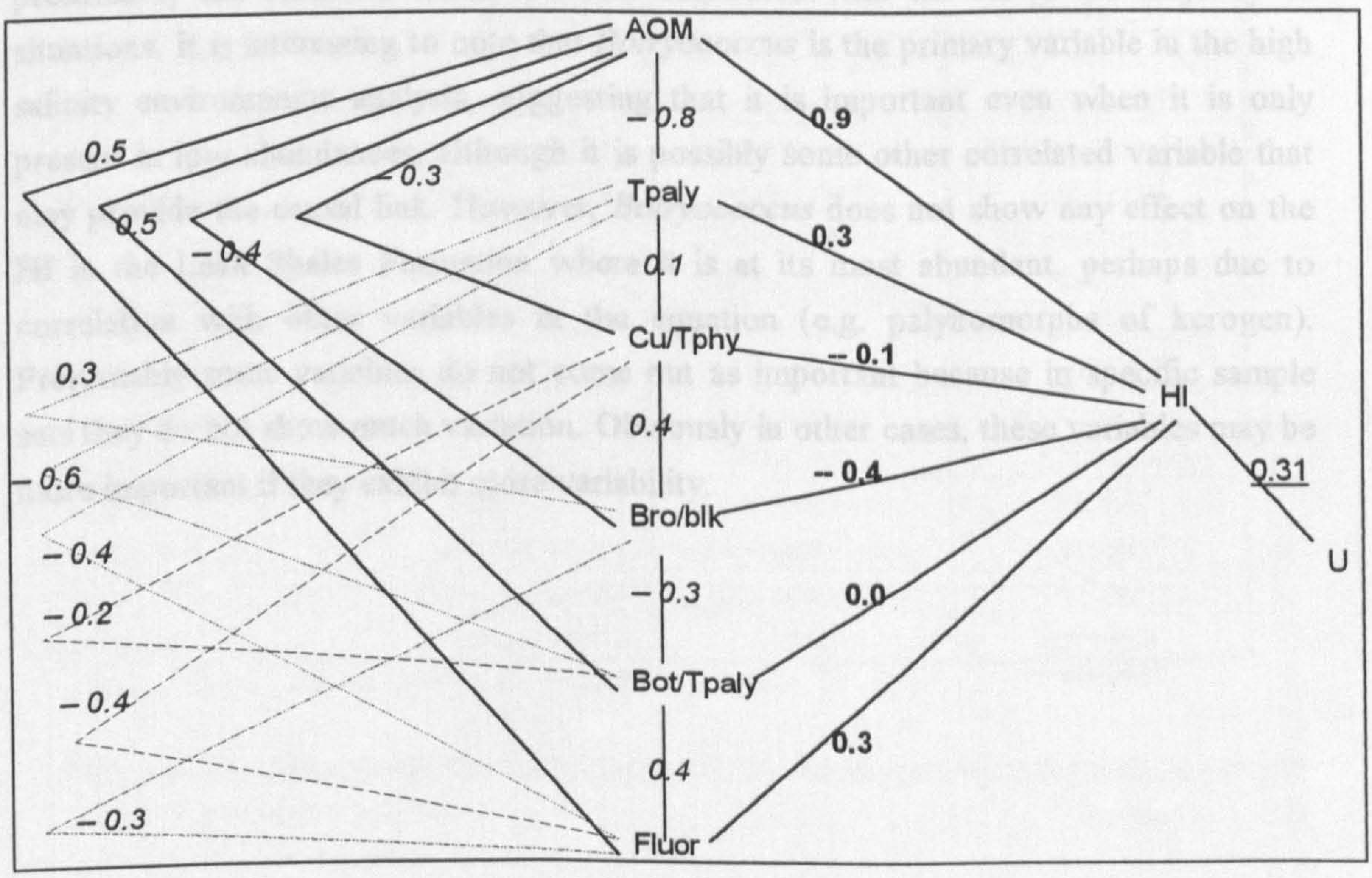


Fig. 6.46. *Path analysis diagram for the Lealt Shales Formation. Key as for Fig. 6.42.*

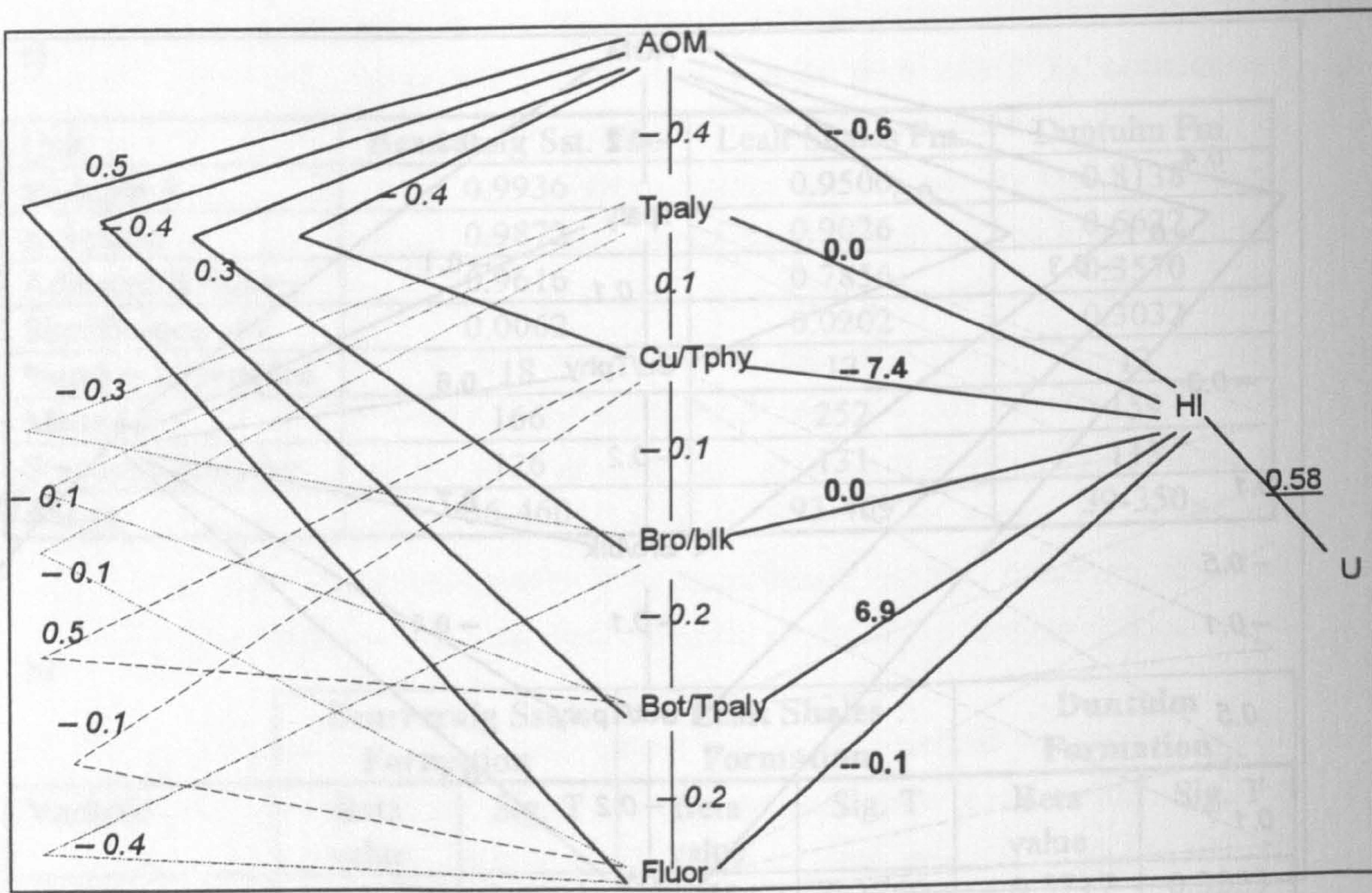


Fig. 6.47. *Path analysis diagram for the Duntulm Formation. Key as for Fig. 6.42.*

In the Staffin Bay Formation simple cross plots of the variables entered into the multiple regression with the HI values (Figs. 6.48 to 6.50) have revealed significant positive correlations with AOM ($r^2 = 0.4$, significant at the 88% level), *Botryococcus* ($r^2 = 0.8$, significant at the 99% level), and fluorescence ($r^2 = 0.5$, significant at the 94% level). A simple ranking of these coefficients of determination shows that *Botryococcus* has the strongest correlation with the HI followed by the kerogen fluorescence level.

Comparison

The best r^2 value occurs in the Bearreraig Sandstone Formation (0.99); other analyses where prediction of the HI should be good are the Lealt Shales Formation and the low salinity environments ($r^2 = 0.9$). These have been tested in section 6.4.5 (d). The three variables which have the greatest causal effect on the HI in each case are shown in Table 6.10.

The independent variables which occur most regularly are
Botryococcus and AOM (both 5), and the brown:black wood ratio (4), these are presumably the variables which are best correlated with the HI in the majority of situations. It is interesting to note that *Botryococcus* is the primary variable in the high salinity environments analysis, suggesting that it is important even when it is only present in low abundances, although it is possibly some other correlated variable that may provide the causal link. However, *Botryococcus* does not show any effect on the HI in the Lealt Shales Formation where it is at its most abundant, perhaps due to correlation with other variables in the equation (e.g. palynomorphs of kerogen). Presumably some variables do not come out as important because in specific sample sets they do not show much variation. Obviously in other cases, these variables may be more important if they exhibit more variability.

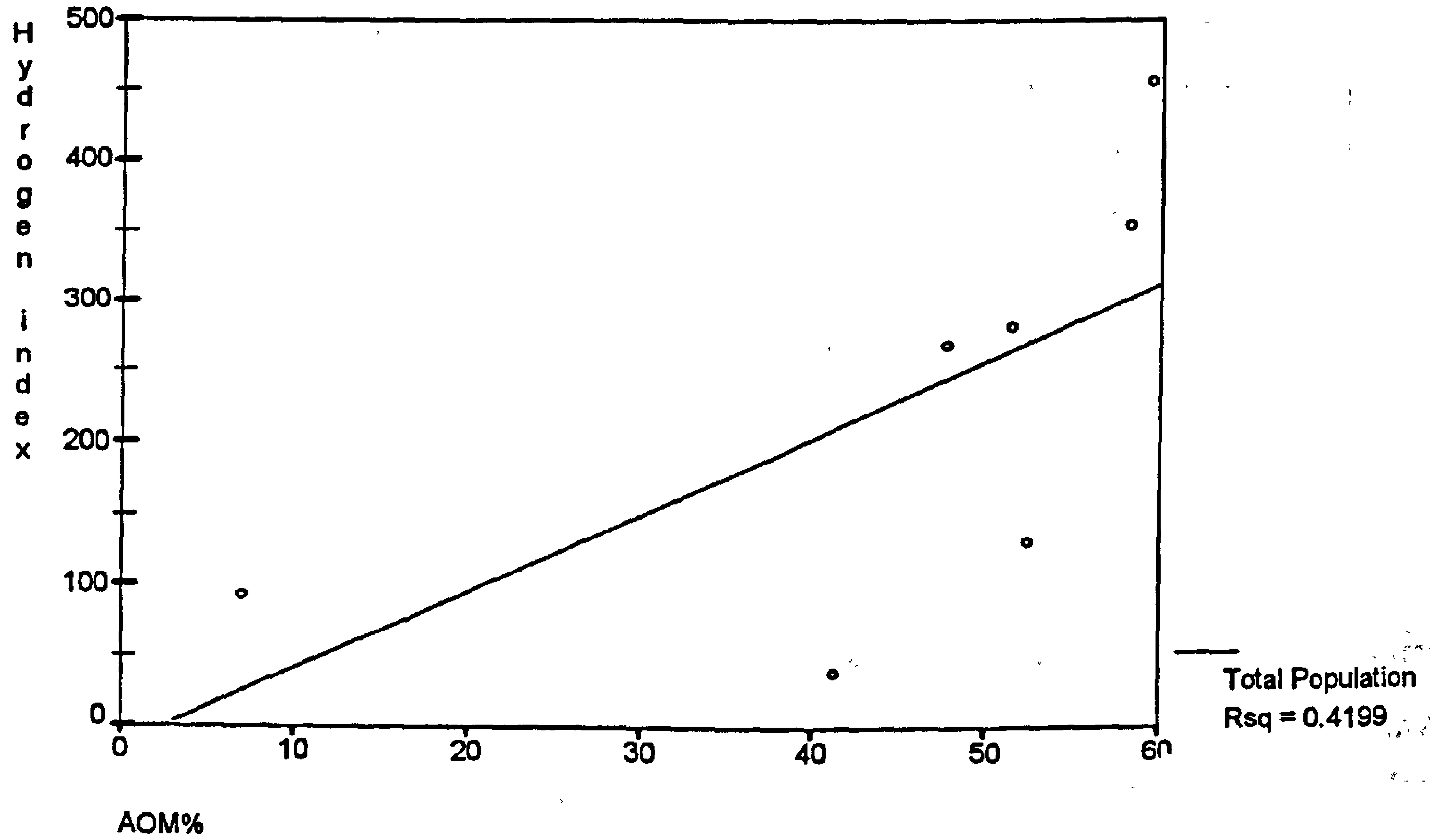


Fig. 6.48. *Crossplot of the percentage AOM of kerogen and hydrogen index in the Staffin Bay Formation. (Note the very strong dependence on the 1 lowest value).*

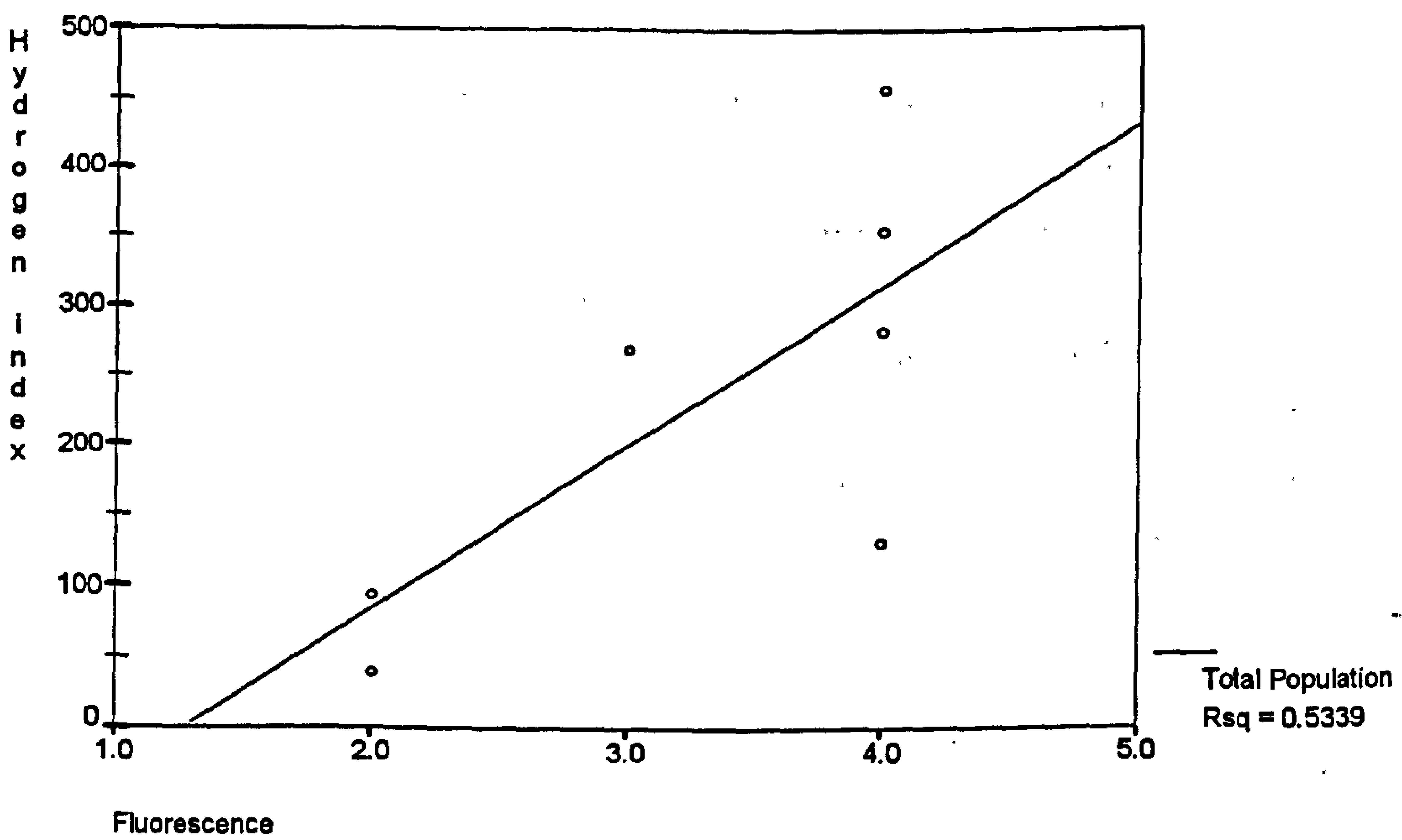


Fig. 6.49. *Crossplot of fluorescence scale point and hydrogen index in the Staffin Bay Formation.*

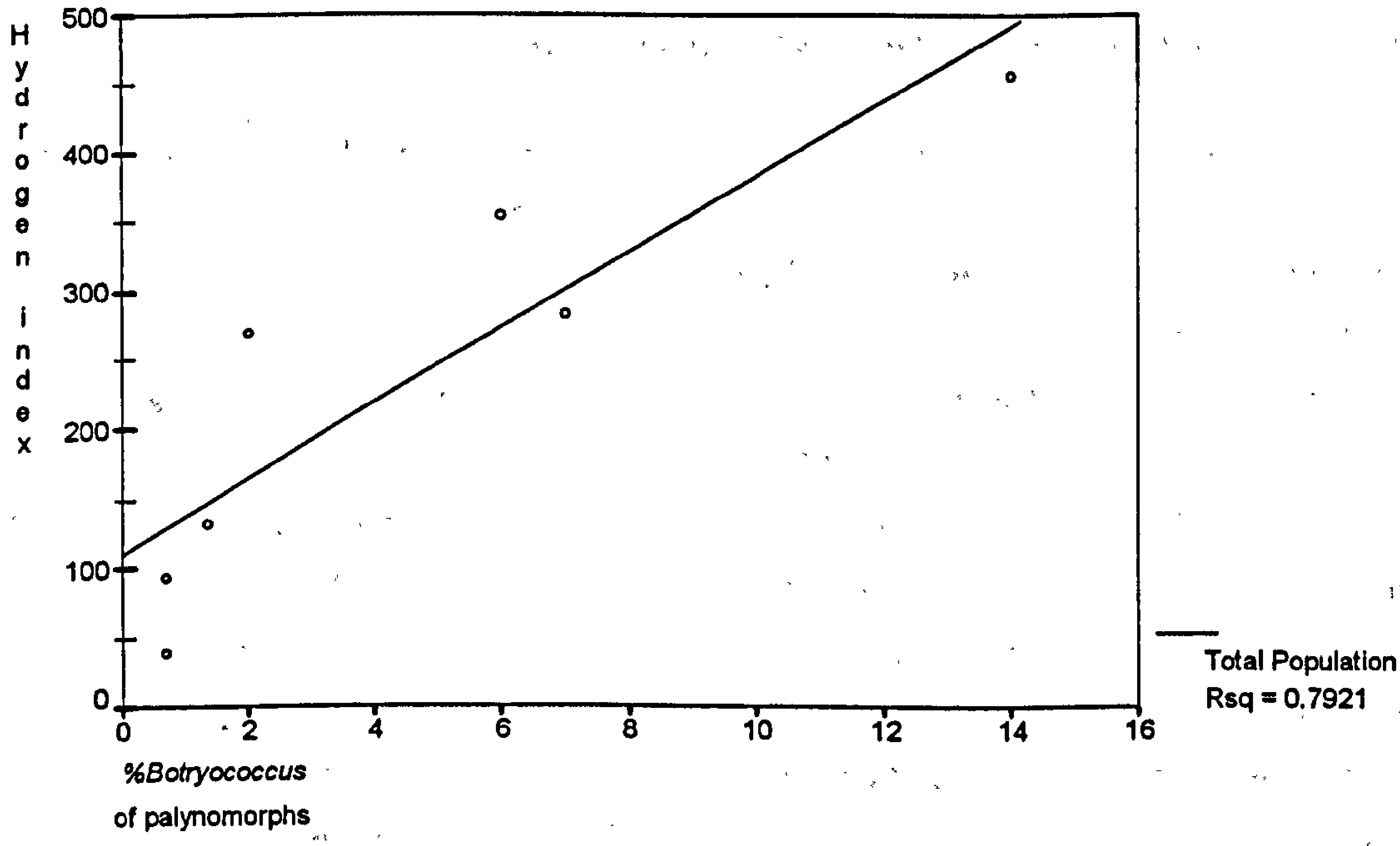


Fig. 6.50. *Crossplot of the percentage* Botryococcus (*of palynomorphs*) *and hydrogen index in the Staffin Bay Formation.*

	Primary variable	Secondary variable	Tertiary variable
Whole dataset	AOM/ kerogen	Brown:black wood ratio	*Botryococcus*/ palynomorphs
'High' salinity environments	*Botryococcus*/ palynomorphs	Brown:black wood ratio	Palynomorphs/ kerogen
'Low' salinity environments	AOM/ kerogen	*Botryococcus*/ palynomorphs	Fluorescence level
Bearreraig Sandstone Formation	Brown:black wood ratio	Cuticle/ phytoclasts	Fluorescence level
Lealt Shales Formation	AOM/ kerogen	Brown:black wood ratio	Palynomorphs/ kerogen
Duntulm Formation	Cuticle/ phytoclasts	*Botryococcus*/ palynomorphs	AOM/ kerogen
Staffin Bay Formation*	*Botryococcus*/ palynomorphs	Fluorescence level	AOM/ kerogen

* Variables derived from cross-plots not multiple regression

Table 6.10. *The three best variables for predicting hydrogen index derived from each multiple regression analysis.*

6.4.5 (d) Predicted versus Measured Hydrogen Index

The regression equations shown in Table 6.11 have been used to calculate a predicted HI value so that this could be compared with the measured HI. Figure 6.51 shows that in the whole dataset the correlation between the two values is relatively good ($r = 0.5$), particularly given the low coefficient of determination ($r^2 = 0.4$) derived from this multiple regression. The predicted HI is most different in the Kilmaluag Formation where the measured HI is 700-800 and the predicted HI is *ca.* 200. There are also significant differences in the Upper Ostrea Member samples where the predicted HI is also underestimated. These underestimates may be due to the measured HI values falling outside one standard deviation around the regression line, as by definition, the multiple regression equation only predicts within this range. In the Bearreraig Sandstone Formation the predicted HI shows a very good ($r = 0.95$) correlation with the measured HI (Fig. 6.52); this is not surprising given the very good coefficient of determination derived from this multiple regression ($r^2 = 0.99$).

The predicted HI values are very different to the measured data in the case of the other formations. This is slightly surprising in the Lealt Shales Formation where the r^2 value is high (0.9), and may be due to the relatively low significance levels of the independent variables in this equation (high significance of T values). The low predictive power of this analysis may cast doubt on the significance of the beta values used to measure the relative effect of each independent variable on the HI.

The whole dataset regression equation has been used on all the samples (including those for which the HI was not measured) in order to create predicted HI values for the whole dataset. The mean predicted HI is 174, some 50 (29%) less than the mean of the measured values. This is possibly due to the poor prediction of high values shown in Fig. 6.51, but also because of the effect of coarser grained sediments which have low predicted HI values (Table 6.12). Figures 6.53 and 6.54 show the mean predicted HI in each formation and environment category; they show a similar pattern to the measured HI means, but the HI values for the Kilmaluag and Staffin Bay formations have been reduced, the latter probably due to the influence of the coarse grained samples from the Belemnite Sands Member. This has also resulted in a lowered predicted HI in the freshwater environment category, which was dominated by Kilmaluag Formation samples in the measured HI means; this is not the case using the whole dataset.

Whole dataset ($r^2 = 0.4$)

$Y = -84.9 + 2.3(AOM) + 1.2(Tpaly) + 1.1(Cu/Tphy) + 9.9(Bro/blk) + 3.5(Bot/Tpaly + 23.3(Fluor)$

High salinity environments ($r^2 = 0.5$)

$Y = 126.3 + 0.0(AOM) + -2.6(Tpaly) + -5.3(Cu/Tphy) + 10.5(Bro/blk) + 9.7(Bot/Tpaly) + 5.0(Fluor)$

Low salinity environments ($r^2 = 0.9$)

$Y = 25.7 + 7.3(AOM) + 7.0(Tpaly) + -3.7(Cu/Tphy) + 20.4(Bro/blk) + 3.5(Bot/Tpaly) + -76.2(Fluor)$

Bearreraig Sandstone Formation ($r^2 = 0.99$)

$Y = -28.6 + -2.3(AOM) + -8.0(Tpaly) + 5.4(Cu/Tphy) + 10.0(Bro/blk) + -100.4(Bot/Tpaly) + 42.2(Fluor)$

Lealt Shales Formation ($r^2 = 0.9$)

$Y = 7.3 + 3.9(AOM) + 2.3(Tpaly) + -1.7(Cu/Tphy) + -38.8(Bro/blk) + -0.1(Bot/Tpaly) + 43.3(Fluor)$

Duntulm Formation ($r^2 = 0.7$)

$Y = 208.6 + -2.7(AOM) + 0.2(Tpaly) + -569.1(Cu/Tphy) + 5.2(Bro/blk) + 204.4(Bot/Tpaly) + -9.6(Fluor)$

Table 6.11. *Regression equations derived from multiple regression analyses (the constant and regression coefficients are only shown to 1 decimal place, but the predicted hydrogen index was calculated using values with 6 decimal places).*

Gross lithology	Mean predicted HI	Std. dev.
Shales	190	83
Silts	170	84
Sands	85	76
Limestones	170	88

Table 6.12. *Mean predicted hydrogen index for each gross lithology category.*

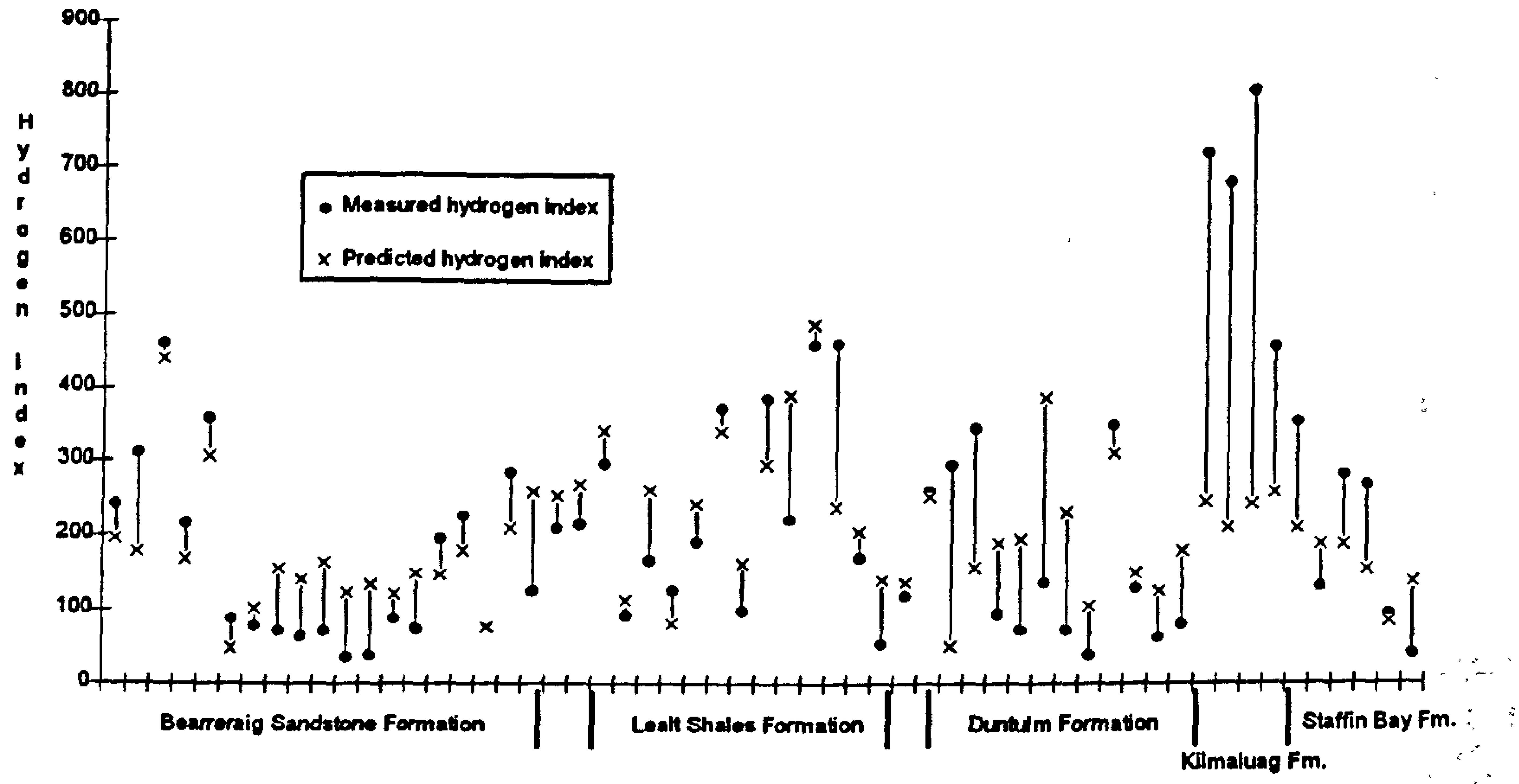


Fig. 6.51. *Plot of the measured and predicted hydrogen index for the whole dataset.*

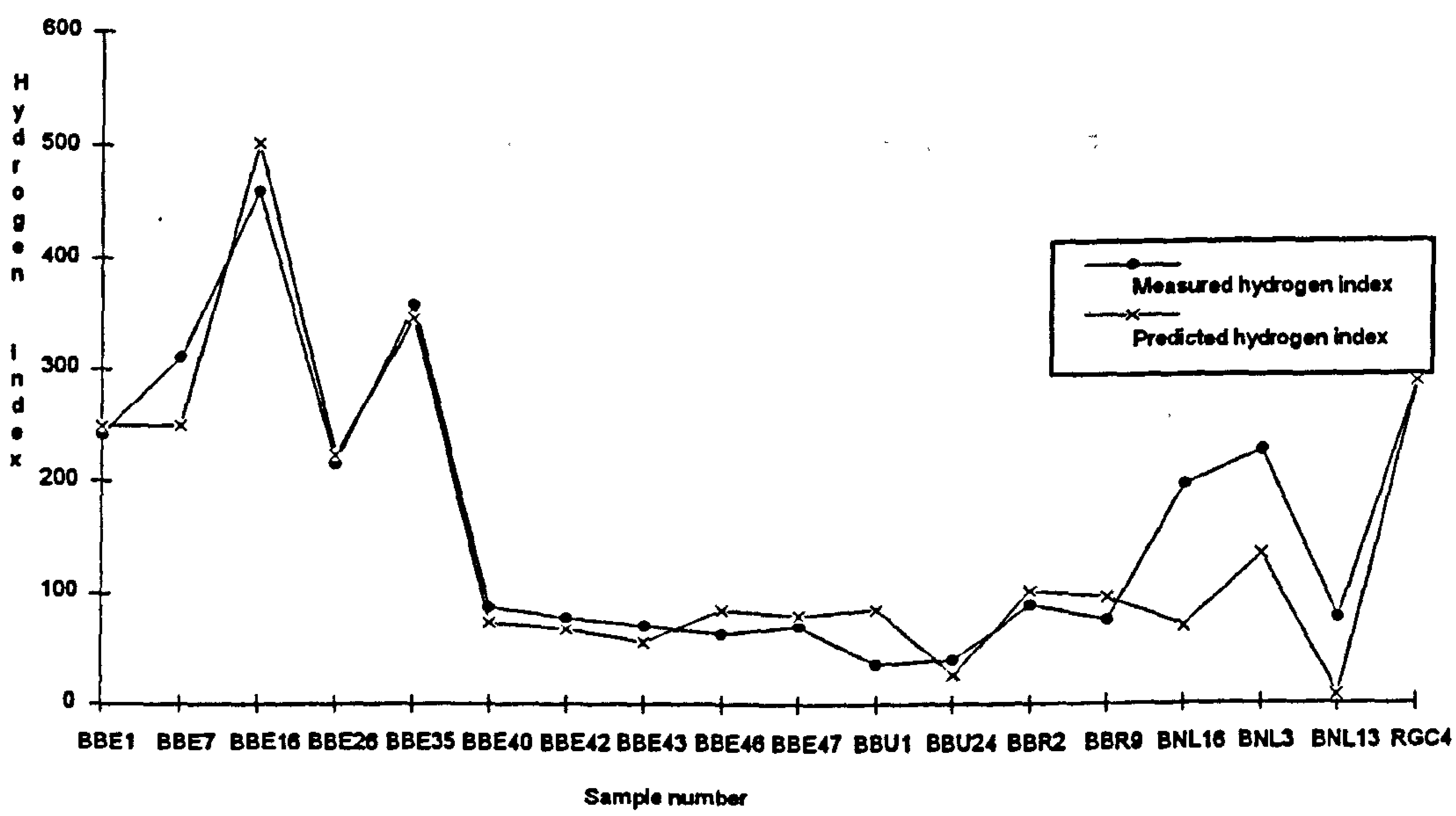


Fig. 6.52. *Plot of measured and predicted hydrogen index in the Bearreraig Sandstone Formation.*

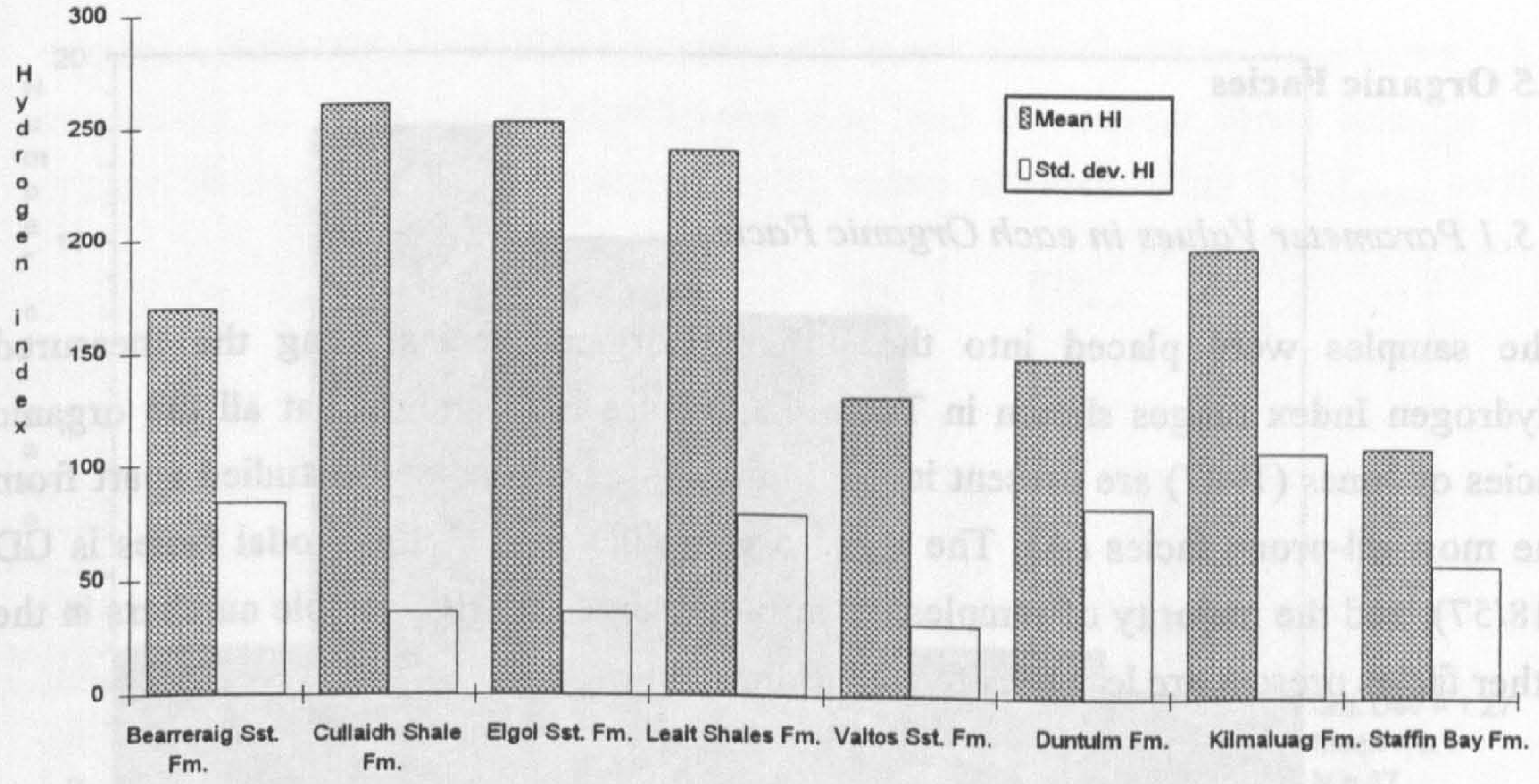


Fig. 6.53. *Mean predicted hydrogen index (HI) in each formation (cf. Fig. 6.32).*

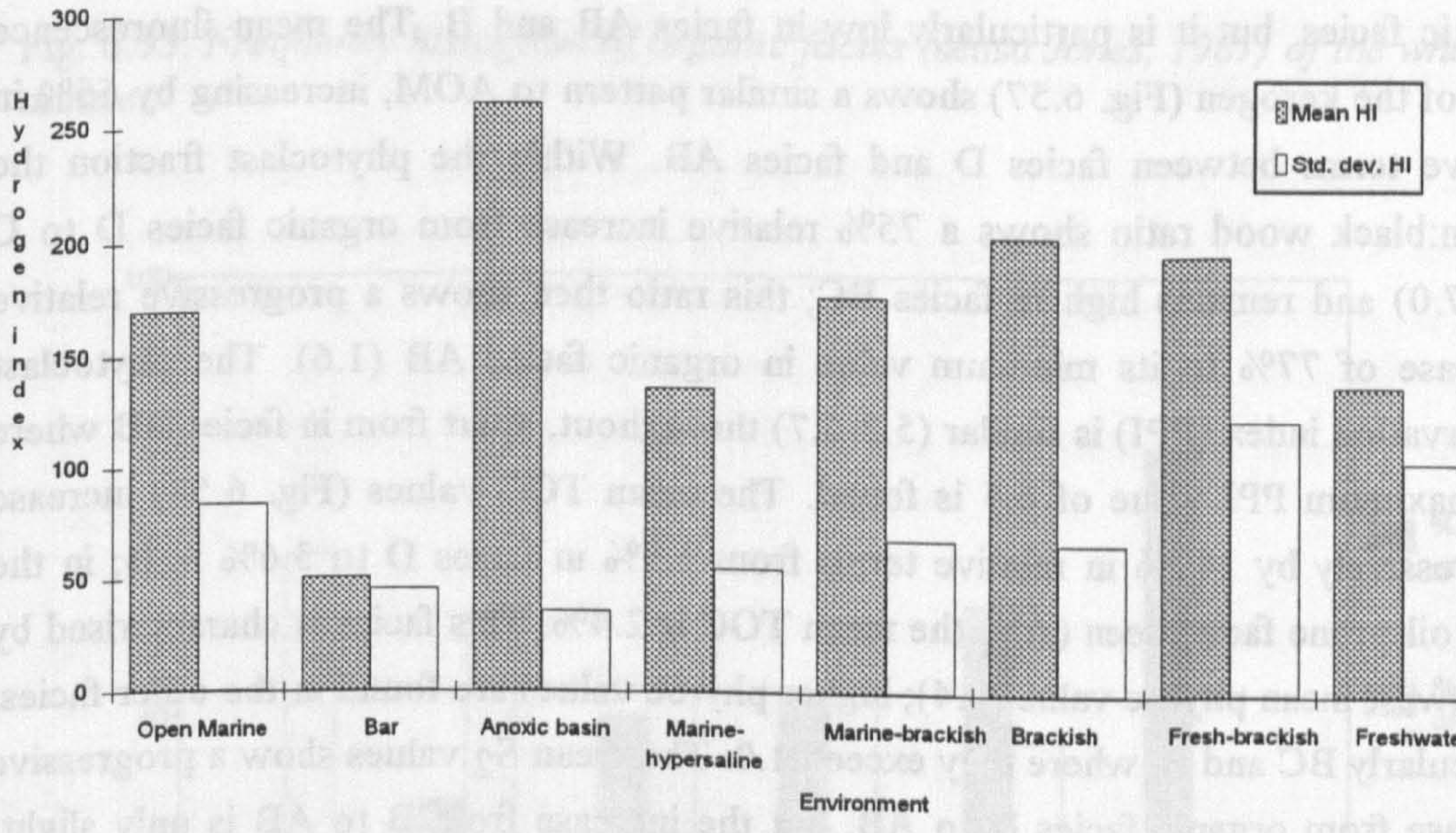


Fig. 6.54. *Mean predicted hydrogen index in each environment category (cf. Fig. 6.34).*

6.5 Organic Facies

6.5.1 Parameter Values in each Organic Facies

The samples were placed into the different organic facies using the measured Hydrogen Index ranges shown in Table 6.3. Figure 6.55 shows that all the organic facies of Jones (1987) are present in the Middle Jurassic sediments studied apart from the most oil-prone facies (A). The mean organic facies is C, the modal facies is CD (18/57), and the majority of samples fall into the range CD-BC; sample numbers in the other facies present are less than five in each.

The percentage AOM of kerogen (Fig. 6.56) shows a progressive relative increase of 285% from facies D to AB, and there is a consequent decrease in the mean percentage phytoclasts of kerogen. The percentage of palynomorphs is below 20% in all the organic facies, but it is particularly low in facies AB and B. The mean fluorescence level of the kerogen (Fig. 6.57) shows a similar pattern to AOM, increasing by 66% in relative terms between facies D and facies AB. Within the phytoclast fraction the brown:black wood ratio shows a 75% relative increase from organic facies D to C (4.0-7.0) and remains high in facies BC; this ratio then shows a progressive relative decrease of 77% to its minimum value in organic facies AB (1.6). The phytoclast preservation index (PPI) is similar (5.2-5.7) throughout, apart from in facies AB where the maximum PPI value of 6.5 is found. The mean TOC values (Fig. 6.58) increase progressively by 140% in relative terms from 1.5% in facies D to 3.6% in B; in the most oil-prone facies seen (AB) the mean TOC is 2.4%. This facies is characterised by the lowest mean phytoc value (0.4); higher phytoc values are found in the other facies, particularly BC and B, where they exceed 1.0. The mean S_2 values show a progressive increase from organic facies D to AB, but the increase from B to AB is only slight, suggesting that these two facies have similar petroleum generating potential. Facies AB, B, and BC have mean S_2 values of greater than 10 mg/g rock showing that they have excellent petroleum generating potential *sensu* Peters (1986).

Examination of the characteristics of the samples within organic facies C shows that there is only one sample (LBT 12) which is dominated by oxidised AOM as opposed to phytoclasts. This sample contains 80% AOM which is completely non-fluorescent (fluorescence preservation scale point 1), and is also characterised by a low brown:black wood ratio (1.5). The organic facies C also includes another sample (LOD1*), which has a relatively high AOM content (64%), but in this case the AOM is well preserved (scale point 5), this would suggest organic facies B or AB on optical

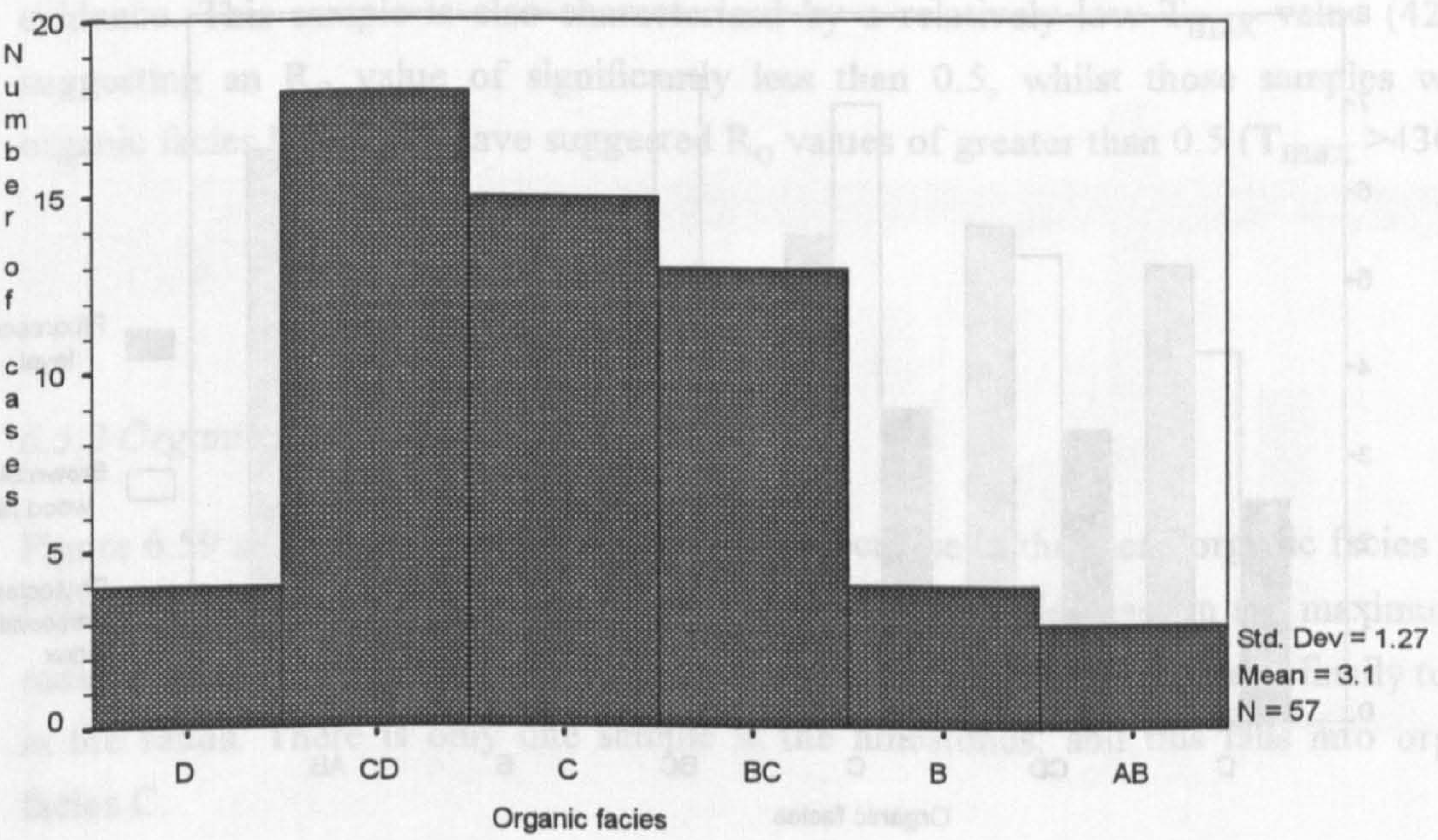


Fig. 6.55. *Frequency histogram of organic facies (sensu Jones, 1987) of the whole dataset.*

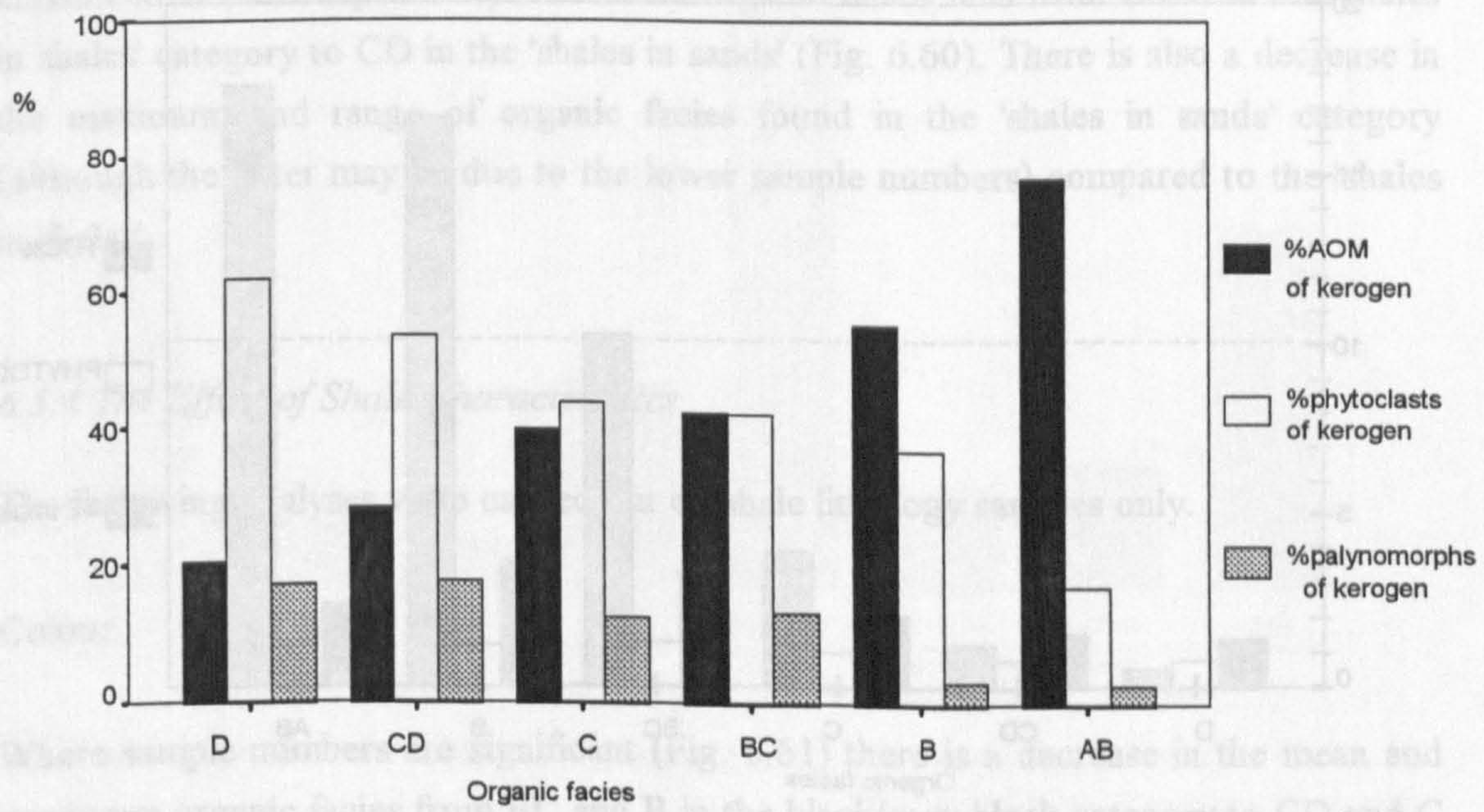


Fig. 6.56. *Mean percentages of the three major kerogen groups in each organic facies unit of the whole dataset.*

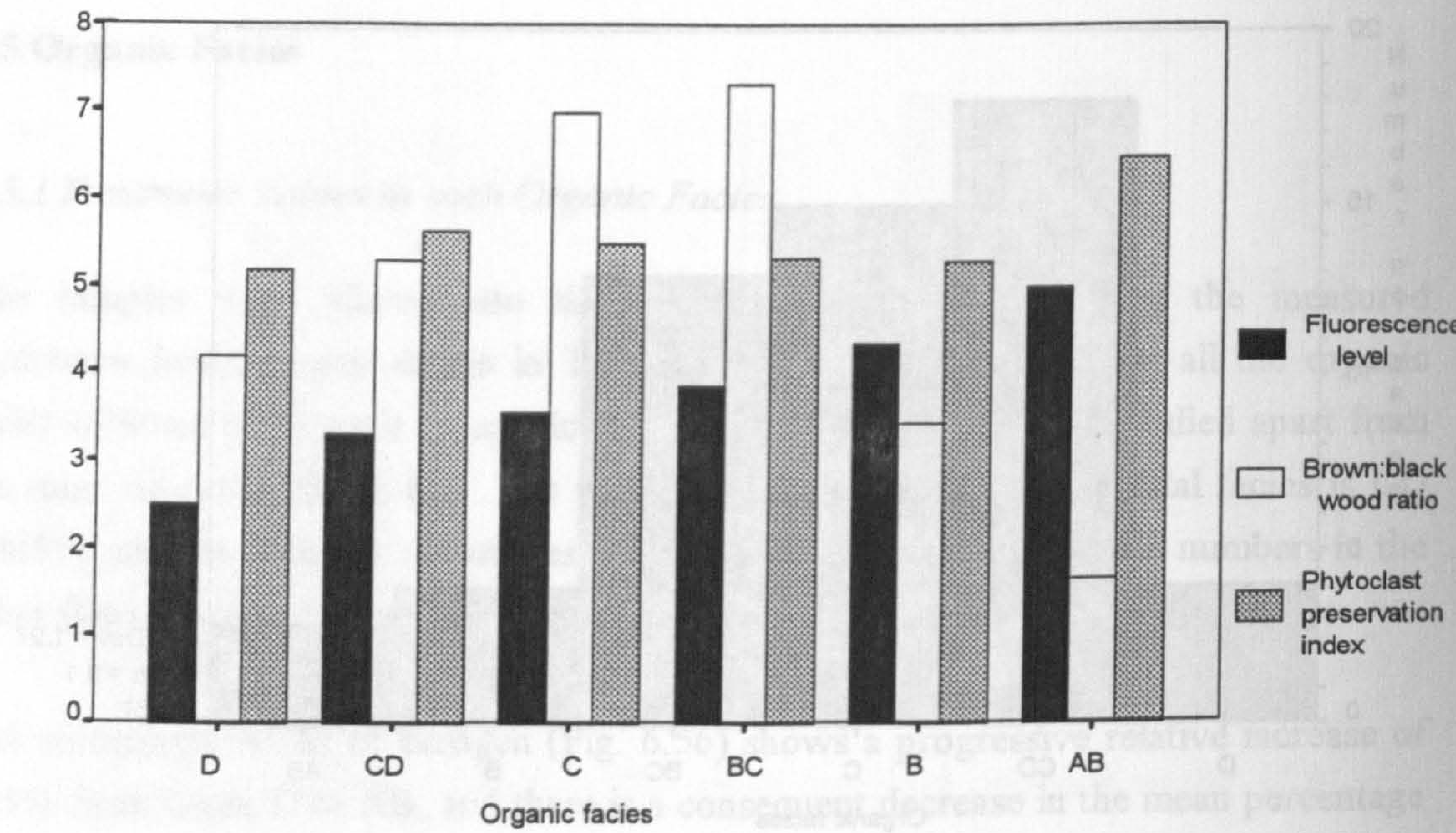


Fig. 6.57. *Mean values of some kerogen preservation parameters in each organic facies unit of the whole dataset.*

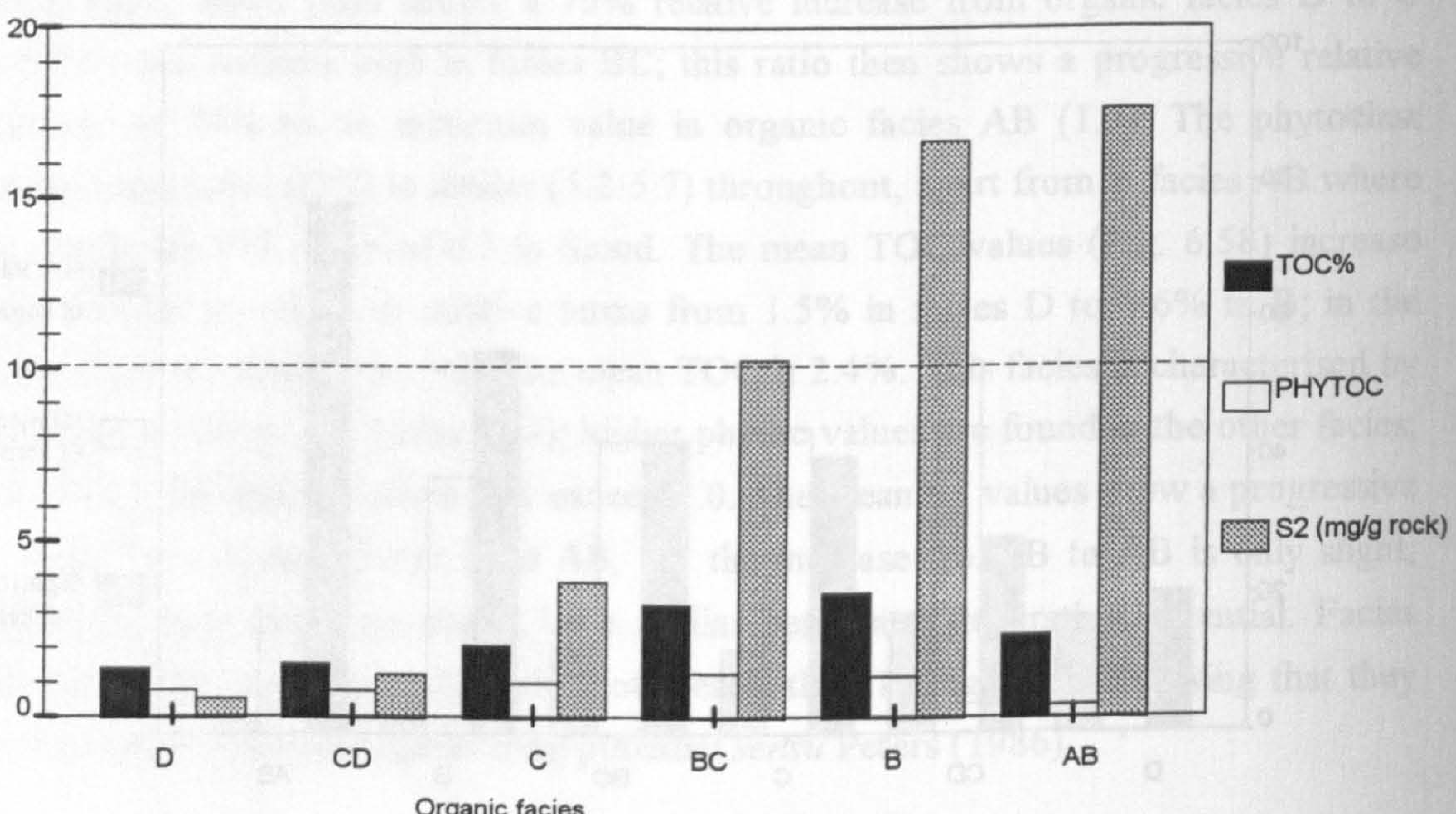


Fig. 6.58. *Mean values of some geochemical parameters in each organic facies unit of the whole dataset. The dashed horizontal line at 10 on the value axis represents the lower S_2 boundary for excellent petroleum potential* sensu *Peters (1986).*

evidence. This sample is also characterised by a relatively low T_{max} value (421°C) suggesting an R_o value of significantly less than 0.5, whilst those samples within organic facies B and AB have suggested R_o values of greater than 0.5 (T_{max} >430°C).

6.5.2 Organic Facies and Gross Lithology

Figure 6.59 shows that there is a progressive decrease in the mean organic facies from C/BC in the shales to CD in the sands; there is a similar decrease in the maximum (= most oil-prone) organic facies from AB in the shales, to B in the silts, and finally to CD in the sands. There is only one sample in the limestones, and this falls into organic facies C.

6.5.3 The Effect of Dominant Lithology

This was carried out using the gross lithology and gross dominant lithology classification (cf. Chapter 4.0). The mean organic facies falls from C/BC in the 'shales in shales' category to CD in the 'shales in sands' (Fig. 6.60). There is also a decrease in the maximum and range of organic facies found in the 'shales in sands' category (although the latter may be due to the lower sample numbers) compared to the 'shales in shales'.

6.5.4 The Effect of Shale Characteristics

The following analyses were carried out on shale lithology samples only.

Colour

Where sample numbers are significant (Fig. 6.61) there is a decrease in the mean and maximum organic facies from BC and B in the black/grey black category to CD and C in the dark grey category; in the other categories with significant sample numbers there is little variation in organic facies (cf. Chapter 4.0).

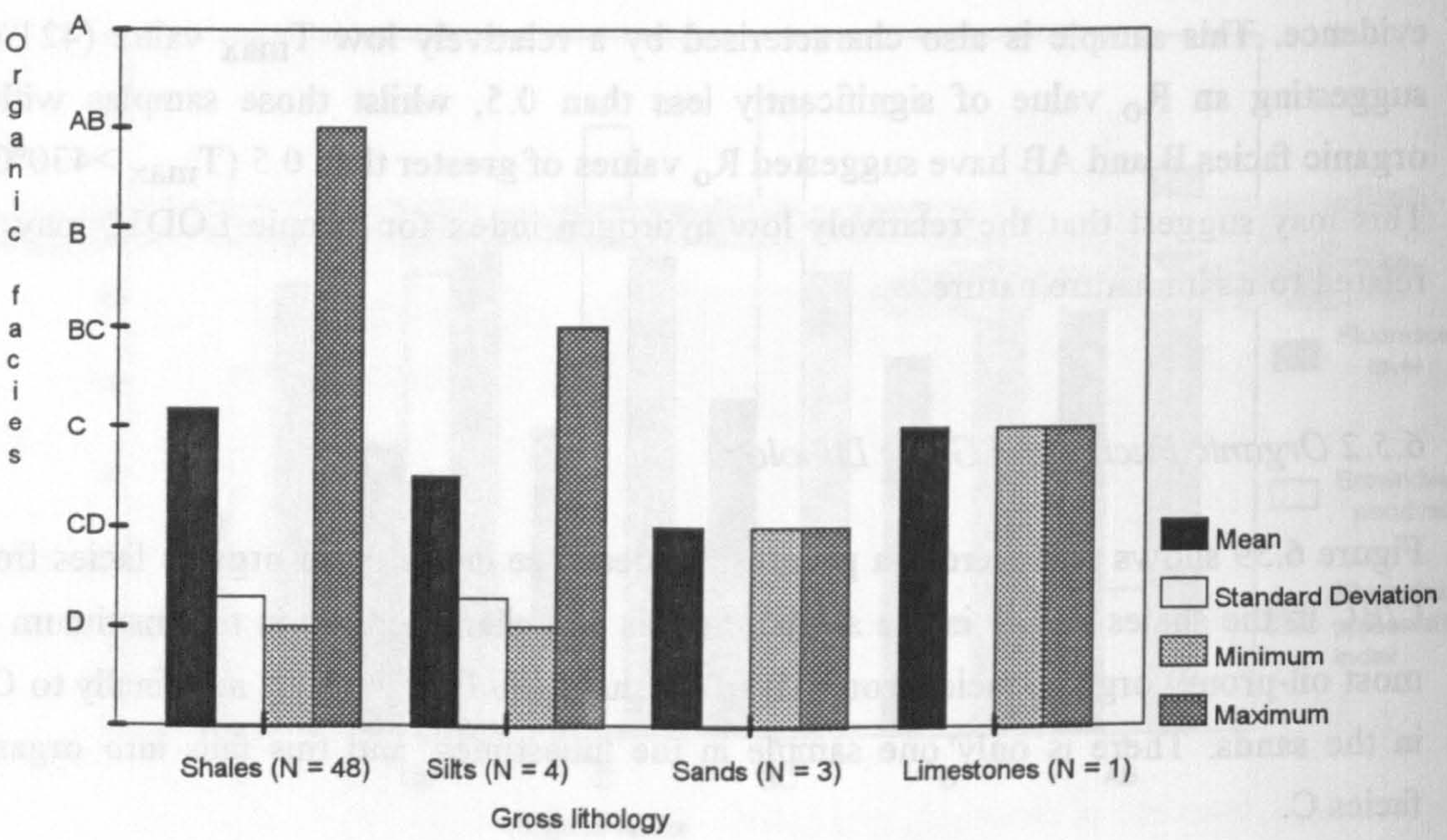


Fig. 6.59. *Organic facies in each gross lithology category of the whole dataset. (N = number of cases).*

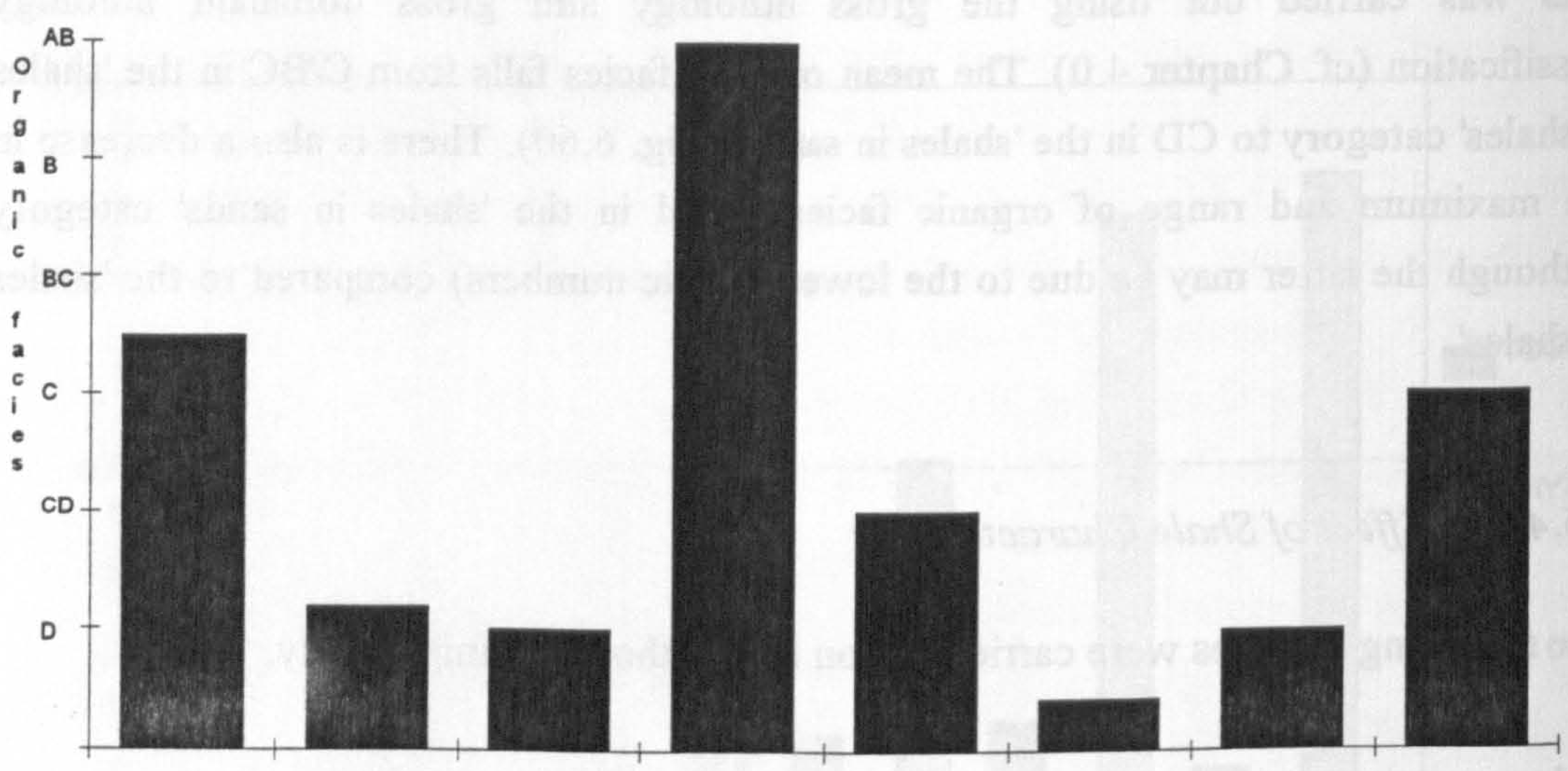


Fig. 6.60. *The effect of dominant lithology on organic facies in the shale gross lithology category, whole dataset.*

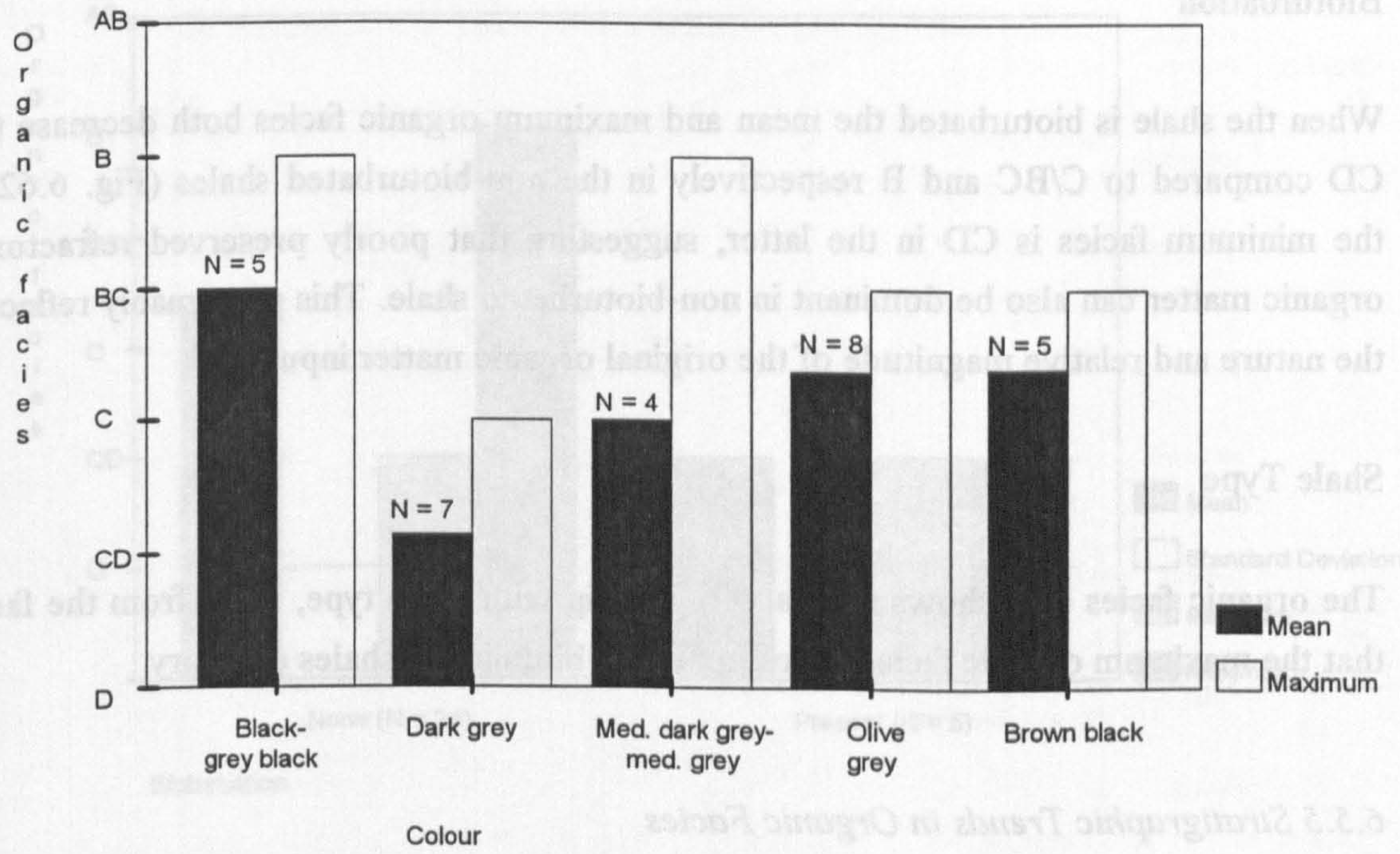


Fig. 6.61. *Organic facies in each shale colour category of the whole dataset. (N = number of cases).*

Bioturbation

When the shale is bioturbated the mean and maximum organic facies both decrease to CD compared to C/BC and B respectively in the non-bioturbated shales (Fig. 6.62); the minimum facies is CD in the latter, suggesting that poorly preserved refractory organic matter can also be dominant in non-bioturbated shale. This presumably reflects the nature and relative magnitude of the original organic matter inputs.

Shale Type

The organic facies data shows no real relationship with shale type, apart from the fact that the maximum organic facies is present in the bituminous shales category.

6.5.5 Stratigraphic Trends in Organic Facies

Between the units

In the Bearreraig Sandstone Formation source rock quality is highest in the Dun Caan Shales (organic facies C) and ?Garantiana Clay (organic facies BC) (Fig. 6.63). The organic facies in the Udairn Shales Member, which forms the base of the second regressive (coarsening-upwards) cycle in the Bearreraig Sandstone Formation, is D. In the uppermost part of the second regressive cycle (Rigg Sandstone Member) the organic facies changes to CD. In the lower part of the Great Estuarine Group the mean organic facies is C, becoming BC only in the Lonfearn Member of the Lealt Shales Formation. The best source rock quality seen (organic facies AB) is found in the Kilmaluag Formation.

Within the formations

Within the Bearreraig Sandstone Formation the lower and middle part of the Dun Caan Shales Member (proximal-distal unit 1) shows a variable organic facies that is never less than C, with a maximum of B (Fig. 6.64). In the upper more distal (proximal-distal unit 2) section the organic facies is of lower quality, all samples falling into organic facies CD.

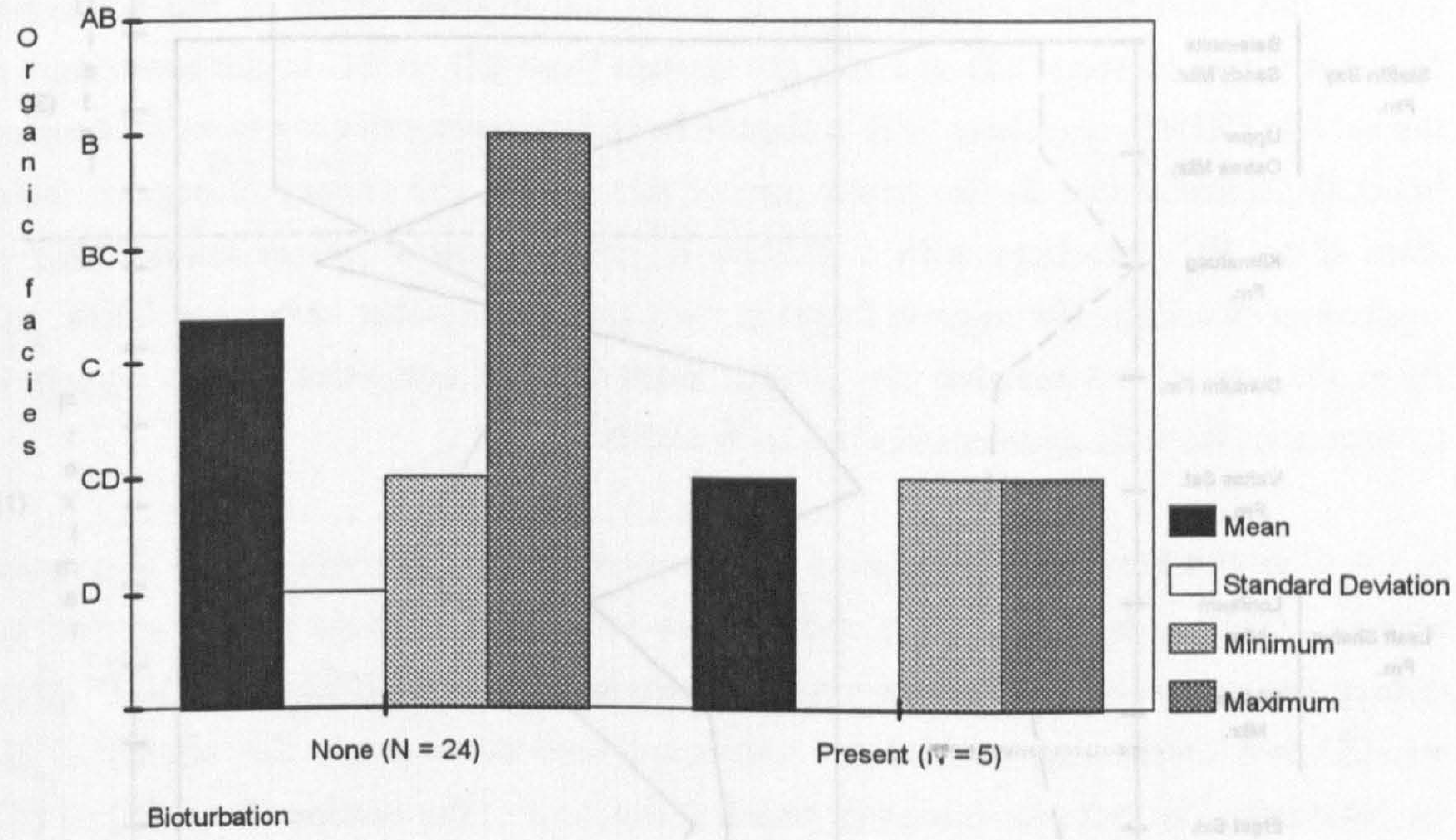


Fig. 6.62. *Organic facies for bioturbated and non-bioturbated shales, whole dataset. (N = number of cases).*

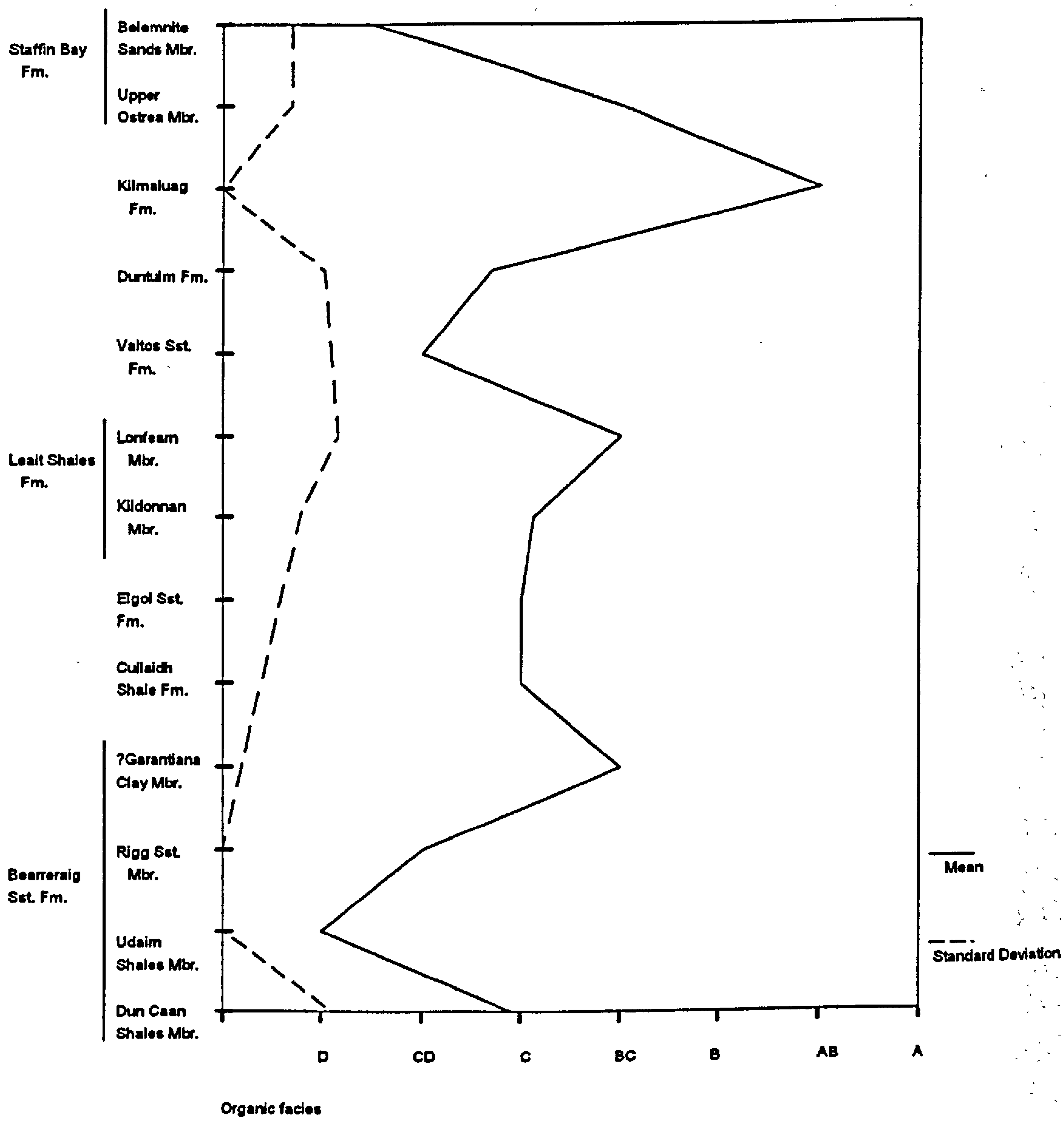


Fig. 6.63. *Mean organic facies in each unit of the Middle Jurassic succession. Number of cases in each unit as in Fig. 6.39.*

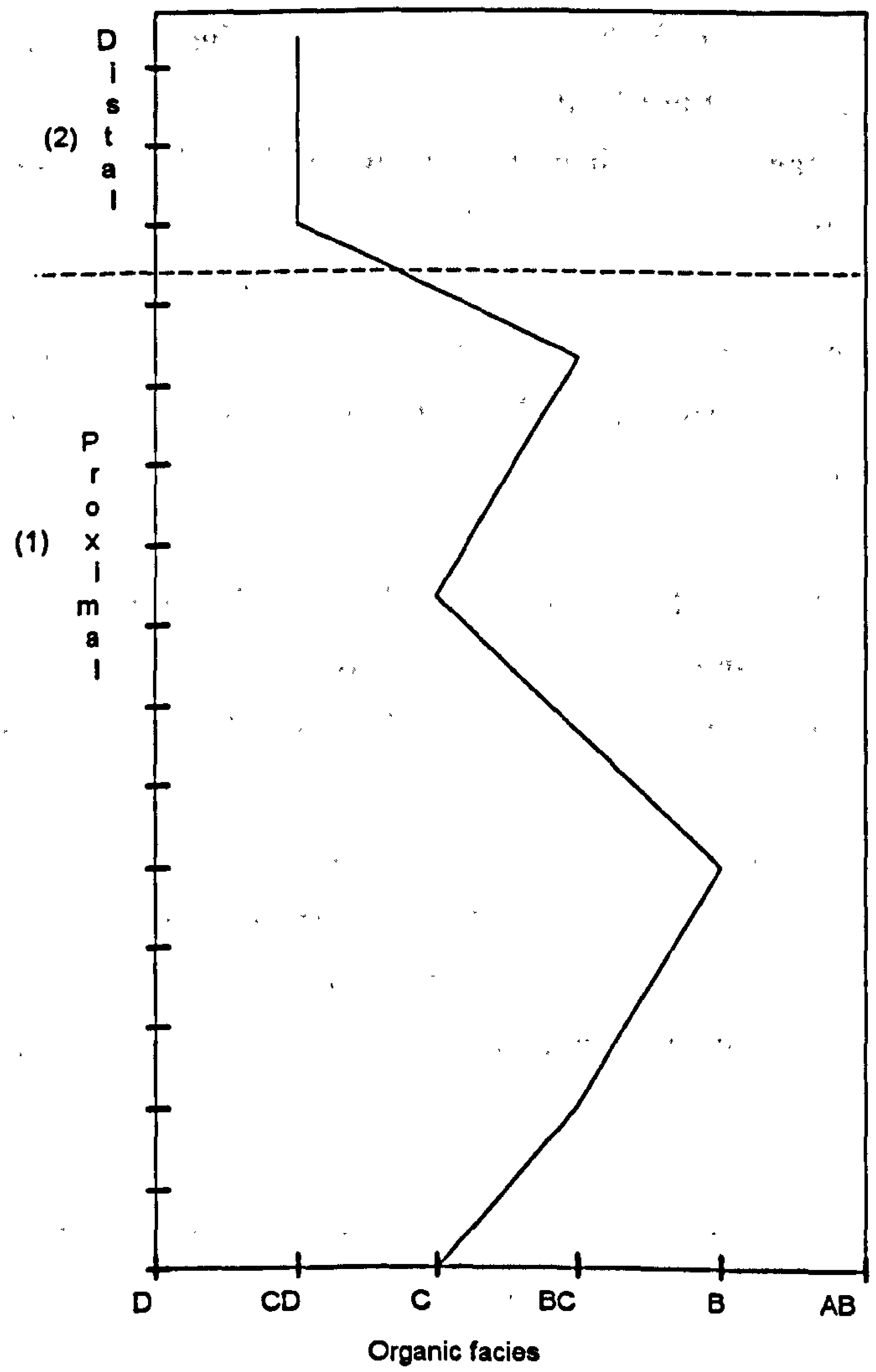


Fig. 6.64. *Stratigraphic variation in organic facies in the Dun Caan Shales Member of the Bearreraig Sandstone Formation.*

Within the Lealt Shales Formation (Fig. 6.65) the organic facies in the Kildonnan Member varies between CD and BC; the change from CD to BC in the lower part of the section (KE40) correlates with a change in environment category from freshwater-brackish to freshwater. In the upper part of this section the change in organic facies from C to BC correlates with a change in environment from marine-brackish to freshwater-brackish. The organic facies in the Lonfearn Member varies between C and B; at the top of this member the change from C to B correlates with a change in environment from freshwater-brackish to brackish.

In the Duntulm Formation composite type section (Fig. 6.66) there is also correlation between changes in environment and organic facies, but they do not all exhibit the same relationship. The changes in organic facies at samples CGD52 and LOD1* (from BC-CD and C-CD respectively) are correlated with increases in the salinity of the environment. The increase in organic facies at the start of the section (from CD to BC) correlates with a decrease in the salinity of the environment (marine-hypersaline to marine-brackish). Conversely, at the top of the section, there is a decrease in organic facies (from CD to D) where the environment changes from marine-hypersaline to freshwater-brackish.

Some of the organic facies changes in the Staffin Bay Formation type section (Fig. 6.67) show a correlation with changes in lithofacies and member; the decline in organic facies quality which begins at sample UOB36 correlates with the change from the argillaceous Upper Ostrea Member to the sand-dominated Belemnite Sands Member, which is also a change from the bituminous shales to argillaceous sands lithofacies. The continued decline in organic facies quality (from CD to D) correlates with a change in lithofacies from the argillaceous sands to the muddy silts which mark the top of the member.

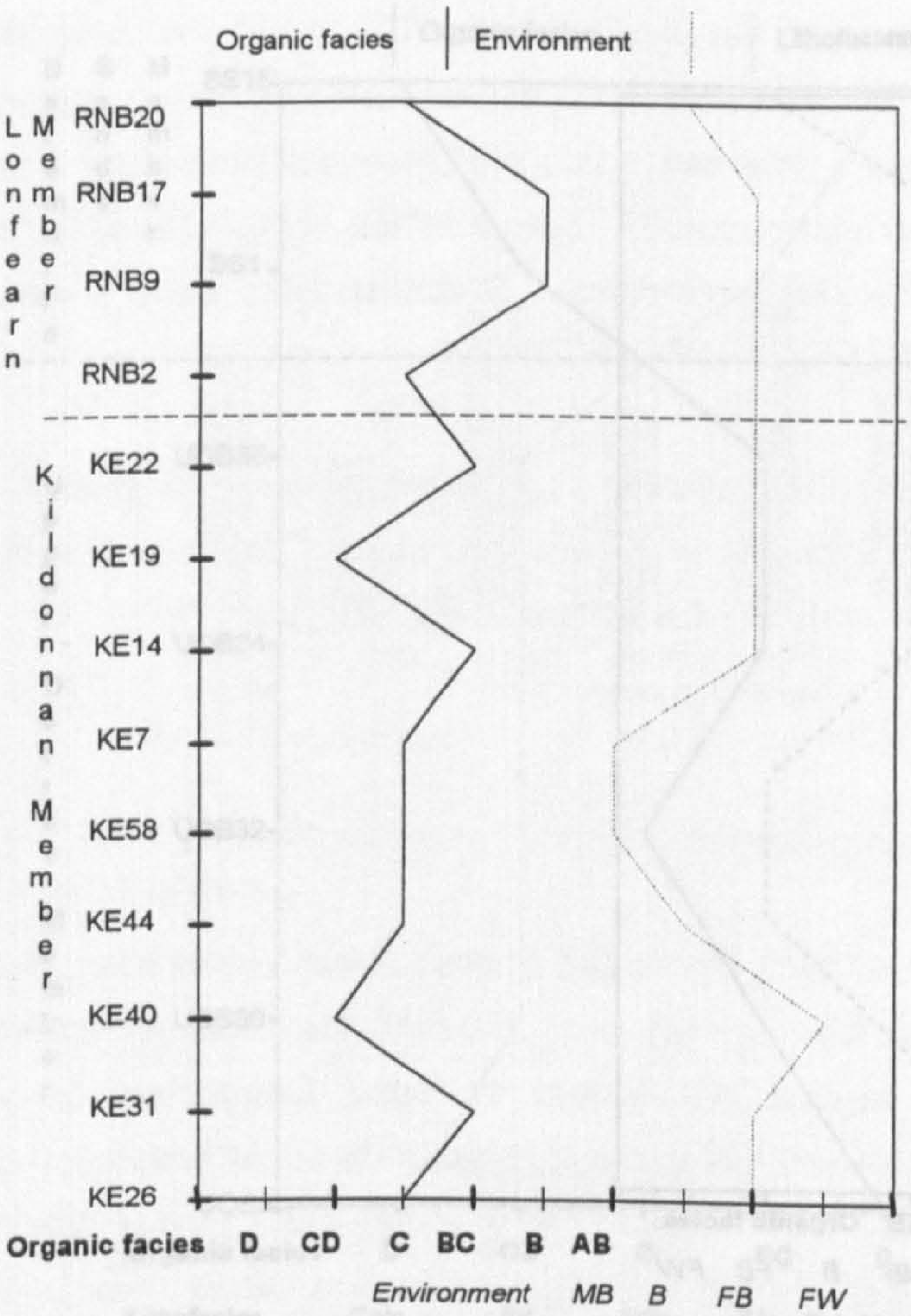


Fig. 6.65. *Stratigraphic variation in organic facies in the Lealt Shales Formation.*

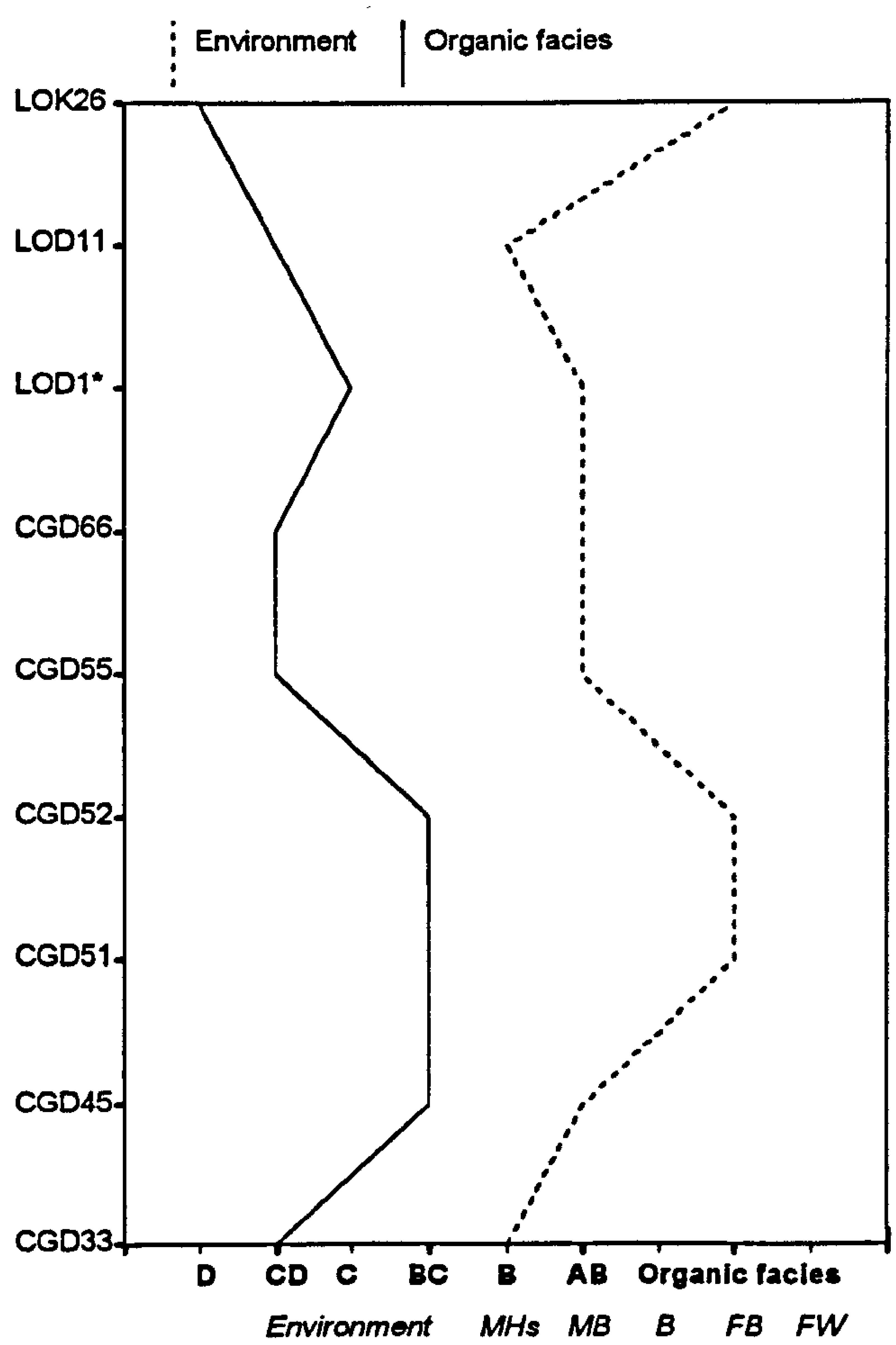


Fig. 6.66. *Stratigraphic variation in organic facies in the Duntulm Formation.*

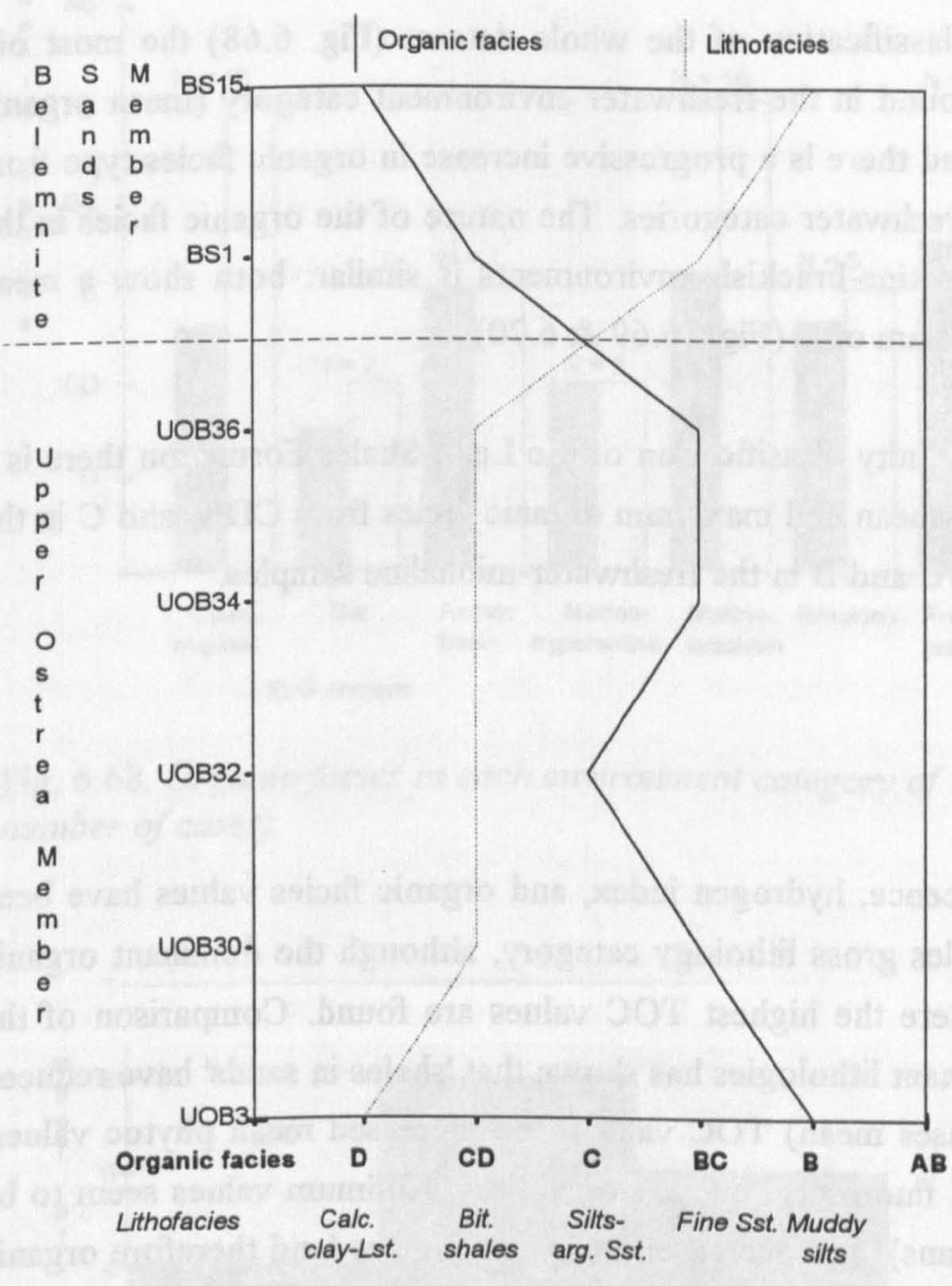


Fig. 6.67. *Stratigraphic variations in organic facies in the Staffin Bay Formation.*

6.5.6 Environment and Salinity

Within the environment classification of the whole dataset (Fig. 6.68) the most oil-prone organic facies are found in the freshwater environment category (mean organic facies B, maximum AB) and there is a progressive increase in organic facies type from the brackish category to freshwater categories. The nature of the organic facies in the freshwater-brackish and marine-brackish environments is similar: both show a mean facies of C/BC and a maximum of B (Figs. 6.69 & 6.70).

In terms of the ostracod-salinity classification of the Lealt Shales Formation there is a progressive increase in the mean and maximum organic facies from CD/C and C in the pliohaline category, to BC/C and B in the freshwater-miohaline samples.

6.6 Summary

The highest TOC, fluorescence, hydrogen index, and organic facies values have been shown to occur in the shales gross lithology category, although the dominant organic matter type can affect where the highest TOC values are found. Comparison of the shales from different dominant lithologies has shown that 'shales in sands' have reduced maximum (and in some cases mean) TOC values, and increased mean phytoc values. They also show decreased fluorescence levels (again the maximum values seem to be effected more than the means), and decreased hydrogen indices (and therefore organic facies). Examination of shale characteristics has revealed that highest TOC values and hydrogen indices (also organic facies) are associated with the black or the darkest coloured, non-bioturbated, bituminous shales. Bioturbation levels also influence fluorescence values.

The highest TOC values are found in parts of the Bearreraig Sandstone Formation (Dun Caan Shales and ?Garantiana Clay members), and in the Lealt Shales and Staffin Bay Formations; these are also the units where TOC values are correlated with AOM percentages, suggesting a potential preservational control on TOC. The highest hydrogen index and organic facies values are found in the Kilmaluag Formation (AB), and Dun Caan Shales and ?Garantiana Clay members, and Lealt and Staffin Bay formations mentioned above; in the latter cases TOC and HI are correlated.

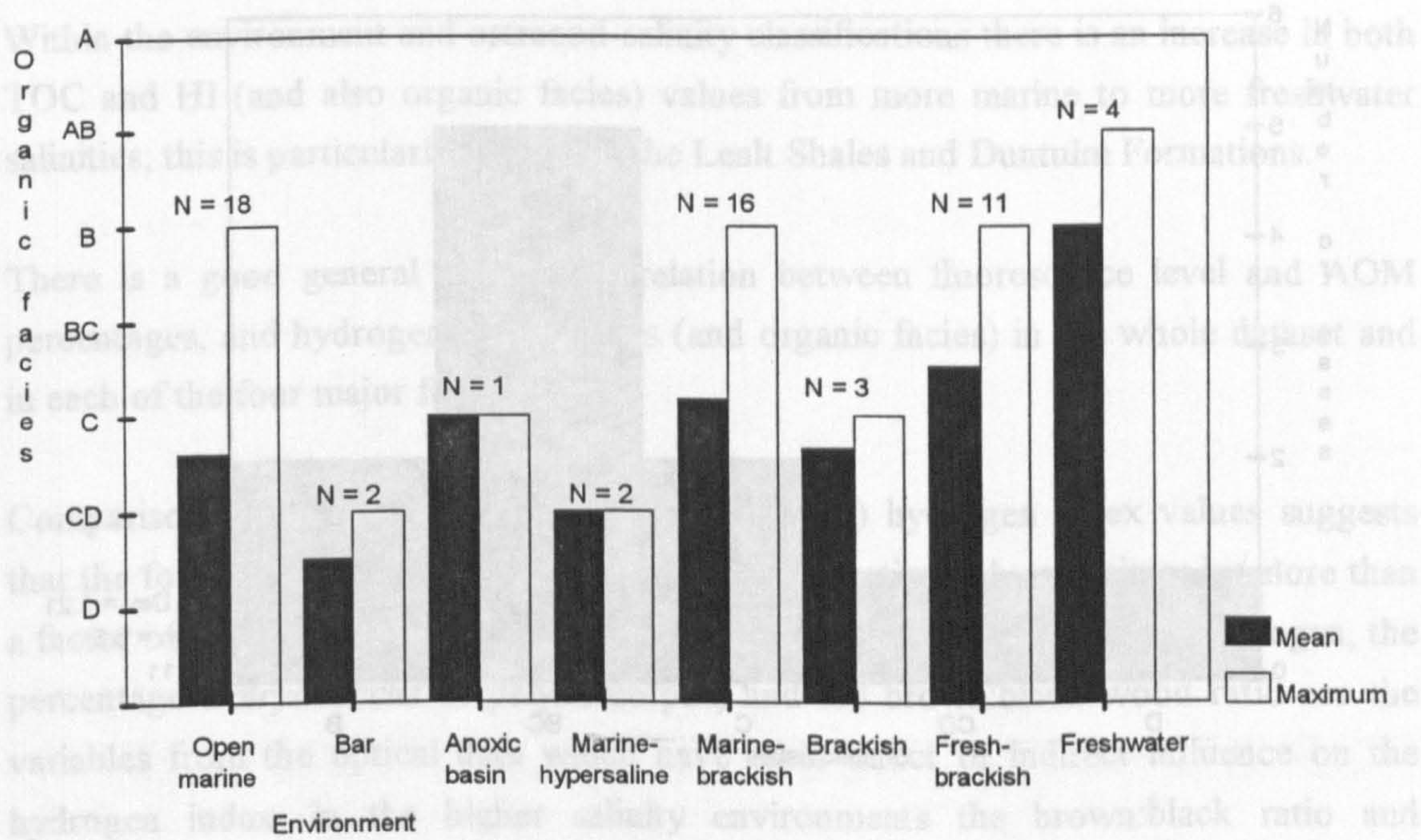


Fig. 6.68. *Organic facies in each environment category of the whole dataset. (N = number of cases).*

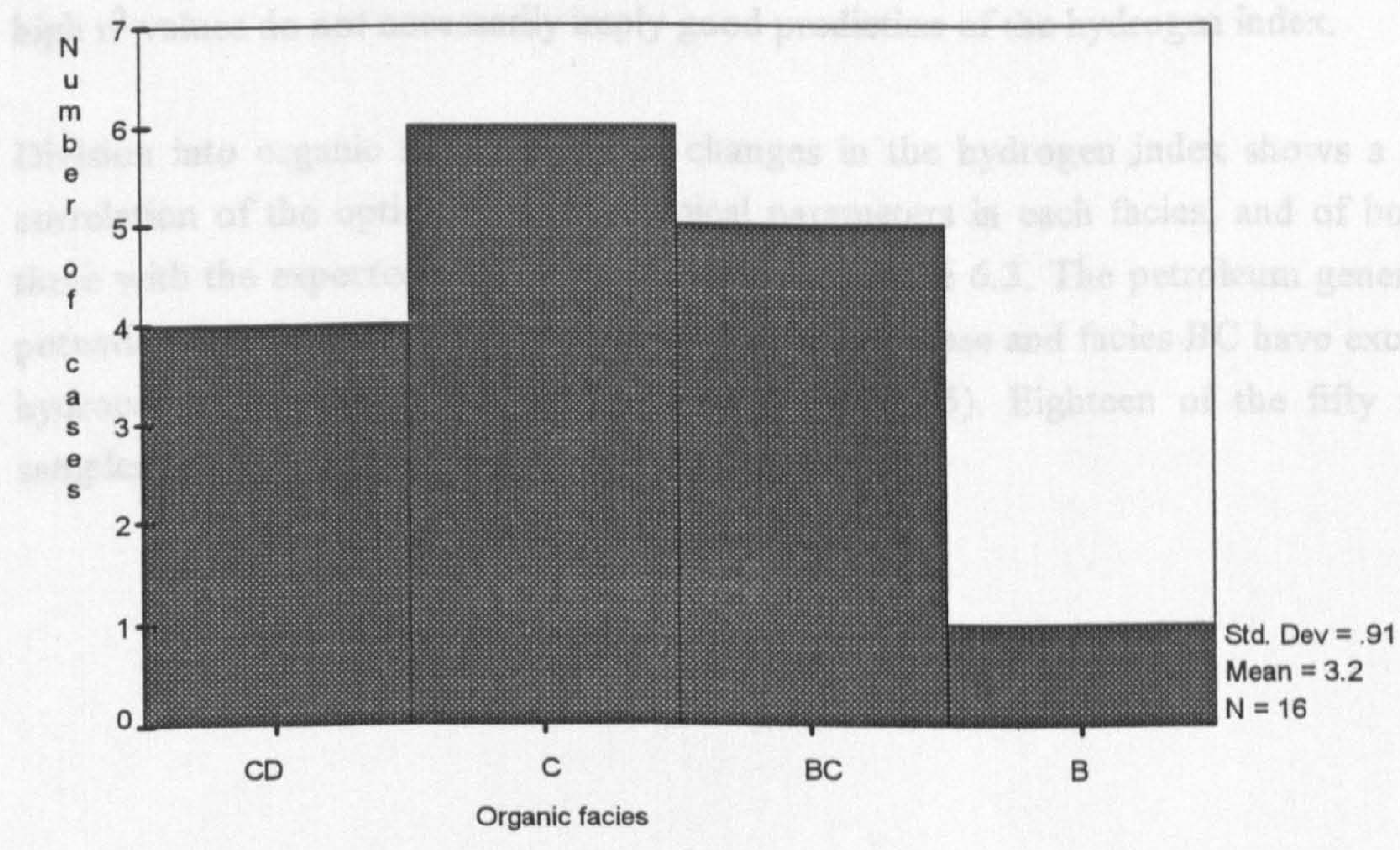


Fig. 6.69. *Frequency histogram of the distribution of organic facies in the marine-brackish environments, whole dataset.*

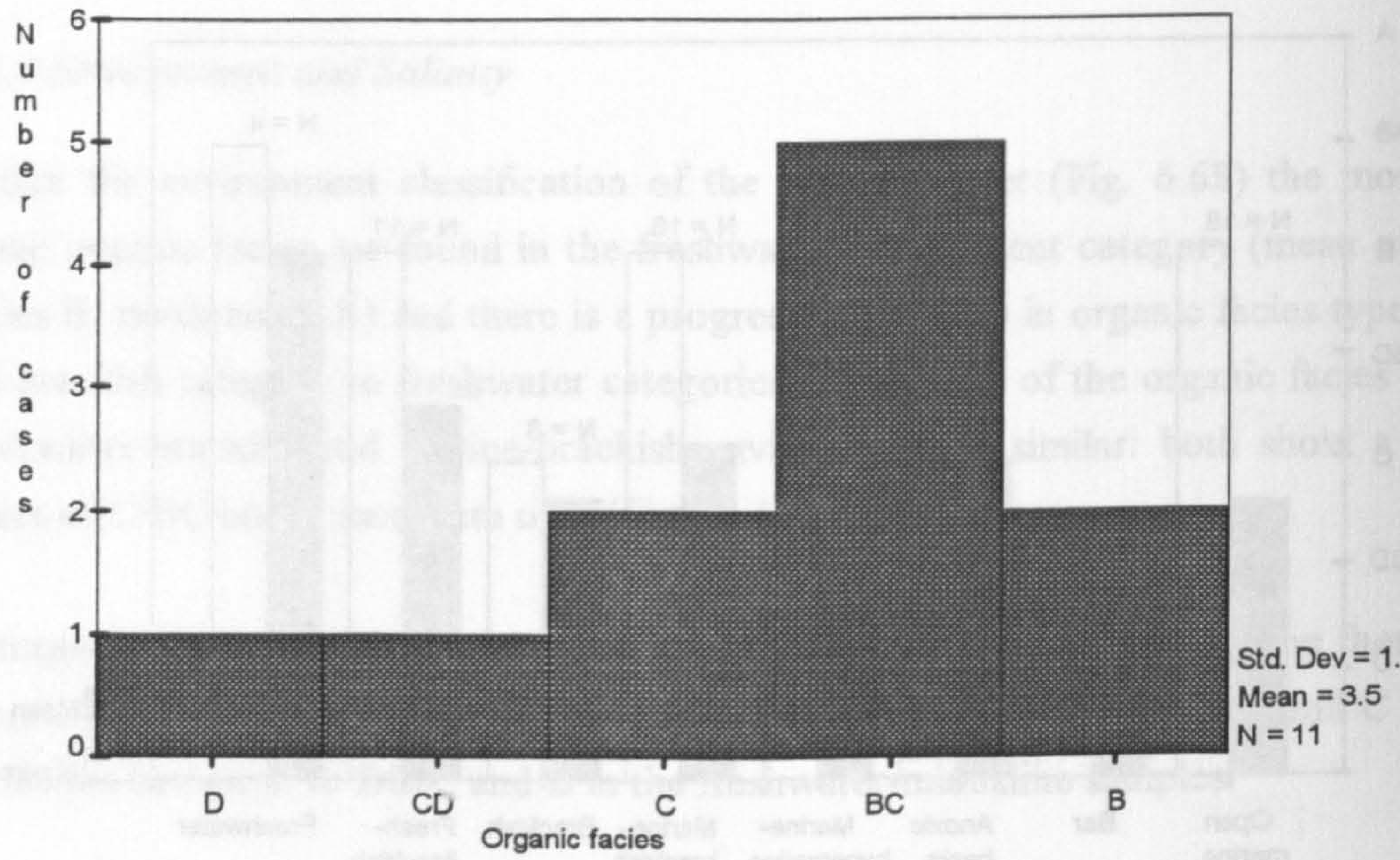


Fig. 6.70. *Frequency histogram of organic facies distribution in the freshwater-brackish environments, whole dataset.*

Within the environment and ostracod-salinity classifications there is an increase in both TOC and HI (and also organic facies) values from more marine to more freshwater salinities; this is particularly marked in the Lealt Shales and Duntulm Formations.

There is a good general positive correlation between fluorescence level and AOM percentages, and hydrogen index values (and organic facies) in the whole dataset and in each of the four major formations.

Comparison of measured and calculated (S_2-TOC) hydrogen index values suggests that the former hydrogen index values can be underestimated, sometimes by more than a factor of two. Multiple regression suggests that the percentage AOM of kerogen, the percentage *Botryococcus* of palynomorphs, and the brown:black wood ratio are the variables from the optical data which have most direct or indirect influence on the hydrogen index; in the higher salinity environments the brown:black ratio and *Botryococcus* are suggested as having the most influence, whilst in the lower salinity facies AOM is suggested as having the greatest influence on the hydrogen index. Comparison of measured and predicted hydrogen index shows that there can be a reasonable correlation between the two even when r^2 values are relatively low, but that high r^2 values do not necessarily imply good prediction of the hydrogen index.

Division into organic facies based on changes in the hydrogen index shows a good correlation of the optical and geochemical parameters in each facies, and of both of these with the expected characteristics shown in Table 6.3. The petroleum generating potential of facies AB and B is shown to be similar; these and facies BC have excellent hydrocarbon generating potential *sensu* Peters (1986). Eighteen of the fifty seven samples (32%) analysed have good-excellent potential.

CHAPTER 7.0
THE PHYTOCLAST PRESERVATION INDEX

7.0 THE PHYTOCLAST PRESERVATION INDEX (PPI)

7.1 Introduction and Method

A phytoclast preservation index (PPI) has been calculated using the degradation pathway shown in Table 2.9. This index is conceptually similar to that defined in Hart (1986), examples of the use of which are given in Gregory and Hart (1990) and Pasley *et al.* (1991). The PPI has been calculated by assigning each phytoclast type a number ("score") between 1 and 10 based on its perceived resistance to degradation: 1 represents the least refractory, undegraded phytoclast types, and 10 the most refractory material (Table 7.1). Membranes have not been included in the index as the origin of this particle type is uncertain (e.g. Tuweni & Tyson, 1994).

The index was calculated by taking the percentage of each type of total phytoclasts (in this case only the total of those phytoclast types included in the calculation of the index), dividing this by 100, then multiplying the product by its "score" and summing the results for all six phytoclast types:

Phytoclast preservation index = Σ((%phytoclast type/total phytoclasts)/100) x "score"
(where Σ = sum of)

A low PPI represents a predominance of 'fresh' undegraded phytoclasts and identifiable higher plant remains (cuticle) over degraded and refractory material; a moderate index suggests an equal abundance of phytoclast types; a high index level occurs when refractory phytoclasts dominate (the maximum possible index, 10, represents 100% black wood). Therefore, the index should increase from proximal to distal settings.

7.2 Results

7.2.1 General Features

The mean value of the phytoclast preservation index (PPI) in the whole dataset is 5.6; it ranges from 4.0 to 9.6, but the standard deviation of $\pm$ 0.7 shows that most of the samples have values of between 4.9 and 6.3, a variation of only $\pm$ 12% in relative terms. Figure 7.1 shows the range of PPI values in the whole dataset cross-plotted against the percentage AOM of kerogen and the fluorescence level. In samples which plot in the top part of the figure, where AOM values are $\geq$40% and fluorescence levels

"Score"	Phytoclast type
2	Undegraded non-biostructured brown
3	Cuticle
5	Degraded (corroded and pseudoamorphous) non-biostructured brown
6	Combined striate and striped (biostructured) brown
8	Combined banded and pitted (biostructured) brown
10	Black

Table 7.1: *Phytoclast Preservation Index ranking of each phytoclast type included.*

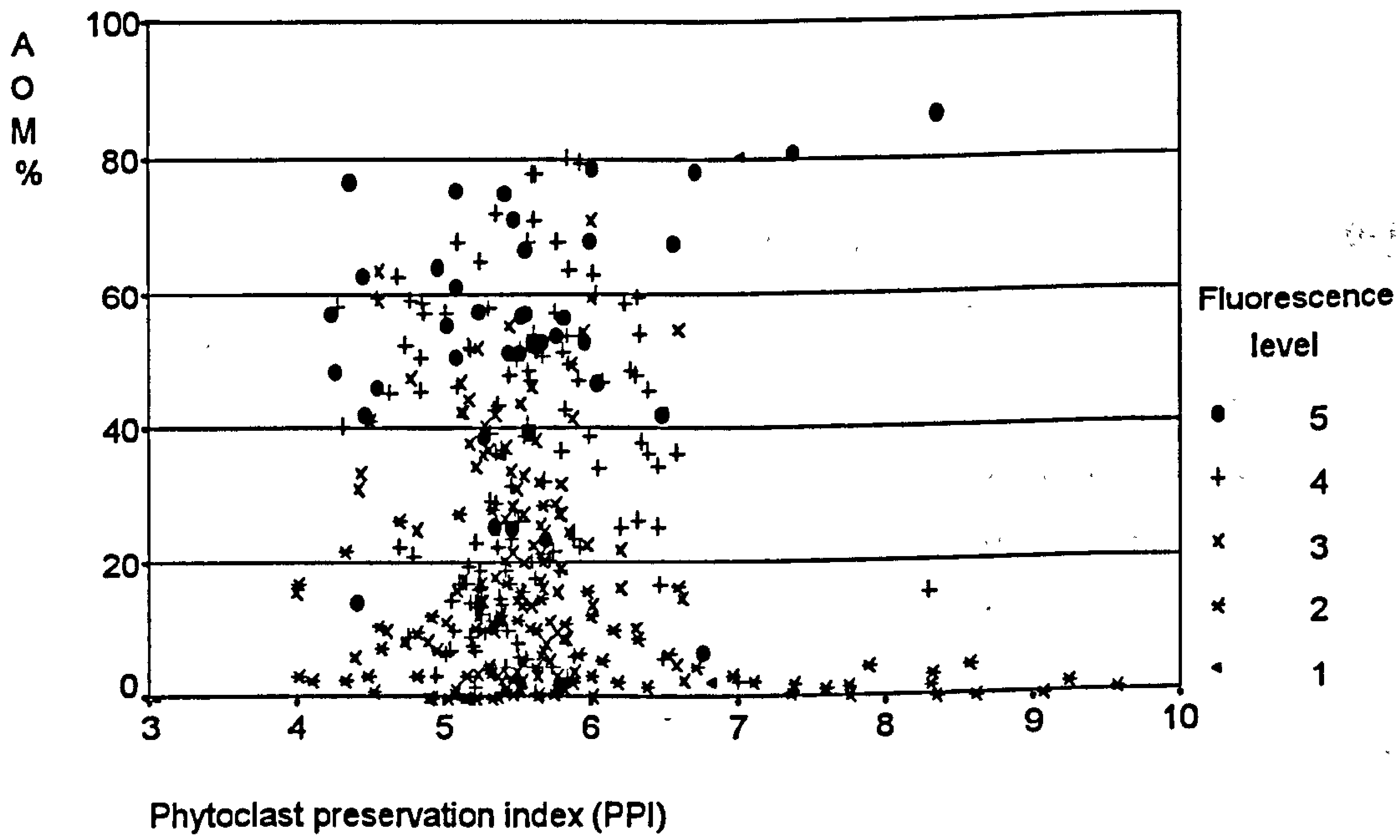


Fig. 7.1. *Phytoclast preservation index (PPI) and percentage AOM/fluorescence for the whole dataset.*

are 4 or 5, it is suggested that any degradation undergone by the phytoclast assemblage is unlikely to have occurred post-depositionally, as the *in situ* preservation of autochthonous organic matter is good. Therefore, those samples in this part of the diagram which have a high PPI are likely to have been produced by preferential sorting (transport) of black wood and banded and pitted biostructured brown wood and their relative greater delivery to distal settings. Conversely, in the samples in the lower (more oxic) part of the figure there is potential for post-depositional degradation of allochthonous organic matter to add to that that has taken place at source or during transport; the greatest range of PPI values occurs in this part of the diagram, due mainly to the presence of samples enriched in refractory phytoclast elements.

7.2.2 Formation Trends

The mean PPI increases through the three regressive cycles in the Great Estuarine Group (Cullaidh Shale-Elgol Sandstone, Lealt Shales-Valtos Sandstone, Duntulm-Kilmaluag-Skudiburgh formations). Although the increases through the two lower cycles are only slight (relative increases of 2% and 4% respectively), there is a relative increase of 50% through the upper cycle. At the top of the Middle Jurassic sequence there is a relative decrease of 43% in the mean PPI over the transgressive Skudiburgh to Staffin Bay Formation transition (Fig. 7.2).

7.2.3 Lithological Trends

7.2.3 (a) Gross Lithology

The mean PPI is similar in the shales and silts categories, but is increased by 9% and 13% relative to the shales in the sands and limestones respectively (Fig. 7.3).

7.2.3 (b) Sample Lithology

Figure 7.4 shows that within the whole dataset the mean PPI values are very similar in the shale, silty shale and shaley silt categories (less than 2% variation relative to shale); there are differences in the silt and sandy silt categories but sample numbers are too low to be significant. The mean PPI values are the same in the argillaceous and silty sands (11% increased relative to shale), but in the clean sands category the value is slightly (2%) decreased relative to shale. The clay-mudstone category (mostly from the

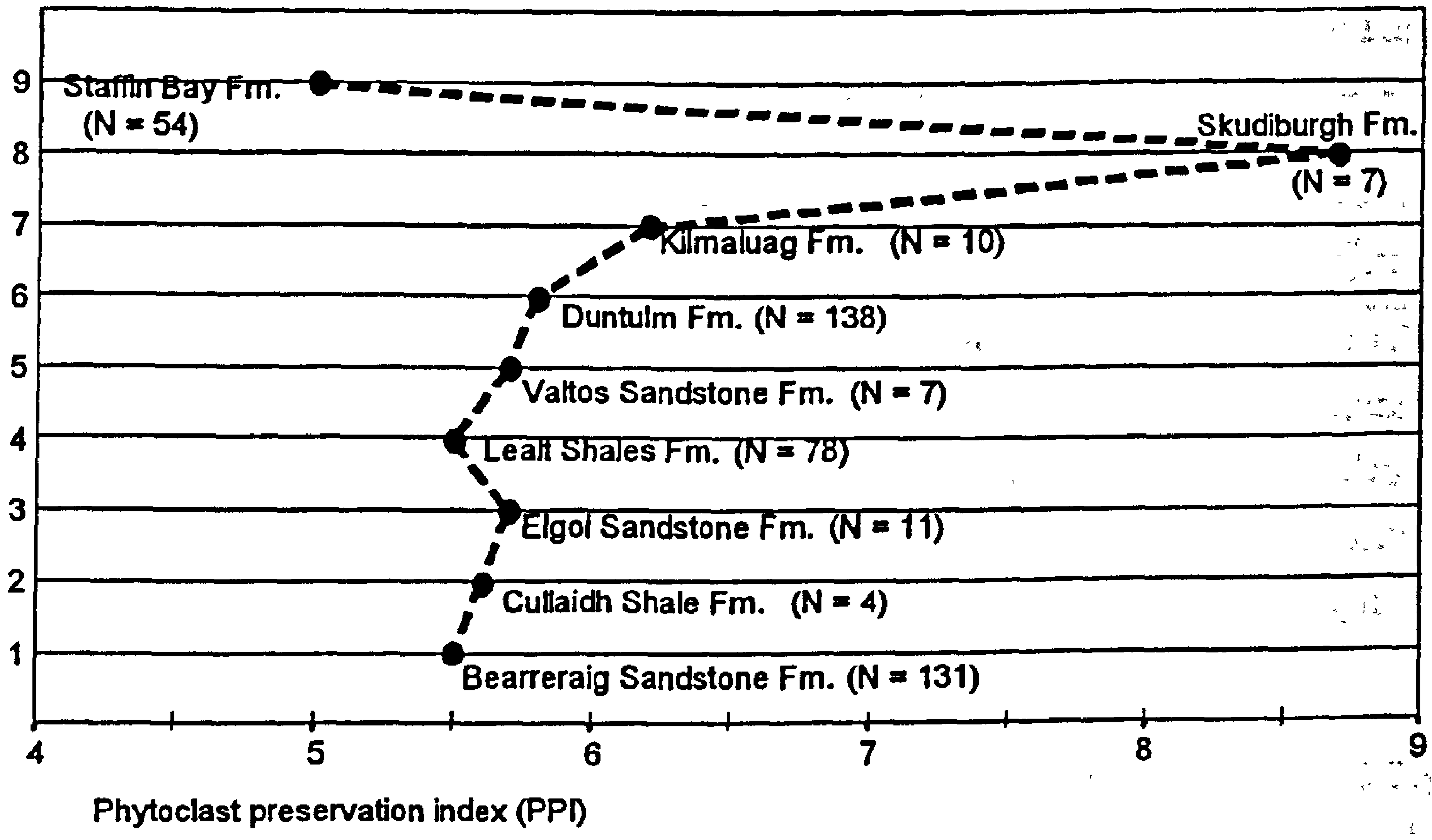


Fig. 7.2. *Mean phytoclast preservation index (PPI) in each formation examined (N = number of samples). (see also section 10.1).*

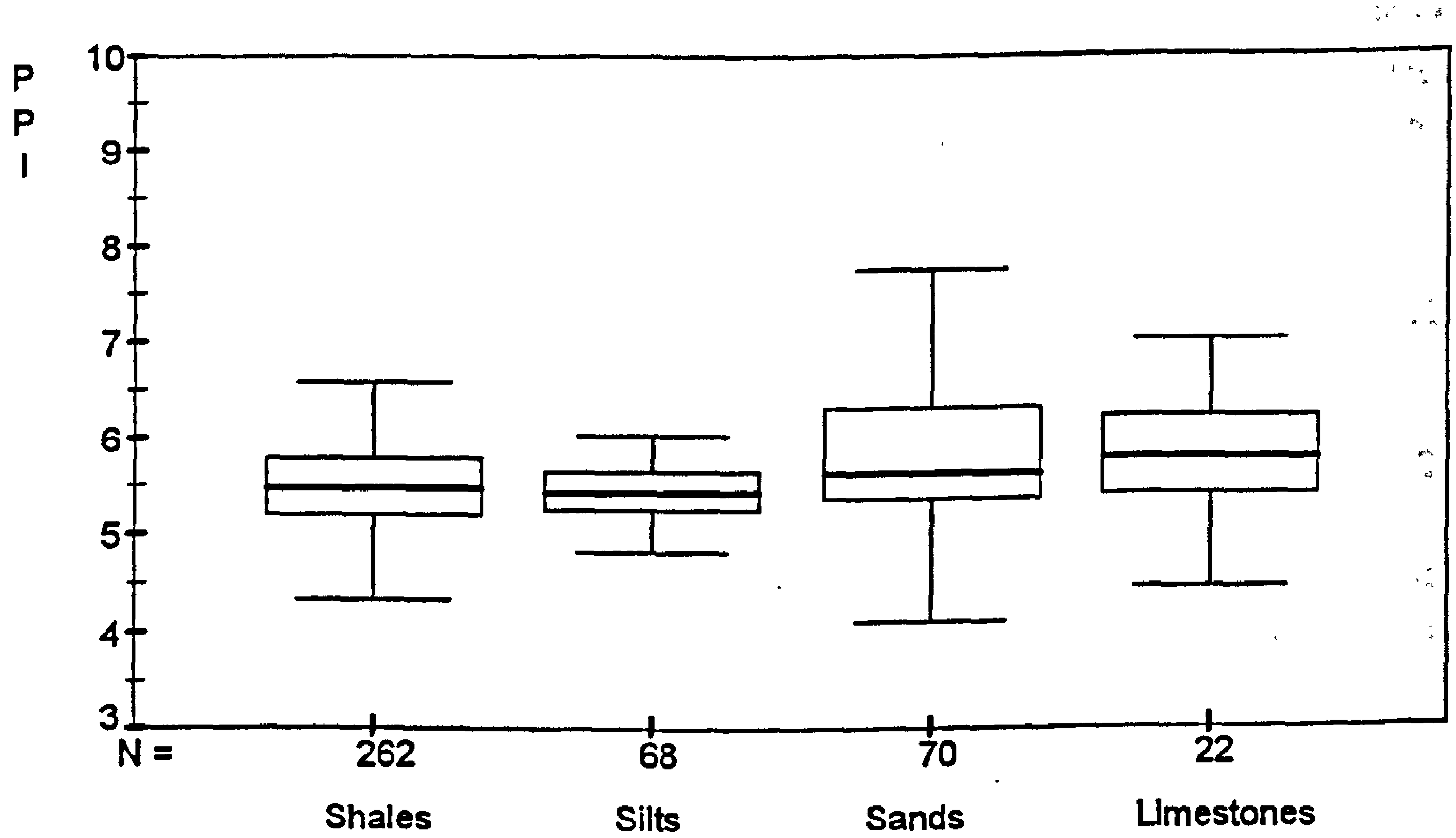


Fig. 7.3. *Boxplot of the distribution of phytoclast preservation index (PPI) values in each gross lithology category of the whole dataset. Each box contains all samples within the upper and lower quartiles (25 & 75%); the whisker lines contain the total range (excluding outliers); the thick black line in the box represents the mean value. (N = number of samples).*

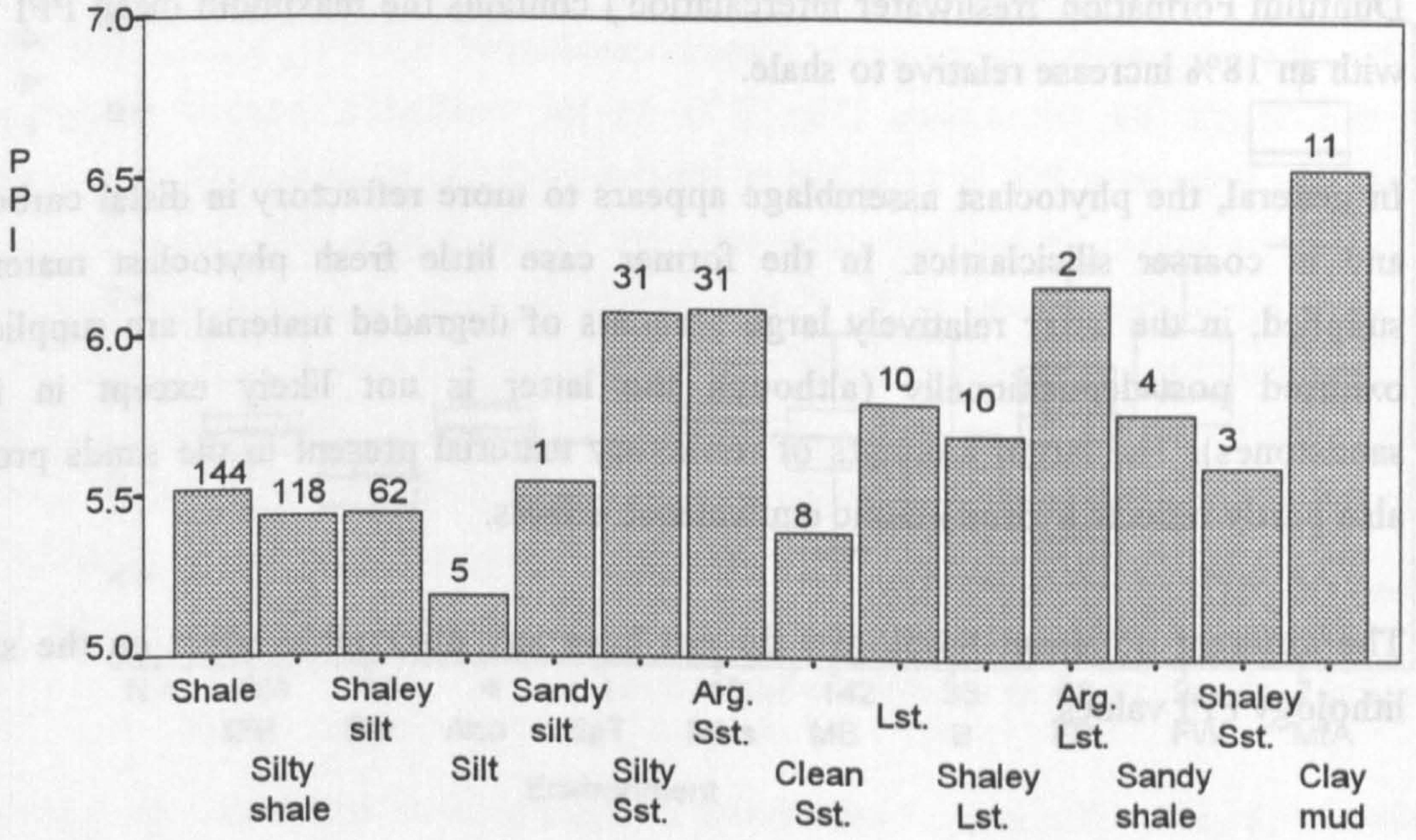


Fig. 7.4. *Mean phytoclast preservation index (PPI) in each sample lithology category in the whole dataset. The number at the top of each bar is the number of samples in that category.*

Duntulm Formation 'freshwater intercalation') contains the maximum mean PPI value, with an 18% increase relative to shale.

In general, the phytoclast assemblage appears to more refractory in distal carbonates and in coarser siliciclastics. In the former case little fresh phytoclast material is supplied, in the latter relatively large amounts of degraded material are supplied, or oxidised post-depositionally (although the latter is not likely except in fluvial sandstones). The larger amounts of refractory material present in the sands probably also partly reflects hydrodynamic equivalence effects.

The different dominant lithologies do not have any discernible effect on the sample lithology PPI values.

7.2.4 Environment and Salinity Trends

Within the environment classification of the whole dataset (Fig. 7.5) the maximum mean PPI occurs in the mudflat-alluvial category (containing all the samples from the Skudiburgh Formation), where atmospheric exposure and wet and dry cycles, which are both known to speed up degradation greatly, are likely to have been experienced. The lowest mean PPI is found in the marine "bar" category (which contains all the samples from the Belemnite Sands Member of the Staffin Bay Formation). The mean PPI decreases progressively by 9% (relative) overall from the marine-hypersaline to the brackish category; it then shows a progressive relative increase to the freshwater category of 15%, most (11%) of this occurring over the change from brackish to freshwater-brackish. This is possibly due to the coarser grained nature of the lithologies in these categories. However, this pattern is not entirely due to differences in lithology as a similar pattern emerges when only the shaley lithologies are included in the analysis (Fig. 7.6). This suggests that the relatively high PPI seen in the marine-hypersaline category may reflect a 'distal' refractory phytoclast assemblage, whilst the high PPI values found in the fresh-brackish and freshwater categories may reflect increased input and oxidation of degraded phytoclasts. This appears unlikely to be the case in the freshwater category which is dominated by restricted lacustrine Kilmaluag Formation samples which are rich in refractory black and biostructured brown wood indicative of a low input setting.

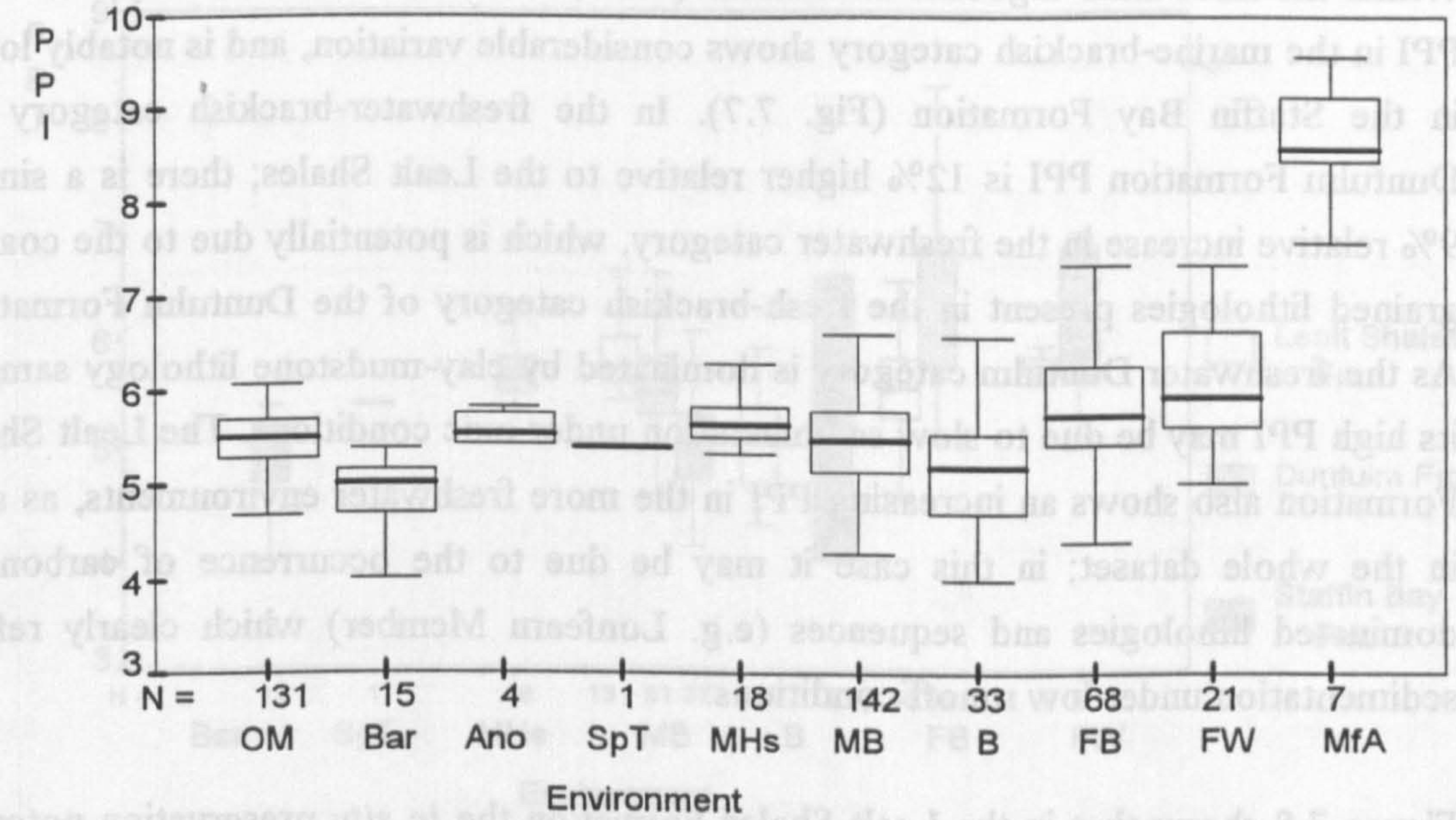


Fig. 7.5. *Boxplot of the distribution of phytoclast preservation index (PPI) values in each environment category of the whole dataset. Key to definitions in Fig. 7.3, key to abbreviations in Table 7.2; B is brackish, the environments to the left of this are all marine.*

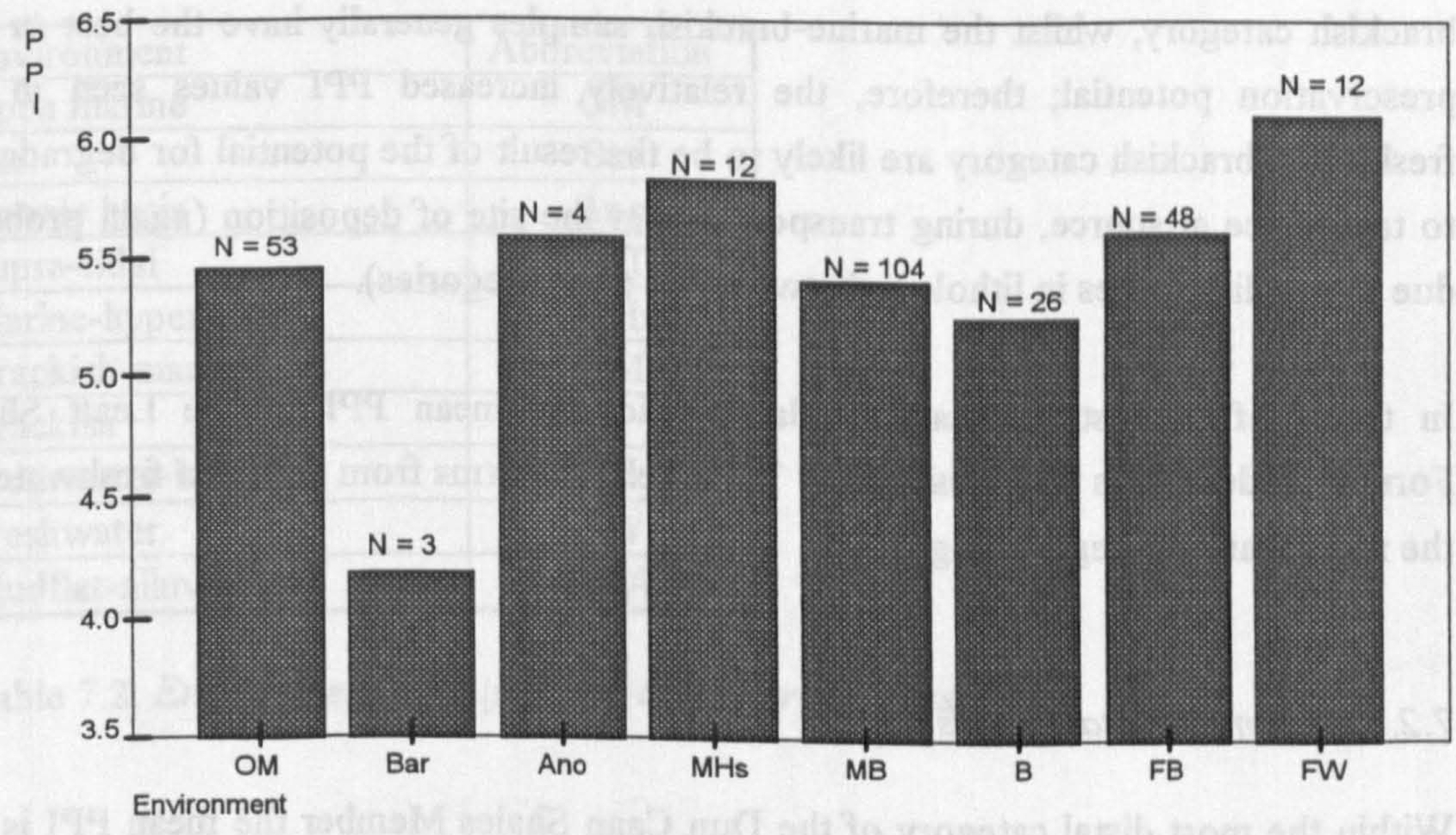


Fig. 7.6. *Mean phytoclast preservation index (PPI) in each environment category. Shales gross lithology only; N = number of cases. Key to abbreviations in Table 7.2.*

Within the three main 'lagoonal' formations (Lealt, Duntulm and Staffin Bay) the mean PPI in the marine-brackish category shows considerable variation, and is notably lower in the Staffin Bay Formation (Fig. 7.7). In the freshwater-brackish category the Duntulm Formation PPI is 12% higher relative to the Lealt Shales; there is a similar 9% relative increase in the freshwater category, which is potentially due to the coarser grained lithologies present in the fresh-brackish category of the Duntulm Formation. As the freshwater Duntulm category is dominated by clay-mudstone lithology samples its high PPI may be due to slow sedimentation under oxic conditions. The Lealt Shales Formation also shows an increasing PPI in the more freshwater environments, as seen in the whole dataset; in this case it may be due to the occurrence of carbonate-dominated lithologies and sequences (e.g. Lonfearn Member) which clearly reflect sedimentation under low runoff conditions.

Figure 7.8 shows that in the Lealt Shales Formation the *in situ* preservation potential (determined by fluorescence) is generally higher in the freshwater and freshwater-brackish than marine-brackish categories, suggesting that the PPI values in the former two categories are more likely to be the result of degradation taking place at source or during transport, whilst in the latter category there is potential for post-depositional degradation of organic matter. Conversely, Figure 7.9 shows that in the Duntulm Formation the largest potential for *in situ* degradation occurs in the freshwater-brackish category, whilst the marine-brackish samples generally have the best *in situ* preservation potential; therefore, the relatively increased PPI values seen in the freshwater-brackish category are likely to be the result of the potential for degradation to take place at source, during transport and at the site of deposition (again probably due to the differences in lithology between the two categories).

In terms of the ostracod-salinity classification,the mean PPI of the Lealt Shales Formation decreases progressively by 7% in relative terms from the most freshwater to the most marine category (Fig. 7.10).

7.2.5 Proximal-Distal Trends

Within the most distal category of the Dun Caan Shales Member the mean PPI is 6% higher relative to the more proximal category. This may be due to lowered *in situ* preservation potential (based on fluorescence) in the distal unit allowing increased post-depositional degradation compared to the majority of samples in the more proximal category (Fig. 7.11); in more distal settings sorting also tends to produce smaller and more refractory particles.

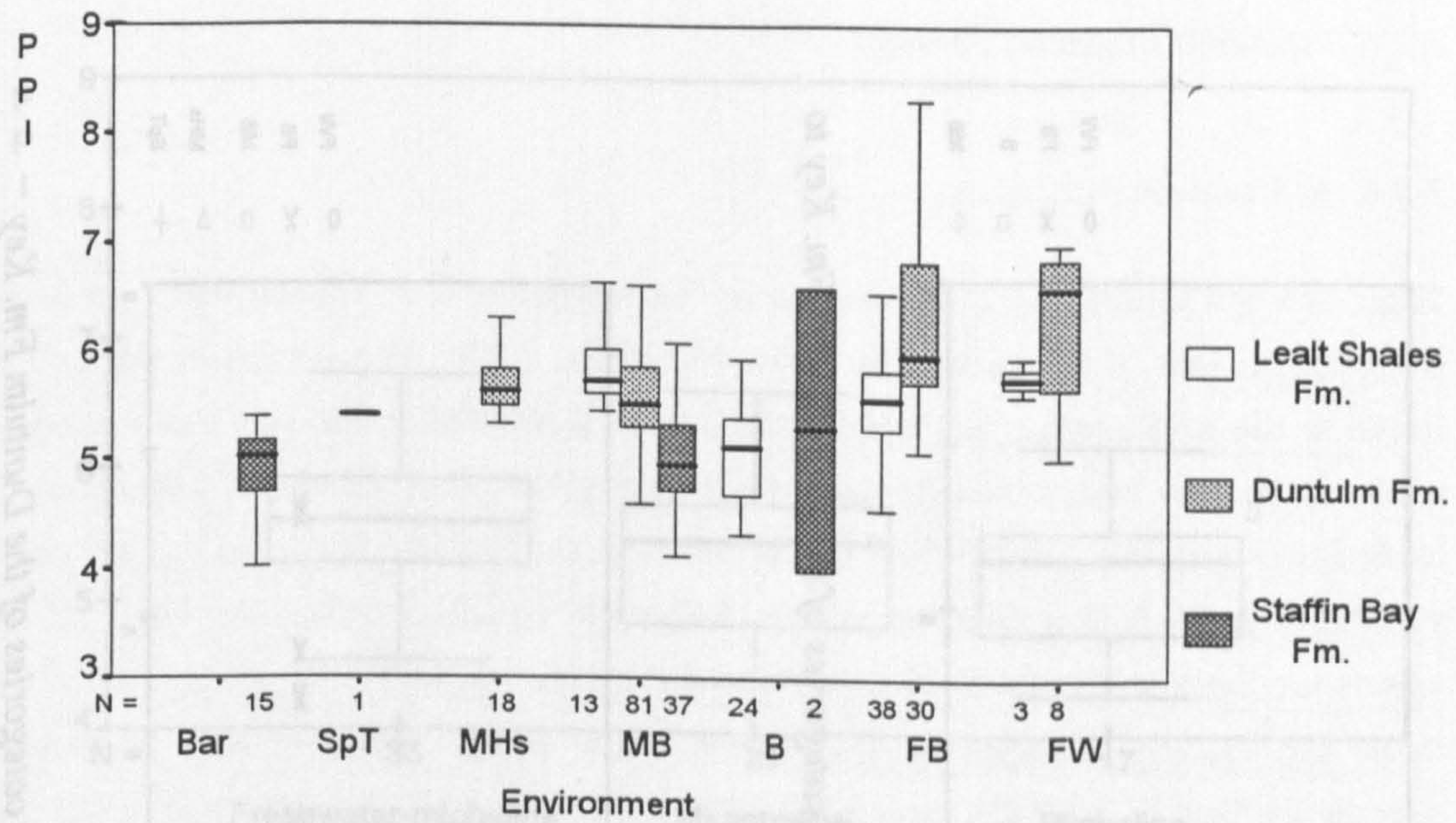


Fig. 7.7. *Boxplot of the distribution of phytoclast preservation index (PPI) values in the environment categories of the three major lagoonal formations. Key to definitions in Fig.7.3, key to abbreviations in Table 7.2. The supratidal category (SpT) only occurs in the Duntulm Formation.*

Environment	Abbreviation
Open marine	OM
Bar	Bar
Anoxic basin	Ano
Supra-tidal	SpT
Marine-hypersaline	MHs
Brackish-marine	BM
Brackish	B
Freshwater-brackish	FB
Freshwater	FW
Mudflat-alluvial	MfA

Table 7.2. *Environment classification and abbreviations.*

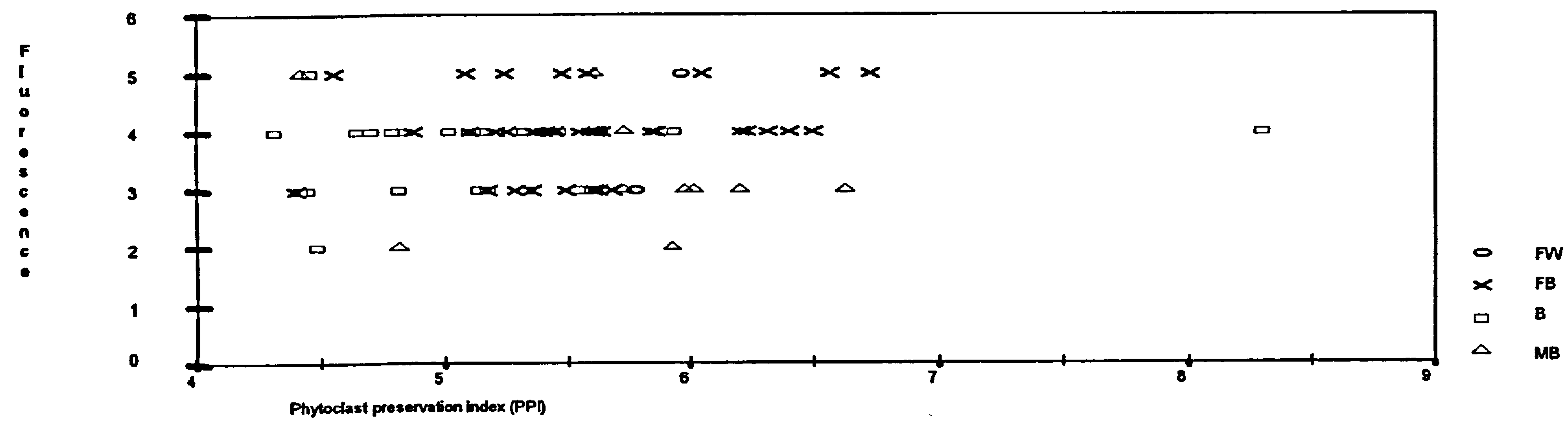


Fig. 7.8. *Phytoclast preservation index and fluorescence level in the environment categories of the Lealt Shales Fm. Key to abbreviations in Table 7.2.*

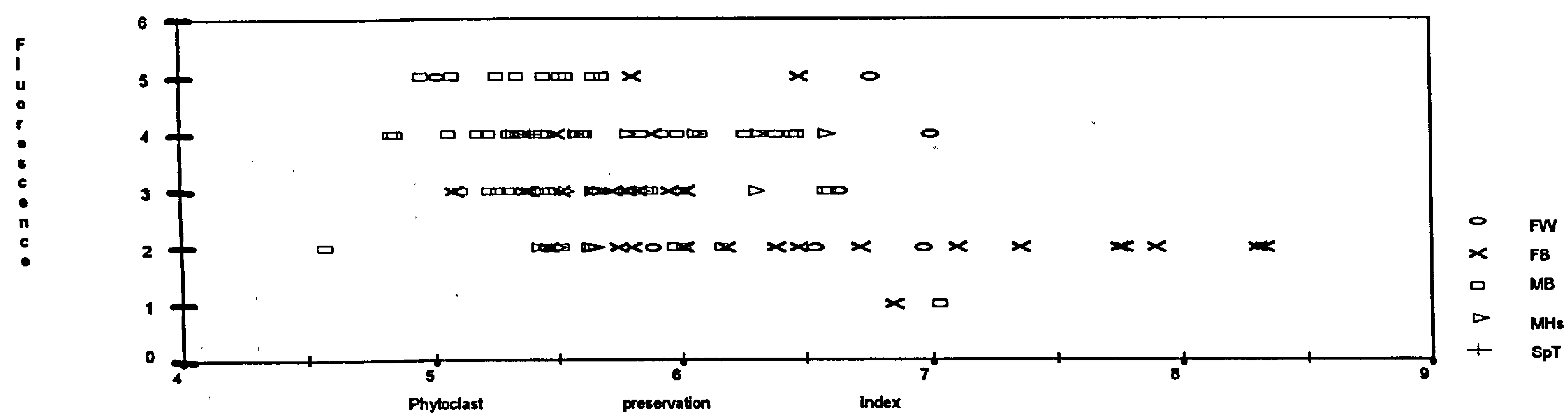


Fig. 7.9. *Phytoclast preservation index and fluorescence level in the environment categories of the Duntulm Fm. Key to abbreviations in Table 7.2.*

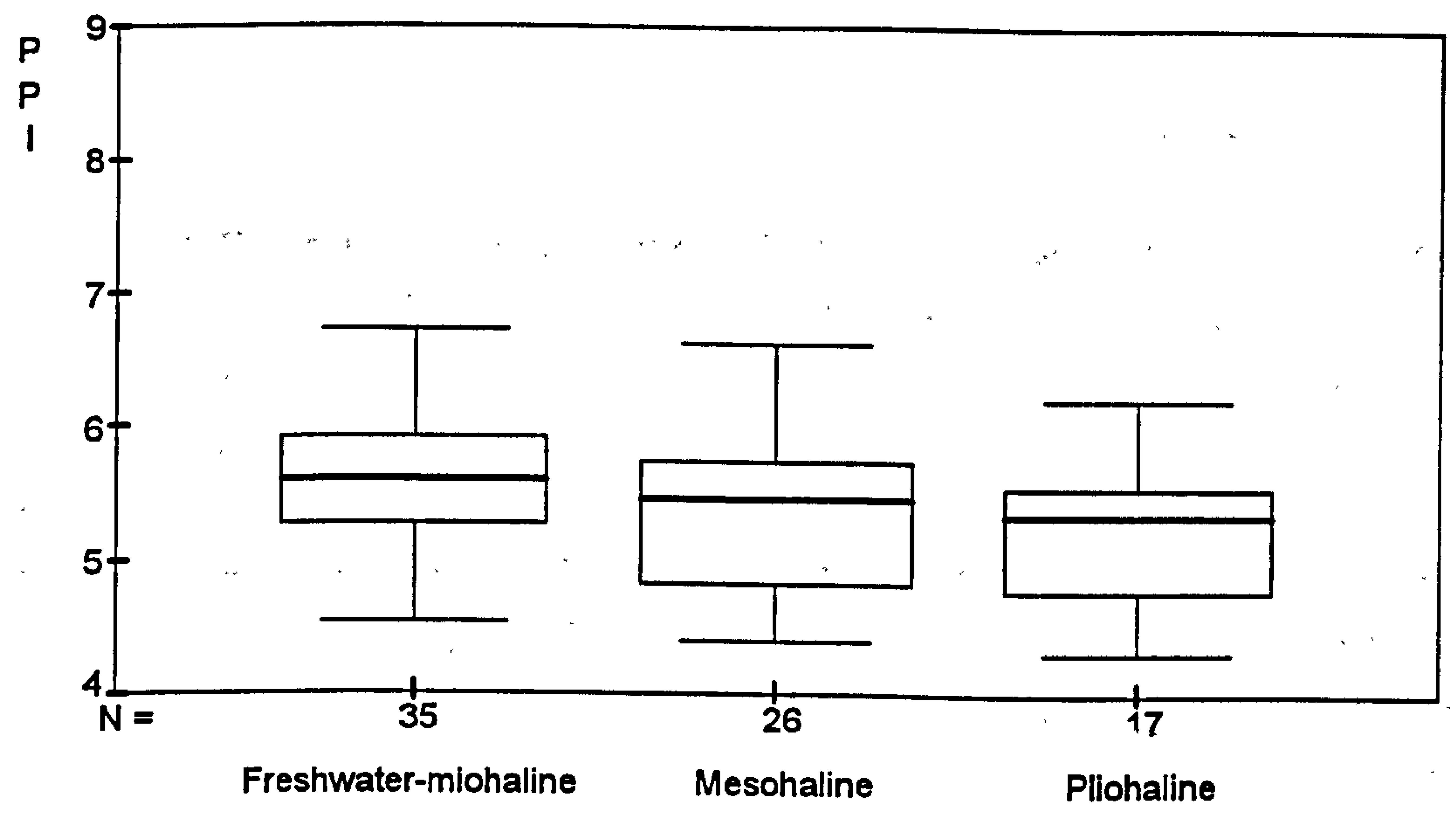


Fig. 7.10. *Boxplot of phytoclast preservation index (PPI) value distribution relative to the ostracod derived salinity classification of the Lealt Shales Formation. Key to definitions in Fig. 7.3.*

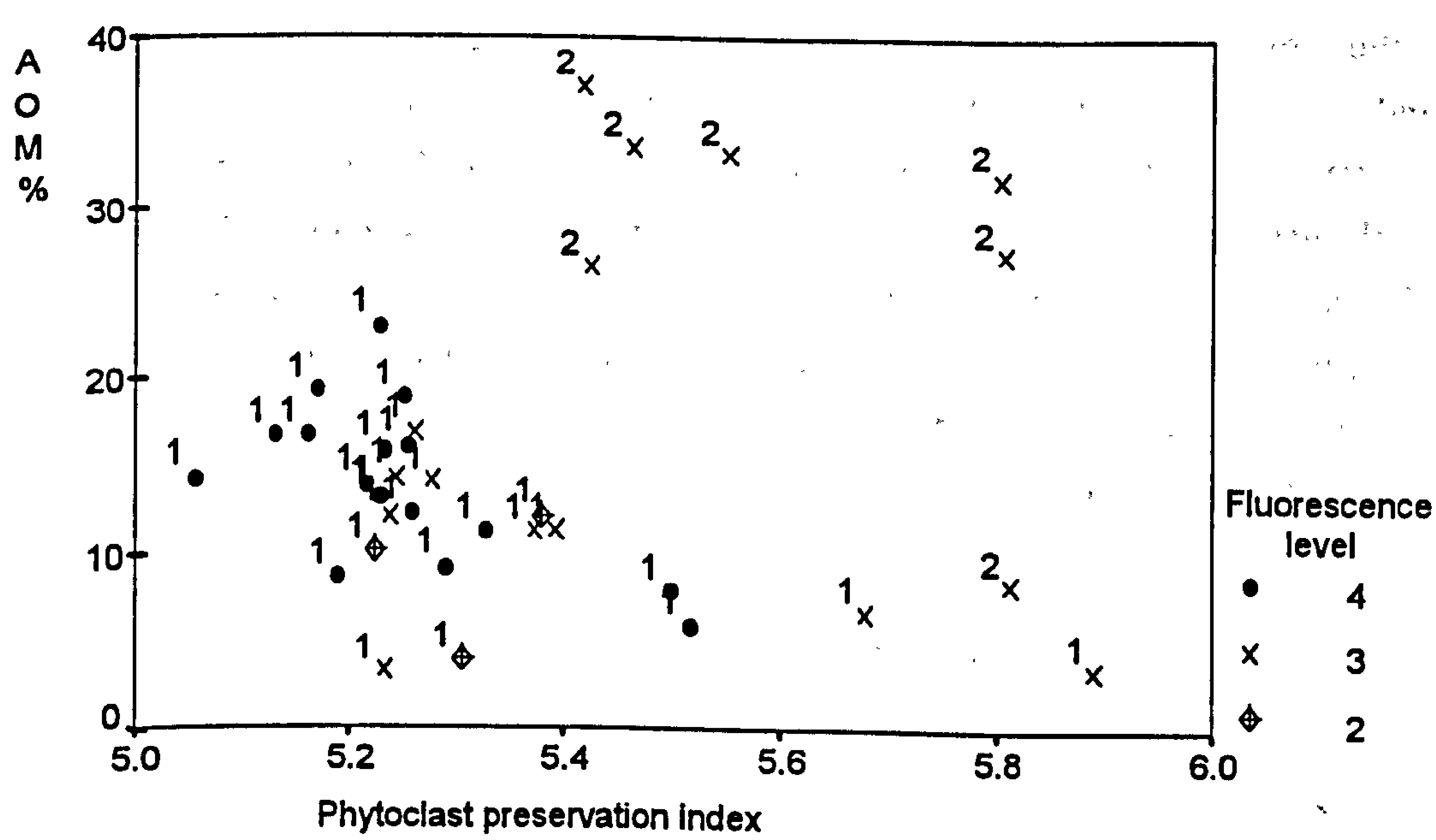


Fig. 7.11. *Phytoclast preservation index (PPI) and percentage AOM/fluorescence levels in the Dun Caan Shales Mbr. (Bearreraig Sst. Fm.). The figure next to each point shows its proximal-distal category: 1 = proximal, 2 = distal.*

7.2.6 Litho-and Biofacies Trends

7.2.6 (a) Duntulm Formation

The dominant lithofacies, *Praeexogyra* limestone-shales, has a mean PPI of 5.6 which is similar to that in the sandstone lithofacies (Fig. 7.12). The maximum mean PPI is found in the argillaceous limestones and *Unio-Neomiodon* muds and sands lithofacies where it is 14% higher relative to the *Praeexogyra* limestone-shales lithofacies. The biofacies classification subdivides this lithofacies: the 'marine' biofacies has a mean PPI value that is 7% higher than the 'oyster shell bank' biofacies. The other biofacies mean values are the same as those in the related lithofacies. Figure 7.13 shows that in some cases the marine biofacies samples have lower potential for *in situ* preservation, suggesting that part of the increased PPI may be due to increased post-depositional degradation. In this case this cannot be attributed to lithological differences as these are comparable (shales and silty shales) in all the *Praeexogyra* limestone-shales lithofacies samples.

7.2.6 (b) Staffin Bay Formation

In the bituminous shales lithofacies the mean PPI is 5.0; the level in the argillaceous sands category is similar (Fig. 7.14). The minimum mean PPI (some 14% lower relative to the bituminous shales lithofacies) is found in the muddy sands lithofacies which marks the top of the formation. Conversely, the maximum PPI is found in the calcareous clay-limestone lithofacies which marks its base (8% increase relative to the bituminous shales). The mean PPI of the '*Neomiodon* and others' biofacies is very slightly (2% relative) lower than that found in the monotypic *Neomiodon* biofacies. The other biofacies mean values are the same as those in the related lithofacies.

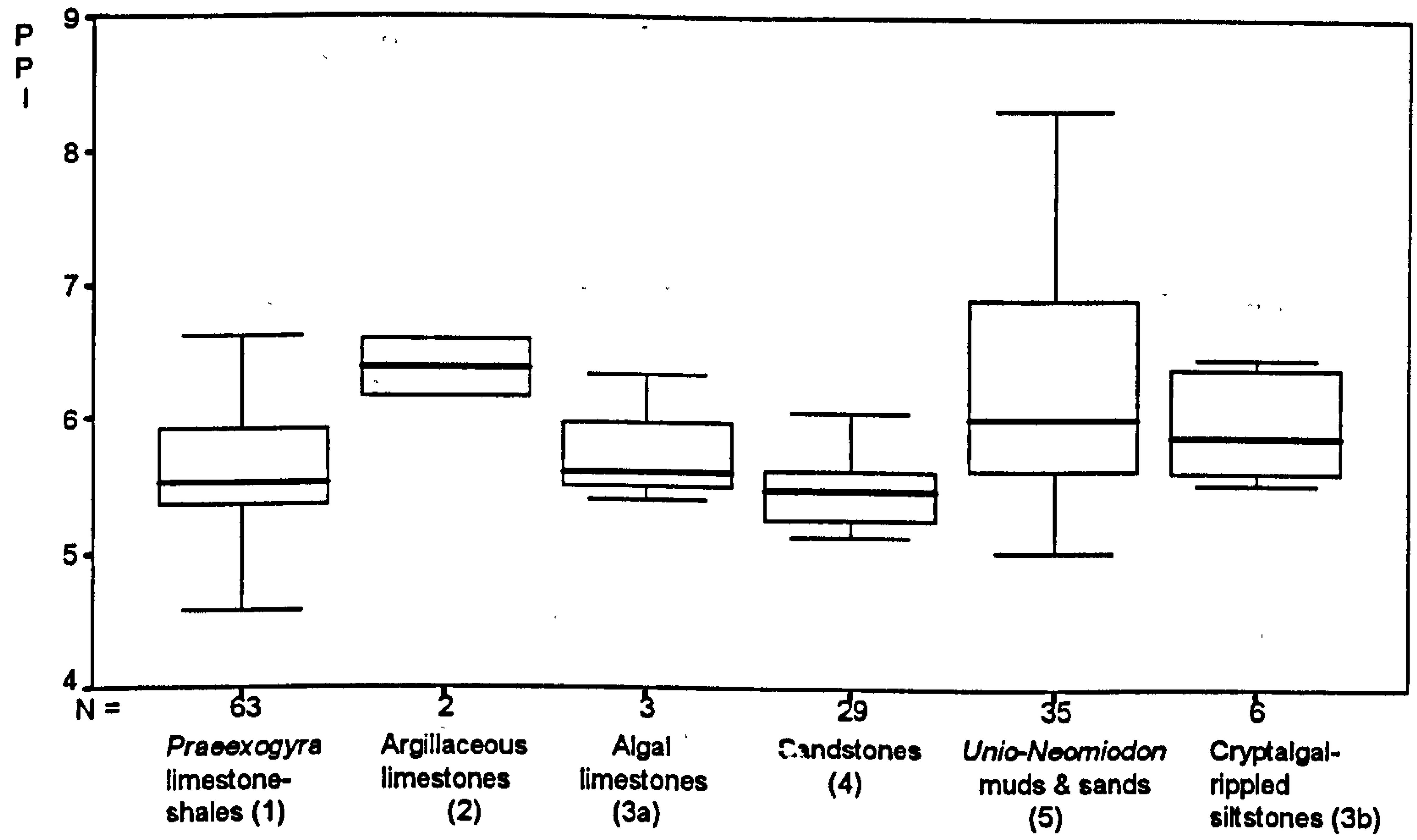


Fig. 7.12. *Boxplot of phytoclast preservation index (PPI) values in each lithofacies of the Duntulm Fm. Key to definitions in Fig. 7.3.*

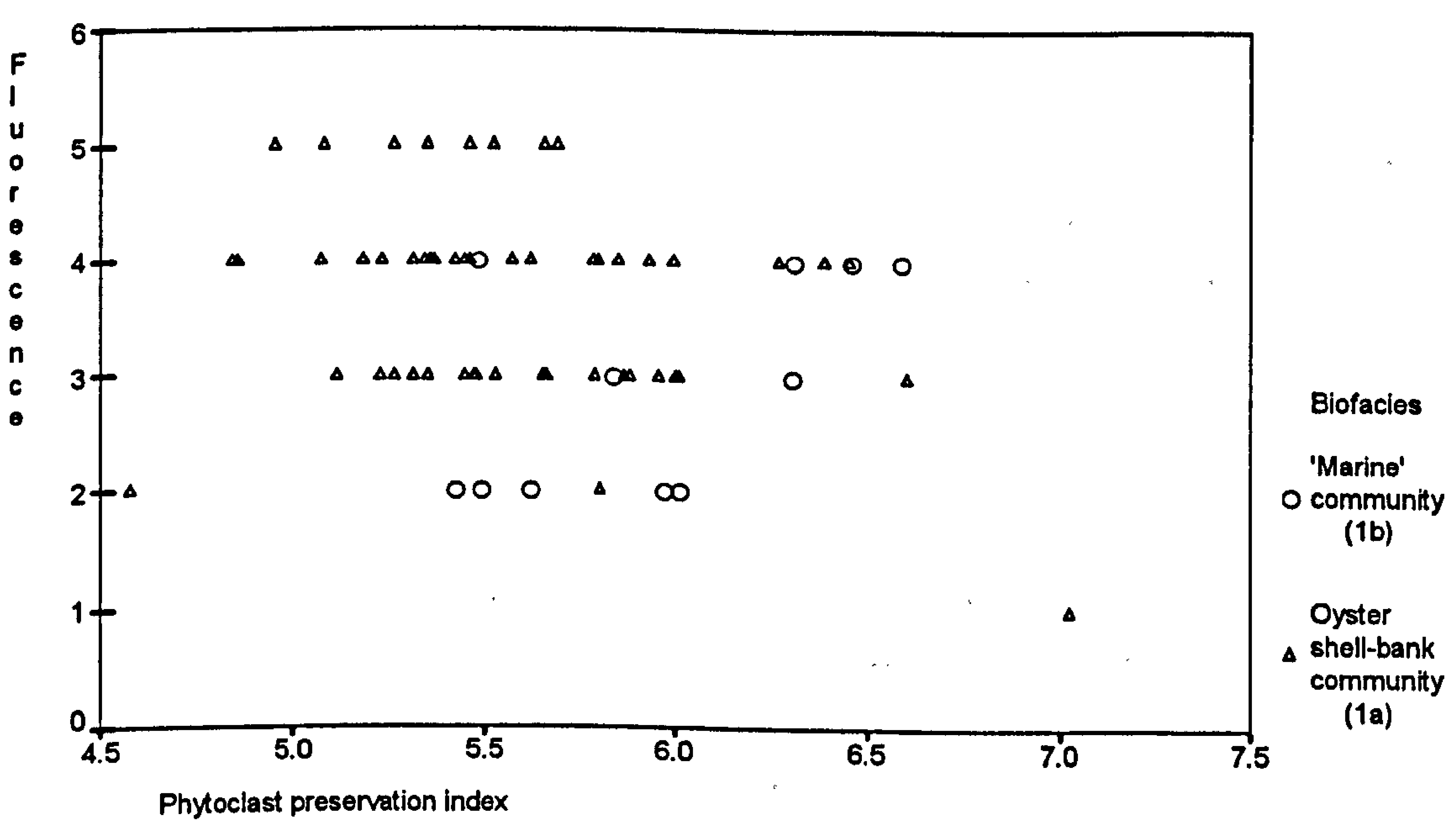


Fig. 7.13. *Fluorescence level and phytoclast preservation index of samples from the two biofacies which relate to the* Praeexogyra *limestone-shale lithofacies in the Duntulm Fm.*

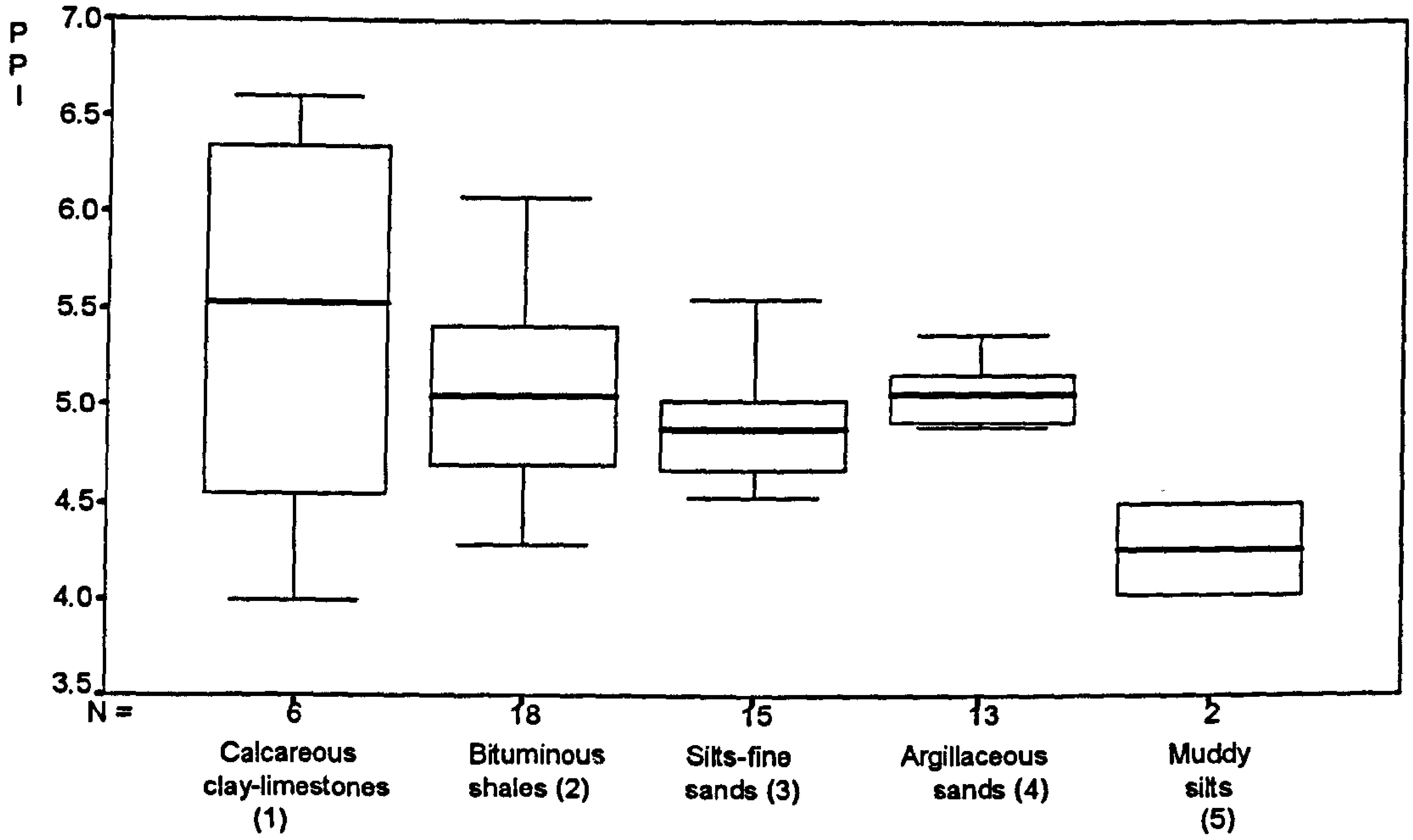


Fig. 7.14. *Boxplot of the distribution of phytoclast preservation index (PPI) values in each lithofacies of the Staffin Bay Fm. Key to definitions in Fig. 7.3.*

7.3 Brown Phytoclast Preservation

7.3.1 Introduction

The changes within the brown wood assemblage are important in determining the PPI value as components of this fraction make up the majority of the phytoclast types used in its calculation. The degradation states of the different groups (non-biostructured, biostructured, striate and striped combined, and banded and pitted combined) have been examined by crossplotting the log ratios of their undegraded:degraded fractions against other groups to try to determine if changes are occurring within, as well as between, phytoclast components, and whether these changes are consistent.

7.3.2 Results and Discussion

Figure 7.15 shows that there is significant variation in the degradation state of both major brown wood groups in the whole dataset. There is a positive relationship (r^2 = 0.3) between the two ratios suggesting that changes in preservation state are reasonably consistent between the two groups, and there is a well defined trend of increasing undegraded (biostructured and non-biostructured) brown wood from the Bearreraig Sandstone, to Duntulm, to Lealt Shales, to Staffin Bay formations. Most of the general trend reflects differences *between* formations, and only the Lealt Shales and Staffin Bay formations (especially the latter) show clear *within* formation trends, which is reflected in the stronger correlation (r^2 = 0.5) when they are considered separately from the rest (Fig. 7.16). The Staffin Bay Formation is also clearly characterised by an increased abundance of undegraded brown wood.

Within the biostructured wood categories (striate and striped combined, banded and pitted combined, latter not shown), there is no consistent variation with the non-biostructured brown wood degradation state (Fig. 7.17), but again the four main formations are reasonably distinct. For example, the Staffin Bay Formation is characterised by at least 50% undegraded/non-biostructured brown wood, and dominantly degraded striate and striped material. This could suggest that in this case the striate and striped material is reworked (it has survived because it is resistant), and has subsequently been added to 'newer', non-biostructured material. When the relationship between the striate + striped and banded + pitted particle types is examined (Fig. 7.18) there is a strong negative relationship between the two ratios; suggesting that in the case of the Staffin Bay Formation there is a positive correlation

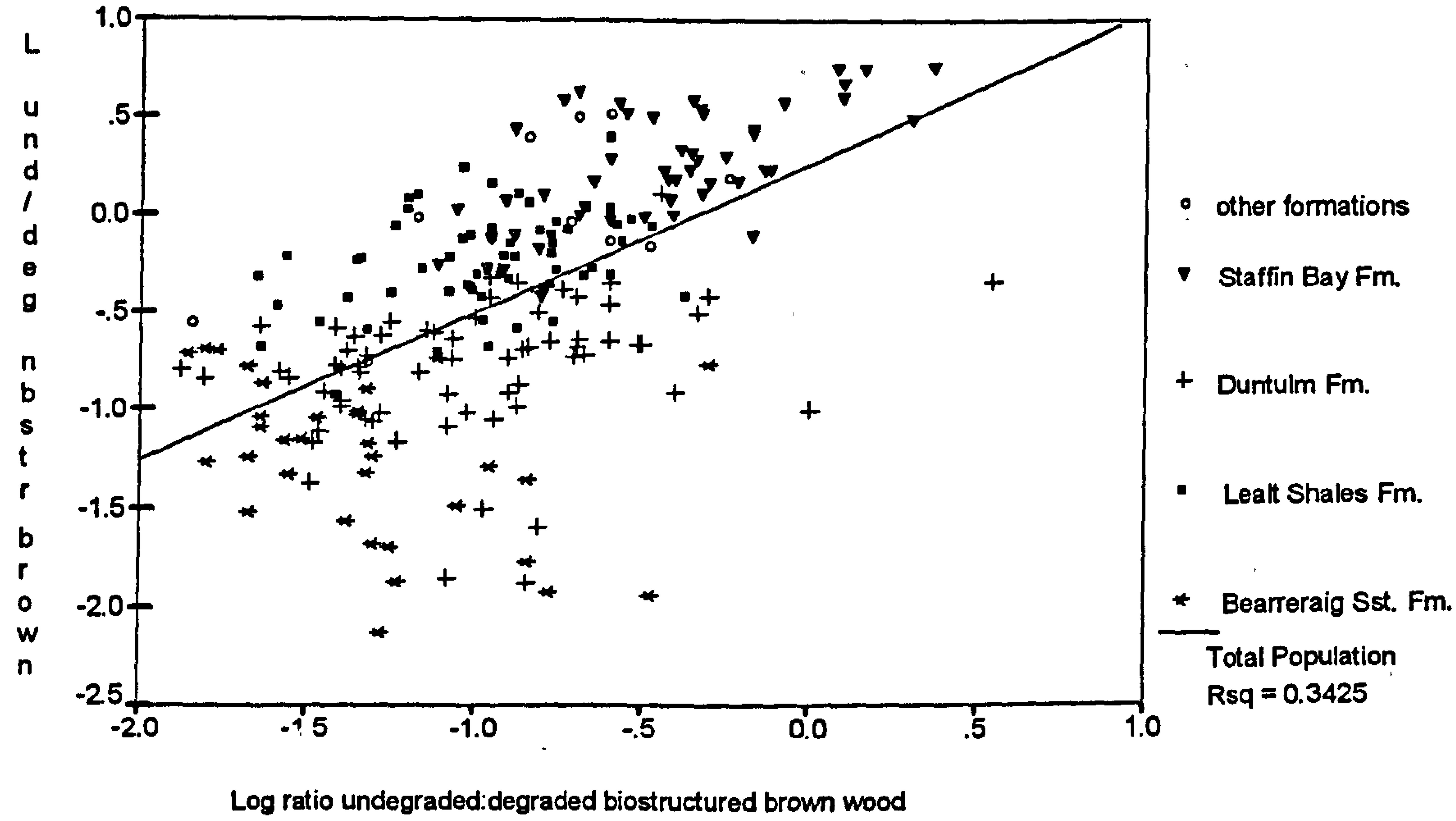


Fig. 7.15. *Crossplot of the degradation state of the biostructured vs. non-biostructured brown wood fraction, whole dataset.*

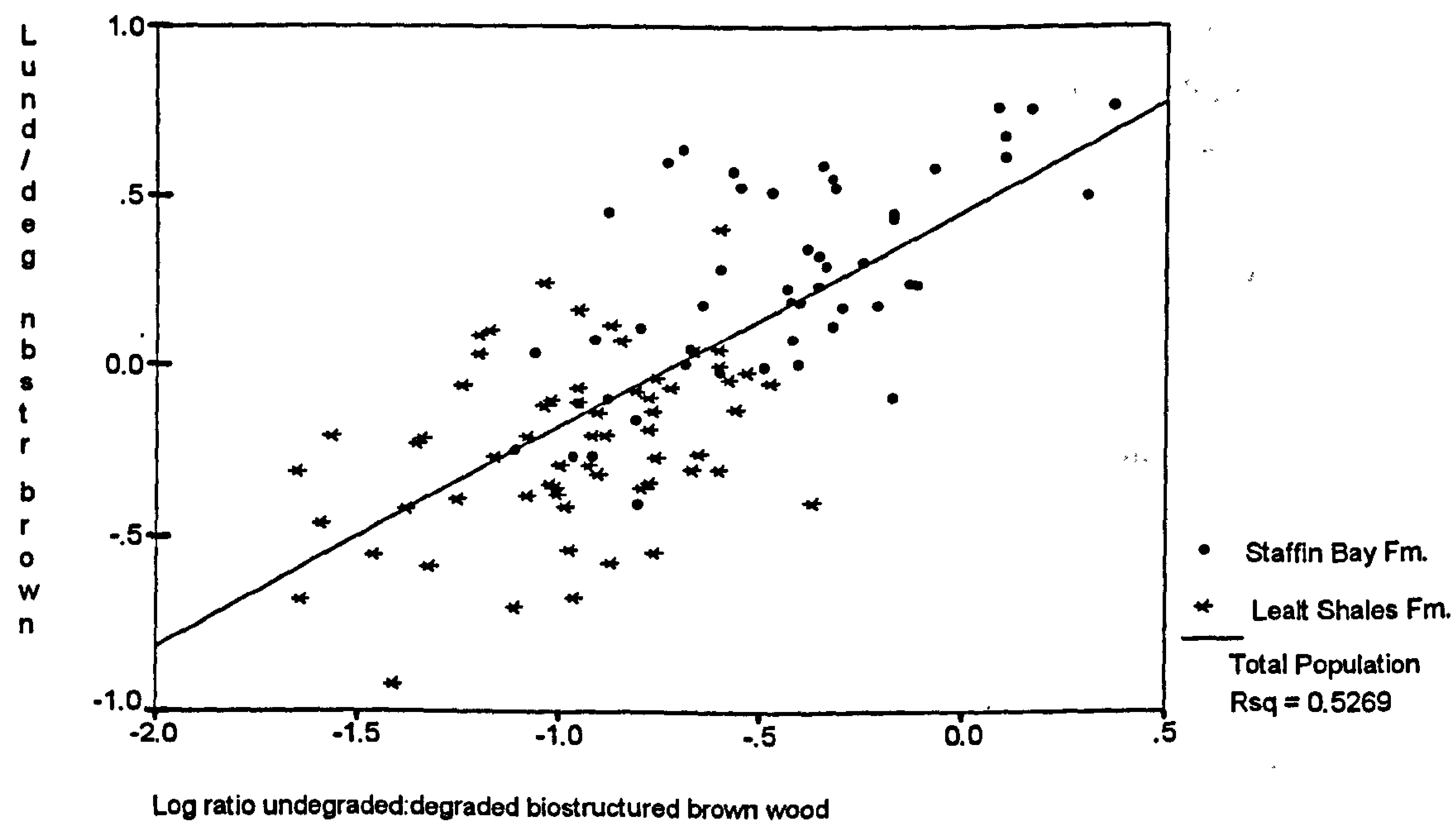


Fig. 7.16. *Crossplot of the degradation state of the biostructured vs. non-biostructured brown wood fractions in the Lealt Shales and Staffin Bay formations.*

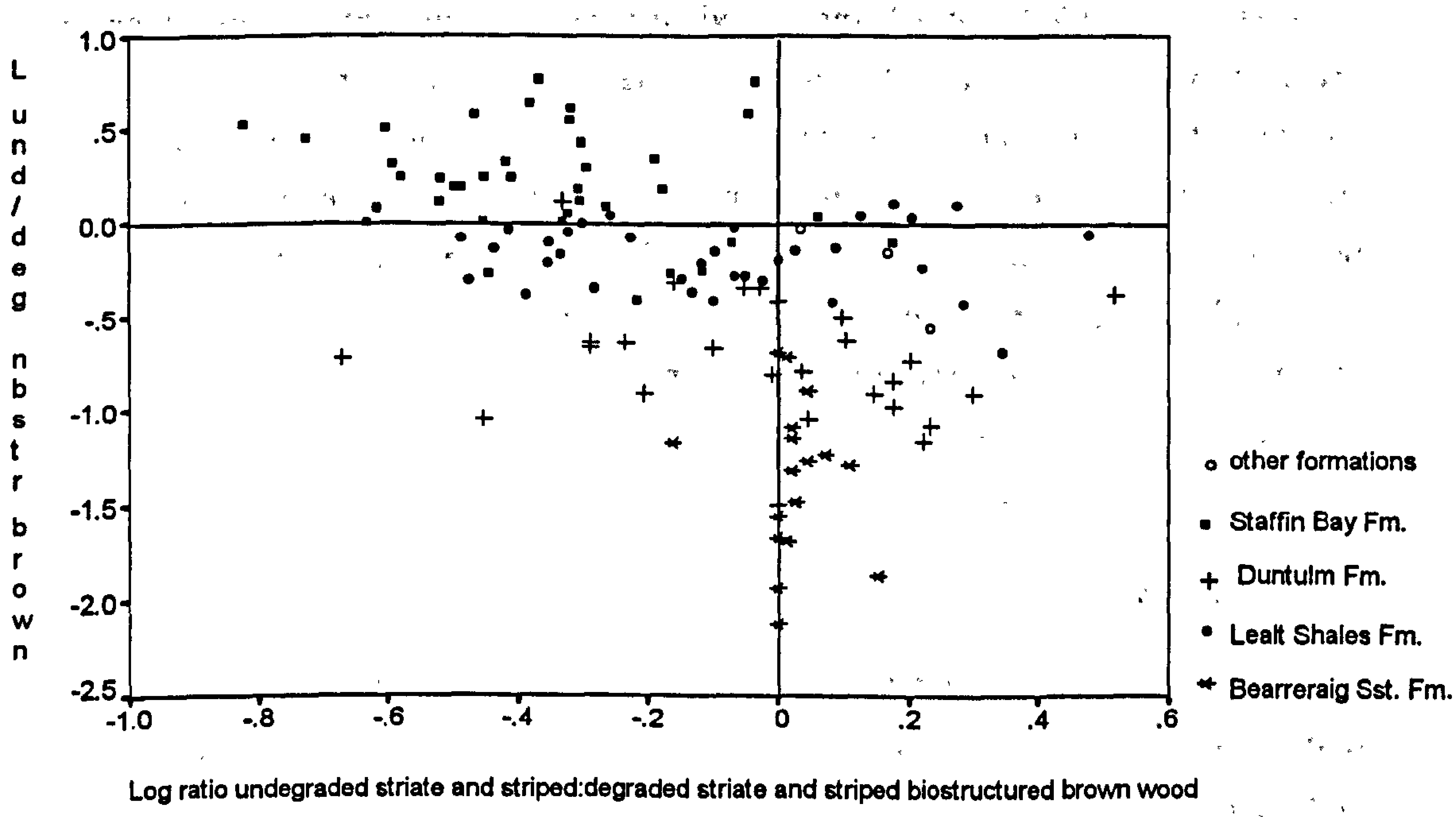


Fig. 7.17. *Crossplot of the degradation state of the non-biostructured vs. striate and striped biostructured brown wood, whole dataset.*

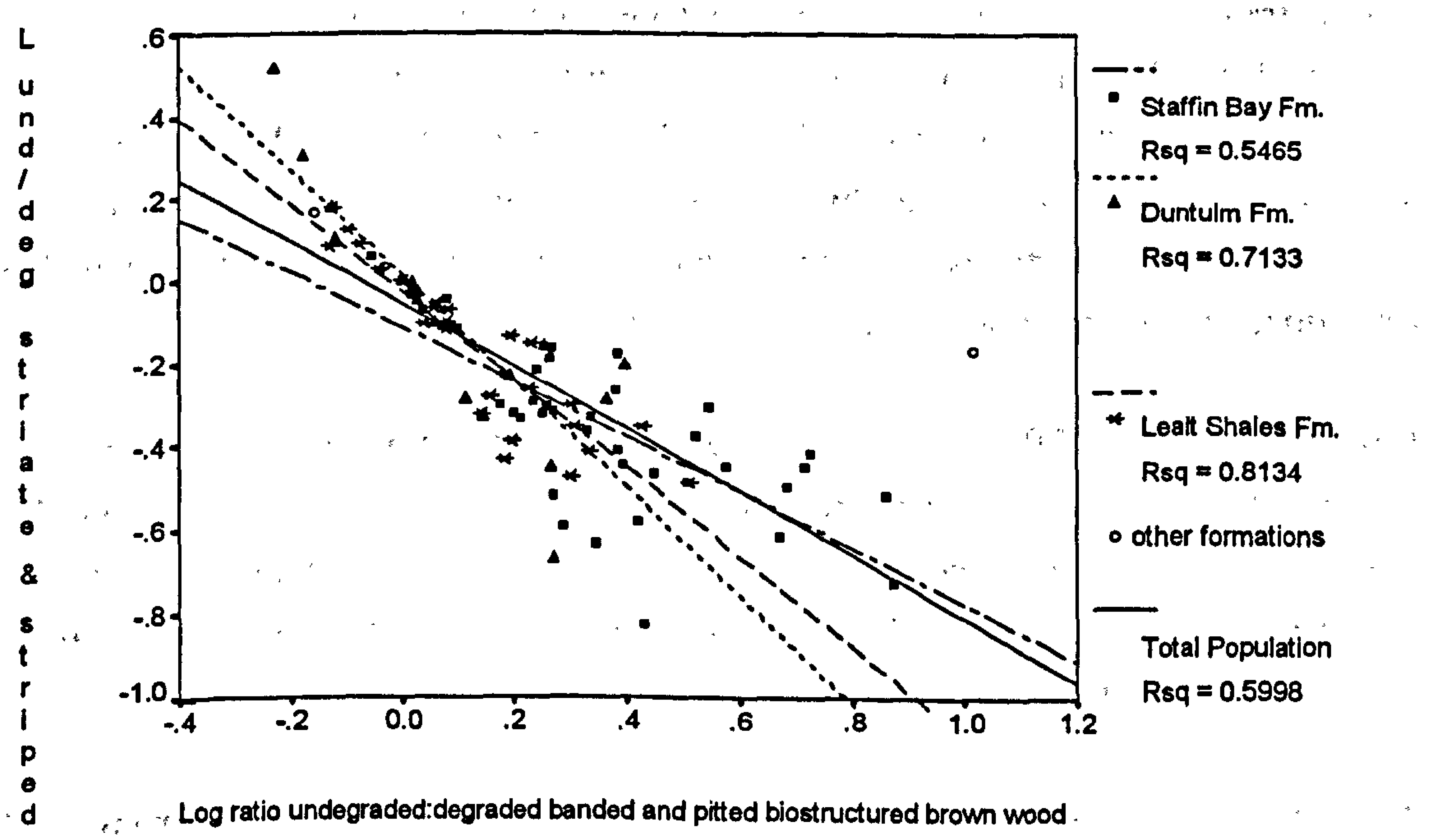


Fig. 7.18. *Crossplot of the degradation state of the striate and striped vs. banded and pited biostructured brown wood, whole dataset.*

between undegraded banded and pitted particles and undegraded non-biostructured brown wood. This relationship may also be due to the more refractory (resistant) nature of the banded and pitted particles, meaning that they remain in an undegraded state, whilst the potentially less resistant striate and striped material become degraded, but this would not explain the correlation of degraded banded and pitted particles with undegraded striate and striped material. This may suggest a difference in supply and transport histories of the two groups of particle types.

7.4 Summary

The PPI has proved useful in summarising the nature of the phytoclast assemblage within the various classifications examined; relatively high PPI values characterise carbonate and coarser grained siliciclastic sediments, and distal shales. However, the expected proximal to distal increase in PPI is often complicated by lithological and environmental (energy) effects, which have lead to PPI maxima occurring in both the most marine (= ?distal) and most freshwater (= ?proximal) environments. High PPI values in distal marine facies are likely to reflect extended exposure to degradation during transport over long distances combined with oxic conditions; in freshwater settings high PPI values are likely to be associated with environments that are relatively distal with respect to siliciclastic/fluvial source when carbonate-dominated, and those that are characterised by slow sedimentation. High PPI values can also be associated with sandstones reflecting higher energy and greater post-depositional oxidation, and perhaps also increased reworking.

Combination of the PPI with kerogen fluorescence values has allowed the tentative estimation of the potential for degradation to take place at the site of deposition; high fluorescence levels combined with low PPI values suggesting that this process is not occurring. However, high PPI values can occur in distal facies where *in situ* preservation potential is also high.

The main problem with the PPI in this dataset is that the magnitude of many of the observed changes are often quite small (mostly less than 10% and often less than 5% relative). This may suggest that in terms of its overall nature the phytoclast assemblage does not change much between the various units, or that in some the changes seen are only subtle due to the limited scale of the facies variation and proximal-distal gradient.

The detailed examination of the brown wood assemblage has shown that changes in the degradation state of both major categories (biostructured and non-biostructured) are reasonably consistent in the whole dataset, but more so in the Lealt and Staffin Bay formations. There is also a strong negative relationship between the two groups of biostructured brown wood suggesting that these two groups do not show consistent variation, possibly due to differences in their resistance to degradation or supply. Relationships between other categories are less strong, but do show that changes within the groups do take place and can be used to distinguish the formations, particularly the Staffin Bay Formation which seems to have a somewhat different brown wood assemblage to the rest (see also Chapter 10.0).

CHAPTER 8.0
DISCRIMINANT FUNCTION AND CLUSTER ANALYSIS

8.0 DISCRIMINANT FUNCTION AND CLUSTER ANALYSIS

8.1 Discriminant Function Analysis (DFA)

Discriminant function analysis (DFA) has been carried out on the whole dataset and on the four main formations sampled (Bearreraig Sandstone, Lealt Shales, Duntulm, and Staffin Bay) using a variety of dependent or categorical variables derived from the literature or the present study. Many of these variables are applicable to only one of the formations studied (e.g. the litho- and biofacies of the Duntulm Formation), but the environment classification of Hudson and Harris (1979) has been applied throughout. The objective has been to use the palynofacies data to discriminate between the categories of the dependent variables, and to provide a measure (= overall classification accuracy) of the control that these variables exert on the palynofacies assemblages. This has allowed: i) the comparison of results derived from applying the same dependent variable to different datasets, and ii) the comparison of the results of applying different dependent variables to the same dataset. The results of different runs have been compared using the % better than proportional chance (Cprop) criterion.

In the case of the majority of dependent variables, simultaneous DFA was carried out using just the variables derived from the kerogen counts (kerogen group variables), just the variables derived from the palynomorph counts (palynomorph group variables), and both variable groups combined (combined). Stepwise DFA (SDFA) was carried out using only the combined variables group. An introduction to DFA is provided in section 3.3; DFA has also been used in section 4.7 to help assess the effect of lithology.

8.2 Dependent Variables and Different Datasets

8.2.1 Formation

Table 8.1 shows that in terms of overall classification accuracy the simultaneous combined variables run is most successful, followed by the kerogen, then the palynomorph run. The pattern shown by the individual categories (= formations) is generally similar to this, but in the Bearreraig Sandstone Formation the palynomorph variables group provides the best accuracy, suggesting that these variables are more distinct in this formation. The maximum difference between the accuracies of the kerogen and palynomorph runs is found in the Lealt Shales Formation, where kerogen

Formation	Kerogen	Palynomorph	Combined	Stepwise
	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2
Bearreraig Sst.	84 / 250	100 / 317	98 / 308	99 / 313
Cullaidh Shale	100*	100*	100*	100*
Elgol Sst.	100 / 317	82 / 242	100 / 317	100 / 317
Lealt Shales	89 / 271	61 / 154	91 / 279	86 / 300
Valtos Sst.	71 / 196	100*	100*	100*
Duntulm	78 / 225	70 / 192	88 / 267	88 / 267
Kilmaluag	80 / 233	50*	50*	50*
Skudiburgh	100 / 317	na	na	na
Staffin Bay	93 / 288	88 / 267	100 / 317	94 / 292
Overall	85 / 254	79 / 229	94 / 292	92 / 283
Cprop	24	24	24	24

* category contains less than 5 samples; na = category not present
acc1 = represents the computed accuracy; acc2 = the relative % acc1 > Cprop

Table 8.1. *Percentage classification accuracies for the discrimination of the formations, all data.*

variables are apparently far more distinct. In the Duntulm Formation there is a 42% increase in accuracy when the variable groups are combined, suggesting that the kerogen and palynomorph variables here show common trends. The highest classification accuracies are found in the Bearreraig and Elgol Sandstone, Skudiburgh, and Staffin Bay formations, indicating that these coarser grained units are more distinct; conversely, the finer grained Duntulm, Kilmaluag, and Lealt Shales formations show lower accuracies.

The SDFA run provides a relatively high accuracy using 17 variables (Table 8.12); palynomorph variables represent 10 of these, including 7/10 of the variables with the highest Wilks' Lambda values.

8.2.2 Environment

Table 8.2 shows the classification accuracies for the different environment categories based on the whole dataset (overall) and the individual formations. In both the whole dataset and 2/3rds of the formations the pattern shown by the overall classification accuracies is the same: combined > palynomorph > kerogen; in the Staffin Bay Formation the kerogen run shows the best overall accuracy, but this would seem to be generally the case in this formation (cf. section 8.3.5). This predominance of palynomorph over kerogen variables suggests that the former are better for discriminating environments. Within the individual environment categories the classification accuracies generally show the same pattern as the overall result; however, the marine-hypersaline, brackish, and fresh-brackish categories of the whole dataset, and the freshwater category in the Duntulm Formation, show that kerogen variables give a greater accuracy than the palynomorphs, suggesting that the former is more distinct in these cases. The fresh-brackish category shows the greatest increase in accuracy on combining the variable groups in the whole dataset and in 2/3rds of the formations, suggesting that the different variable groups integrate well in the definition of this category. The greatest difference in accuracy between the palynomorph and kerogen run occurs in the brackish category of the whole dataset (excluding the formation specific open marine environment), but in the three formations it is the marine-brackish category which shows the greatest difference. In the whole dataset the highest accuracies occur in formation specific environment categories (open marine = Bearreraig Sst. Fm., mudflat-alluvial = Skudiburgh Fm.); examination of the average increases in the 'lagoonal' categories (marine-hypersaline to freshwater) suggests that the marine-hypersaline, brackish, and freshwater environments are the most distinct in terms of the palynofacies data.

Environment	Open marine	Bar	Anoxic basin	Supra tidal	Marine-hypersaline	Marine-brackish	Brackish	Fresh-brackish	Fresh water	Mudflat-alluvial	Overall	Cprop
	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2	
Whole dataset kerogen	82 / 228	93 / 272	100*	100*	78 / 212	39 / 56	82 / 228	53 / 112	71 / 184	100 / 300	64 / 156	25
Whole dataset palynomorph	100 / 335	92 / 300	100*	100*	61 / 165	46 / 100	62 / 170	44 / 91	69 / 200	na	65 / 183	23
Whole dataset combined	100 / 335	92 / 300	100*	100*	89 / 287	58 / 152	69 / 200	68 / 196	77 / 235	na	76 / 230	23
Lealt Shales Fm. kerogen	na	na	na	na	na	61 / 69	75 / 108	68 / 88	100 / 178	na	70 / 94	36
Lealt Shales Fm. palynomorph	na	na	na	na	na	77 / 114	78 / 117	70 / 94	67*	na	74 / 106	36
Lealt Shales Fm. combined	na	na	na	na	na	77 / 114	87 / 142	84 / 133	67*	na	83 / 131	36
Duntulm Fm. kerogen	na	na	na	100*	78 / 81	67 / 56	na	80 / 86	88 / 105	na	72 / 67	43
Duntulm Fm. palynomorph	na	na	na	100*	67 / 81	79 / 114	na	77 / 108	75 / 103	na	76 / 105	37
Duntulm Fm. combined	na	na	na	100*	89 / 141	87 / 135	na	89 / 141	75 / 103	na	87 / 135	37
Staffin Bay Fm. kerogen	na	93 / 69	na	na	na	100 / 82	100*	na	na	na	98 / 78	55
Staffin Bay Fm. palynomorph	na	92 / 56	na	na	na	77 / 31	100*	na	na	na	82 / 39	59
Staffin Bay Fm. combined	na	100 / 69	na	na	na	97 / 64	100*	na	na	na	98 / 66	59
Average change					161	91	161	117	158			

* = category contains less than 5 samples; na = category not present; acc1 = computed classification accuracy; acc2 = relative% acc1 > Cprop.

Table 8.2. *Percentage classification accuracies of the environment categories in the whole dataset and in each formation.*

Table 8.3 shows that the variables selected by SDFA in each analysis are not the same for the individual formations; this is particularly the case in the Staffin Bay Formation where the variables are mostly from the kerogen group. There are two variables which appear in three out of four of the analyses: %marine plankton/palynomorphs and %dinocysts/marine plankton (both salinity indicators). These two variables presumably show systematic variation between the different environment categories in nearly all cases. Overall, 15/29 variables are from the palynomorph group, also in three out of the four analyses 3 of the top 5 variables come from the palynomorph variables group, suggesting that this group shows the most systematic variation with environment. Of the palynomorph variables selected, 10/15 are palaeosalinity indicators, and this pattern is also reflected in the occurrence of the %forams/kerogen twice. Most of these results are also expressed by Table 8.4, showing that in the Staffin Bay Formation the kerogen variables contribute by far the most to discrimination, whereas in the Duntulm Formation this characteristic is reversed; this indicates that the whole dataset results are an average of differing characteristics between the individual formations.

8.2.3 Member

The overall accuracies show that in all the analyses there is a strong control, i.e. the palynofacies assemblages of each member are relatively distinct (Table 8.5); this is particularly true for the Bearreraig Sandstone Formation because it has seven different members. In 2/3rds of the cases the kerogen run is the most successful, and in the third case there is little difference between the most successful combined run and the kerogen run; this suggests that the kerogen variables are most distinct in terms of the member subdivision. The palynomorph variables are indistinct in all the analyses, and there is also a lack of integration between the groups as combining the variables results in at most only a small increase in classification accuracy.

The predominance of the kerogen group is also suggested by the stepwise variables (Table 8.6), 12/22 of which come from the kerogen group. The first variable chosen in each case comes from the kerogen assemblage and the kerogen variables dominate, apart from in the Staffin Bay Formation. The total Wilks' lambda values shown in Table 8.7 show that in all cases the kerogen variables are the greatest contributors to the discriminating power of the equation; this is particularly marked in the Bearreraig Sandstone Formation and less so in the Staffin Bay Formation.

Whole dataset		Lealt Shales Fm.		Duntulm Fm.		Staffin Bay Fm.	
Variable	Wilks' lambda	Variable	Wilks' lambda	Variable	Wilks' lambda	Variable	Wilks' lambda
Striate/ biostructured brown	0.43	*Botryococcus*/ palynomorphs	0.72	Marine plankton /palynomorphs	0.42	Pseudoamorphous/ non-biostructured brown	0.68
Marine plankton/ palynomorphs	0.20	Dinocysts/ marine plankton	0.56	Pollen/ sporomorphs	0.23	Phytoclast/ kerogen	0.55
Dinocysts/ marine plankton	0.12			Dinocysts/ marine plankton	0.17	Corroded/ non-biostructured brown	0.34
Undegraded/ non-biostructured brown	.08			AOM/ kerogen	0.17	Marine plankton /palynomorphs	0.23
Thick-walled/ spores	.06			Foram. linings/ kerogen	0.11	Membranes/ phytoclasts	0.20
Bisaccates/ pollen	.04			Thick-walled/ spores	0.10	Spores/ sporomorphs	0.16
Brown wood/ phytoclasts	.03			Banded/ biostructured brown	0.08		
Phytoclasts/ kerogen	.03			Sporomorph/ palynomorphs	0.07		
Botryococcus/ palynomorphs	.02						
Spores/ sporomorphs	.02						
Foram. linings/ kerogen	.02						
Acritarchs/ marine plankton	.01						
Black wood/ phytoclasts	.01						

Table 8.3. *Variables chosen for the stepwise analysis (SDFA) on each of the occasions where the environment classification was used.*

	Kerogen	Palynomorph
All data	0.60	0.47
Lealt Shales Fm.	na	1.30
Duntulm Fm.	0.33	0.98
Staffin Bay Fm.	1.77	0.39

Table 8.4. *Total Wilks' Lambda values for each variables group from the SDFA of environment (from Table 8.3).*

Formation	Kerogen	Palynomorph	Combined
	acc1 / acc2	acc1 / acc2	acc1 / acc2
Bearreraig Sst.	91 / 296	74 / 155	99 / 241
Lealt Shales	95 / 53	87 / 38	99 / 57
Staffin Bay	96 / 60	82 / 30	96 / 52

Table 8.5. *Overall percentage classification accuracies from the discrimination of members. (acc1 = computed classification accuracy, acc2 = relative% acc1 > Cprop).*

Bearreraig Sst. Fm		Lealt Shales Fm.		Staffin Bay Fm.	
Variable	Wilks' Lambda	Variable	Wilks' Lambda	Variable	Wilks' Lambda
Non-biostructured/ brown	0.38	Pseudoamorphous/ non-biostructured brown	0.72	Phytoclasts/ kerogen	0.80
Striate/ biostructured brown	0.10	*Botryococcus*/ palynomorphs	0.59	Corroded/ non-biostructured brown	0.58
Undifferentiated/ palynomorphs	0.08	Membranes/ phytoclasts	0.49	Pollen/ sporomorphs	0.50
Pseudoamorphous/ non-biostructured brown	0.03	Banded/ biostructured brown	0.44	Bisaccates/ pollen	0.45
Phytoclasts/ kerogen	0.02	Cuticle/ phytoclasts	0.40		
Marine plankton/ palynomorphs	0.01	Sporomorphs/ palynomorphs	0.36		
Bisaccates/ pollen	0.01	Corroded/ non-biostructured brown	0.34		
Equant/ black	0.01	Acritarchs/ marine plankton	0.29		
Tasmanites type/ marine plankton	0.01	*Tasmanites* type/ marine plankton	0.27		

Table 8.6. *Variables selected for the SDFA of member.*

Formation	Kerogen	Palynomorph
Bearreraig Sst.	0.49	0.10
Lealt Shales	2.38	1.50
Staffin Bay	1.38	1.00

Table 8.7. *Total Wilks' Lambda values for each of the variable groups for the stepwise discrimination of member (from Table 8.6).*

8.2.4 Lithofacies

Comparison of the overall accuracies from the two sets of analyses shows that the kerogen variables group achieves the highest accuracy in the Duntulm Formation. In the Staffin Bay Formation the accuracy of the kerogen and combined runs is similar (Table 8.8). This suggests that the kerogen variables best distinguish between lithofacies. This is also suggested by the stepwise variables (Table 8.9), only 3/11 of which are from the palynomorph group. One variable (%phytoclast/kerogen) is seen in both lists, and may show systematic variation through both sets of lithofacies. The Wilks' lambda totals in each formation are different, reflecting the combination of variable groups used in the Duntulm Formation and the dominance of the kerogen variables group in the Staffin Bay Formation (Table 8.10).

8.3 Datasets and Different Dependent Variables

8.3.1 Whole Dataset

Table 8.11 shows the overall classification accuracies from the discriminant function analyses carried out on the whole dataset. The best classification accuracy is achieved when formation is the dependent variable used. All the accuracies follow a similar pattern apart from the analyses by environment, where the palynomorph analysis provides a better classification accuracy than when the kerogen variables are used. The largest difference between the kerogen and palynomorph runs occurs when dominant lithology is the dependant variable used, suggesting that in this case the palynomorph variables are particularly indistinct. The greatest increase in accuracy when the variable groups are combined is found in the sample lithology analysis, suggesting that in this case the variable groups provide complementary information.

Table 8.12 shows that the only variable that occurs in all four stepwise variable lists is striate of biostructured brown wood; this shows the potential importance of minor components, justifying the detailed subdivision of the phytoclast fraction. Two variables appear three times (%phytoclasts/kerogen and %acritarchs/marine plankton). These variables (particularly those occurring 3 or 4 times) presumably show systematic variation between categories in the different analyses, suggesting that they may account for much of the variation seen in the assemblage. In total 22/47 variables come from the palynomorph variables group. In the sample and dominant lithology lists

Formation	Kerogen	Palynomorph	Combined
	acc1 / aac2	acc1 / acc2	acc1 / acc2
Duntulm	82 / 156	61 / 61	86 / 126
Staffin Bay	94 / 262	71 / 173	98 / 277

Table 8.8. *Overall percentage classification accuracies of the discrimination of lithofacies. (acc1 = computed accuracy, acc2 = relative% acc1 > Cprop).*

Duntulm Fm.		Staffin Bay Fm.	
Variable	Wilks' Lambda	Variable	Wilks' Lambda
Marine plankton/palynomorphs	0.46	Striate/biostructured brown	0.54
Banded/biostructured brown	0.28	Phytoclasts/kerogen	0.31
Phytoclasts/kerogen	0.19	Non-biostructured/brown	0.19
Membranes/phytoclasts	0.13	Undegraded/non-biostructured brown	0.12
Dinocysts/marine plankton	0.10	Undifferentiated/palynomorphs	0.08
		Brown/phytoclasts	0.06

Table 8.9. *Variables selected by the stepwise discrimination of lithofacies.*

Formation	Kerogen	Palynomorph
Duntulm	0.60	0.55
Staffin Bay	1.22	0.08

Table 8.10. *Total Wilks' lambda values for the two variable groups from the stepwise discrimination of lithofacies (from Table 8.9).*

Dependent variable	Kerogen	Palynomorph	Combined	Stepwise
	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2
Sample lithology	38 / 81	36 / 57	56 / 144	33 / 43
Dominant Lithology	52 / 160	39 / 86	64 / 205	54 / 157
Environment	64 / 156	65 / 183	76 / 230	70 / 204
Formation	85 / 254	79 / 229	94 / 292	92 / 283

Table 8.11. *Overall percentage classification accuracies from the whole dataset discriminant function analyses. (acc1 = computed accuracy, acc2 = relative% acc1 > Cprop).*

Sample Lithology		Dominant lithology		Environment		Formation	
Variable	Wilks' Lambda	Variable	Wilks' Lambda	Variable	Wilks' Lambda	Variable	Wilks' Lambda
Phytoclasts/ kerogen	0.62	Sporomorphs/ palynomorphs	0.61	Striate/ biostructured brown	0.43	Undegraded/ non-biostructured brown	0.25
Striate/ biostructured brown	0.44	Striate/ biostructured brown	0.47	Marine plankton/ palynomorphs	0.20	*Botryococcus*/ palynomorphs	0.11
Undifferentiated/ palynomorphs	0.36	Pseudoamorph./ non-biostructured brown	0.38	Dinocysts/ marine plankton	0.12	Bisaccates/ pollen	.06
Banded/ biostructured brown	0.31	Phytoclasts/ kerogen	0.31	Undegraded/ non-biostructured brown	.08	Striate/ biostructured brown	0.04
Sporomorphs/ palynomorphs	0.26	Membranes/ phytoclasts	0.27	Thick-walled/ spores	.06	Marine plankton/ palynomorphs	0.03
Corroded/ non-biostructured brown	0.22	Acritarchs/ marine plankton	0.23	Bisaccates/ pollen	.04	Membranes/ phytoclasts	0.02
		Black wood/ phytoclasts	0.20	Brown wood/ phytoclasts	.03	Acritarchs/ marine plankton	0.01
		Palynomorphs/ kerogen	0.18	Phytoclasts/ kerogen	.03	Spores/ sporomorphs	0.01
		Biostructured/ brown	0.15	*Botryococcus*/ palynomorphs	.02	Dinocysts/ marine plankton	0.01
		Undifferentiated/ palynomorphs	0.13	Spores/ sporomorphs	.02	*Tasmanites* type/ marine plankton	0.01
		Striped/ biostructured brown	0.12	Foram. linings/ kerogen	.02	Thick-walled/ spores	0.01
				Acritarchs/ marine plankton	.01	AOM/ kerogen	0.01
				Black wood/ phytoclasts	.01	Banded/ biostructured brown	0.004
						Callialasporites/ pollen	0.004
						Unidentified/ pollen	0.003
						Biostructured/ brown	0.003
						Brown wood/ phytoclasts	0.003

Table 8.12. *Variables selected by the stepwise discrimination of the whole dataset.*

variables from the phytoclasts group make up the bulk of the variables chosen, whilst in the environment and formation lists more variables derived from the palynomorph fraction are present and these palynomorph variables are similar.

Comparison of the total Wilks' lambda values for each variable group (Table 8.13) shows that the kerogen variables always contribute the most to the discriminating power of the equation, even when the total number of palynomorph variables chosen exceeds that of kerogen group variables (as in the formation list). In the sample and dominant lithology stepwise runs the kerogen group variables are dominant, whilst the values show a more even distribution in the cases of environment and formation, reflecting the increased number of palynomorph group variables chosen. It is these two dependent variables (environment and formation) that provide the best stepwise classification accuracies (Table 8.11).

8.3.2 Bearreraig Sandstone Formation

Table 8.14 shows that in the sample lithology analyses the combined variables run provides the best accuracy, whilst in the dominant lithology and member analyses the kerogen variables group accuracy is highest. The strongest control (= maximum classification accuracy) is provided by the member subdivision. The largest difference between the kerogen and palynomorph accuracies occurs in the member classification, suggesting that the palynomorph variables are particularly indistinct in this case. The largest increase seen when the variable groups are combined occurs in the sample lithology classification, suggesting that the variable groups provide complementary information.

No variable appears in all five stepwise lists (Table 8.15), but the percentage pseudoamorphous of non-biostructured brown wood occurs in the three analyses carried out on the whole formation. The percentage pitted of biostructured brown wood is the first variable chosen in the sample and dominant lithology analyses, suggesting that this variable characterises lithology most effectively, again showing the potential importance of relatively minor components of the phytoclast assemblage. The first variable chosen in each case comes from the kerogen variables group, and in the member and sample lithology lists this variable provides more than three times the amount of discrimination of the second most important variable. The majority of the rest (18/32) of the variables chosen also come from the kerogen group. The Wilks' lambda totals shown in Table 8.16 demonstrate the predominance of the kerogen variables, especially in the stepwise discrimination of member; the low contribution

Dependent variable	Kerogen	Palynomorph
Sample lithology	1.80	0.62
Dominant lithology	1.81	0.98
Environment	0.60	0.47
Formation	0.32	0.24

Table 8.13. *Total Wilks' lambda values from the two variable groups, stepwise discrimination of the whole dataset (from Table 8.12).*

Bearreraig Sst. Fm.	Kerogen	Palynomorph	Combined	Stepwise
Dependent variable	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2
Sample lithology	69 / 138	62 / 130	82 / 204	47 / 74
Dominant lithology	82 / 215	74 / 139	95 / 207	90 / 190
Member	91 / 296	74 / 155	99 / 241	96 / 231
Proximal-distal (Dun Caan Shales Mbr.)	100 / 56	100 / 56	100 / 56	100 / 56
Distal-proximal (Udairn Shales-Holm Sst. mbrs.)	100 / 89	81 / 53	100 / 89	77 / 45

Table 8.14. *Overall percentage classification accuracies from the Bearreraig Sandstone Formation. (acc1 = computed accuracy, acc2 = relative % acc1 > Cprop).*

Member		Sample lithology		Dominant lithology		Proximal-distal (Dun Caan Shales Mbr.)	
Variable	Wilks' Lambda	Variable	Wilks' Lambda	Variable	Wilks' Lambda	Variable	Wilks' Lambda
Non-biostructured/ brown wood	0.38	Pitted/ biostructured brown	0.19	Pitted/ biostructured brown	0.20	Corroded/ brown wood	0.19
Striate/ biostructured brown	0.10	Pseudoamorphous/ non-biostructured brown	0.04	Black wood/ phytoclasts	0.10	Striped/ biostructured brown	0.11
Undifferentiated/ palynomorphs	0.48	*Cerebropollenites*/ pollen	0.03	Pseudoamorphous/ non-biostructured brown	0.06	Black wood/ phytoclasts	0.06
Pseudoamorphous/ non-biostructured brown	0.33	*Callialasporites*/ pollen	0.02	Undegraded/ non-biostructured brown	0.04	*Callialasporites*/ pollen	0.05
Phytoclasts/ kerogen	0.02			Undifferentiated/ palynomorphs	0.02	Marine plankton/ palynomorphs	0.05
Marine plankton/ palynomorphs	0.01			Striped/ biostructured brown	0.02		
Bisaccates/ pollen	0.01			*Tasmanites* type/ marine plankton	0.01	Distal-proximal (Udairn Shales-Holm Sst. mbrs.)	
Equant/ black wood	0.01			Marine plankton/ palynomorphs	0.01	Variable	Wilks' Lambda
Tasmanites type/ marine plankton	0.01			Unidentified/ pollen	0.01	Non-biostructured/ brown wood	0.25
				Cerebropollenites/ pollen	0.01	Unidentified/ pollen	0.18
				Phytoclasts/ kerogen	0.004		
				Undegraded/ biostructured brown	0.003		

Table 8.15. *Variables selected by the stepwise analyses, Bearreraig Sandstone Formation.*

Dependent variable	Kerogen	Palynomorphs
Sample lithology	0.23	0.05
Dominant lithology	0.42	0.06
Member	0.47	0.02
Proximal-distal (Dun Caan Shales Mbr.)	0.36	0.10
Distal-proximal (Udairn Shales-Holm Sst. mbrs.)	0.25	0.18

Table 8.16. *Total Wilks' lambda values from the two variable groups, Bearreraig Sandstone Formation (from Table 8.15).*

from palynomorph group variables relates to the large difference in classification accuracy between the kerogen and palynomorph groups in this case (Table 8.14).

8.3.3 Lealt Shales Formation

All the analyses show a similar pattern of overall accuracies apart from the environment classification (Table 8.17), in which the palynomorph run provides a better result than the kerogen, suggesting a more distinct set of palynomorph assemblages. The best accuracy is provided by the dominant lithology classification; this also shows the greatest increase in accuracy when the variable groups are combined. The greatest difference between the kerogen and palynomorph run accuracy occurs in the sample lithology analyses.

Table 8.18 shows that the %*Botryococcus*/palynomorphs occurs in three of the stepwise variable lists (it is the first variable chosen in two), and several variables occur in two (e.g. %membranes and %cuticle/phytoclasts). Palynomorph group variables are the first chosen in four out of five of the analyses: overall 10/21 variables are from this group, and of these 8/10 are indicators of palaeosalinity. The Wilks' lambda totals, (Table 8.19) show the predominance of the palynomorph variables in the environment, salinity and sample lithology analyses, but that kerogen variables contribute the most to the discriminating power of the equation for dominant lithology, closely followed by the palynomorph group variables. In the member analysis the kerogen variables are more dominant.

8.3.4 Duntulm Formation

The overall accuracies show different patterns, with the combined and kerogen runs predominant in two analyses each, and the palynomorph run accuracy exceeding that of the kerogen in the environment analyses (Table 8.20). The best classification accuracy occurs in the discrimination of lithofacies using the kerogen variables, and this kerogen variables run provides a high accuracy in all but the environment analyses. The latter shows the greatest increase in accuracy on combining the variable groups, suggesting that the parameters integrate well to discriminate between the environment categories.

Lealt Shales Fm.	Kerogen	Palynomorph	Combined	Stepwise
Dependent variable	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2
Sample lithology	77 / 103	54 / 46	86 / 132	57 / 54
Dominant lithology	76 / 117	65 / 86	91 / 160	54 / 54
Environment	70 / 94	74 / 106	83 / 131	54 / 50
Salinity	75 / 108	68 / 89	82 / 128	63 / 75
Member	95 / 53	87 / 38	99 / 57	96 / 52

Table 8.17. *Overall percentage classification accuracies from the Lealt Shales DFA.*

Sample lithology		Environment		Member	
Variable	Wilks' Lambda	Variable	Wilks' Lambda	Variable	Wilks' Lambda
Undifferentiated/ palynomorphs	0.51	*Botryococcus*/ palynomorphs	0.72	Pseudoamorphous/ non-biostructured brown	0.72
Marine plankton/ palynomorphs	0.31	Dinocysts/ marine plankton	0.56	*Botryococcus*/ palynomorphs	0.59
Membranes/ phytoclasts	0.21			Membranes/ phytoclasts	0.49
Banded/ biostructured brown	0.15			Banded/ biostructured brown	0.44
AOM/ kerogen	0.11			Cuticle/ phytoclasts	0.40
Dominant lithology		Salinity		Sporomorphs/ palynomorphs	0.36
Variable	Wilks' Lambda	Variable	Wilks' Lambda	Corroded/ non-biostructured brown	0.34
Undifferentiated/ palynomorphs	0.70	*Botryococcus*/ palynomorphs	0.68	Acritarchs/ marine plankton	0.29
Brown wood/ phytoclasts	0.50	Acritarchs/ marine plankton	0.61	*Tasmanites* type/ marine plankton	0.27
Cuticle/ phytoclasts	0.39				

Table 8.18. *Variables selected by the SDFA, Lealt Shales Formation.*

Dependent variable	Kerogen	Palynomorph
Sample lithology	0.46	0.81
Dominant lithology	0.90	0.70
Environment	0	1.30
Salinity	0	1.30
Member	2.38	1.50

Table 8.19. *Total Wilks' lambda values of the two variable groups, Lealt Shales Formation (from Table 8.18).*

Duntulm Formation	Kerogen%	Palynomorph%	Combined%	Stepwise%
Dependent variable	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2
Sample lithology	62 / 121	52 / 63	68 / 113	61 / 91
Dominant lithology	65 / 150	56 / 87	76 / 153	38 / 27
Environment	72 / 67	76 / 105	87 / 135	79 / 84
Lithofacies	82 / 156	61 / 61	86 / 126	61 / 61
Biofacies	na	62 / 100	na	52 / 68

Table 8.20. *Overall percentage classification accuracies, Duntulm Formation. (acc1 = computed accuracy, acc2 = relative% acc1 > Cprop).*

Table 8.21 shows that the only variable that appears in all five stepwise lists is the %dinocysts/marine plankton; %marine plankton/palynomorphs is the first variable chosen in three of the analyses, and %phytoclasts/kerogen occurs in three lists as does the %banded/biostructured brown wood. This suggests that these variables encompass the majority of the variation within the formation as they vary systematically in many different analyses. The kerogen variables chosen in the sample lithology and lithofacies analyses are the same. In all five lists the first variable chosen comes from the palynomorph group, and in all 17/28 variables come from this group. Of these, 12/17 are palaeosalinity indicators; they are complemented by the %forams/kerogen. The Wilks' lambda totals shown in Table 8.22 show the predominance of the palynomorph variables in the environment classification; in the other classifications the values for each variable group are similar.

8.3.5 Staffin Bay Formation

Table 8.23 shows that the highest classification accuracies are derived from the combined or kerogen runs; the palynomorph variables always provide the lowest accuracies, and appear to detrimentally affect the kerogen accuracies when the variables are combined in the sample lithology and environment analyses. However, in the dominant lithology analyses there is a relatively large increase in accuracy when the variable groups are combined, and in the lithofacies analyses combination of the variable groups leads to the maximum overall accuracy present.

Table 8.24 shows that the %phytoclasts/kerogen appears in all five stepwise lists, and is the first variable chosen in three of these and is second best in the other two; in the two lithology lists the Wilks' lambda values associated with this variable are *ca.* twice those for the second best variable suggesting that in these cases the %phytoclasts/kerogen is particularly important. This suggests that this variable shows systematic variation when many different dependent variables are used; the same may also be true for the %corroded/non-biostructured brown, which is present in three of the stepwise lists. Variables from the kerogen group are the first (best) chosen in all five analyses, and dominate all five variable lists (in the sample and dominant lithology analyses only kerogen variables are chosen). Overall, only 5/20 variables are from the palynomorph group. The total Wilks' lambda values (Table 8.25) reflect this, showing a dominance of kerogen variables in all the analyses, but an increased contribution from the palynomorph variables can be identified in the environment and member analyses.

Sample lithology		Environment		Lithofacies	
Variable	Wilks' Lambda	Variable	Wilks' Lambda	Variable	Wilks' Lambda
Botryococcus/ palynomorphs	0.56	Marine plankton/ palynomorphs	0.42	Marine plankton/ palynomorphs	0.46
Phytoclasts/ kerogen	0.39	Pollen/ sporomorphs	0.23	Banded/ biostructured brown	0.28
Membranes/ phytoclasts	0.28	Dinocysts/ marine plankton	0.17	Phytoclasts/ kerogen	0.19
Banded/ biostructured brown	0.20	AOM/ kerogen	0.17	Membranes/ phytoclasts	0.13
Dinocysts/ marine plankton	0.15	Foram. linings/ kerogen	0.11	Dinocysts/ marine plankton	0.10
Tasmanites type/ marine plankton	0.12	Thick-walled/ spores	0.10		
		Banded/ biostructured brown	0.08	Biofacies	
Dominant lithology		Sporomorphs/ palynomorphs	0.07	Variable	Wilks' Lambda
Variable	Wilks' Lambda			Marine plankton/ palynomorphs	0.44
Acritarchs/ marine plankton	0.008			*Botryococcus*/ palynomorphs	0.30
Phytoclasts/ kerogen	0.005			Thick-walled/ spores	0.23
AOM/ kerogen	0.003			Pollen/ sporomorphs	0.20
Dinocysts/ marine plankton	0.003			Dinocysts/ marine plankton	0.10

Table 8.21. *Variables selected by the stepwise analyses, Duntulm Formation.*

Dependent variable	Kerogen	Palynomorph
Sample lithology	0.86	0.82
Dominant lithology	0.01	0.01
Environment	0.33	1.0
Lithofacies	0.60	0.55

Table 8.22. *Total Wilks' lambda values of the two variable groups, Duntulm Formation (from Table 8.21).*

Staffin Bay Formation	Kerogen%	Palynomorph%	Combined%	Stepwise%
Dependent variable	acc1 / acc2	acc1 / acc2	acc1 / acc2	acc1 / acc2
Sample lithology	87 / 235	57 / 119	82 / 215	44 / 69
Dominant lithology	76 / 192	67 / 158	88 / 239	67 / 158
Environment	98 / 78	82 / 39	98 / 66	89 / 51
Lithofacies	94 / 262	71 / 173	98 / 277	78 / 200
Biofacies	na	76 / 124	na	na
Member	96 / 60	82 / 30	96 / 52	88 / 40

Table 8.23. *Overall classification accuracies, Staffin Bay Formation. (acc1 = computed classification accuracy, acc2 = relative% acc1 > Cprop).*

Sample lithology		Environment		Lithofacies		Member	
Variable	Wilks' Lambda	Variable	Wilks' Lambda	Variable	Wilks' Lambda	Variable	Wilks' Lambda
Phytoclasts/ kerogen	0.30	Pseudoamorph./ non-biostructured brown	0.68	Striate/ biostructured brown	0.54	Phytoclasts/ kerogen	0.80
Corroded/ non-biostructured brown	0.16	Phytoclasts/ kerogen	0.55	Phytoclasts/ kerogen	0.31	Corroded/ non-biostructured brown	0.58
		Corroded/ non-biostructured brown	0.34	Non-biostructured/ brown wood	0.19	Pollen/ sporomorphs	0.50
Dominant lithology		Marine plankton/ palynomorphs	0.23	Undegraded/ non-biostructured brown	0.12	Bisaccates/ pollen	0.45
Variable	Wilks' Lambda	Membranes/ phytoclasts	0.20	Undifferentiated/ palynomorphs	0.08		
Phytoclasts/ kerogen	0.42	Spores/ sporomorphs	0.16	Brown wood/ phytoclasts	0.06		
Brown wood/ phytoclasts	0.24						

Table 8.24. *Variables selected by the SDFA, Staffin Bay Formation.*

Dependent variable	Kerogen	Palynomorphs
Sample lithology	0.46	0
Dominant lithology	0.66	0
Environment	1.77	0.39
Lithofacies	1.22	0.08
Member	1.38	0.95

Table 8.25. *Total Wilks' Lambda values for the two variable groups, Staffin Bay Formation (from Table 8.24).*

8.4 Profiling of Mis-classified samples

Examination of the profiles of the mis-classified samples reveals several factors or 'effects' that may provide reasons for the incorrect classification of samples (summarised in Table 8.26).

The first two effects were also apparent in Chapter 4.0, and relate to the often subtle controls of sample and dominant lithology on assemblages. These are perhaps best illustrated by the behaviour of the samples taken from the 'complex bed' of the Kildonnan Member (Lealt Shales Formation), where the sandstone-dominated lithology causes the incorrect classification of shale samples into the silty shale category in the sample lithology analyses. In the dominant lithology analyses the shale sample lithology causes the samples to again classify incorrectly into the silty shale as opposed to the sandstone category (section 4.7.4).

The third 'section' effect, describes the tendency of samples being more similar to stratigraphically adjacent samples than they are to the rest of the samples in the same category. This effect is particularly marked in samples from the Cullaidh Shale-Elgol Sandstone formations section on Raasay in the whole dataset environment analyses. Here, the samples from the Elgol Sandstone Formation classify incorrectly into the category (anoxic basin) which contains the samples from directly below their position. This effect can also be seen in the Duntulm Formation 'freshwater intercalation' section and elsewhere. The fourth 'formation/member' effect identified is related and results from samples being more similar to the other samples in their member/formation than to those from the same category, therefore classifying into the category which contains the majority of samples from that member/formation. An example of this can be found again in the whole dataset by environment analyses where the mis-classified Upper Ostrea Member (Staffin Bay Formation) samples from the marine-brackish environment category classify incorrectly into the bar environment, which contains all the samples from the upper member of this formation, the Belemnite Sands.

The final 'ambiguous control' effect results from the potential of different classifications to be better reflected in the palynofacies assemblages than the one that is being used as the dependent variable, such as the environment classification seeming to reflect assemblages in certain samples better than lithofacies. An example of this can be seen in the Lealt Shales Formation environment analyses, where mis-classified samples from the marine-brackish environment category classify into 'lower salinity' environment categories; these samples appear in the two lowest ostracod determined salinity

Reason for mis-classification	Example
1 Sample lithology effect	Kildonnan Member — sandstone-dominated lithology samples classify as silty shale due to effect of shale sample lithology.
2 Dominant lithology effect	Kildonnan Member — shale lithology samples classify as silty shale due to sandstone-dominated lithology.
3 Section effect	Cullaidh Shale-Elgol Sst. fms. Raasay — marine-brackish samples classify as anoxic basin due to similarity with samples from same locality.
4 Member/Formation effect	Staffin Bay Fm. — marine-brackish samples from lower member classify into bar category as contains all samples from upper member.
5 Ambiguous control	Lealt Shales Fm. — marine-brackish samples classify into lower palaeosalinity categories suggested by ostracod-salinity classification.

Table 8.26. *Reasons for the mis-classification of samples in the discriminant function analyses.*

categories. This suggests that in the case of these samples the assemblages are reflected better in the ostracod determined palaeo-salinities than the macro-faunal derived environment categories.

8.5 Summary

Discriminant function analysis has proved to be a useful technique in characterising the level of control exerted by different factors on the palynofacies assemblage, and has allowed the comparison of the relative strengths of various controls. It has also enabled the assessment of the relative usefulness of total kerogen vs. palynomorph data. In terms of the whole dataset it appears that the formations are the most distinct groupings of samples, more so than depositional environment or lithology; within the individual formations the most distinct controls differ, reflecting local differences, and vary from member to lithofacies. Comparison of the accuracies obtained from the kerogen, palynomorph, and combined variables groups shows that, as expected, the combined group generally provides the most distinct categories. However, there are occasions where both the kerogen and palynomorph variables group are more effective in discriminating the dependent variables, in particular the palynomorph variables best distinguish between the environment categories in most cases, while the kerogen variables seem more effective in discriminating between member and lithofacies sudivisions.

The stepwise DFA variables provide a useful guide to the variables that best discriminate between the categories; in some cases the classification accuracies using just these variables are relatively high, often nearing those derived from the full variable groups. This suggests that in the simultaneous analyses there are variables that contribute little, or even interfere with, the discrimination algorithm. The variables selected vary from case to case and generally include those which would be expected, such as indicators of palaeosalinity in the environment and ostracod-salinity analyses, together with several eclectic variables, often including those which represent only minor components of the assemblage; variables also seem to be sometimes used by DFA in a presence-absence manner.

8.6 Cluster Analysis

Hierarchical cluster analysis has been carried out using the variables selected by stepwise DFA for a variety of dependent variables within the four main formations. It was not possible to use the whole dataset (all samples) as the large number of samples would not run on the computer package used (SPSS). The dendrogram produced would also have been extremely large and complex. This approach was used as clustering using all the variables produced very noisy, and therefore difficult to interpret dendrograms; clustering using the reduced number of variables selected by stepwise DFA allowed the examination of the natural relationships within the datasets biased towards a certain control suggested by the dependant variable used (e.g. environment). The clustering algorithm used was average linkage (between groups), and the distance measure was the squared euclidean distance. The main features of the dendrograms in each case have been tabulated (e.g. Table 8.27); the dendrograms themselves are shown in Appendix 8.1.

8.7 Bearreraig Sandstone Formation

The variables derived from the functions using the dependent variables 'member' (on the whole formation) and 'proximal-distal' (on the two main sections: Dun Caan Shales Member, Udairn Shales-Holm Sandstone members) have been used.

8.7.1 Member

The cluster memberships (Table 8.27) show that there is no differentiation between the Udairn Shales and Holm Sandstone members, and the Rigg Sandstone Member samples are not clustered at all. The clustering appears to relate more to the different sections sampled rather than the actual members, which is surprising given the high overall classification accuracy obtained using stepwise DFA, but the scattering of the Rigg Sandstone Member samples through the dendrogram agrees with the low DFA classification accuracy for this unit.

Figure 8.1 shows the mean percentages of the variables in the different clusters. The differences between clusters are sometimes subtle, and if the clusters were defined at a lower level than this it would be difficult to justify their separation as the differences between the variable values would approach the reproducibility errors described in

Member	% original samples correctly classified	Main cluster letter	Exported	Imported
Dun Caan Shales	87	C	−5 B −1 A	+1 B
Udairn Shales/Holm Sandstone	91	B	−1 C −3 A	+5 C +1 A +3 (5)
Rigg Sandstone (5)	0	na	−3 B −3 A	
Beinn na Leac	83	A	−1 B	+1 C +3 B + (5)

Table 8.27. *Summary of dendrogram, Bearreraig Sandstone Formation using variables from SDFA of member. Exported refers to the number of samples which have been removed from the target cluster and placed in the cluster indicated. Imported refers to the number of samples incorrectly added to the target cluster from the cluster indicated. 5 = code for Rigg Sandstone Member samples which do not have their own cluster.*

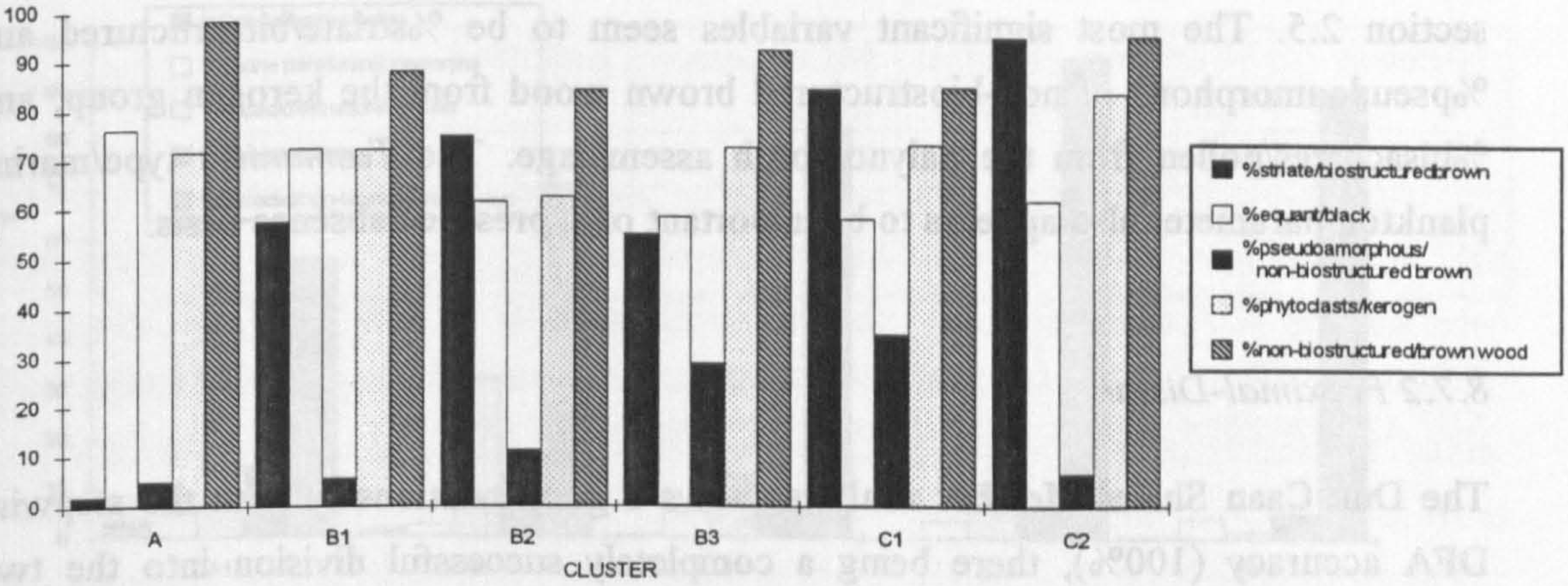


Fig. 8.1a. *Mean values of phytoclast variables (selected by SDFA) for each cluster, Bearreraig Sandstone Formation by member.*

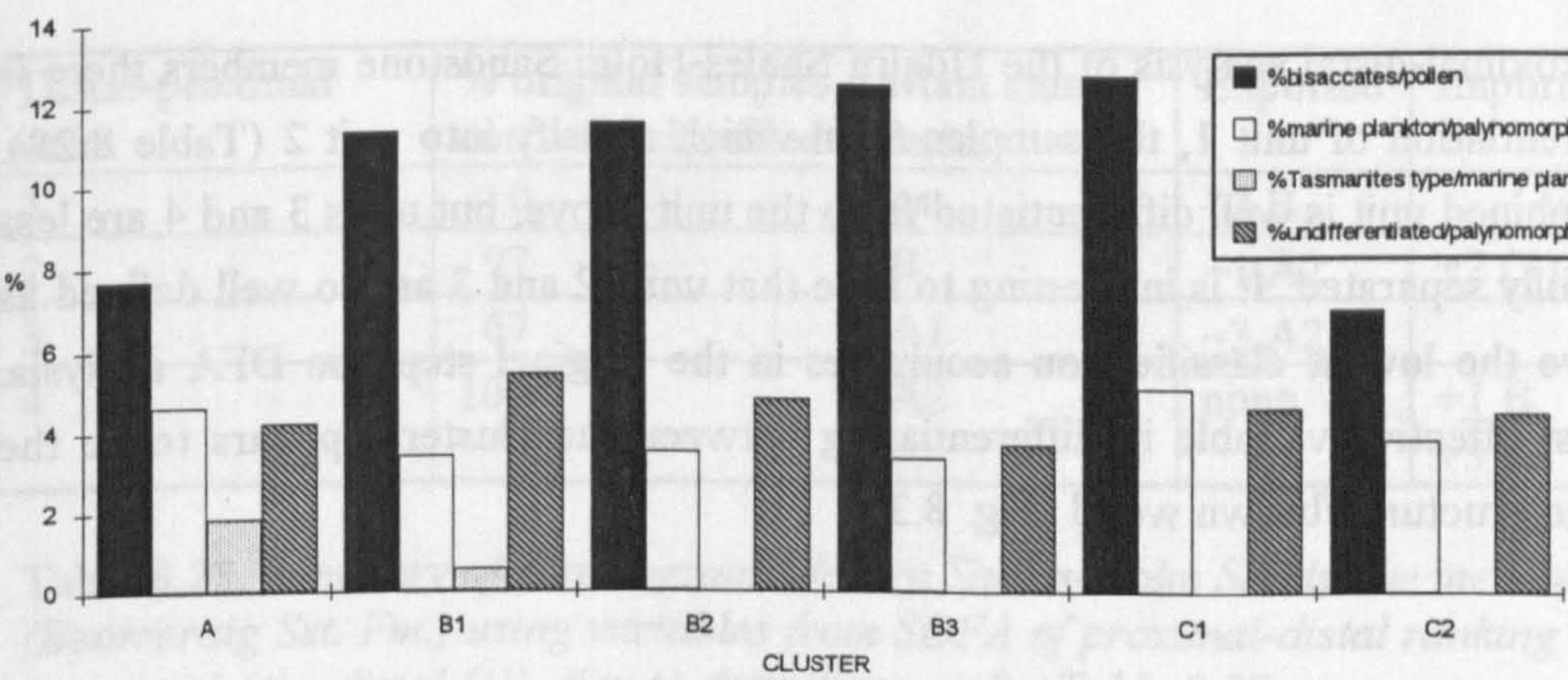


Fig. 8.1b. *Mean values of palynomorph variables (selected by SDFA) for each cluster, Bearreraig Sandstone Formation by member.*

section 2.5. The most significant variables seem to be %striate/biostructured and %pseudoamorphous of non-biostructured brown wood from the kerogen group, and %bisaccates/pollen from the palynomorph assemblage. The *Tasmanites* type/marine plankton parameter also appears to be important on a presence/absence basis.

8.7.2 Proximal-Distal

The Dun Caan Shales Member analysis shows a good relationship with the stepwise DFA accuracy (100%), there being a completely successful division into the two proximal-distal units. The variable percentages (Fig. 8.2) suggest that the most significant variables are %black wood/phytoclasts and % corroded of biostructured brown wood.

In the proximal-distal analysis of the Udairn Shales-Holm Sandstone members there is no differentiation of unit 1, the samples from which classify into unit 2 (Table 8.28). This combined unit is well differentiated from the unit above, but units 3 and 4 are less successfully separated. It is interesting to note that units 2 and 3 are so well defined as they have the lowest classification accuracies in the original stepwise DFA analysis. The most effective variable in differentiating between the clusters appears to be the %non-biostructured/brown wood (Fig. 8.3).

8.8 Lealt Shales Formation

Cluster analysis has been carried out on this formation using the variables derived from the stepwise DFA using member, environment, and salinity as the dependent variable.

8.8.1 Member

Despite the 96% overall classification accuracy of the stepwise DFA for members there are considerable numbers of samples that are not grouped correctly in the dendrogram (Table 8.29). The percentages of corroded/non-biostructured brown wood and membranes/phytoclasts from the kerogen group, and %acritarchs/marine plankton, %*Botryococcus*/palynomorphs, and %*Tasmanites* type/marine plankton of the palynomorph variables appear to be the most significant parameters in distinguishing between the clusters (Fig. 8.4), the latter partly on a presence/absence basis.

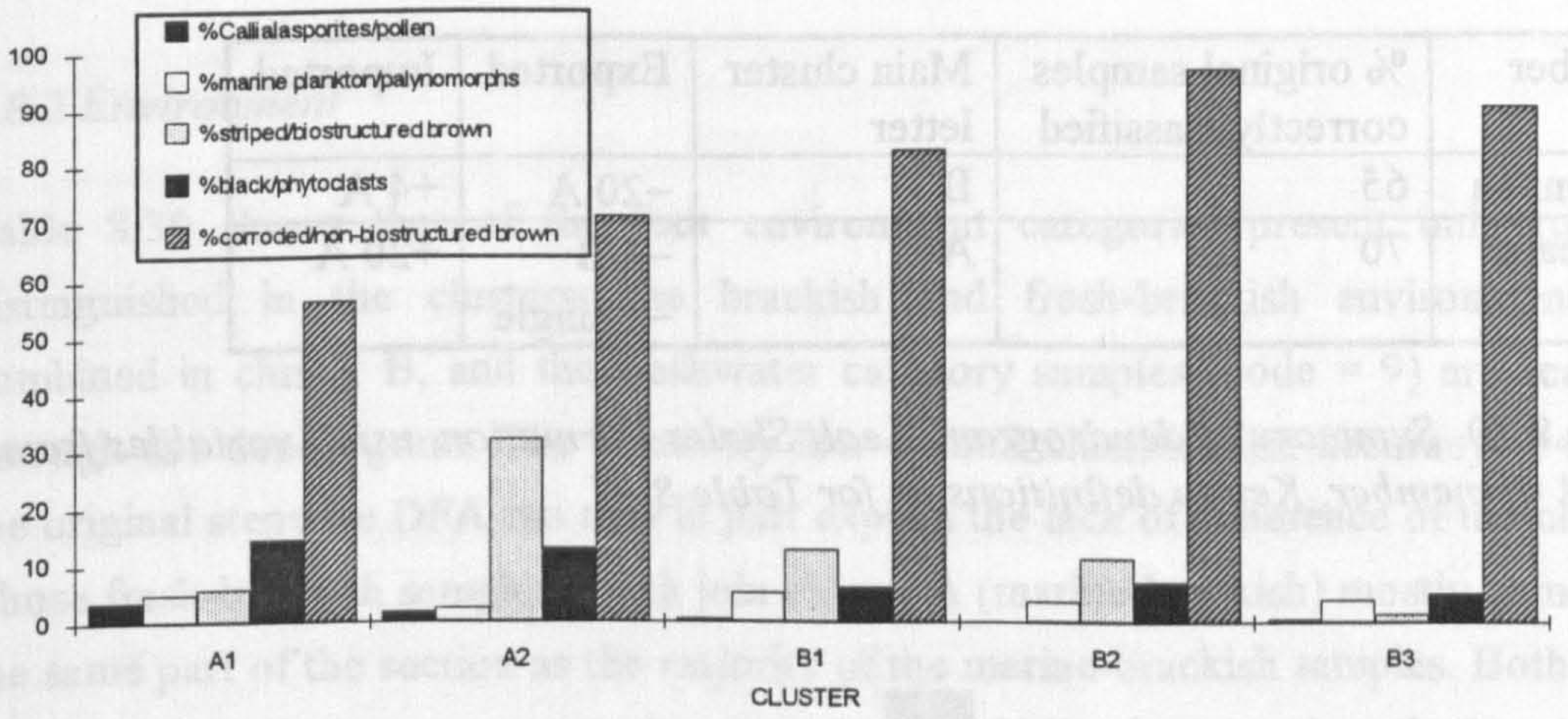


Fig. 8.2. *Mean values of variables (selected by SDFA) for each cluster, Dun Caan Shales Member by proximal-distal.*

Distal-proximal unit	% original samples correctly classified	Main cluster letter	Exported	Imported
1	0	na	−2 B	
2	97	B	−1 A2	+2 (1)
3	67	A1	−3 A2	
4	100	A2	none	+1 B +3 A1

Table 8.28. *Summary of dendrogram, Udairn Shales-Holm Sandstone members (Bearreraig Sst. Fm.) using variables from SDFA of proximal-distal ranking (proximal (4) - distal (1)). Key to definitions as for Table 8.27.*

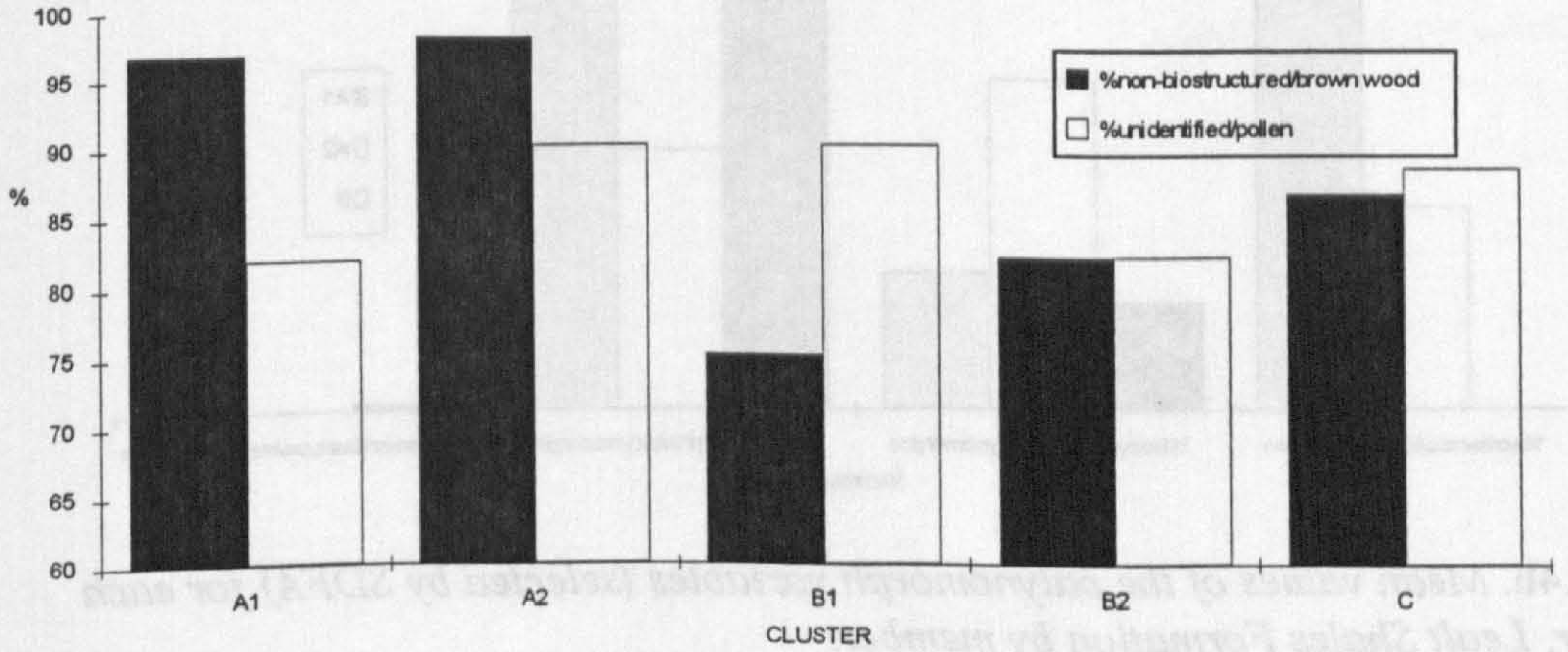


Fig. 8.3. *Mean values of variables (selected by SDFA) for each cluster, Udairn Shales-Holm Sandstone members by distal-proximal.*

Member	% original samples correctly classified	Main cluster letter	Exported	Imported
Kildonnan	65	B	−20 A	+4 A
Lonfearn	70	A	−4 B −1 single	+20 A

Table 8.29. *Summary of dendrogram, Lealt Shales Formation, using variables from SDFA of member. Key to definitions as for Table 8.27.*

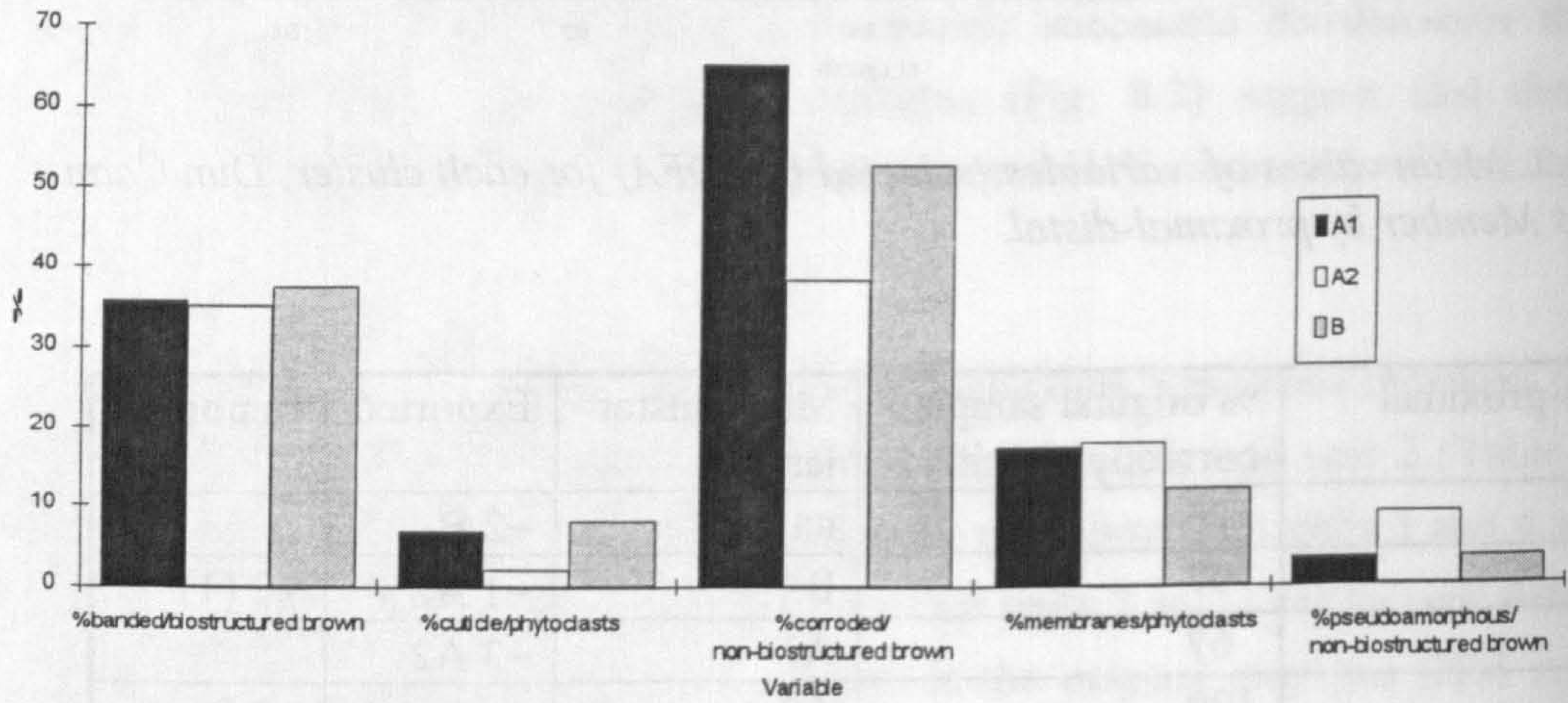


Fig. 8.4a. *Mean values of phytoclast variables (selected by SDFA) for each cluster, Lealt Shales Formation by member.*

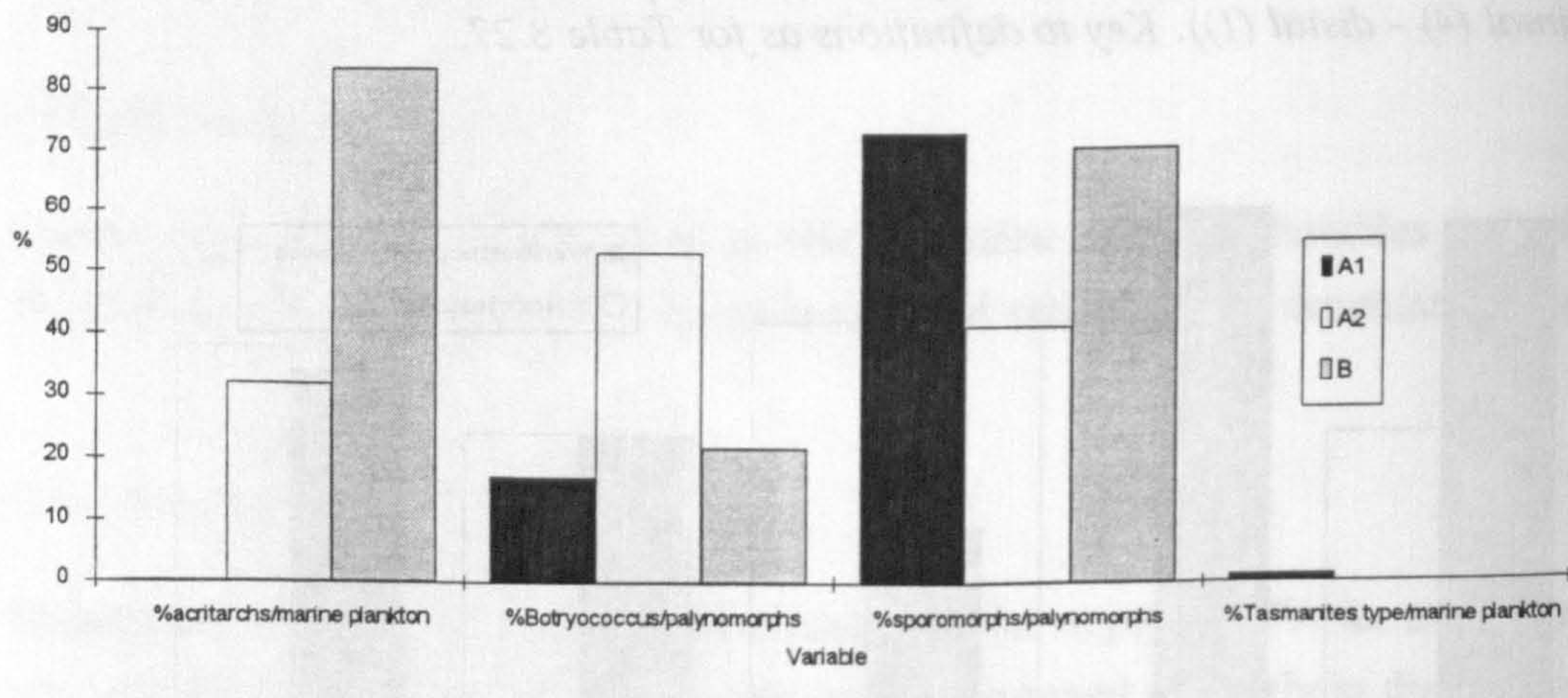


Fig. 8.4b. *Mean values of the palynomorph variables (selected by SDFA) for each cluster, Lealt Shales Formation by member.*

8.8.2 Environment

Table 8.30 shows that of the four environment categories present only two are distinguished in the clusters; the brackish and fresh-brackish environments are combined in cluster B, and the freshwater category samples (code = 9) are scattered through the dendrogram. The relatively low overall classification accuracy (54%) of the original stepwise DFA run may in part explain the lack of coherence of the clusters. Those fresh-brackish samples which join cluster A (marine-brackish) mostly come from the same part of the section as the majority of the marine-brackish samples. Both of the variable used (%*Botryococcus*/palynomorphs and %dinocysts/marine plankton) show significant variation between the clusters (Fig. 8.5).

8.8.3 Salinity

In the dendrogram the salinity categories are relatively poorly defined (Table 8.31), with no cluster representing the mesohaline category (code = 2), there is also considerable exchange of samples between clusters A and B. Again this may partly be due to the low overall accuracy derived from the stepwise DFA run (63%), but also suggests a lack of similarity between samples from the same salinity category. The variable which shows the most significant variation between the clusters is %acritarchs/marine plankton (Fig. 8.6).

Environment	% original samples correctly classified	Main cluster letter	Exported	Imported
Marine-brackish	82	A	−2 B	+17 B +2 (9)
Brackish	83	B	−4 A	+2 A +1 (9)
Fresh-brackish	67	B	−13 A	+2 A +1 (9)
Freshwater (9)	0	na	−2 A −1 B	

Table 8.30. *Summary of dendrogram, Lealt Shales Formation, using variables from SDFA of environment. Key to definitions as for Table 8.27. (9 = code for freshwater category samples which do not have their own cluster).*

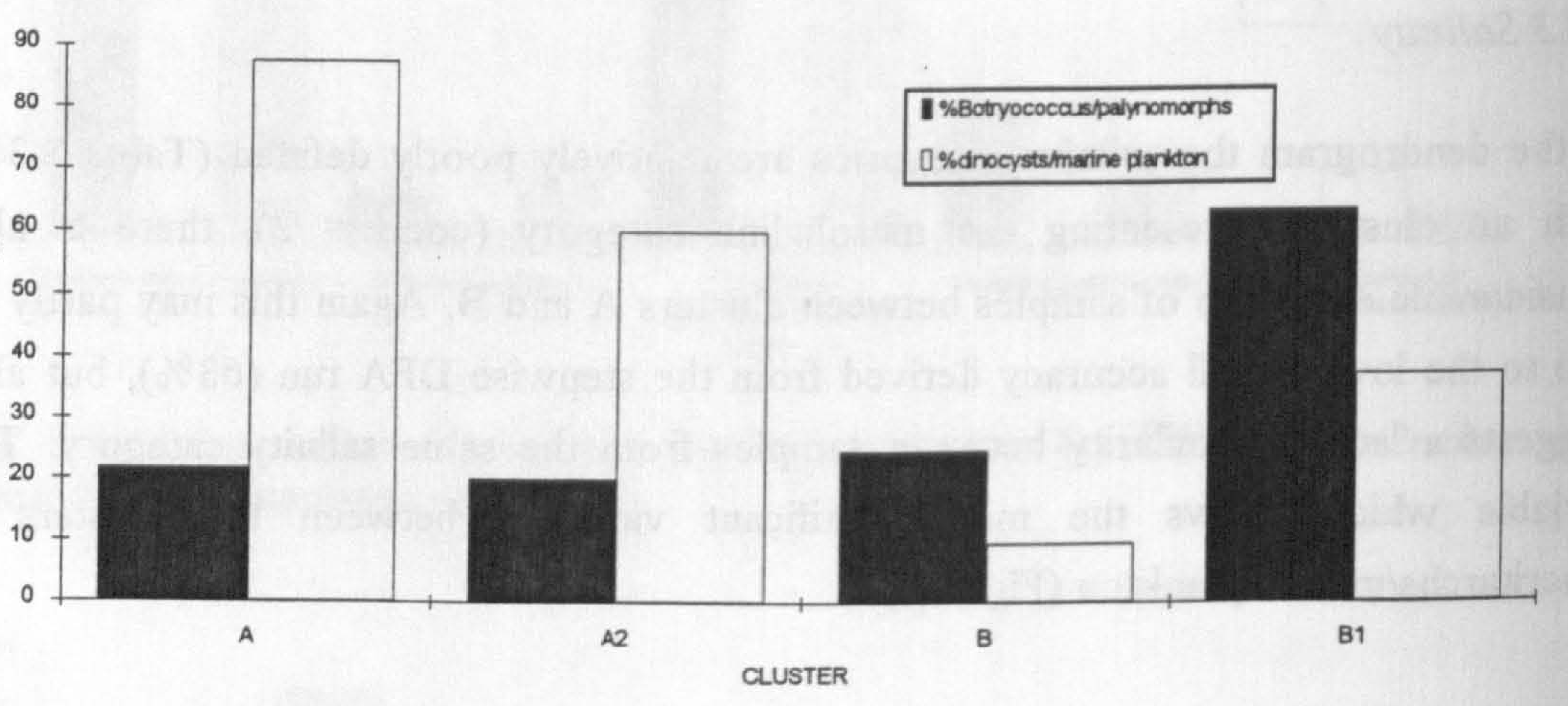


Fig. 8.5. *Mean values of variables (selected by SDFA) for each cluster, Lealt Shales Formation by environment.*

Salinity	% original samples correctly classified	Main cluster letter	Exported	Imported
Freshwater -miohaline	61	B	−12 A	+12 (2) +6 A
Mesohaline (2)	0	na	−12 A −12 B	
Pliohaline	59	A	−6 B	+12 (2) +12 B

Table 8.31. *Summary of dendrogram, Lealt Shales Formation, using variables from SDFA of salinity. Key to definitions as for Table 8.27 (2 = code for mesohaline category samples which do not have their own cluster).*

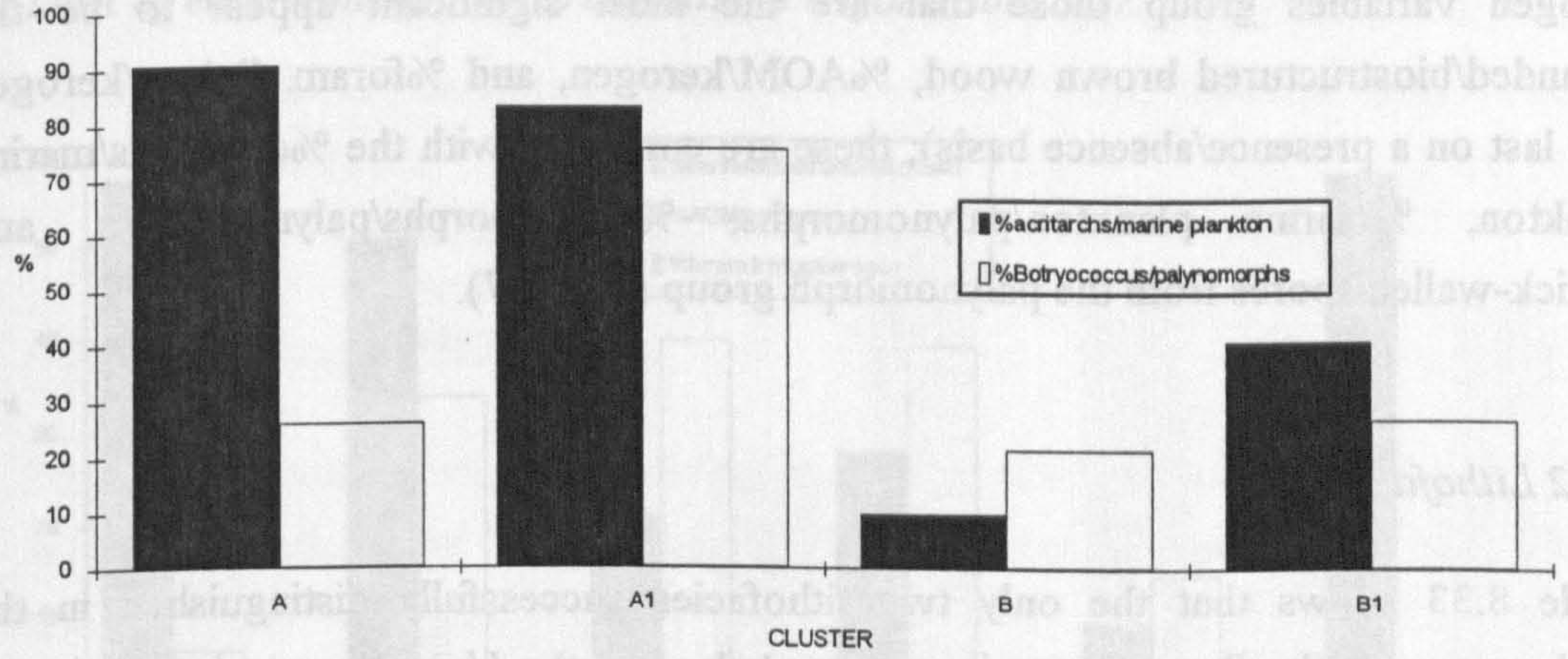


Fig. 8.6. *Mean values of variables (selected by SDFA) for each cluster, Lealt Shales Formation by salinity.*

8.9 Duntulm Formation

The variables derived from stepwise DFA using environment and lithofacies have been used in this section.

8.9.1 Environment

The four environment categories present characterise the four main clusters (Table 8.32), although there is a degree of 'mis-classification' with samples mostly mis-classifying only into the most closely associated environment category (e.g. exchange of samples between the marine-hypersaline and marine-brackish categories). Within the kerogen variables group those that are the most significant appear to be the %banded/biostructured brown wood, %AOM/kerogen, and %foram. linings/kerogen (the last on a presence/absence basis); these are combined with the %dinocysts/marine plankton, %marine plankton/palynomorphs, %sporomorphs/palynomorphs, and %thick-walled/spores from the palynomorph group (Fig. 8.7).

8.9.2 Lithofacies

Table 8.33 shows that the only two lithofacies successfully distinguished in the dendrogram are the *Praeexogyra* limestone-shales and the *Unio-Neomiodon* muds and sands; the other lithofacies samples are combined with the *Praeexogyra* limestone-shales suggesting that in terms of the variables used they are not significantly different from this facies. Figure 8.8 shows that the samples from the *Unio-Neomidon* muds and sands which join cluster A are those which contain marine plankton; the other variables which show significant variation between the clusters are the %banded/biostructured brown wood, %membranes/phytoclasts, %phytoclasts/kerogen, and %dinocysts/marine plankton (the last partly on a presence/absence basis).

Environment	% original samples correctly classified	Main cluster letter	Exported	Imported
Marine-hypersaline	59	D	−6 C −1 B	+8 C
Marine-brackish	81	C	−8 D −1 E −2 B	+6 D +2 E +1 A
Fresh-brackish	50	E	−11 A −2 C	+1 C +1 A
Freshwater	75	A	−1 C −1 E	+11 E

Table 8.32. *Summary of dendrogram, Duntulm Formation, using variables from SDFA of environment. Key to definitions as for Table 8.27.*

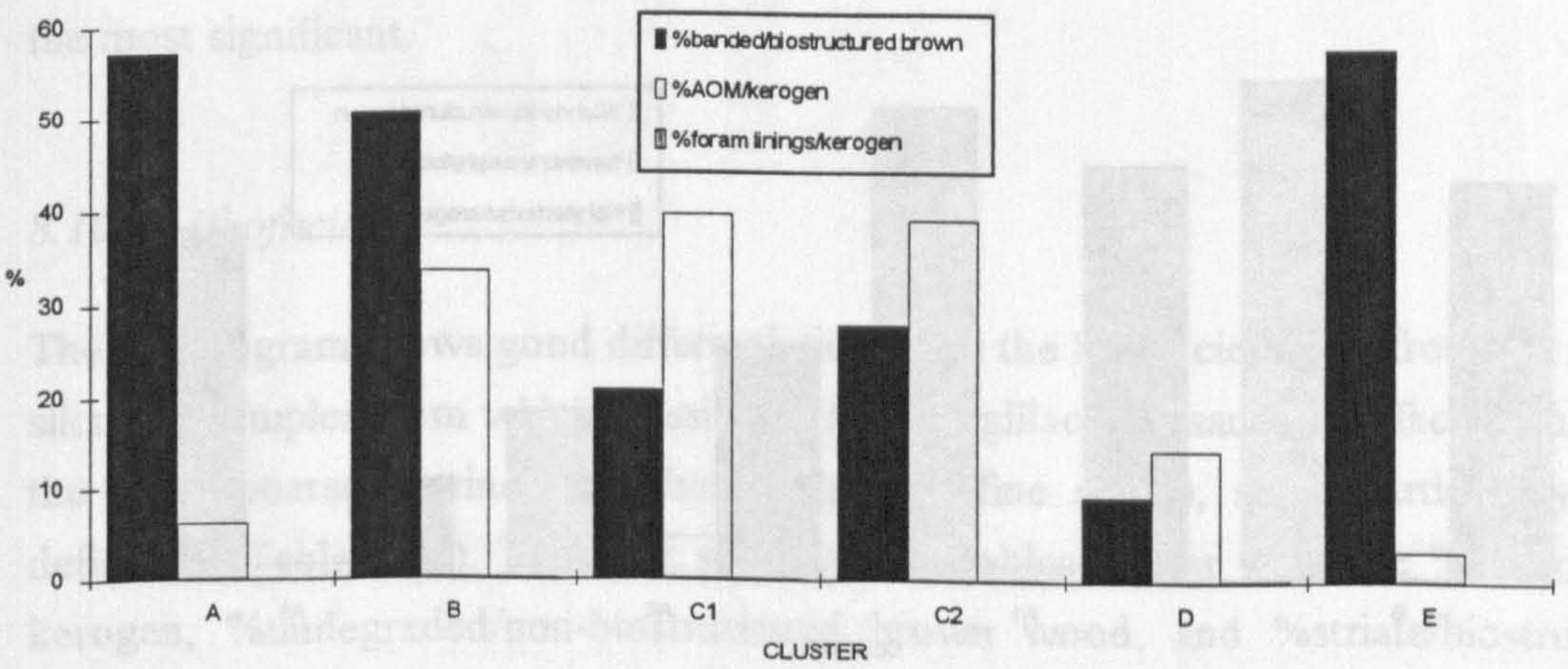


Fig. 8.7a. *Mean values of phytoclast variables (selected by SDFA) for each cluster, Duntulm Formation by environment.*

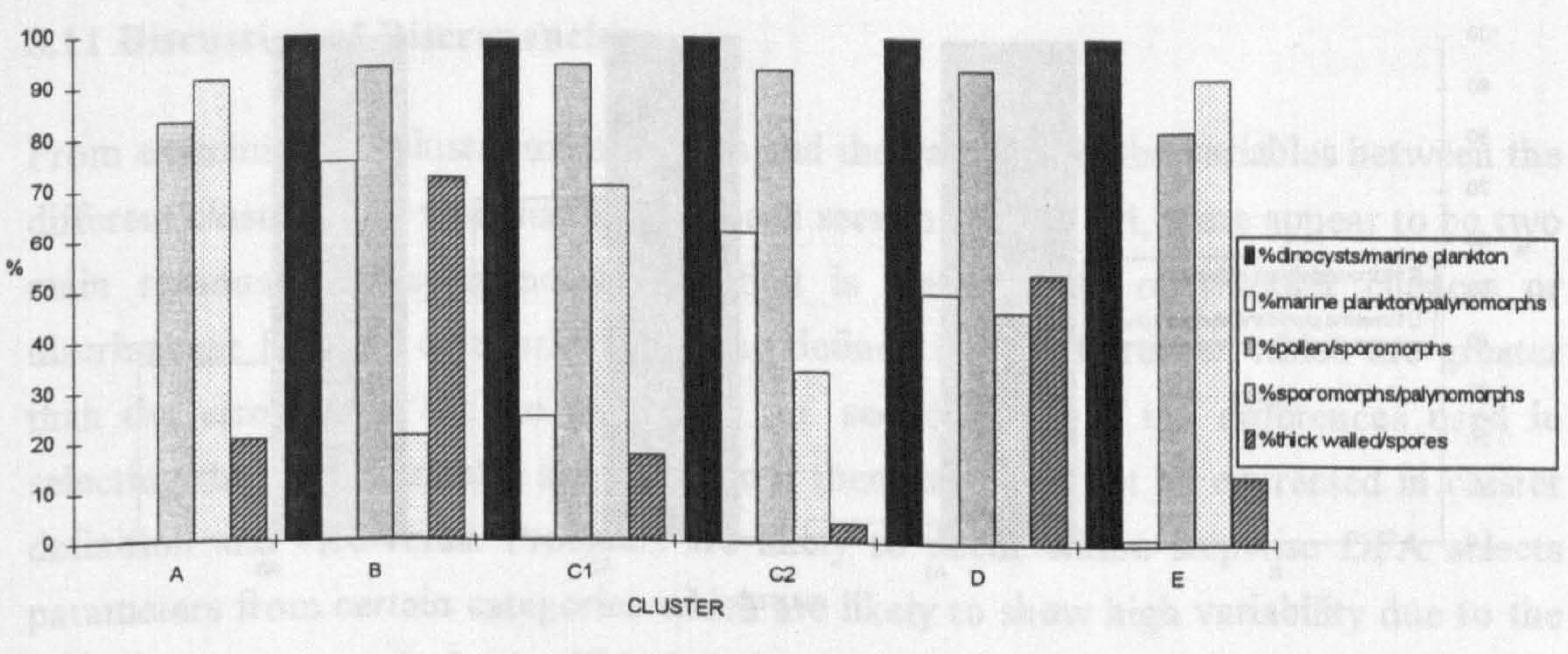


Fig. 8.7b. *Mean values of palynomorph variables (selected by SDFA) for each cluster, Duntulm Formation by environment.*

Lithofacies	% original samples correctly classified	Main cluster letter	Exported	Imported
Praeexogyra Lst.-shale	100	A		+ 2 (2) + 5 (3) +13 B
Argillaceous Lsts. (2)	0	na	−2 A	
Algal Lsts. & cryptalgal-rippled silts (3)	0	na	−5 A	
Sands	0	na	−8 A	
Unio-Neomiodon muds & sands	57	B	−13 A	

Table 8.33. *Summary of dendrogram, Duntulm Formation, using variables from SDFA of lithofacies. Key to definitions as for Table 8.27 (2 = code for argillaceous limestone samples, 3 = code for algal limestone and cryptalgal-rippled silts samples, both of which do not have their own clusters).*

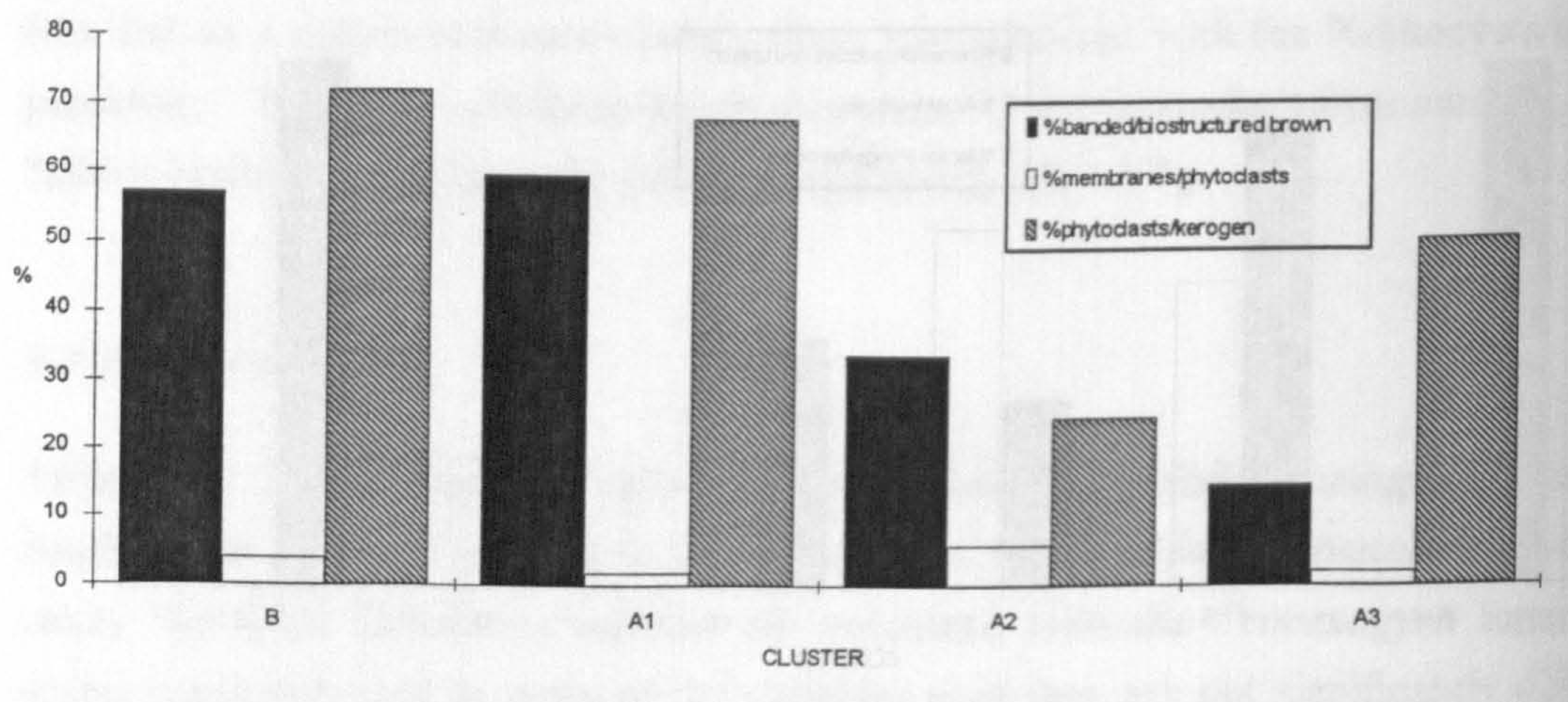


Fig. 8.8a. *Mean values of the kerogen variables (selected by SDFA) for each cluster, Duntulm Formation by lithofacies.*

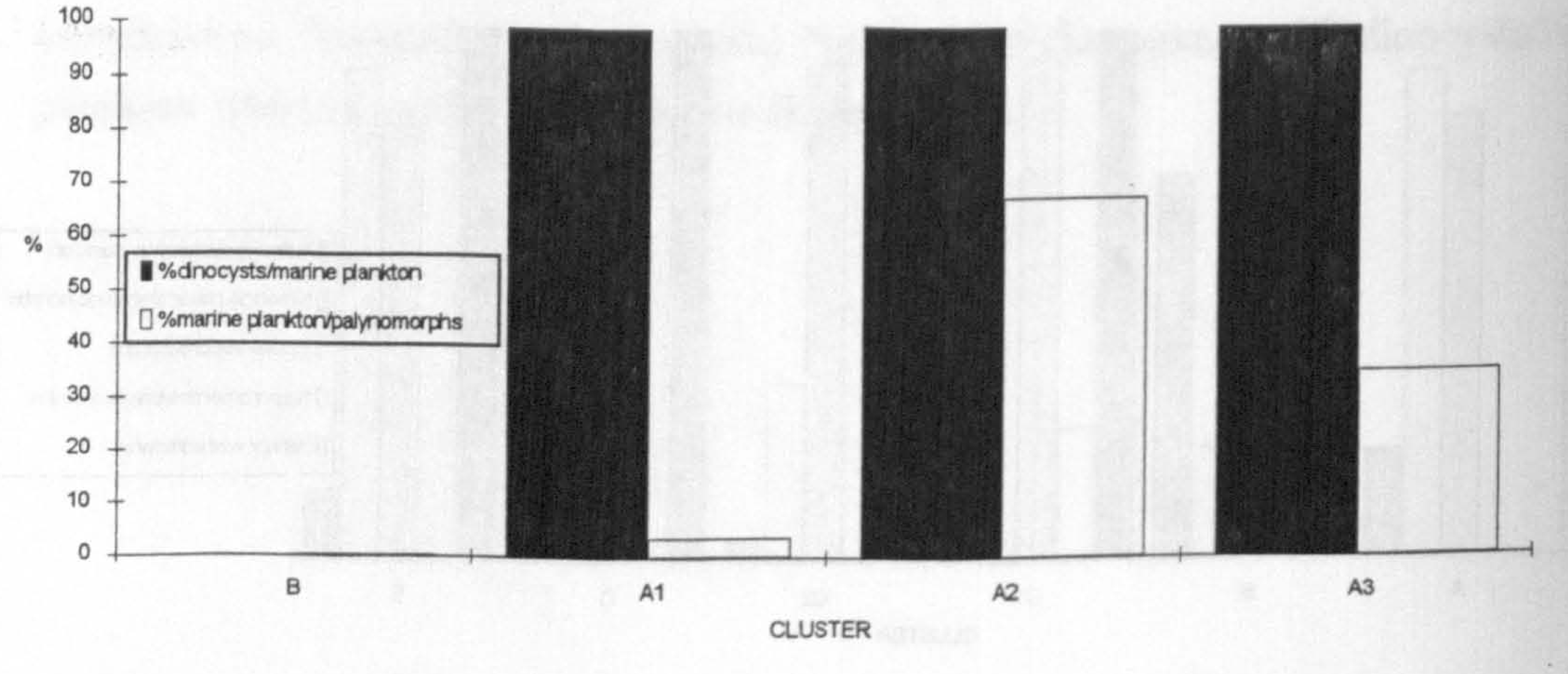


Fig. 8.8b. *Mean values of the palynomorph variables (selected by SDFA) for each cluster, Duntulm Formation by lithofacies.*

8.10 Staffin Bay Formation

Cluster analysis was carried out on this formation using the variables derived from the stepwise analyses using the dependent variables member and lithofacies.

8.10.1 Member

The dendrogram does not seem to reflect the overall DFA classification accuracy of 88%, there is considerable 'mis-classification' of the Belemnite Sands Member samples (Table 8.34), especially of those samples from the lower and upper finer grained parts of the member. There is a similar cluster membership when the DFA by environment stepwise variables are used (not shown). Figure 8.9 shows that of the variables used the %corroded/non-biostructured brown wood and %phytoclasts/kerogen appear to be the most significant.

8.10.2 Lithofacies

The dendrogram shows good differentiation of all the lithofacies apart from the muddy silts, the samples from which classify with the argillaceous sands lithofacies; this, and the other coarser grained lithofacies (the silts-fine sands), show particularly good definition (Table 8.35). The most significant variables appear to be the %phytoclasts/ kerogen, %undegraded/non-biostructured brown wood, and %striate/biostructured brown wood (Fig. 8.10).

8.11 Discussion of Discrepancies

From examining the cluster memberships and the variation in the variables between the different clusters, and what has already been seen in section 8.4, there appear to be two main reasons for discrepancies. The first is the problem of whether clusters or discriminant function categories are being defined using differences which are greater than the error value for the parameter (cf. section 2.5). If the differences used in selecting the DFA variables are only minor then they may not be expressed in cluster definition and vice-versa. Problems are likely to occur where stepwise DFA selects parameters from certain categories which are likely to show high variability due to the often low count totals from which they are calculated; parameters which are likely to

Member	% original samples correctly classified	Main cluster letter	Exported	Imported
Upper Ostrea	89	B	–4 B	+5 A
Belemnite Sands	58	A	–5 A	+4 B

8.34. *Summary of dendrogram, Staffin Bay Formation, using variables from SDFA of member. Key to definitions as for Table 8.27.*

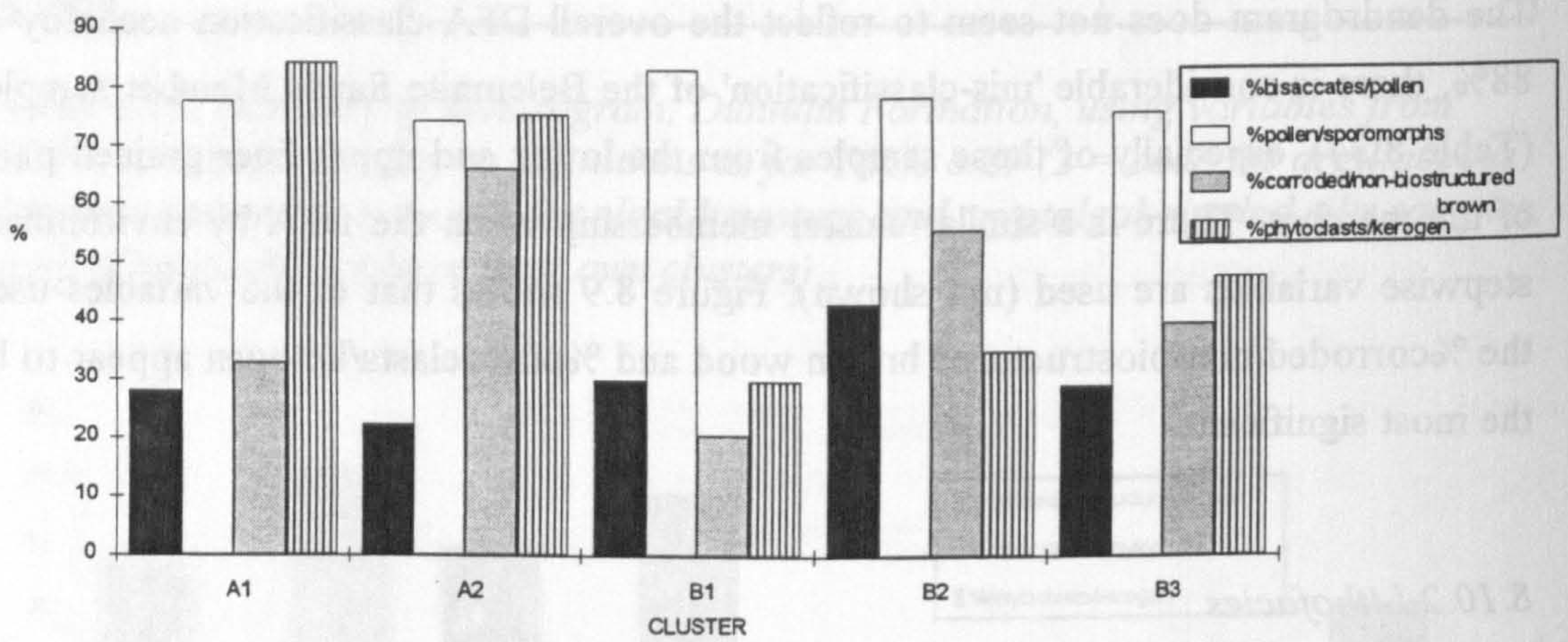


Fig. 8.9. *Mean values of variables (selected by SDFA) for each cluster, Staffin Bay Formation by member.*

Lithofacies	% original samples correctly classified	Main cluster letter	Exported	Imported
Calc. clay-Lst.	60	A	–1 C –1 D	+1 D +1 C
Bituminous shales	63	D	–4 C –1 A	+1 A +2 B +2 (5)
Silt-fine sands	93	C	–1 A	+1A +1 B
Arg. sands	70	B	–1 C –2 D	
Muddy silts (5)	0	na	–2 D	

Table 8.35. *Summary of dendrogram, Staffin Bay Formation, using variables from SDFA of lithofacies. Key to definitions as for Table 8.27 (5 = code for muddy silts lithofacies samples which do not have their own cluster).*

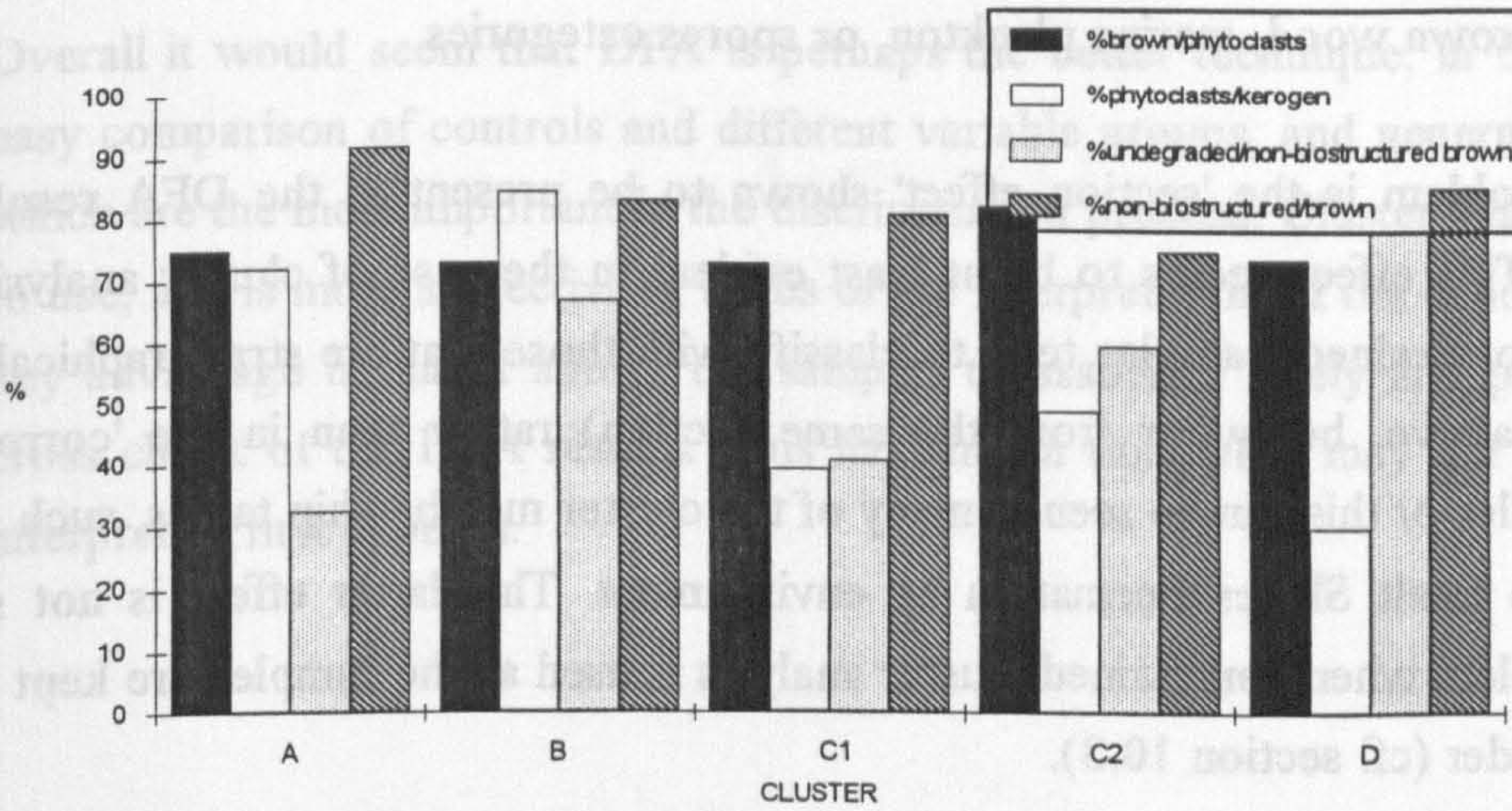


Fig. 8.10a *Mean values of variables (selected by SDFA) for each cluster, Staffin Bay Formation by lithofacies (I).*

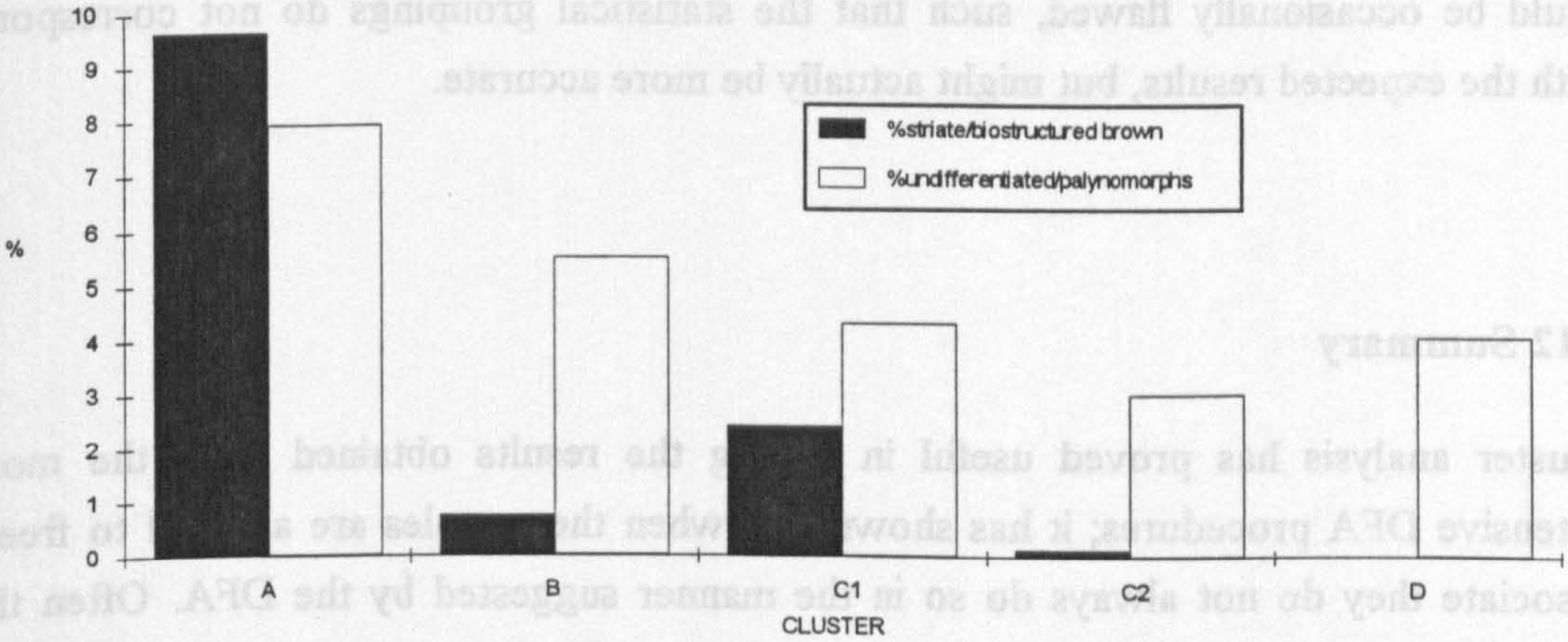


Fig. 8.10b *Mean values of variables (selected by SDFA) for each cluster, Staffin Bay Formation by lithofacies (II).*

suffer from this problem are particularly those which come from within the biostructured brown wood, marine plankton, or spores categories.

The second problem is the 'section effect' shown to be present in the DFA results (section 8.4). This effect seems to be at least evident in the case of cluster analysis, where, if not constrained, samples tend to classify with those that are stratigraphically adjacent (e.g. above, below or from the same section) rather than in the 'correct cluster'. Examples of this can be seen in many of the cluster membership tables, such as those from the Lealt Shales Formation by environment. This latter effect is not so much of a problem when constrained cluster analysis is used as the samples are kept in stratigraphic order (cf. section 10.3).

Another potential effect is that in DFA the categories are 'pre-judged'. The basis for this pre-judgement (especially for facies, environment, proximal-distal, and salinity) could be occasionally flawed, such that the statistical groupings do not correspond with the expected results, but might actually be more accurate.

8.12 Summary

Cluster analysis has proved useful in testing the results obtained from the more extensive DFA procedures; it has shown that when the samples are allowed to freely associate they do not always do so in the manner suggested by the DFA. Often the reason for the mis-classification of samples can be related to the lowered classification accuracy in the original DFA run, suggesting that the variables chosen will not perfectly classify the samples into the dependent variable categories. However, there are occasions when this does not seem to be the case, for example in the Lealt Shales Formation by member analysis, the accuracy of the DFA run was good (96%), but clustering using the same variables produced large numbers of samples classifying into 'incorrect clusters'. This suggests that, in some cases, the DFA uses samples which are not actually that similar in order to generate the algorithms; this may cause problems if the algorithm was applied to discriminate a new dataset.

Cluster analysis has also allowed the examination of the variable percentages in each cluster; it would appear that in most cases there only a few of the selected variables show significant variation, and sometimes in an essentially presence/absence fashion. These variables are not always those with the highest Wilks' lambda values, although this is the case in the Staffin Bay Formation.

Overall it would seem that DFA is perhaps the better technique, in that it allows the easy comparison of controls and different variable groups, and generates the variables which are the most important in the discrimination process. Cluster analysis is less easy to use, and is more subjective in terms of the interpretation of the dendrograms, but its key advantage is that it allows the samples to associate freely and provides a useful cross check of the DFA results. This has shown that DFA may not be as simple to interpret as first appears.

Appendix 8.1

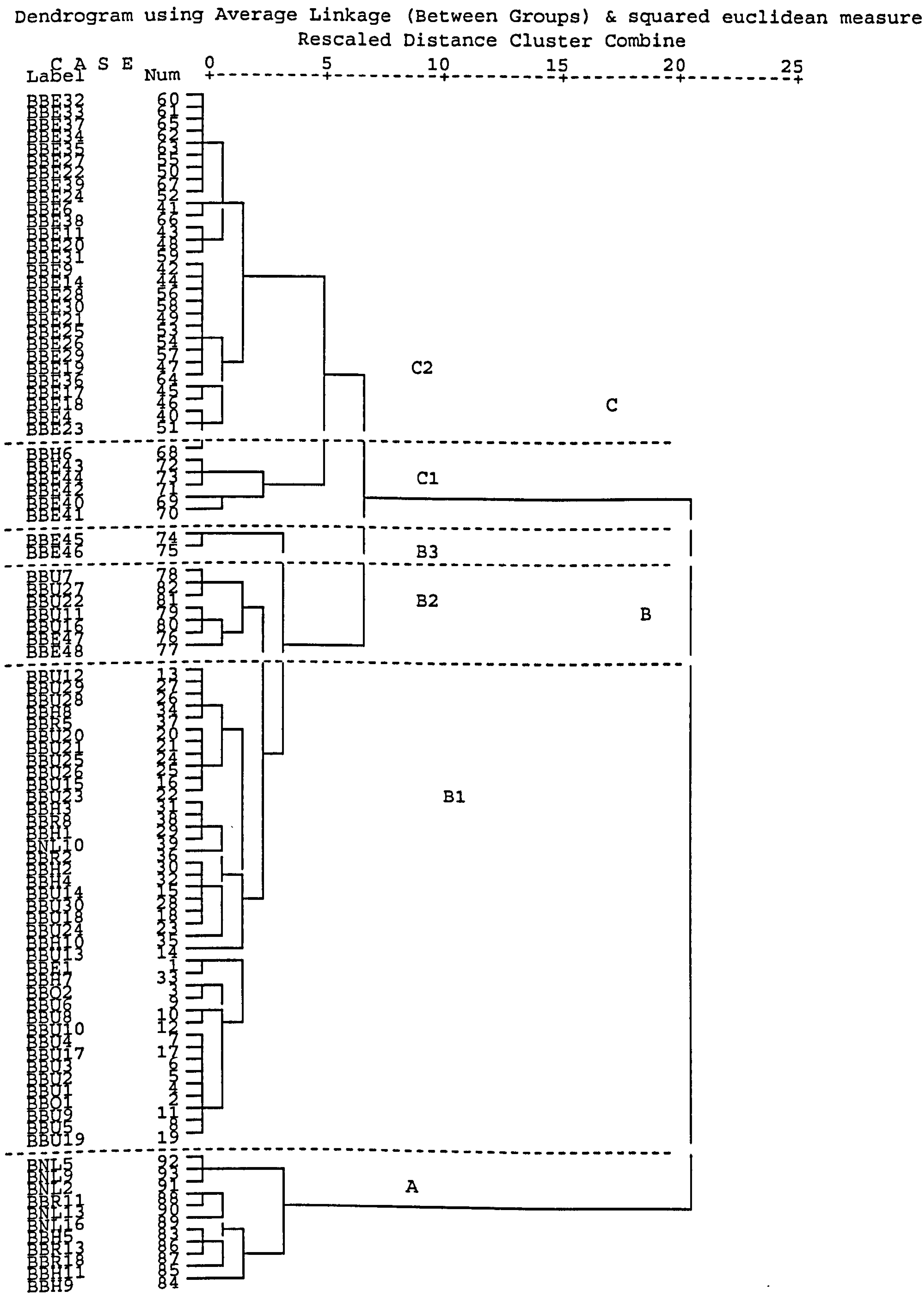


Fig. 8.11. *Dendrogram of the Bearreraig Sandstone Formation by member analysis.*

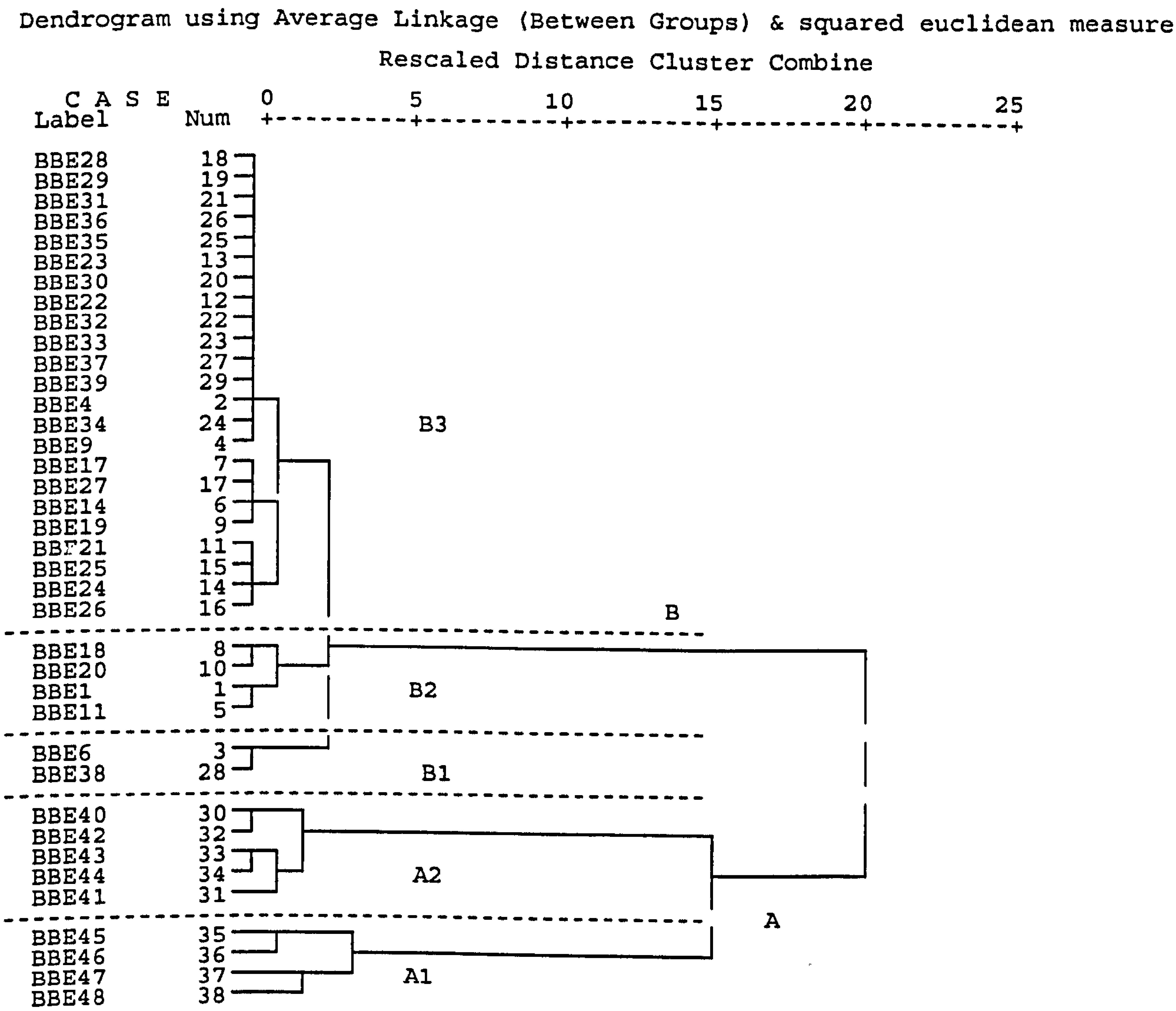


Fig. 8.12. *Dendrogram from the Dun Caan Shales Member (Bearreraig Sst. Fm.) by proximal-distal analysis.*

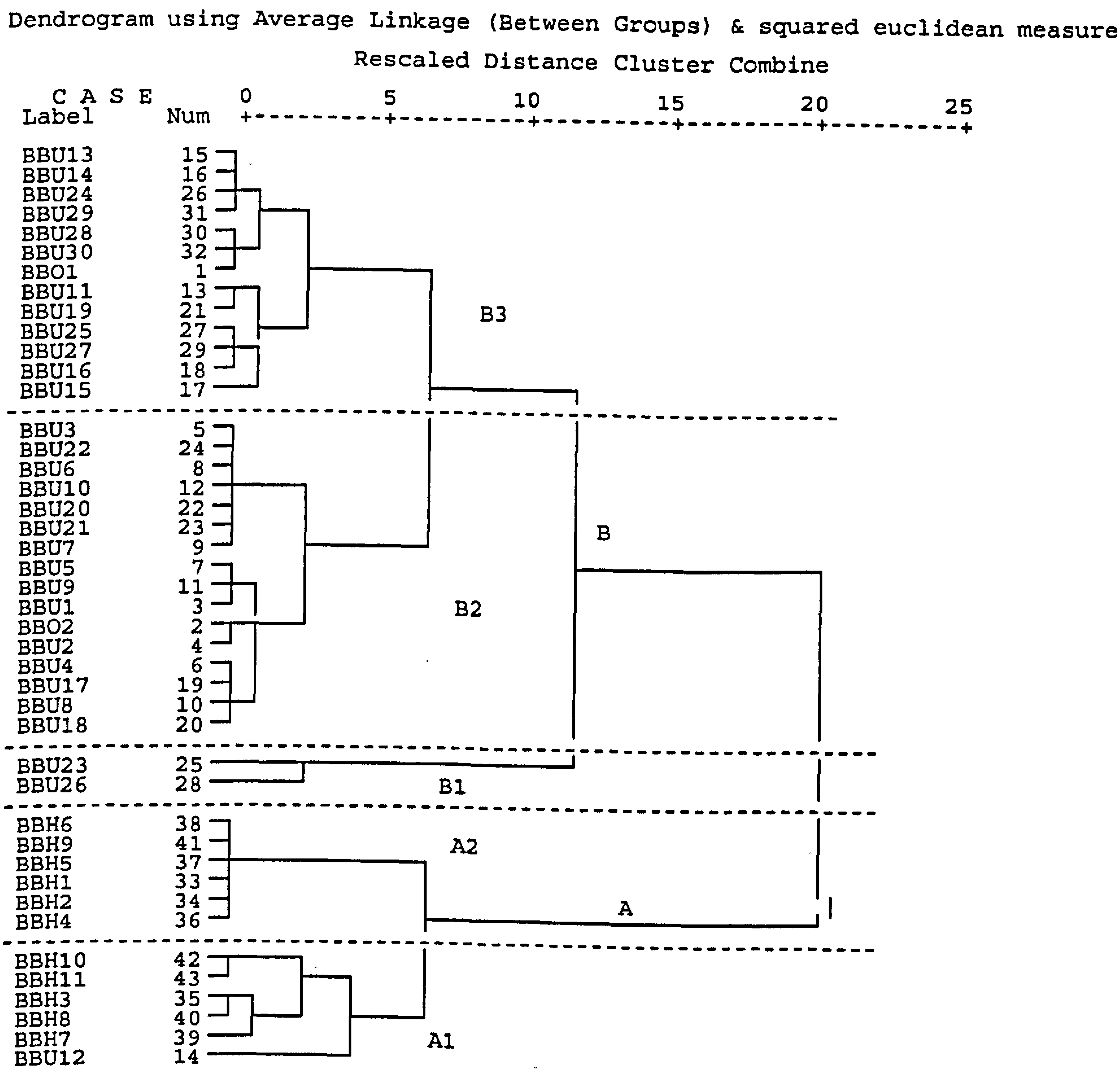


Fig. 8.13. *Dendrogram of the Udairn Shales-Holm Sandstone members (Bearreraig Sst. Fm.) by distal-proximal analysis.*

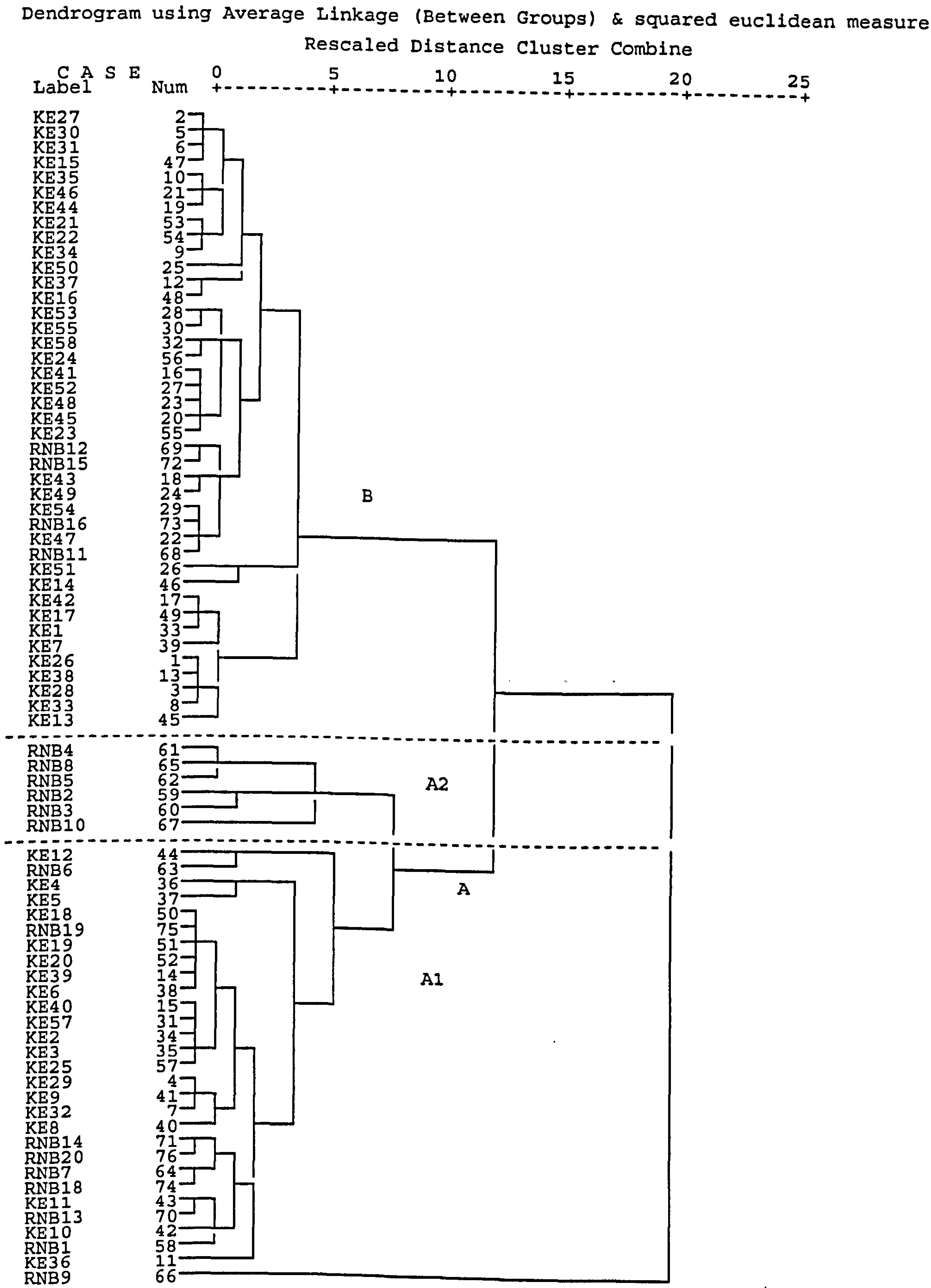


Fig. 8.14. *Dendrogram of the Lealt Shales Formation by member analysis.*

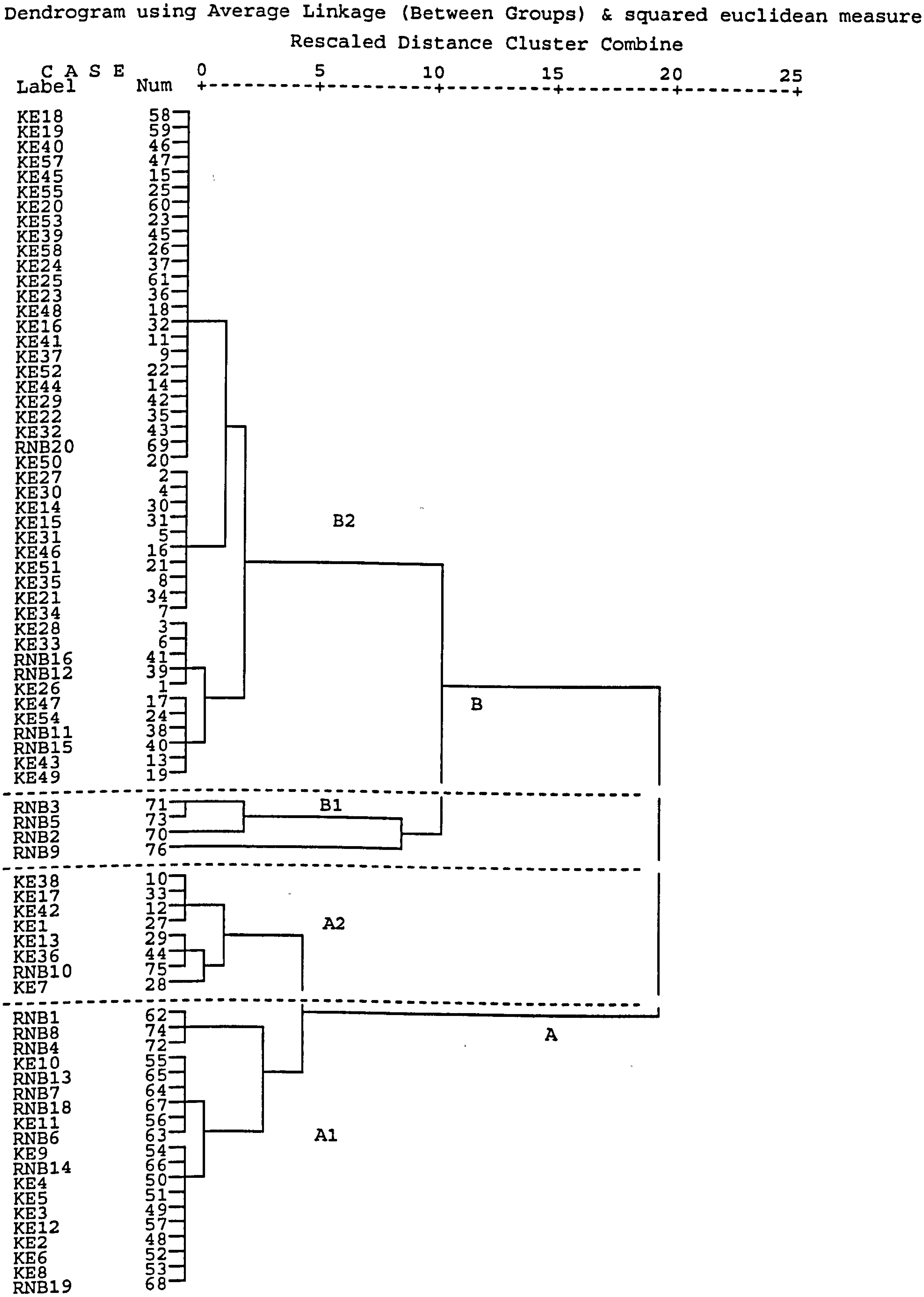


Fig. 8.15. *Dendrogram of the Lealt Shales Formation by environment analysis.*

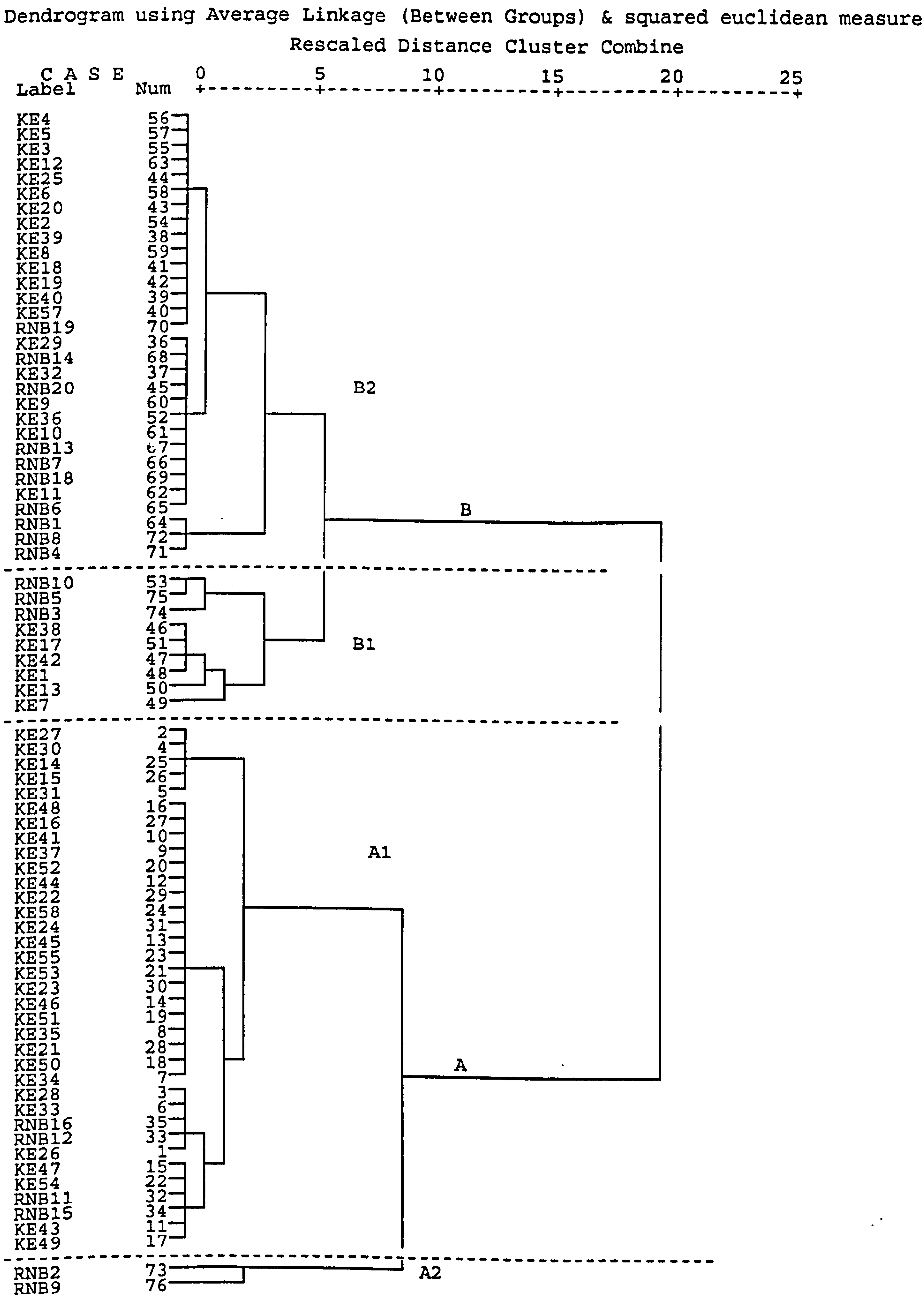


Fig. 8.16. *Dendrogram of the Lealt Shales Formation by salinity analysis.*

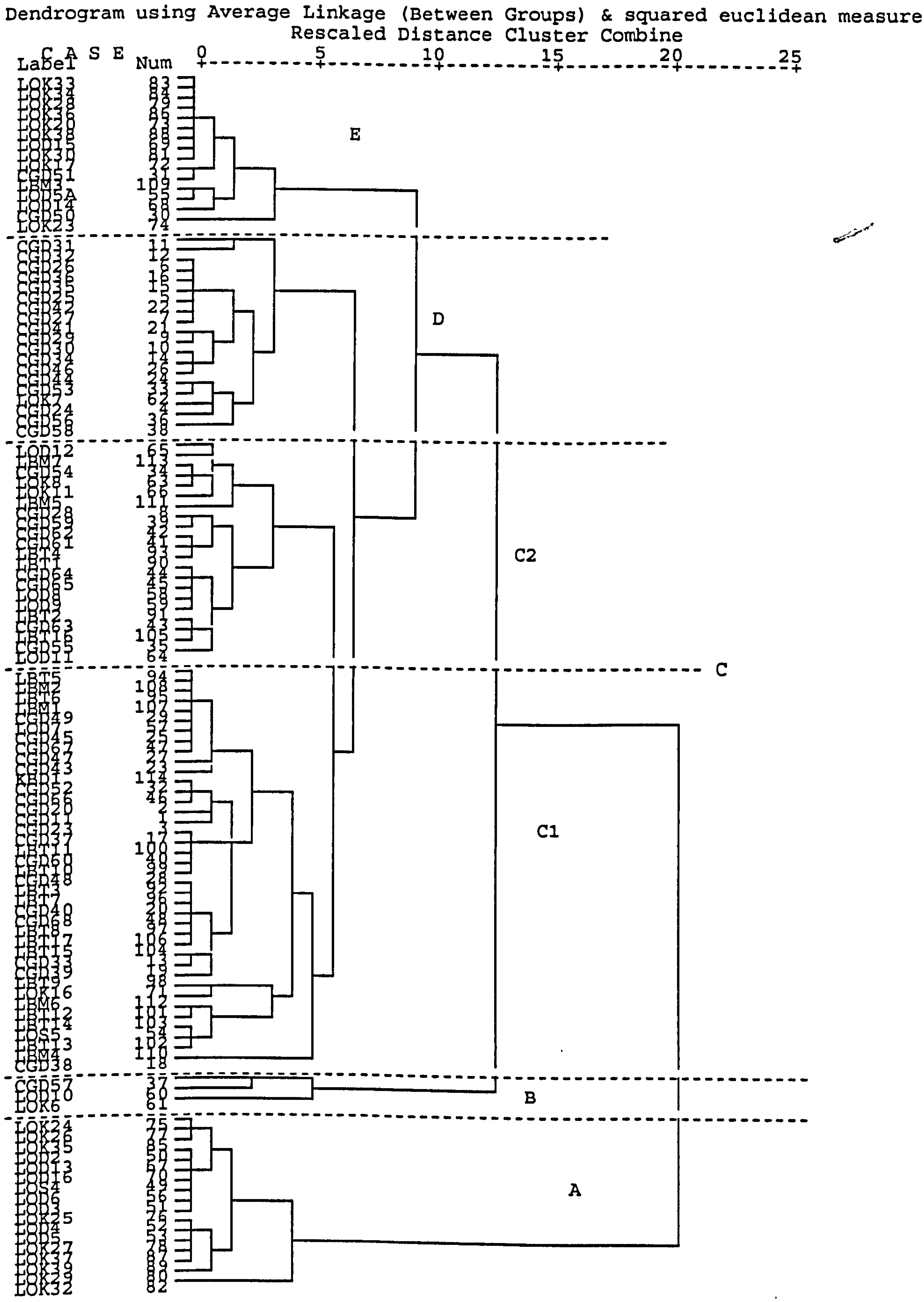


Fig. 8.17. *Dendrogram of the Duntulm Formation by environment analysis.*

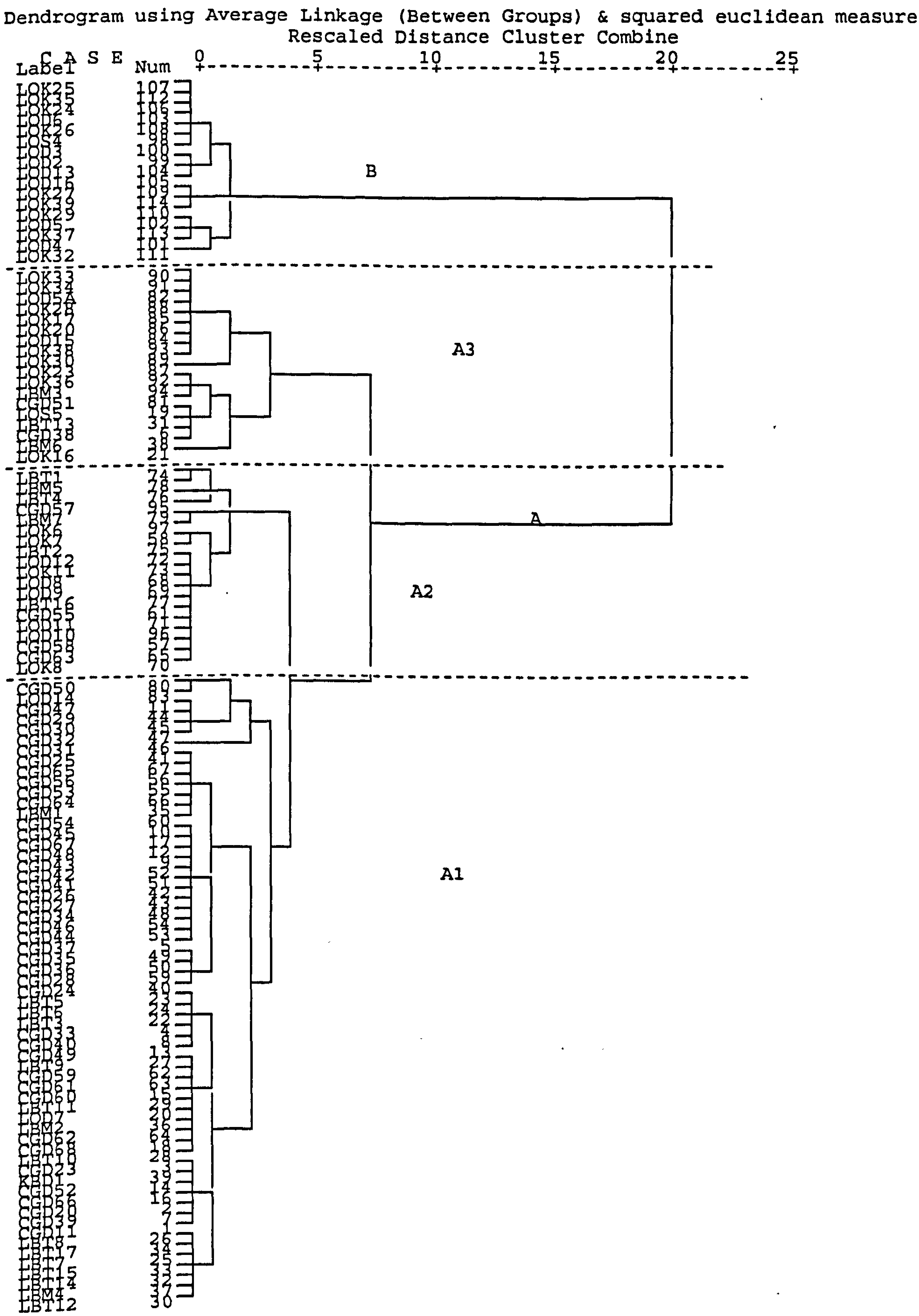


Fig. 8.18. *Dendrogram of the Duntulm Formation by lithofacies analysis.*

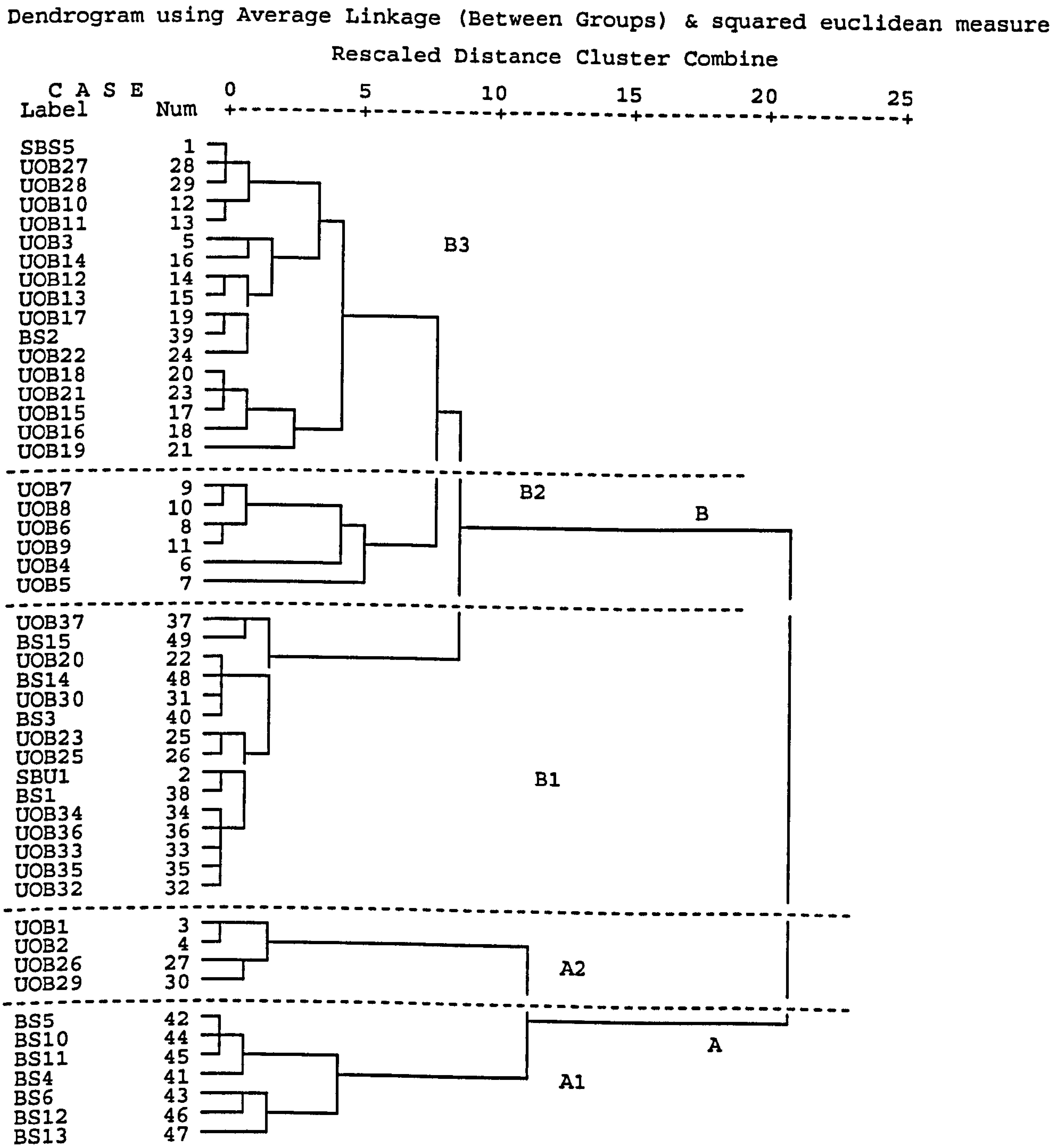


Fig. 8.19. *Dendrogram of the Staffin Bay Formation by member analysis.*

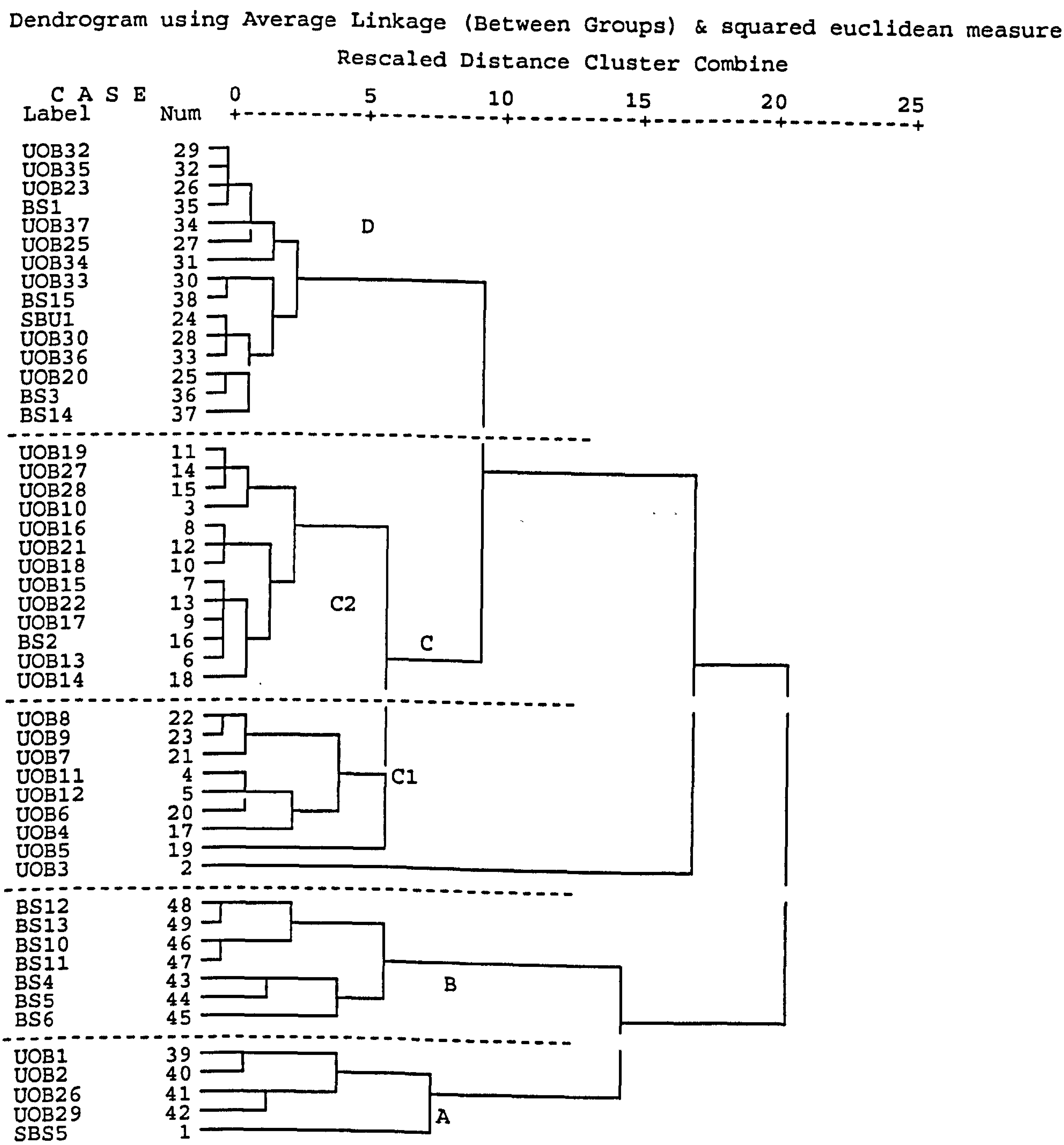


Fig. 8.20. *Dendrogram of the Staffin Bay Formation by lithofacies analysis.*

CHAPTER 9.0
FACTOR ANALYSIS

9.0 FACTOR ANALYSIS

Factor analysis (FA) has been carried out on the whole dataset and on each of the major formations (Bearreraig Sst., Lealt Shales, Duntulm, and Staffin Bay) using only the combined variables set (kerogen and palynomorph groups combined), as when the individual variable groups are entered the results are very similar to those derived from the combined analysis. The objective of using FA has been to summarise the main sources of variation within the different divisions of the dataset (whole and formation specific). The identity of these main sources of variation, or 'factors' has been determined using both the established trends in palynofacies parameters (section 2.4) and by comparing the variable loadings on the derived factors with those generated by stepwise Discriminant Function Analysis (Chapter 8.0). Where the latter comparison is possible, and there are several variables common to both, crossplots of the ranked factor loadings and Wilks' lambda values have been used; ranking was found to achieve better results than using the actual values, which show a large difference in magnitude between the factor loadings and the Wilks' lambda values. Normalising the two sets of values (to the maximum in each) was also attempted, but the resulting correlations were poor, mostly due to the highest Wilks' lambda value being far greater than the rest, compared to the more gradual changes in the factor loadings.

The factors are considered in a stratigraphic context in section 10.3.

9.1 Eigenvalues (Percentage of Variance)

Table 9.1 shows the percentage of variance accounted for by each factor in all the analyses. In the whole dataset and in the Lealt Shales Formation Factor 1 is twice Factor 2; in the other analyses the difference between these two factors is *ca.* 33% (relative). In all cases the % of variance attributable to Factors 3 and 4 are very similar to each other. The cumulative percentage of variance (i.e. Factors 1 to 4) explained is also similar, only falling below 50% in the Lealt Shales Formation; the maximum (54%) occurs for the Staffin Bay Formation data.

9.2 Factor Loadings and the Identification of Factors

Only factor loadings greater than ± 0.4 are considered significant (cf. Chapter 3.0), but the full list of factor loadings is given in Appendix 9.1. Data closure effects are endemic when dealing with factors based on percentage variables, and the parameters thus often occur in complementary pairs/groups; data closure effects are unavoidable where there are only two components in a particular subset, e.g. black equant vs. lath wood, thin- vs. thick- walled spores, and pollen vs. spores (of sporomorphs). When one of these paired parameters has a positive loading it is almost certain that the other is negative. However, closure effects can also manifest themselves where there are more components; often one component shows little variation leaving the other two components to exhibit inverse correlation (e.g. the non-biostructured brown wood fraction where the pseudoamorphous component is usually low and stable leaving the undegraded and corroded components to show closure effects).

9.2.1 Whole Dataset

Factor 1: 23.6% of variance (Fig. 9.1a)

The variables with a high negative loading suggest a degraded, mixed phytoclast assemblage dominated by brown wood, characteristic of more near shore/proximal high terrestrial input settings, whilst the positively loaded variables characterise more distal environments where some selective preservation has taken place. *Botryococcus* may not plot on the negative side of the factor due to dilution of this particle type by the high sporomorph input in more proximal settings, although the reason may in part be preservational. Comparison of the variables with those derived from stepwise DFA carried out on the whole dataset (section 8.3.1) shows that several variables from these lists are present; those used in the stepwise discrimination of formation and environment are particularly common (Table 9.2). The %undegraded/non-biostructured brown, and %striate/biostructured brown wood show a high rank in both methods. Figures 9.2 and 9.3 show that there is a reasonable correlation between the ranks of some of the common variables in the Factor 1 and formation list comparison, and that in the Factor 1 and environment comparison there is a very good correlation between the ranks. The factor is named as proximal-distal, but seems to be specifically related to the terrigenous component.

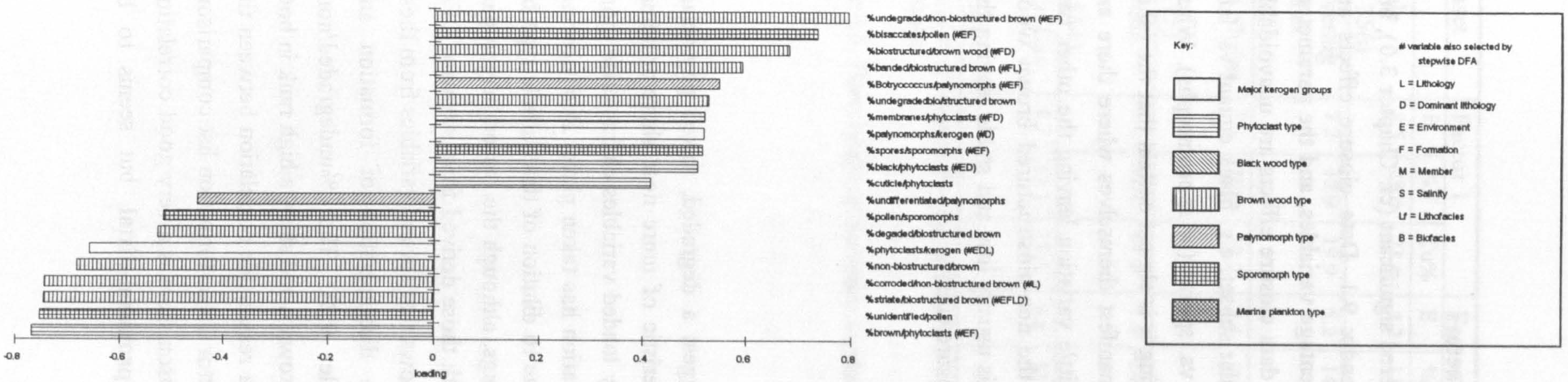


Fig. 9.1a *Factor 1 variable loadings for the whole dataset.*

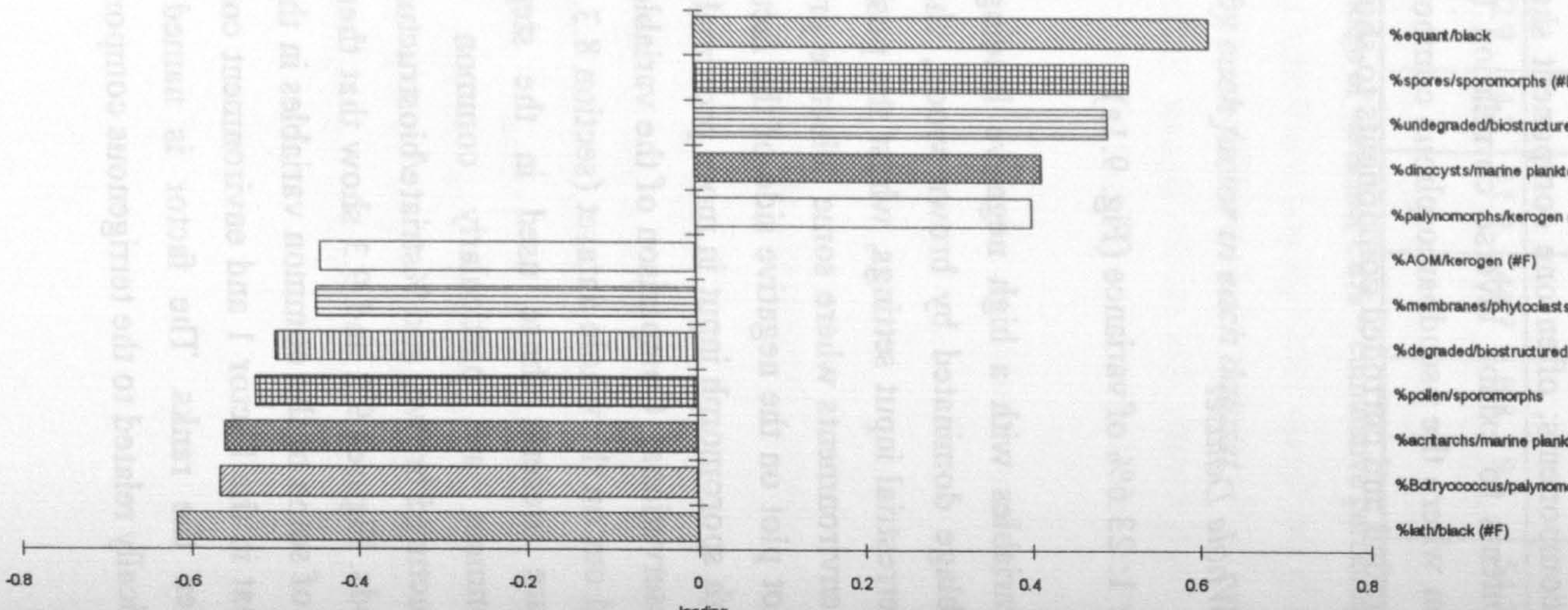


Fig. 9.1b. *Factor 2 variable loadings for the whole dataset. Key as in Fig. 9.1a.*

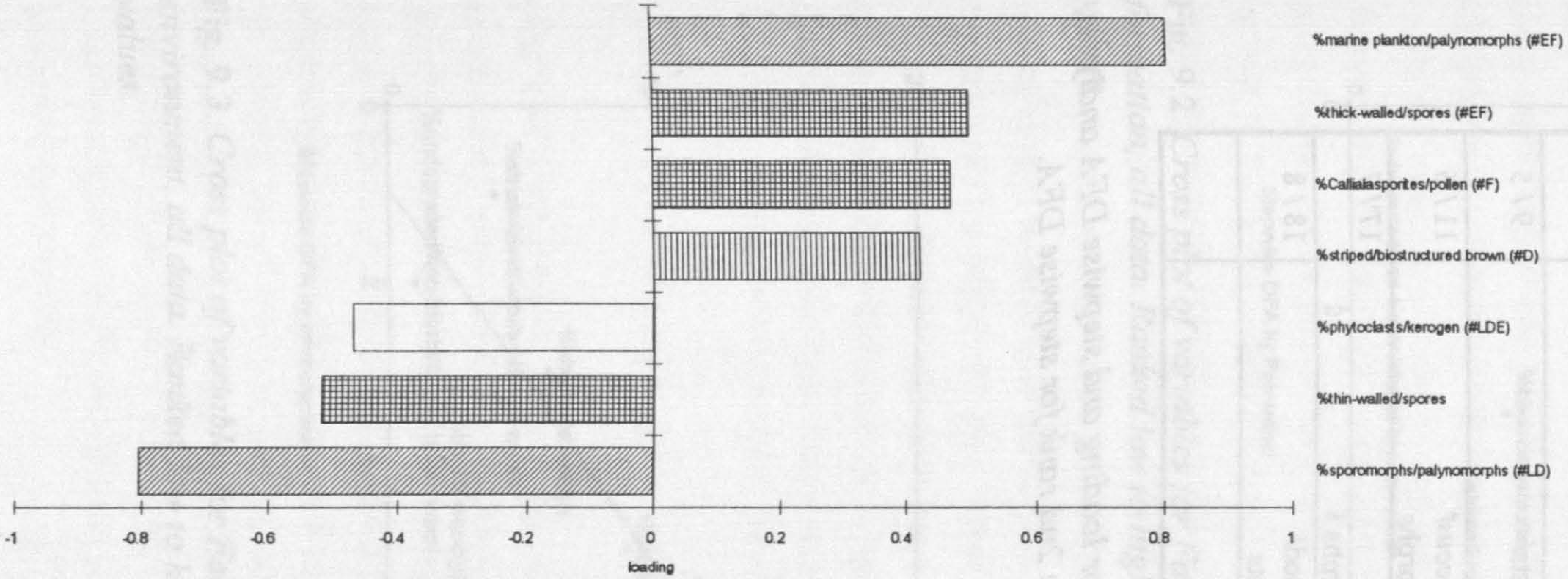


Fig. 9.1c. *Factor 3 variable loadings for the whole dataset. Key as in Fig. 9.1a.*

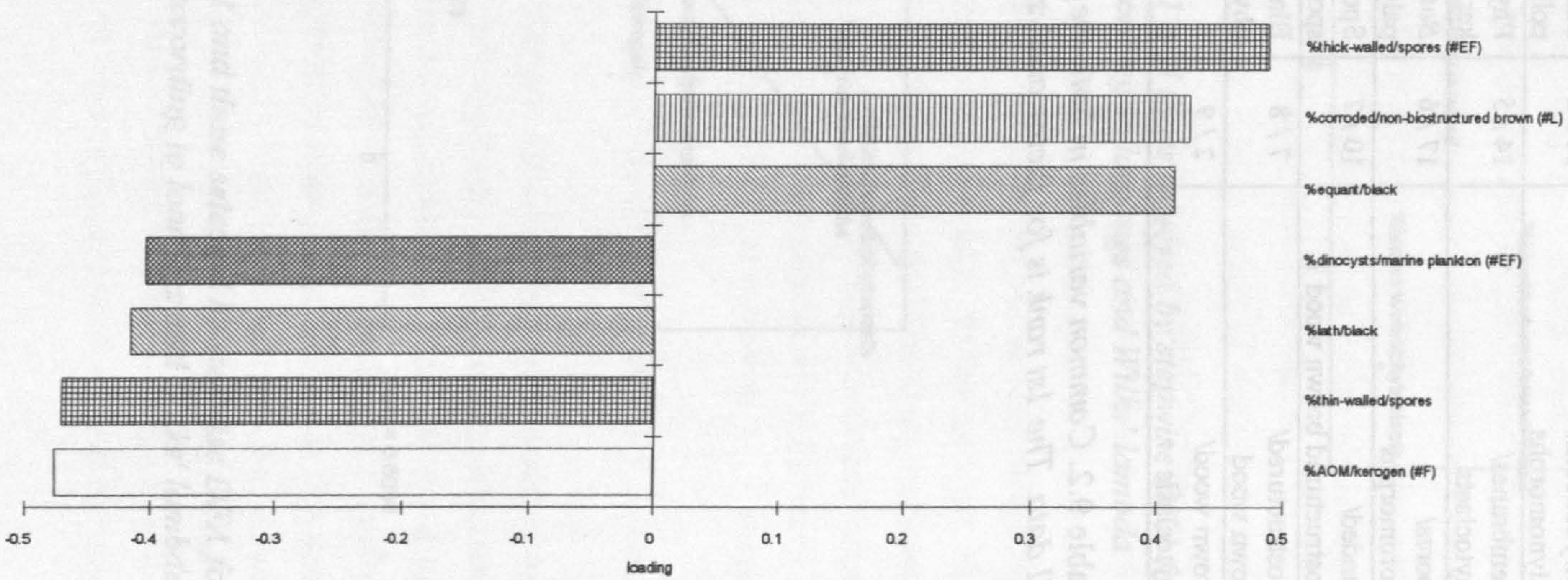


Fig. 9.1d. *Factor 4 variable loadings for the whole dataset. Key as in Fig. 9.1a.*

Factor 1 and formation	Ranks	Factor 1 and environment	Ranks
Undegraded/ non-biostructured brown wood	1 / 1	Undegraded/ non-biostructured brown wood	1 / 2
Striate/ biostructured brown wood	4 / 4	Striate/ biostructured brown wood	4 / 1
Bisaccates/ pollen	6 / 3	Brown wood/ phytoclasts	2 / 4
Botryococcus/ palynomorphs	11 / 2	Bisaccates/ pollen	6 / 3
Membranes/ phytoclasts	14 / 5	Phytoclasts/ kerogen	9 / 5
Spores/ sporomorphs	17 / 6	*Botryococcus*/ palynomorphs	11 / 6
Banded/ biostructured brown wood	10 / 7	Spores/ sporomorphs	17 / 7
Biostructured/ brown wood	7 / 8	Black wood/ phytoclasts	18 / 8
Brown wood/ phytoclasts	2 / 9		

Table 9.2. *Common variables in both the factor loading and stepwise DFA analyses, all data. The 1st rank is for factor analysis, the 2nd rank for stepwise DFA.*

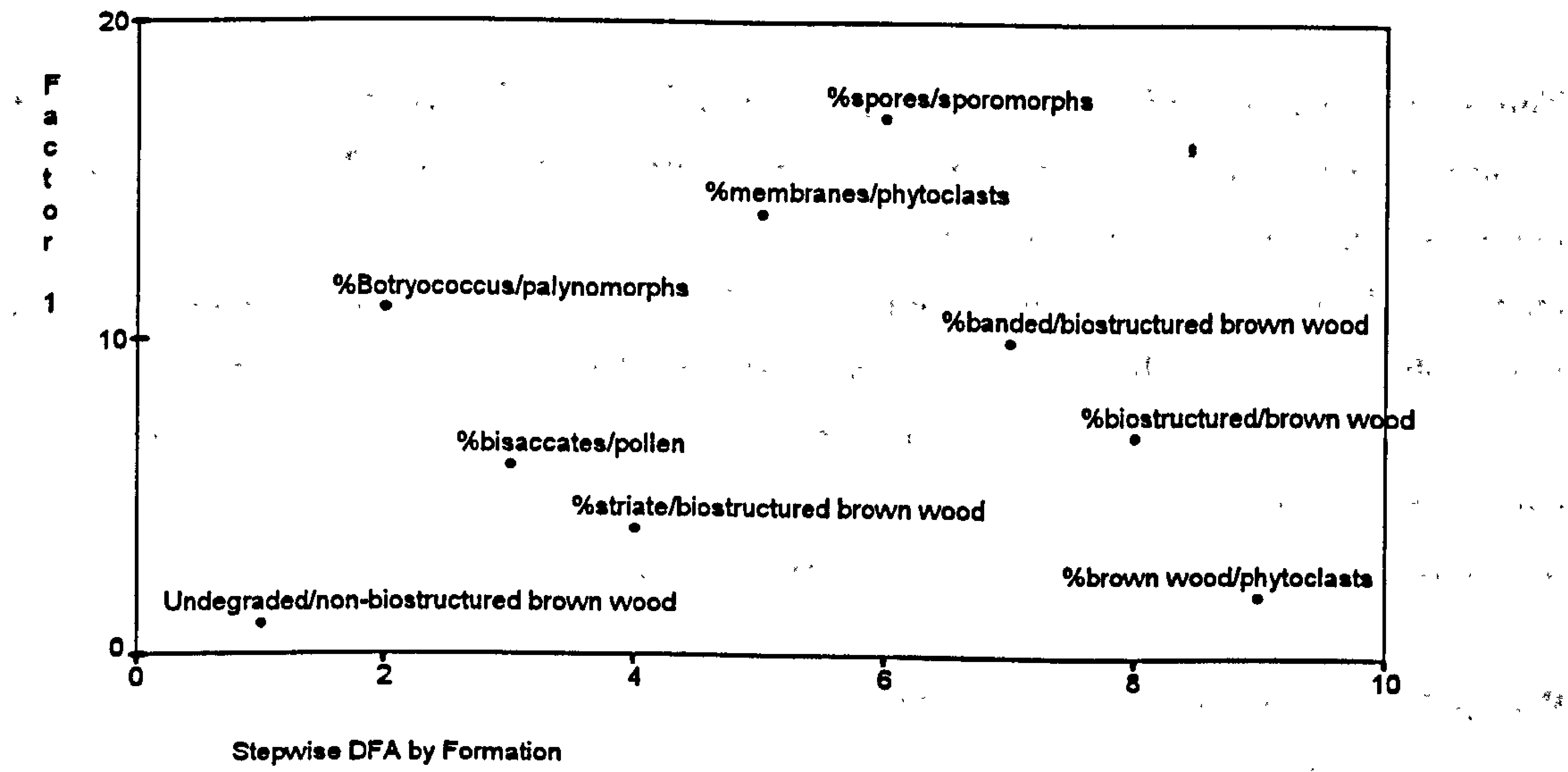


Fig. 9.2. *Cross plot of variables for Factor 1 and those selected by stepwise DFA for formation, all data. Ranked low to high according to loadings and Wilks' lambda values.*

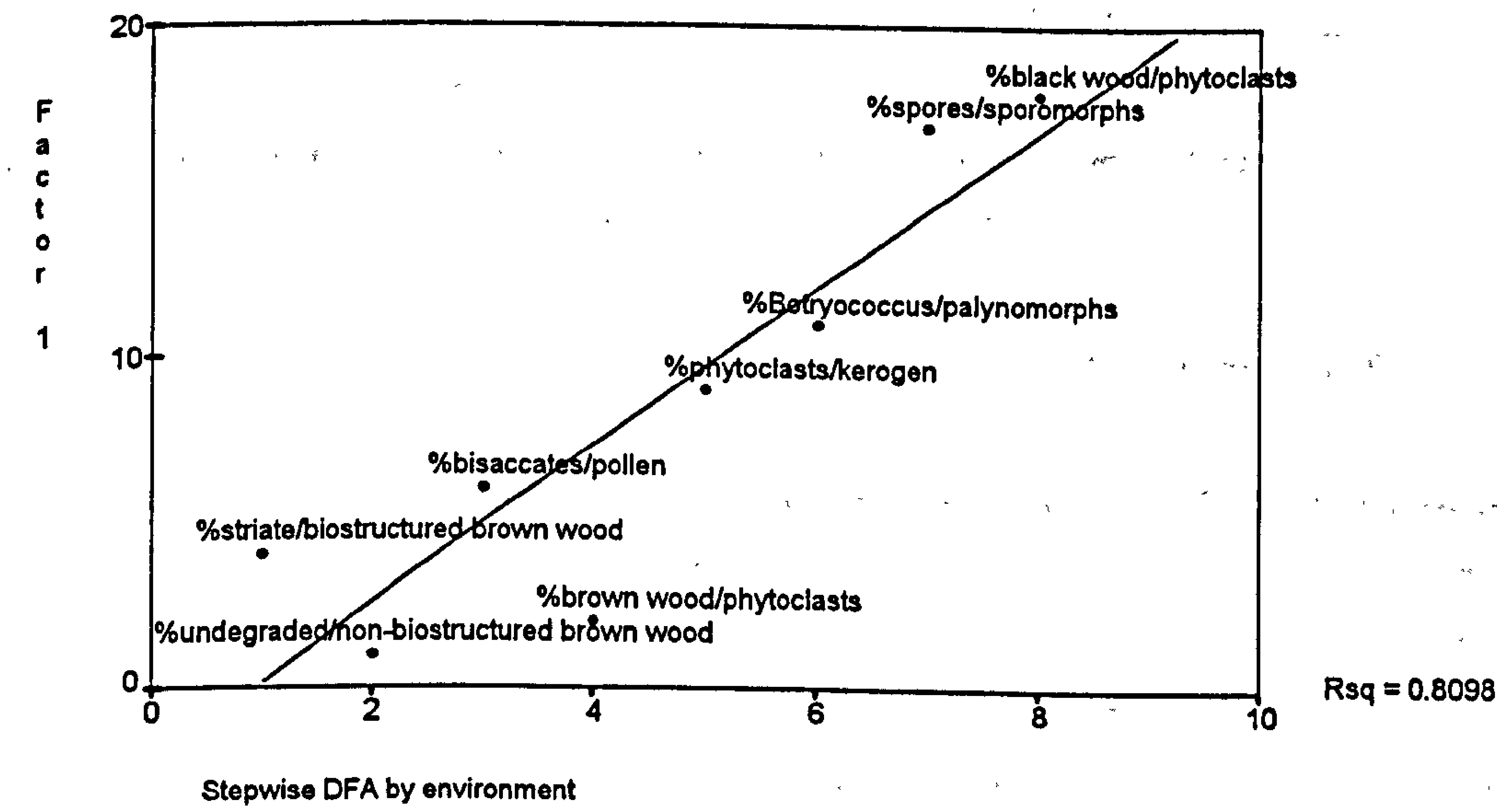


Fig. 9.3. *Cross plot of variables for Factor 1 and those selected by stepwise DFA for environment, all data. Ranked low to high according to loadings and Wilks' lambda values.*

Factor 2: 11.6% of variance (Fig. 9.1b)

The negatively loaded variables suggest reducing conditions in a lowered salinity setting, also a potentially distal/low terrestrial input association. The positively loaded variables may indicate more proximal (higher energy) conditions of more normal marine salinities. The pattern seen may also reflect lithological changes as the positively loaded variables are also characteristic of coarser grained sediments. Again variables from the whole dataset stepwise lists are present; the palynomorph group variables on this factor seem to relate to those selected in the stepwise discrimination of environment. Factor named as **salinity/preservation.**

Factor 3: 9.8% of variance (Fig. 9.1c)

The negatively loaded variables suggest a more proximal setting than the positively loaded variables which suggest more marine conditions, with a potential selective preservation of striped material in the latter. The presence of thick-walled spores on the positive side of the factor seems to be anomalous, but this particle type is present with high levels of marine plankton in the more proximal part of the Duntulm Formation (section 10.2.3). This factor may reflect salinity changes rather than a simple proximal-distal effect. This seems likely as variables from the stepwise discrimination of environment list are also present. Factor named as **marine vs. non-marine.**

Factor 4: 7.2% of variance (Fig. 9.1d)

The negatively loaded variables suggest significantly reducing conditions in a more distal setting/finer grained lithology with more normal marine conditions, whereas the positively loaded variables suggest proximal/coarser grained sedimentation. The loadings may also suggests a difference in environmental energy as this effects lithology, redox and sorting of the particles. Factor named as **proximal-distal/energy.**

9.2.2 The Formations

The Bearreraig Sandstone Formation

Factor 1: 19.9% of variance (Fig. 9.4a)

The negatively loaded variables characterise a relatively proximal assemblage dominated by degraded non-biostructured brown wood, whilst the positively loaded variables suggest a distal setting with some selective preservation of biostructured brown and undegraded non-biostructured brown wood. However, the association of pseudoamorphous phytoclasts and spores (of sporomorphs) in the distal variables group is not what would normally be expected. The presence of pseudoamorphous material suggests enhanced preservation of this particle type in distal settings within this formation (it associates with AOM in Factor 4). The presence of spores of sporomorphs may be due to data closure with pollen of sporomorphs, or it may reflect the relatively increased levels of spores found in the top part of the Dun Caan Shales Member with a refractory phytoclast assemblage (section 10.2.1). Comparison of the variables with those selected in the stepwise DFA (section 8.3.2) shows that there is most relationship with those variables in the proximal-distal lists; the three highest rank variables are similar and there is a good correlation between the rankings (Table 9.3 & Fig. 9.5). Factor named as **proximal-distal, relating to all the variables.**

Factor 2: 14.4% of variance (Fig. 9.4b)

The positively loaded variables suggest preservation of certain particle types (striate wood, pseudoamorphous and membranes) potentially in a distal setting, whilst the negatively loaded variables suggest preservation of different phytoclast types in a more proximal setting. The presence of thick-walled spores on the positive side of the factor may again reflect values found in the top part of the Dun Caan Shales Member where an assemblage of this type is seen (section 10.2.1). The preservational effects which characterise this factor may also be due to lithological effects: the more refractory assemblages suggested by the negatively loaded variables are more likely to be found in coarser grained sediments. Factor named as **selective preservation, relating only to the phytoclast fraction.**

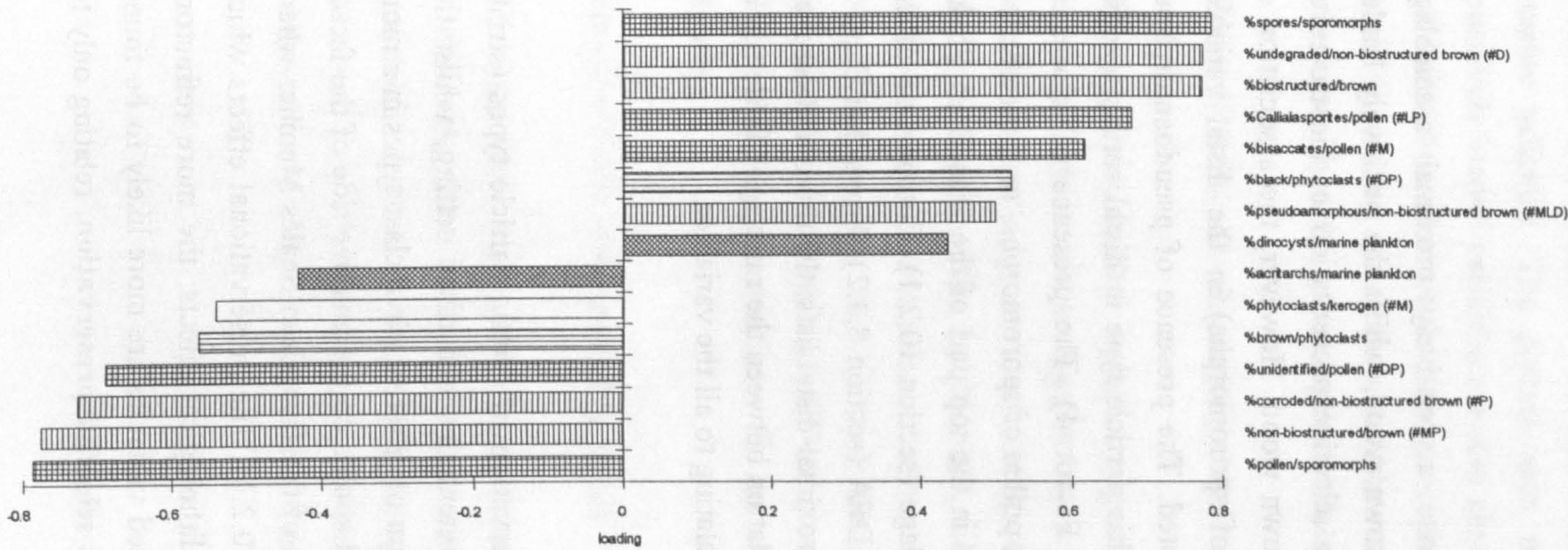


Fig. 9.4a. *Factor 1 variable loadings: Bearreraig Sandstone Formation. Key as in Fig. 9.1a.*

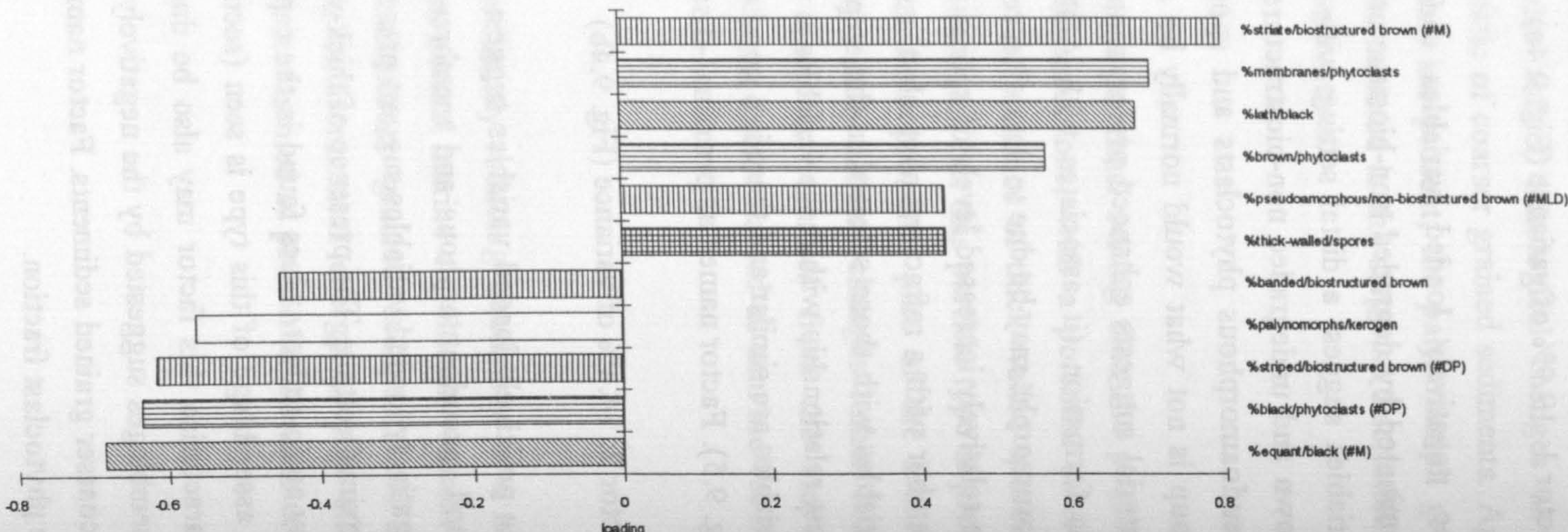


Fig. 9.4b. *Factor 2 variable loadings: Bearreraig Sandstone Formation. Key as in Fig. 9.1a.*

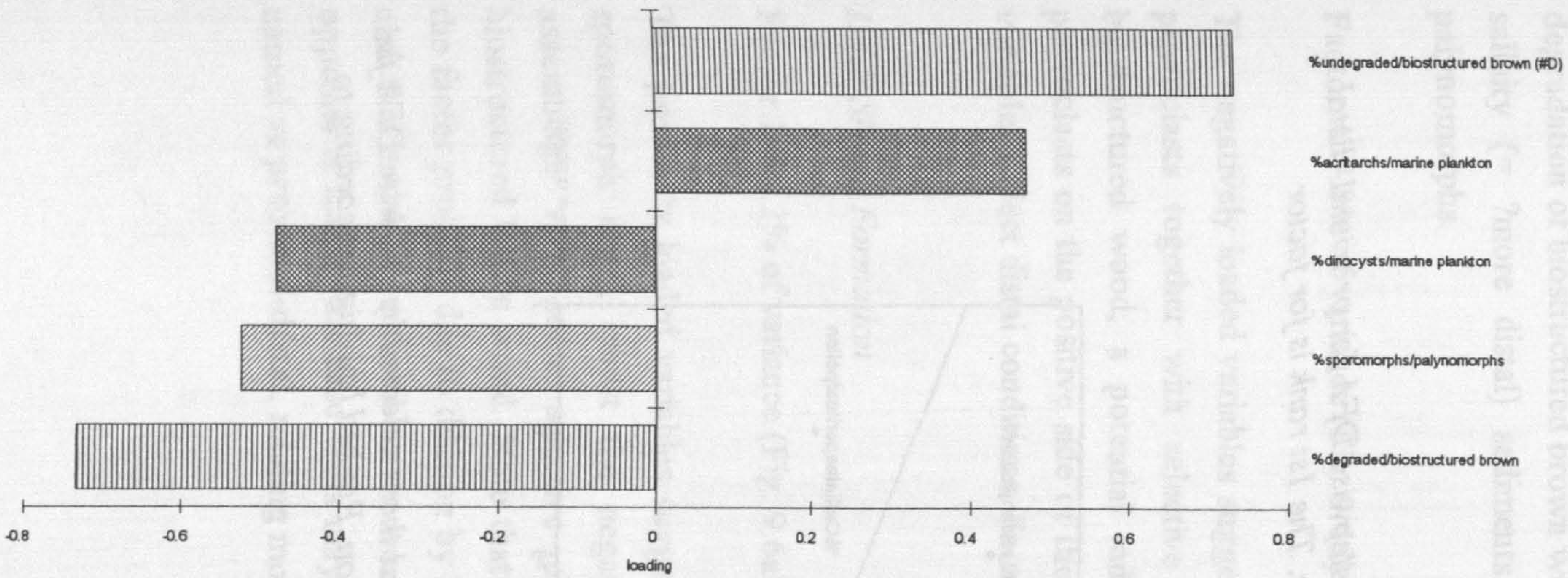


Fig. 9.4c. *Factor 3 variable loadings: Bearreraig Sandstone Formation. Key as in Fig. 9.1a.*

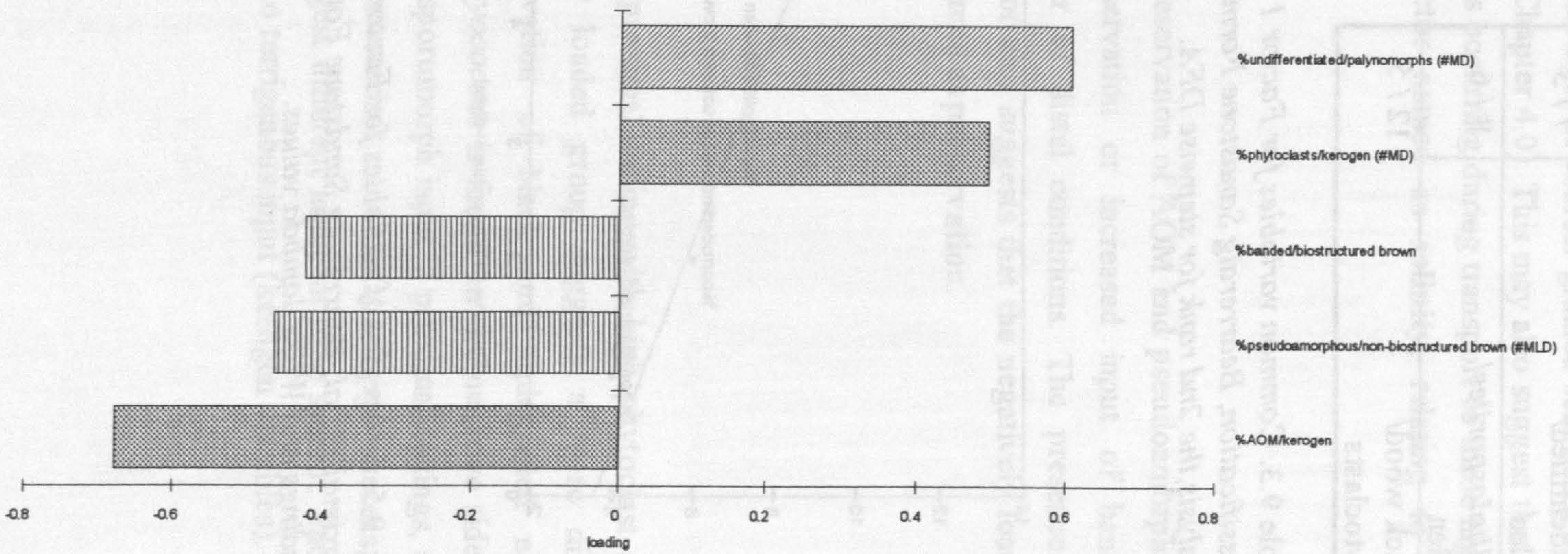


Fig. 9.4d. *Factor 4 variable loadings: Bearreraig Sandstone Formation. Key as in Fig. 9.1a.*

Variable	Ranks
Non-biostructured/ brown wood	1 / 1
Corroded/non-biostructured brown wood	6 / 2
Unidentified/ pollen	7 / 3
Callialasporites/ pollen	8 / 6
Black wood/ phytoclasts	12 / 5

Table 9.3. *Common variables for Factor 1 and stepwise DFA for proximal-distal classification, Bearreraig Sandstone Formation. The 1st rank is for factor analysis, the 2nd rank for stepwise DFA.*

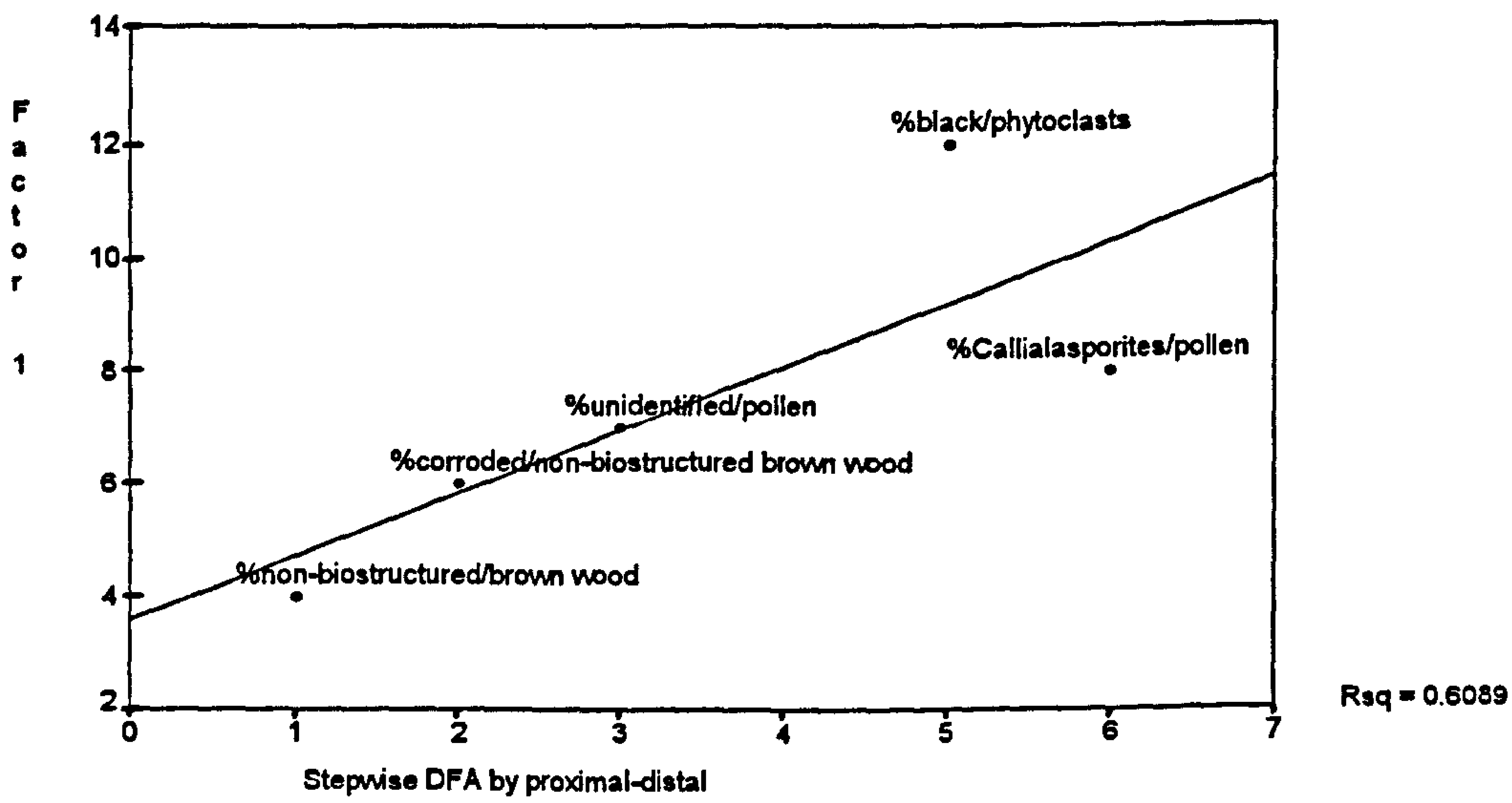


Fig. 9.5. *Cross plot of variables for Factor 1 and those selected by stepwise DFA for proximal-distal, Bearreraig Sandstone Formation. Ranked low-high according to loadings and Wilks' lambda values.*

Factor 3: 8.1% of variance (Fig. 9.4c)

The variable loadings on this factor suggest a potential salinity control on assemblages. The correlation between sporomorphs and dinocysts also suggests a potential lithologic control, the marine plankton assemblages of coarser grained sediments being more likely to be dominated by dinocysts (Chapter 4.0). This may also suggest that the degradation of biostructured brown wood is occurring during transport to these higher salinity (= ?more distal) sediments. Factor named as **salinity**, relating to the palynomorphs.

Factor 4: 7.8% of variance (Fig. 9.4d)

The negatively loaded variables suggest preservation of AOM and pseudoamorphous phytoclasts together with selective preservation or increased input of banded biostructured wood, a potential indicator of distal conditions. The presence of phytoclasts on the positive side of the factor also suggests that the negatively loaded variables reflect distal conditions. Factor named as **preservation**.

Lealt Shales Formation

Factor 1: 20.2% of variance (Fig. 9.6a)

The positively loaded variables suggest a proximal setting with high phytoclast and sporomorph input, whilst the negatively loaded group suggests a more distal assemblage with some selective preservation of black and undegraded non-biostructured brown wood. Note that *Botryococcus* is found on the negative side of the factor probably due to dilution by high sporomorph input in proximal settings, and also that non-biostructured brown wood characterises more distal settings whereas the opposite is usually the case. This may suggest different input into the system. Factor named as **proximal-distal**, relating mostly to terrigenous input (kerogen variables).

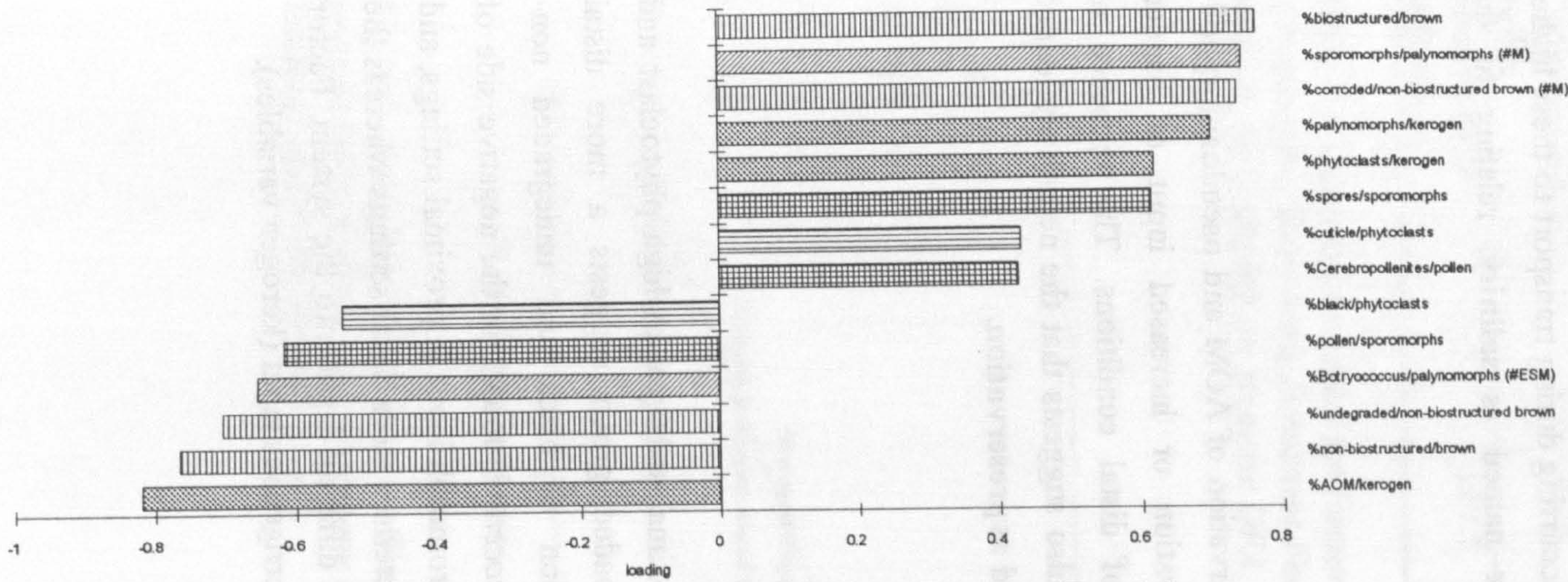


Fig. 9.6a. *Factor 1 variable loading: Lealt Shales Formation. Key as in Fig. 9.1a.*

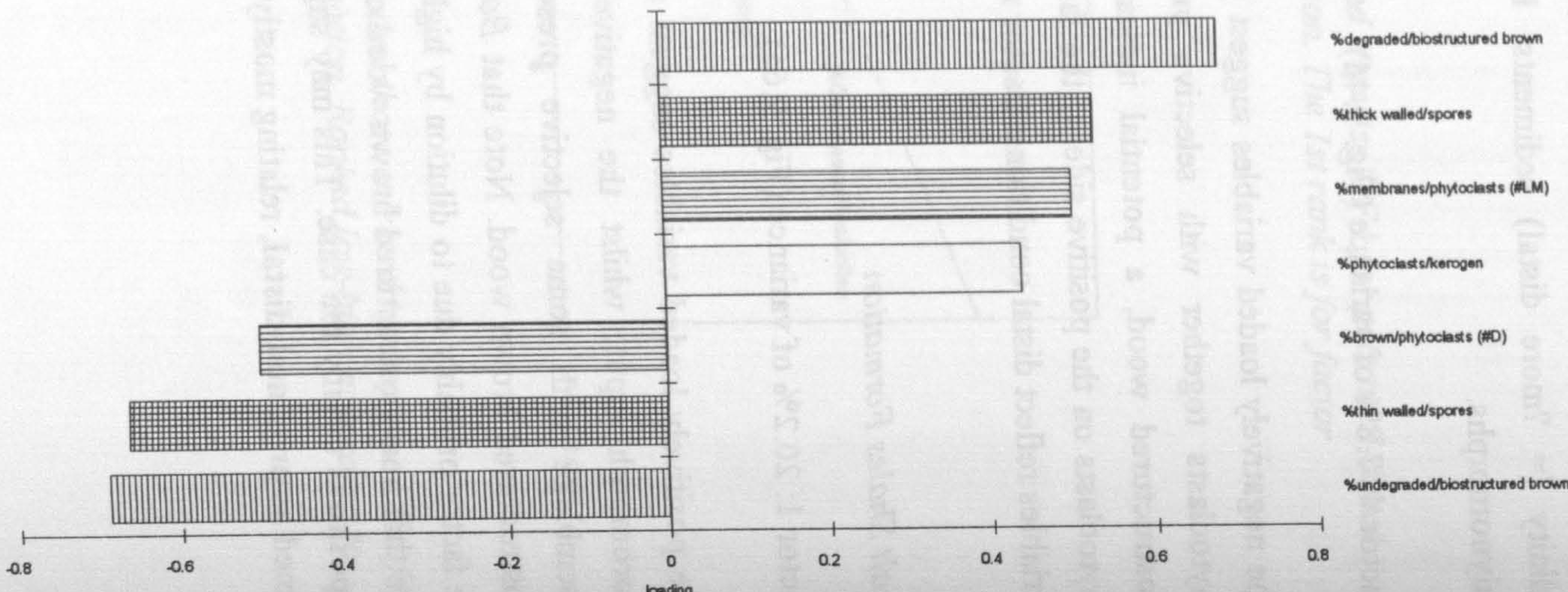


Fig. 9.6b. *Factor 2 variable loadings: Lealt Shales Formation. Key as in Fig. 9.1a.*

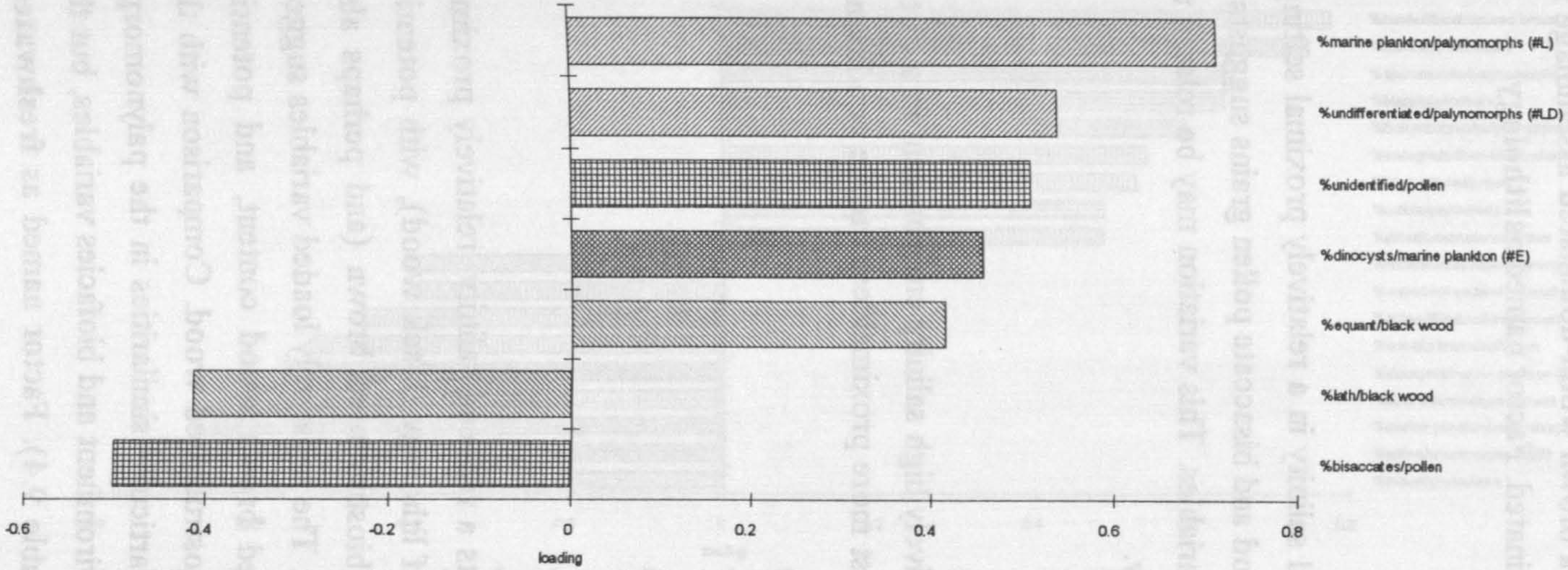


Fig. 9.6c. *Factor 3 variable loadings: Lealt shales Formation. Key as in Fig. 9.1a.*

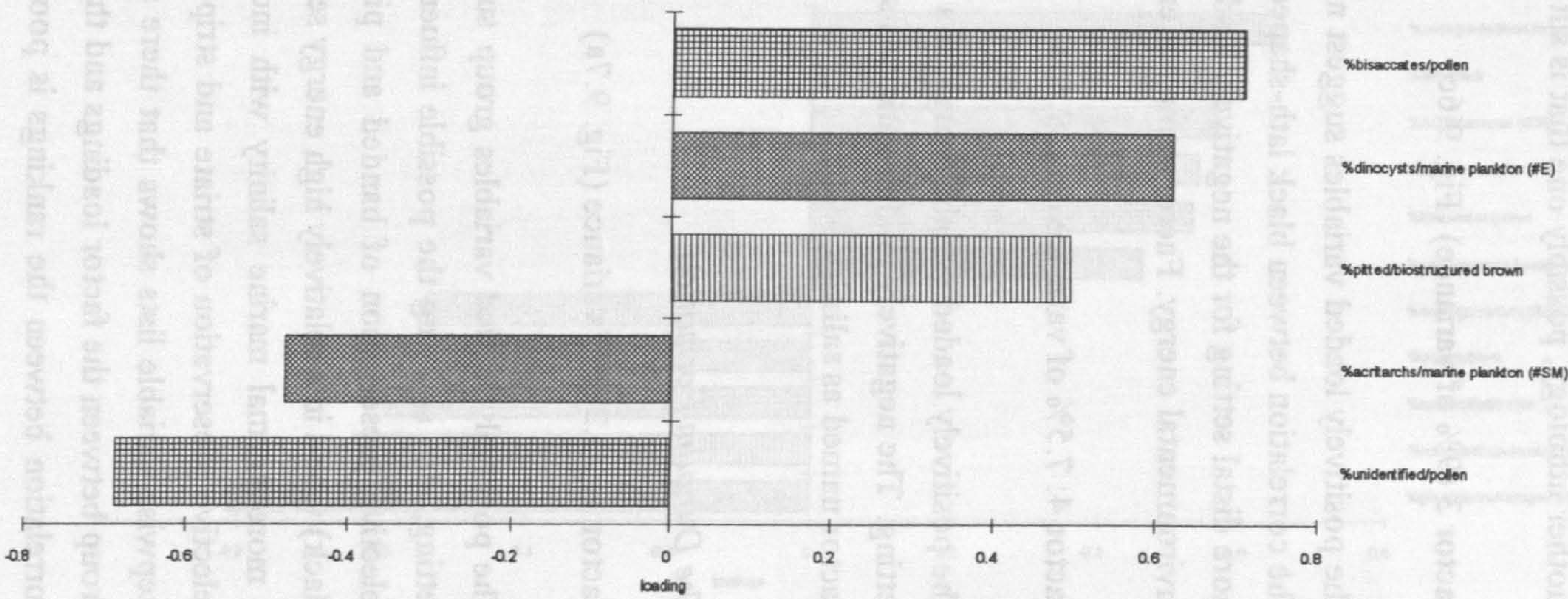


Fig. 9.6d. *Factor 4 variable loading: Lealt Shales Formation. Key as in Fig. 9.1a.*

Factor 2: 9.6% of variance (Fig. 9.6b)

The positively loaded variables group suggests the effect of limestone-dominated lithologies (see Chapter 4.0), where membrane percentages are increased, possibly due to concentration in low input settings. This may also suggest that the degradation of the biostructured brown wood is due to increased residence time within the system. The negatively loaded variable group suggest a brown wood-dominated assemblage in another lithology, possibly one that is silt-dominated. Factor named aslithology.

Factor 3 (9% of variance) (Fig. 9.6c)

The positively loaded variables suggest normal salinity in a relatively proximal setting. The correlation between black lath-shaped wood and bisaccate pollen grains suggests a more distal setting for the negatively loaded variables. This variation may be related to environmental energy. Factor named as **energy**.

Factor 4: 7.5% of variance (Fig. 9.6d)

The positively loaded variables suggest a relatively high salinity environment in a distal setting. The negatively loaded variables suggest more proximal/less marine conditions. Factor named as **salinity**.

The Duntulm Formation

Factor 1: 21.2% of variance (Fig. 9.7a)

The positively loaded variables group suggests a reduced salinity, relatively proximal setting, also showing the possible influence of lithology (black wood), with potential selective preservation of banded and pitted biostructured brown (and perhaps also black) wood in a relatively high energy setting. The negatively loaded variables suggest a more normal marine salinity with increased brown wood content, and potential selective preservation of striate and striped biostructured wood. Comparison with the stepwise variable lists shows that there are particular similarities in the palynomorph group between the factor loadings and the environment and biofacies variables, but the correlation between the rankings is poor (Table 9.4). Factor named as **freshwater-marine**.

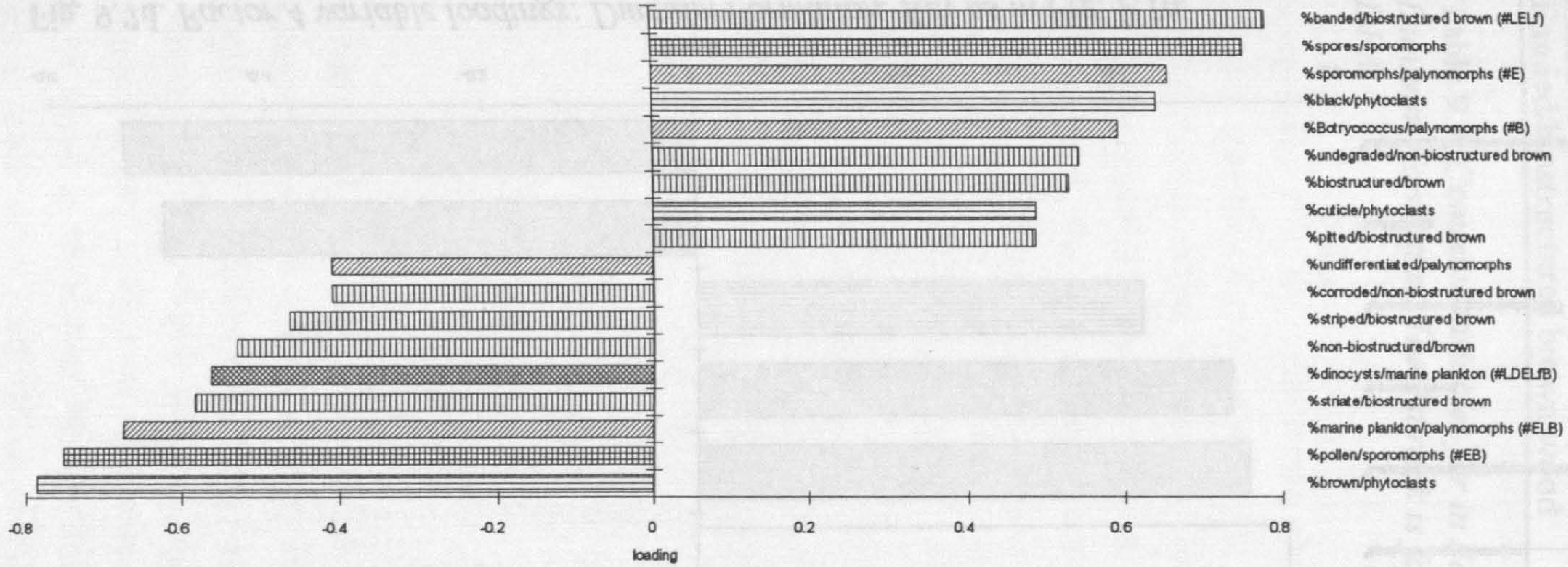


Fig. 9.7a. *Factor 1 variable loadings: Duntulm Formation. Key as in Fig. 9.1a.*

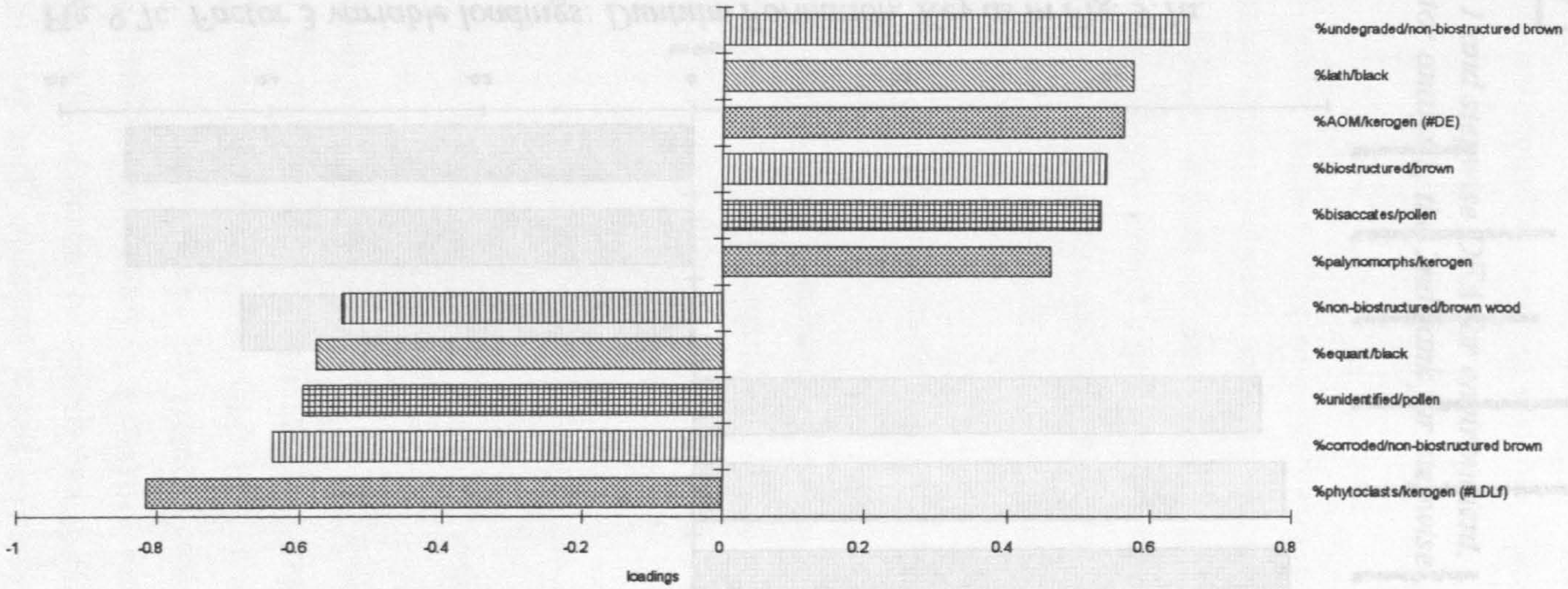


Fig. 9.7b. *Factor 2 variable loadings: Duntulm Formation. Key as in Fig. 9.1a.*

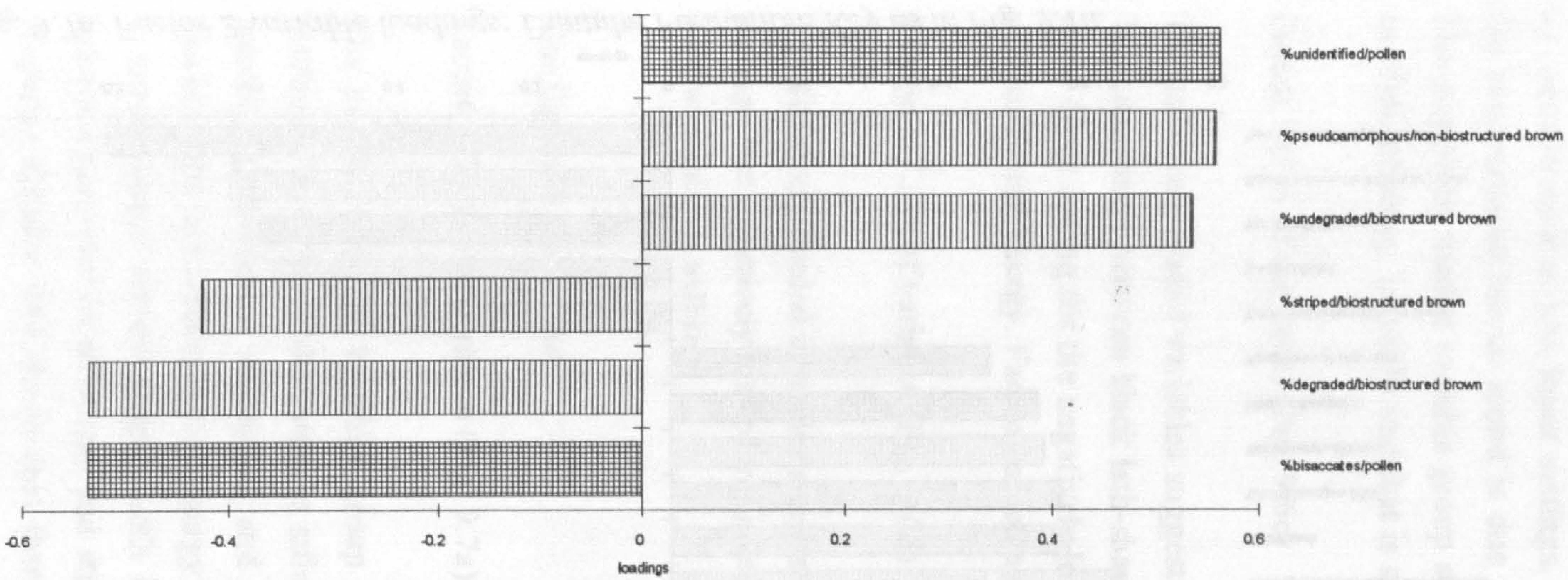


Fig. 9.7c. *Factor 3 variable loadings: Duntulm Formation. Key as in Fig. 9.1a.*

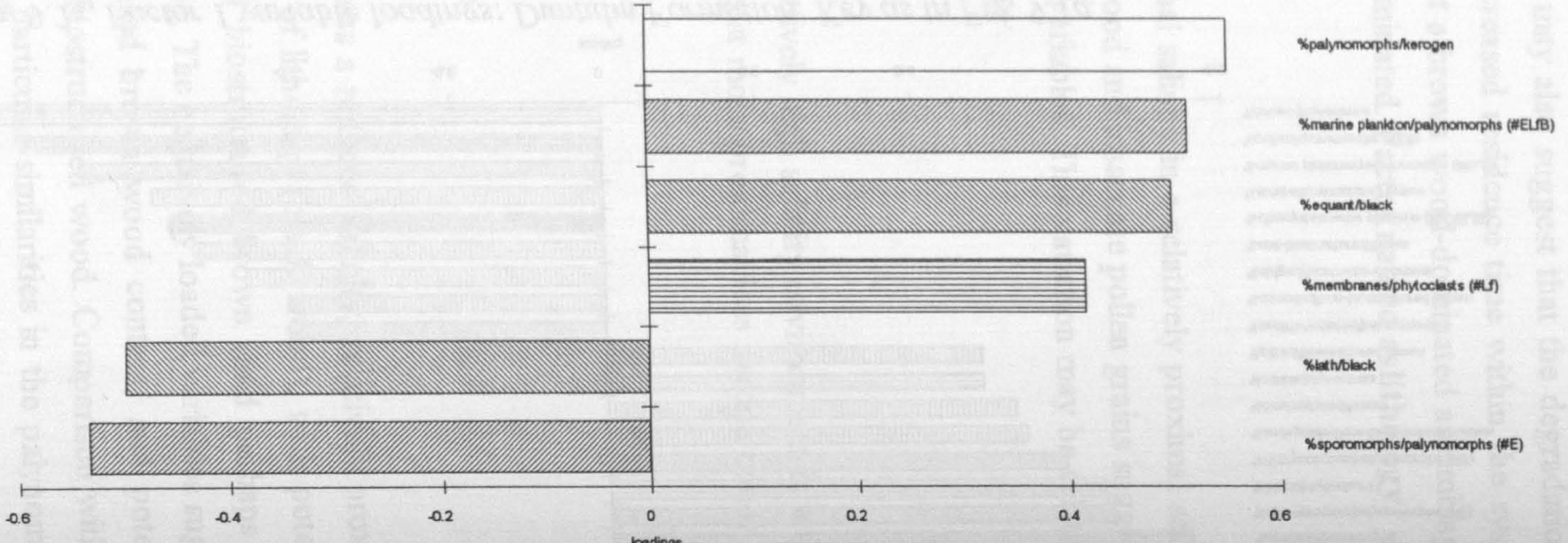


Fig. 9.7d. *Factor 4 variable loadings: Duntulm Formation. Key as in Fig. 9.1a.*

Variable	Ranks
Pollen/sporomorphs	3 / 2
Marine plankton/palynomorphs	5 / 1
Dinocysts/marine plankton	10 / 3
Sporomorphs/palynomorphs	6 / 8
Banded/biostructured brown wood	2 / 7

Table 9.4. *Common variables for in Factor 1 and stepwise DFA for environment, Duntulm Formation. The 1st rank is for factor analysis, the 2nd rank for stepwise DFA.*

Factor 2: 14.9% of variance (Fig. 9.7b)

The positively loaded variables group suggests distal/finer grained facies with sufficiently reducing conditions to preserve AOM and also exhibiting potential selective preservation of biostructured brown and undegraded non-biostructured brown wood. The positively loaded variables group suggests relatively proximal, possibly coarser grained sedimentation. Factor named as **proximal-distal.**

Factor 3: 8.9% of variance (Fig. 9.7c)

The positively loaded variables group suggests preservation of pseudoamorphous phytoclast particles and undegraded biostructured brown wood in a relatively proximal setting. The negatively loaded variables suggest potential selective preservation of striped biostructured brown wood in a possibly more distal setting (bisaccates of total pollen), with the degradation of the biostructured wood potentially being due to extended transport. Factor named as **selective preservation.**

Factor 4: 6.2% of variance (Fig. 9.7d)

The positively loaded variables from this factor suggest a limestone-dominated association (see Chapter 4.0). The negatively loaded variables are probably due to data closure. Factor named as **lithology.**

Staffin Bay Formation

Factor 1: 19.1% of variance (Fig. 9.8a)

The positively loaded variables from this factor suggest preservation of non-refractory phytoclast types, possibly in a relatively proximal marine setting; further examination shows that these variables are associated in the fine grained sediments of the Upper Ostrea Member (cf. section 10.2.4). The negatively loaded variables group suggests a more refractory phytoclast assemblage in a potentially more distal but less marine setting, and further examination reveals that this variable association is found in the Belemnite Sands Member. This was deposited in a relatively more distal setting (reflected in the black lath wood category), but is coarser grained (reflected in the refractory phytoclast assemblage and increased levels of sporomorphs).

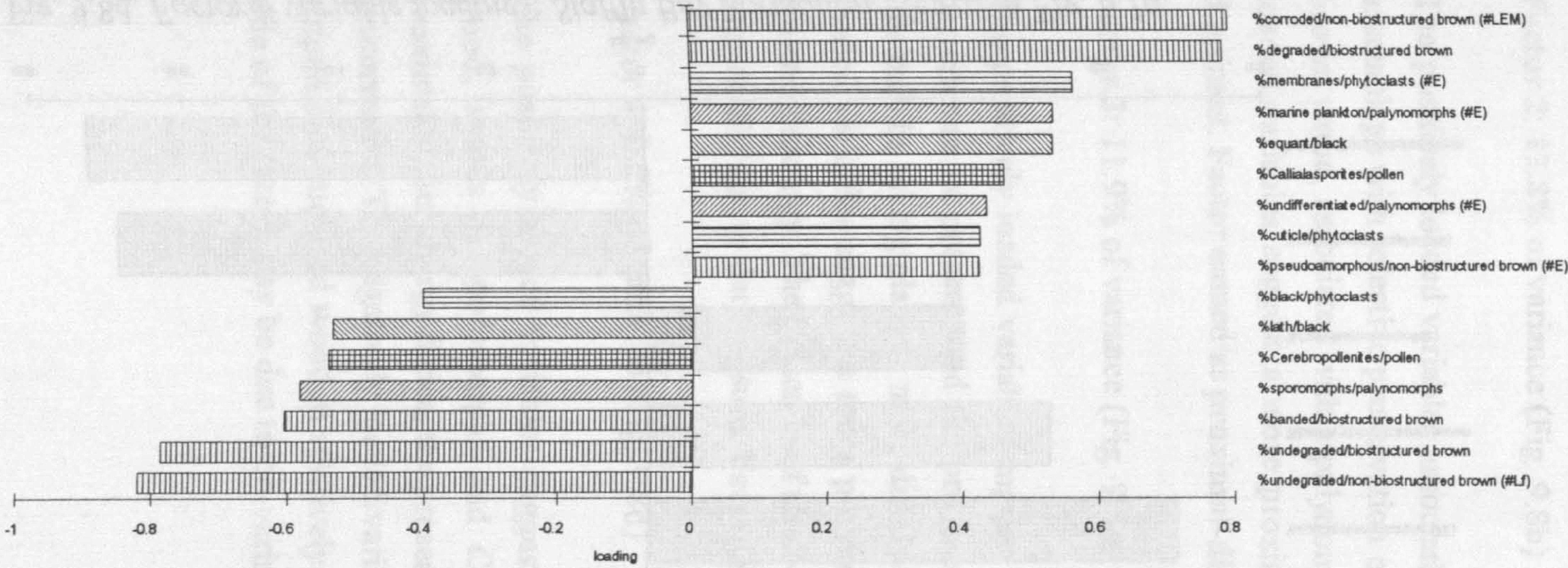


Fig. 9.8a. *Factor 1 variable loadings: Staffin Bay Formation. Key as in Fig. 9.1a.*

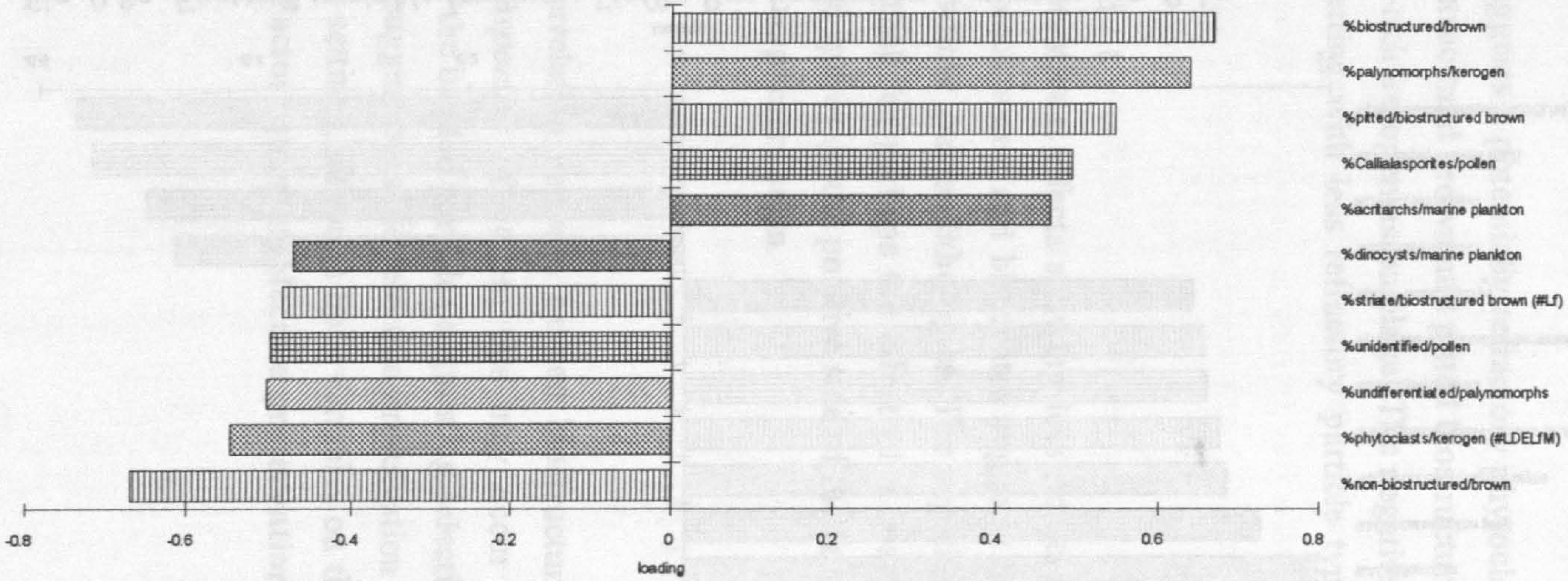


Fig. 9.8b. *Factor 2 variable loadings: Staffin Bay Formation. Key as in Fig. 9.1a.*

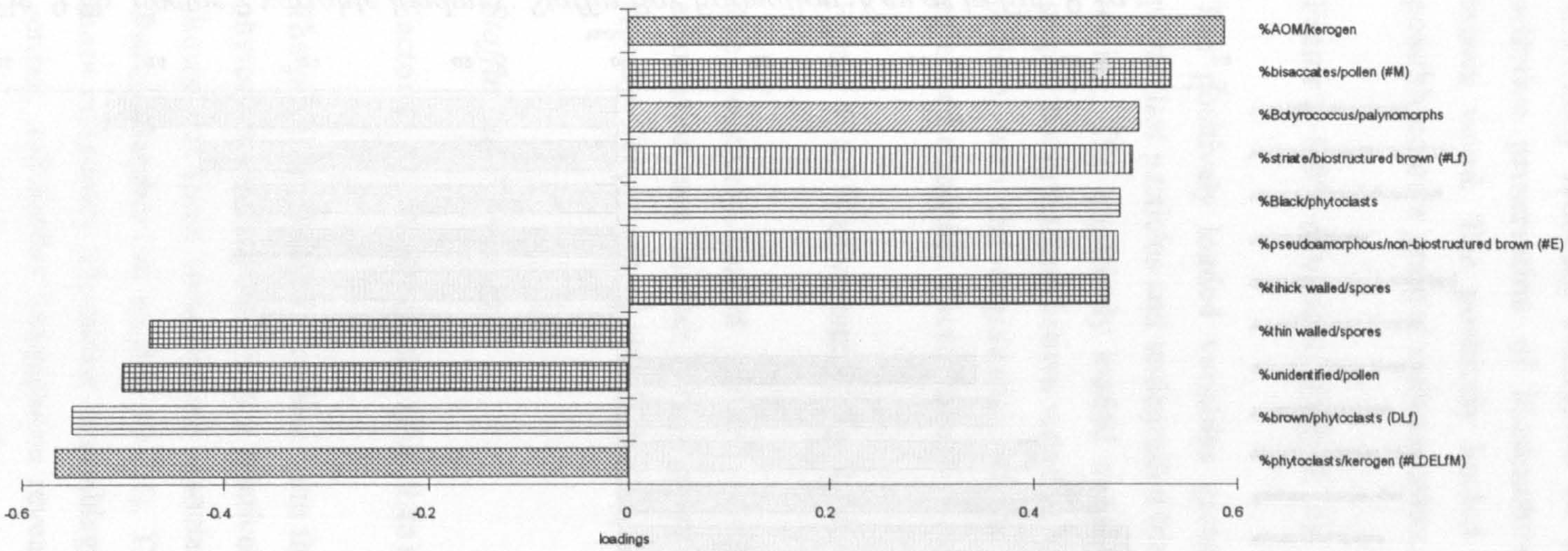


Fig. 9.8c. *Factor 3 variable loadings: Staffin Bay Formation. Key as in Fig. 9.1a.*

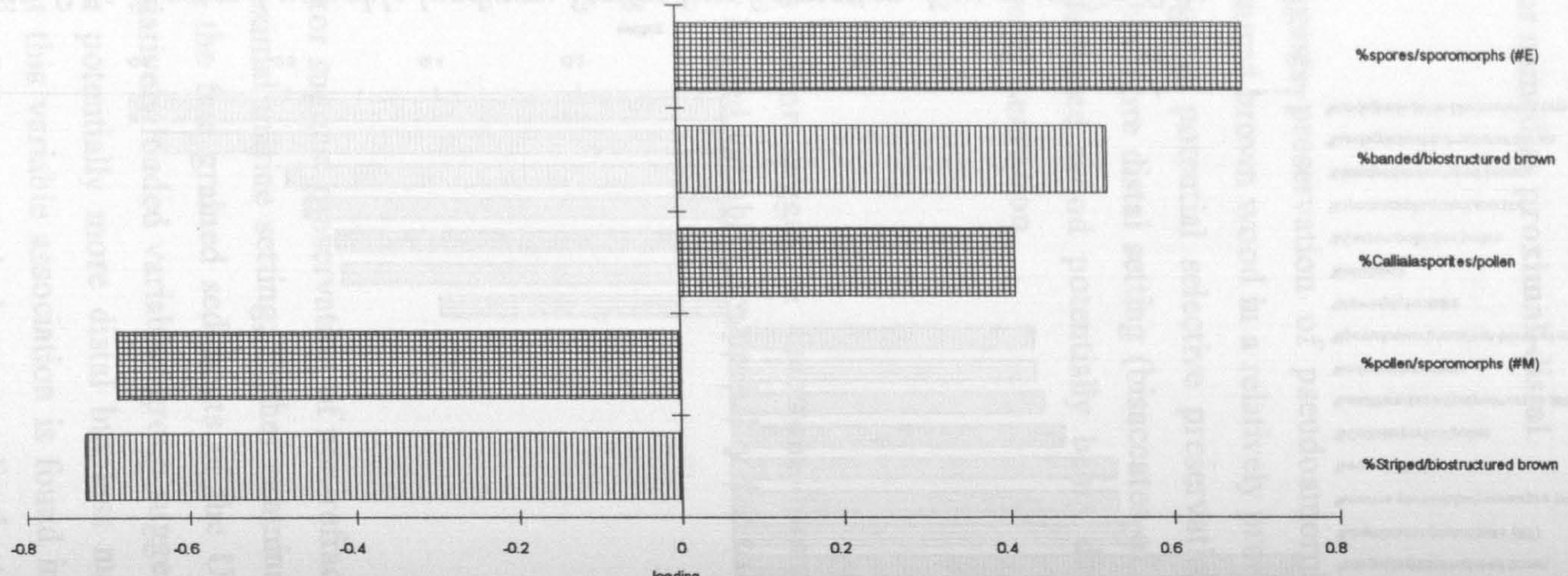


Fig. 9.8d. *Factor 4 variable loadings: Staffin Bay Formation. Key as in Fig. 6.1a.*

Comparison with the stepwise variables lists shows that the environment DFA variables are most common in the factor loadings. Factor named as **environment/member.**

Factor 2: 13.8% of variance (Fig. 9.8b)

The positively loaded variables association suggests a potentially refractory phytoclast assemblage with selective preservation of biostructured brown and pitted biostructured brown wood, associated with a palynomorph-rich kerogen assemblage. The negatively loaded variables suggest a more proximal setting with less refractory particle types dominant. Factor named as **proximal-distal.**

Factor 3: 11.9% of variance (Fig. 9.8c)

The positively loaded variables suggest preservational effects allowing less refractory particles to be present, and the presence of black wood and bisaccates suggests that this may be taking place in more distal settings/finer grained lithologies. The negatively loaded variables suggest a more proximal setting, or perhaps the effect of a coarser grained lithology. The presence of thick-walled spores on the positive side of the factor is probably due to data closure. Factor named as **preservation.**

Factor 4: 9.5% of variance (Fig. 9.8d)

The positively loaded variables suggest a correlation between banded biostructured wood, spores of sporomorphs and *Callialasporites* of pollen; this may occur in proximal/higher energy facies, the presence of the banded particles suggesting selective preservation. The negatively loaded variables suggest possible selective preservation of striped biostructured wood in relatively distal settings, although both variables on this side of the factor may be due to co-variance. Factor named as **selective preservation.**

9.3 Comparison

Due to the large amount of data closure the variables which characterise each factor have been expressed only as the 'type' of parameters which encompass the variation on each factor, such as biostructured brown wood type, brown:black wood ratio, marine plankton type etc. (Table 9.5). Comparison of the factor identities shows that proximal-distal is the most common, occurring six times in total, and three times as Factor 1. Salinity variation occurs five times in one form or another, but only once on Factor 1. Preservation and lithology occur three times each. The occurrence of freshwater-marine and environment-member as the first factor in the Duntulm and Staffin Bay formations (respectively) suggests a locally elevated importance for these factors. Proximal-distal variation seems to be the most important factor overall.

When the variable types which characterise the proximal-distal factors are compared it appears that the most important variables are those from within the brown wood fraction, with both the type of brown wood (biostructured or non-biostructured) and the type of non-biostructured brown wood (undegraded, corroded, or pseudoamorphous) occurring on 4/6 factors. In the case of the salinity factors palynomorph type (sporomorph, marine plankton, or *Botryococcus*) and marine plankton type (dinocyst or acritarch) are present on 3/5 factors. These variables presumably encompass much of the variation due to proximal-distal or salinity changes.

Comparison of the variable types which occur on Factor 1 shows that in all five of the analyses phytoclast type (brown wood, black wood, membranes, or cuticle) shows variation; non-biostructured brown wood and sporomorph type vary in 3/5 Factor 1 loadings. In the case of Factor 2, black wood type and biostructured brown wood type vary in 3/5 analyses. This suggests that a significant proportion of the variance within the datasets is likely to be occurring within these variables.

	Factor 1		Factor 2		Factor 3		Factor4	
	Name	Characterised by	Name	Characterised by	Name	Characterised by	Name	Characterised by
All data	Proximal-distal (terr. input)	Brown:black wood; biostructured:non-biostructured brown wood; unidentified pollen:bisaccates	Salinity/ preservation	Black equant:lath wood; marine plankton type; *Botryococcus*/palynomorphs; AOM/kerogen	Marine vs. non-marine	Sporomorph:marine plankton; spore type; phytoclasts/kerogen	Proximal-distal (energy)	Black equant:lath wood; spore type; non-biostructured brown wood type; AOM/kerogen
Bearreraig Sandstone Formation	Proximal-distal	Brown:black wood; non-biostructured brown wood type; unidentified pollen :bisaccates; marine plankton type; sporomorph type	Selective preservation	Brown:black wood; black equant:lath wood; biostructured brown wood type;	Salinity	Marine plankton type; sporomorphs/palynomorphs; biostructured brown wood type	Preservation	AOM or phytoclasts /kerogen; biostructured & non-biostructured brown wood type
Lealt Shales Formation	Proximal-distal (terr. input)	Major kerogen group; biostructured:non-biostructured brown wood; non-biostructured brown wood type; sporomorph type; sporomorph:*Botryococcus*	Lithology	Phytoclasts/kerogen; brown wood or membranes/phytoclasts; biostructured brown wood type; spore type	Energy	Black equant:lath wood; unident. pollen:bisaccates; marine plankton/ palynomorphs; dinocysts/marine plankton	Salinity	Marine plankton type; unidentified pollen :bisaccates
Duntulm Formation	Freshwater - marine	Brown:black wood; brown wood type (biostructured & non-biostructured); sporomorph/marine plankton /*Botryococcus*; sporomorph type	Proximal-distal	Major kerogen group; black equant:lath wood; biostructured:non-biostructured brown wood; non-biostructured brown wood type; unident. pollen:bisaccates	Preservation	Biostructured brown wood type; pseudoaom/non-biostructured wood; unidentified pollen :bisaccates	Lithology	Black equant:lath wood; palynomorph/kerogen; membranes/phytoclasts; sporomorph:marine plankton
Staffin Bay Formation	Environment/ member	Black wood, membranes, cuticle/phytoclasts; biostructured:non-biostructured brown wood; black equant:lath wood; sporomorph:marine plankton; pollen type	Proximal-distal	Phytoclasts, palynomorphs /kerogen; biostructured:non-biostructured brown wood: biostructured wood type; pollen type; marine plankton type	Preservation	AOM, phytoclasts/kerogen; brown;black wood; striate/biostructured brown; pseudoaom/non-biostructured brown; unidentified pollen:bisaccates; spore type	Lithology?	Biostructured brown wood type; sporomorph type; *Callialasporites*/pollen

Table 9.5. *Factor names and loading characteristics from each of the analyses performed.*

9.4 Summary

Factor analysis has proved useful in summarising the main sources of variation within the datasets; these seem to be proximal-distal setting and palaeosalinity variation. However, while proximal-distal can relate to terrestrial input, environmental energy, and salinity variation, palaeosalinity variation need not necessarily relate to proximal-distal salinity changes. Other factors can also be of increased importance 'locally'. The variables which best reflect the two main controls tend to come from within the brown wood category (proximal-distal) and major palynomorph type category (palaeosalinity). However, there are problems with FA, mostly related to the data closure effects inherent in the dataset, meaning that when one component is high the other has to be low, making it difficult to discover which parameter is truly varying. This means that the identification of the factors by their loadings can be difficult as some variables are likely to be present due to closure effects; this can complicate the identification of factors which are often already composite, although comparison with the variables selected in stepwise DFA can aid in assigning factor identities. However, this is not always possible, as in many cases there is not a sufficiently large number of variables in common.

One potential way to limit the effects of data closure is to log transform the data; this was tested using the Staffin Bay Formation dataset. Simple log (base 10) transformation reduces the skewness of the dataset (i.e. reduces the importance of extreme values; Kovach, 1993). Factor analysis carried out on the log transformed data produced virtually the same results as for the non-transformed dataset, with closure effects just as endemic. A more advanced form of data transformation is logratio transformation, which replaces the proportions with the 'log of the ratio between the proportion and the geometric mean of the sample' (Kovach & Batten, 1994, p. 392). Factor analysis carried out on this logratio transformed data produced very different results to those of the non-transformed data (cf. Kovach & Batten, *ibid.*), but data closure effects were still present, although less marked. This may suggest that the data should be logratio transformed before factor analysis is performed; however, this was not carried out because of the desire to keep the statistical treatment as simple and as consistent as possible.

APPENDIX 9.1

Whole dataset				
Variable	Factor1	Factor2	Factor3	Factor4
foram/ker	-0.1	0.2	0.3	0.1
AOM/ker	0.2	-0.4	0.3	-0.5
phy/ker	-0.7	0.2	-0.5	0.4
paly/ker	0.5	0.4	0.3	0.1
stria/bstr	-0.7	-0.3	-0.2	-0.1
stripe/bstr	0.3	0.3	0.4	0.0
ban/bstr	0.6	0.2	-0.2	0.2
pit/bstr	0.4	-0.1	0.0	0.1
lath/blk	0.1	-0.6	0.0	-0.4
eq/blk	-0.1	0.6	0.0	0.4
blk/phy	0.5	0.2	-0.2	0.0
br/phy	-0.8	0.2	0.1	-0.2
co/nbstr	-0.7	-0.1	0.2	0.4
un/nbstr	0.8	0.2	-0.1	-0.4
psu/nbstr	-0.3	-0.3	0.0	-0.2
cu/phy	0.4	-0.3	-0.2	0.3
mem/phy	0.5	-0.4	0.1	0.2
bstr/br	0.7	-0.1	-0.1	0.2
nbstr/br	-0.7	0.1	0.1	-0.2
un/bstr	0.5	0.5	-0.2	-0.4
deg/bstr	-0.5	-0.5	0.2	0.4
bot/pal	0.5	-0.6	0.0	0.1
undif/pal	-0.5	0.2	0.0	-0.3
mp/pal	0.0	0.4	0.8	-0.1
sporo/pal	-0.2	0.0	-0.8	0.1
tnw/sp	0.0	0.1	-0.5	-0.5
tkw/sp	0.1	-0.1	0.5	0.5
sp/sporo	0.5	0.5	-0.4	0.2
up/tp	-0.8	0.1	-0.3	0.0
cal/tp	0.1	0.4	0.5	0.1
bis/tp	0.7	-0.2	0.2	0.0
tp/sporo	-0.5	-0.5	0.4	-0.2
din/mp	-0.4	0.4	0.3	-0.4
ac/mp	0.3	-0.6	-0.1	0.0
tas/mp	0.0	0.0	-0.1	0.2
lei/mp	0.0	0.1	0.1	0.0

Table 9.6. Complete factor loadings for the whole dataset analysis. Key to abbreviations in Table 9.11.

Bearreraig Sandstone Formation				
Variable	Factor1	Factor2	Factor3	Factor4
foram/ker	0.2	-0.1	0.0	-0.1
AOM/ker	0.4	-0.1	-0.3	-0.7
phy/ker	-0.5	0.3	0.3	0.5
paly/ker	0.3	-0.6	0.0	0.3
stria/bstr	0.0	0.8	0.1	0.3
stripe/bstr	0.1	-0.6	-0.3	-0.2
ban/bstr	0.0	-0.5	0.4	-0.4
pit/bstr	-0.1	-0.3	-0.3	0.2
lath/blk	0.1	0.7	0.2	-0.3
eq/blk	-0.1	-0.7	-0.2	0.3
blk/phy	0.5	-0.6	0.1	-0.2
br/phy	-0.6	0.6	-0.2	0.3
co/nbstr	-0.7	-0.3	-0.1	0.3
un/nbstr	0.8	-0.1	0.0	0.1
psu/nbstr	0.5	0.4	0.1	-0.5
cu/phy	-0.2	0.2	0.2	0.0
mem/phy	0.1	0.7	0.0	0.0
bstr/br	0.8	0.0	0.1	0.3
nbstr/br	-0.8	0.0	-0.1	-0.3
un/bstr	0.2	-0.4	0.7	0.0
deg/bstr	-0.2	0.4	-0.7	0.0
bot/pal	0.2	0.1	0.2	0.2
undif/pal	0.0	-0.2	0.2	0.6
mp/pal	0.1	0.1	0.4	-0.3
sporo/pal	-0.1	0.1	-0.5	-0.2
tnw/sp	0.0	-0.1	0.0	0.3
tkw/sp	0.4	0.4	0.0	-0.1
sp/sporo	0.8	0.2	-0.2	0.3
up/tp	-0.7	-0.1	-0.1	-0.2
cal/tp	0.7	0.3	-0.1	0.1
cer/tp	0.1	0.2	0.1	0.1
bis/tp	0.6	0.0	0.1	0.2
tp/sporo	-0.8	-0.2	0.2	-0.3
din/mp	0.4	-0.1	-0.5	0.0
ac/mp	-0.4	0.2	0.5	0.0
tas/mp	-0.1	-0.2	0.1	0.1

Table 9.7. Complete factor loadings for the Bearreraig Sandstone Formation analysis. Key to abbreviations in Table 9.11.

Lealt Shales Formation				
Variable	Factor1	Factor2	Factor3	Factor4
AOM/ker	-0.8	-0.2	-0.2	0.0
phy/ker	0.6	0.4	0.0	-0.2
paly/ker	0.7	-0.2	0.3	0.2
stria/bstr	0.0	0.2	-0.1	0.1
stripe/bstr	0.0	-0.1	-0.2	0.0
ban/bstr	-0.1	0.0	0.2	-0.3
pit/bstr	0.2	-0.2	0.1	0.5
lath/blk	-0.2	0.1	-0.4	0.0
eq/blk	0.2	-0.1	0.4	0.0
blk/phy	-0.5	-0.1	-0.1	0.0
br/phy	0.3	-0.5	0.0	-0.1
co/nbstr	0.7	0.2	0.3	-0.1
un/nbstr	-0.7	-0.3	-0.3	0.0
psu/nbstr	-0.3	0.4	0.0	0.3
cu/phy	0.4	0.1	-0.3	-0.4
mem/phy	-0.2	0.5	0.4	0.3
bstr/br	0.8	0.1	-0.2	0.1
nbstr/br	-0.8	-0.1	0.2	-0.1
un/bstr	0.3	-0.7	0.2	0.2
deg/bstr	-0.3	0.7	-0.2	-0.2
bot/pal	-0.7	0.2	-0.3	0.2
undif/pal	-0.2	0.1	0.5	-0.2
mp/pal	-0.2	-0.3	0.7	-0.1
sporo/pal	0.7	-0.1	-0.2	-0.1
tnw/sp	-0.1	-0.7	0.0	0.1
tkw/sp	0.2	0.5	-0.2	-0.2
sp/sporo	0.6	-0.1	-0.2	-0.1
up/tp	-0.2	0.1	0.5	-0.7
cal/tp	0.3	0.1	0.0	0.1
cer/tp	0.4	-0.2	-0.1	-0.2
bis/tp	0.1	-0.1	-0.5	0.7
tp/sporo	-0.6	0.1	0.2	0.1
din/mp	0.0	0.3	0.5	0.6
ac/mp	-0.3	-0.4	-0.4	-0.5
tas/mp	0.0	0.1	0.1	0.1

Table 9.8. Complete factor loadings for the Lealt Shales Formation analysis. Key to abbreviations in Table 9.11.

Duntulm Formation				
Variable	Factor1	Factor2	Factor3	Factor4
foram/ker	-0.3	0.0	-0.2	0.2
AOM/ker	-0.3	0.6	0.3	-0.3
phy/ker	0.3	-0.8	-0.1	-0.1
paly/ker	0.0	0.5	-0.2	0.6
stria/bstr	-0.6	-0.2	0.2	-0.1
stripe/bstr	-0.5	0.1	-0.4	0.1
ban/bstr	0.8	-0.1	0.2	0.1
pit/bstr	0.5	0.3	0.2	-0.2
lath/blk	-0.1	0.6	0.0	-0.5
eq/blk	0.1	-0.6	0.0	0.5
blk/phy	0.6	0.1	0.4	0.1
br/phy	-0.8	-0.1	-0.2	-0.2
co/nbstr	-0.4	-0.6	-0.4	-0.1
un/nbstr	0.5	0.7	0.2	0.2
psu/nbstr	-0.3	0.1	0.6	0.0
cu/phy	0.5	-0.1	-0.4	0.0
mem/phy	0.2	0.3	-0.2	0.4
bstr/br	0.5	0.5	-0.3	0.1
nbstr/br	-0.5	-0.5	0.3	-0.1
un/bstr	0.4	0.3	0.5	0.0
deg/bstr	-0.4	-0.3	-0.5	0.0
bot/pal	0.6	-0.3	-0.3	-0.2
undif/pal	-0.4	0.1	0.3	0.2
mp/pal	-0.7	0.3	0.0	0.5
sporo/pal	0.7	-0.3	0.0	-0.5
tnw/sp	0.4	0.3	0.0	-0.2
tkw/sp	-0.3	-0.3	0.1	0.1
sp/sporo	0.8	-0.3	-0.2	0.2
up/tp	0.0	-0.6	0.6	0.2
cal/tp	0.0	0.4	-0.2	0.0
bis/tp	0.0	0.5	-0.5	-0.2
tp/sporo	-0.8	0.3	0.2	-0.2
din/mp	-0.6	0.3	0.2	0.1
ac/mp	0.2	-0.2	0.1	0.1
tas/mp	0.1	-0.1	0.0	0.2
lei/mp	-0.1	0.0	0.4	-0.1

Table 9.9. Complete factor loadings for the Duntulm Formation analysis. Key to abbreviations in Table 9.11.

Staffin Bay Formation				
Variable	Factor1	Factor2	Factor3	Factor4
foram/ker	0.2	0.2	-0.1	0.0
AOM/ker	-0.4	0.0	0.6	-0.2
phy/ker	0.2	-0.5	-0.6	0.1
paly/ker	0.3	0.6	0.0	0.2
stria/bstr	0.4	-0.5	0.5	0.0
stripe/bstr	0.3	-0.1	-0.2	-0.7
ban/bstr	-0.6	0.0	-0.2	0.5
pit/bstr	-0.1	0.5	0.2	0.4
lath/blk	-0.5	0.3	0.3	-0.1
eq/blk	0.5	-0.3	-0.3	0.1
blk/phy	-0.4	-0.3	0.5	0.3
br/phy	0.3	0.2	-0.6	-0.4
co/nbstr	0.8	-0.2	-0.3	0.2
un/nbstr	-0.8	0.3	0.2	-0.3
psu/nbstr	0.4	-0.3	0.5	0.2
cu/phy	0.4	0.3	-0.1	0.3
mem/phy	0.6	0.2	0.4	0.0
bstr/br	0.2	0.7	-0.4	-0.1
nbstr/br	-0.2	-0.7	0.4	0.1
un/bstr	-0.8	0.2	0.0	0.0
deg/bstr	0.8	-0.2	0.0	0.0
bot/pal	0.0	-0.2	0.5	-0.1
undif/pal	0.4	-0.5	0.2	-0.2
mp/pal	0.5	0.3	0.2	-0.2
sporo/pal	-0.6	-0.1	-0.4	0.3
tnw/sp	-0.3	0.2	-0.5	0.1
tkw/sp	0.3	-0.2	0.5	-0.1
sp/sporo	-0.1	-0.4	-0.3	0.7
up/tp	-0.2	-0.5	-0.5	-0.4
cal/tp	0.5	0.5	0.0	0.4
cer/tp	-0.5	0.0	0.2	0.0
bis/tp	0.3	0.4	0.5	0.3
tp/sporo	0.1	0.4	0.3	-0.7
din/mp	-0.2	-0.5	-0.1	-0.3
ac/mp	0.2	0.5	0.1	0.3

Table 9.10. Complete factor loadings for the Staffin Bay Formation analysis. Key to abbreviations in Table 9.11.

Key:
foram/ker = %foraminiferal linings of kerogen
AOM/ker = %AOM of kerogen
phy/ker = %phytoclasts of kerogen
paly/ker = %palynomorphs of kerogen
stria/bstr = %striate of biostructured brown wood
stripe/bstr = %striped of biostructured brown wood
ban/bstr = %banded of biostructured brown wood
pit/bstr = %pitted of biostructured brown wood
lath/blk = %lath of black wood
eq/blk = %equant of black wood
blk/phy = % black wood of phytoclasts
br/phy = %brown wood of phytoclasts
co/nbstr = %corroded of non-biostructured brown wood
un/nbstr = %undegraded of non-biostructured brown wood
psu/nbstr = %pseudoamorphous of non-biostructured brown wood
cu/phy = %cuticle of phytoclasts
mem/phy = %membranes of phytoclasts
bstr/br = %biostructured of brown wood
nbstr/br = %non-biostructured of brown wood
un/bstr = %undegraded of biostructured brown wood
deg/bstr = %degraded of biostructured brown wood
bot/pal = %*Botryococcus* of palynomorphs
undif/pal = %undifferentiated of palynomorphs
mp/pal = %marine plankton of palynomorphs
sporo/pal = %sporomorphs of palynomorphs
tnw/sp = %thin-walled of spores
tkw/sp = %thick-walled of spores
sp/sporo = %spores of sporomorphs
up/tp = %unidentified of pollen
cal/tp = %*Callialasporites* of pollen
cer/tp = %*Cerebropollenites* of pollen
bis/tp = %bisaccates of pollen
tp/sporo = %pollen of sporomorphs
din/mp = %dinocysts of marine plankton
ac/mp = %acritarchs of marine plankton
tas/mp = %*Tasmanites* type of marine plankton
lei/mp = %leiospheres of marine plankton

Table 9.11. Key to abbreviations used in Tables 9.6 to 9.10.

CHAPTER 10.0
STRATIGRAPHIC TRENDS

10.0 STRATIGRAPHIC TRENDS IN PARAMETERS

10.1 Mean Trends through the Middle Jurassic Succession

The succession examined has been subdivided into the lowest order stratigraphic divisions available (either formation or member). The mean values of selected parameters for each of these units have been calculated and plotted to allow examination of large scale changes in a (sequence) stratigraphic context.

10.1.1 Trends through the Sequences of Morton

Selected parameter values have been examined in terms of the sequences of Morton (1989; section 1.9); the changes in these parameters are summarised in Tables 10.1 to 10.3. Some of the trends reflect local changes in lithology or facies, or sampling bias (e.g. Elgol Sandstone Formation where only the shaley base was sampled); however, there are trends in some parameters that are common to many of the regressive minor sequences or transgressive sequence boundaries.

The black equant:lath wood ratio shows an increase in equant particles in all five minor regressive sequences (no other parameter does this), but two other parameters show consistent trends through three of the sequences: %AOM (decreasing) and the phytoclast preservation index (increasing). Although not applicable to all five sequences, the spore:bisacccate ratio shows increasing spore content in 4/4 of the minor regressive sequences to which it is applicable, marine plankton percentages decrease in 3/4, and the acritarch:dinocyst ratio increases in 2/3. The changes seen in these palynomorph parameters reflect the coarsening-upwards, distal-proximal, marine-marginal marine nature of the regressive sequences.

The black equant:lath wood ratio decreases over four out of the five transgressive sequence and minor sequence boundaries examined; several other parameters show similar changes over the same four boundaries (Table 10.4). The parameters reflect the more argillaceous, distal, and marine nature of the sediments deposited above the sequence boundary compared to those below it. The E1-E2 boundary is anomalous, the unrepresentative nature of the samples from the Elgol Sandstone Formation (which is at the top of minor sequence E1) masking any signs of significant regression. The trends seen through the transgressive sequence (F) reflect the change from argillaceous to coarse grained siliciclastic-dominated sediments in a distal direction.

Major sequence	Overall parameter change	Values	% relative difference
F	AOM decrease	24←5	−79 (2)
Transgressive	Phytoclasts increase	42→70	+67 (3)
Coarsens-upwards	Palynomorphs decrease	33←25	−24 (5)
	PPI decrease	5.0←4.9	−2
Belemnite Sands Mbr.^	Log brown:black wood decrease	0.56←0.51	−10
	Log biostructured:non-biostructured brown no change	na	na
Upper Ostrea Mbr.^	Corroded/non-biostructured brown decrease	38←30	−21
	Log black equant:lath wood increase	0.44→0.55	+25 (4)
	Sporomorphs no change	na	an
	Marine plankton no change	na	na
	Botryococcus no change	na	na
	Log spores:bisaccates decrease	−0.03←−0.1	−233 (1)
	Log unidentified pollen:bisaccates no change	na	na
	Log acritarchs:dinocysts no change	na	na
E	AOM decrease	53←1	−98 (=4)
Regressive	Phytoclasts increase	45→96	+113 (3)
	Palynomorphs no change	na	na
Skudiburgh Fm+.	PPI increase	4.4→8.7	+98 (=4)
Kilmaluag Fm.+	Log brown:black wood decrease	0.59←−0.63	−207 (2)
Duntulm Fm.+	Log biostructured:non-biostructured brown decrease	−1.51←−1.77	−17
	Corroded/non-biostructured brown decrease	76←56	−26
Valtos Sst. Fm.+	Log black equant:lath wood increase	0.1→1.54	+1440 (1)
Lealt Shales Fm.+	Sporomorphs no change	na	na
	Marine plankton decrease	8←1	−88
Elgol Sst. Fm.+	*Botryococcus* increase	0→10	10 (absolute)
Cullaidh Shale Fm.+	Log spores:bisaccates increase	−0.91→−0.33	+64
?Garantiana Clay Mbr.*	Log unidentified pollen:bisaccates decrease	0.67←0.43	−36
	Log acritarchs:dinocysts na	na	na
D	AOM increase	15→20	+35 (5)
Regressive	Phytoclasts decrease	82←73	−11
Coarsens-upwards	Palynomorphs increase	3→7	+135 (1)
	PPI no change	na	na
Rigg Sst. Mbr.*	Log brown:black wood decrease	1.14←0.93	−18
	Log biostructured:non-biostructured brown decrease	−1.25←−1.85	−48 (3)
Holm Sst. Mbr.*	Corroded/non-biostructured brown increase	86→96	+12
	Log black equant:lath wood increase	0.22→0.52	+36 (4)
Udairn Shales Mbr.*	Sporomorphs no change	na	na
	Marine plankton no change	na	na
Ollach Sst. Mbr.*	*Botryococcus* na	na	na
	Log spores:bisaccates increase	−0.27→−0.21	+28
Dun Caan Shales Mbr.*	Log unidentified pollen:bisaccates increase	1.05→1.25	+19
	Log acritarchs:dinocysts increase	−0.65→−0.02	+97 (2)

* = Bearreraig Sandstone Formation; + = Great Estuarine Group; ^ = Staffin Bay Formation
+ = relative increase; − = relative decrease; na = not applicable

Table 10.1. *Parameter changes through each major sequence examined; sequences as defined by Morton. The parameters showing the greatest magnitude of change in each sequence are ranked 1-5 (numbers in parentheses in the last column).*

Environment	Cycle	Parameter change
Alluvial mudflat Freshwater lagoon Marine-brackish lagoon	E3 Skudiburgh Fm. Kilmaluag Fm. Duntulm Fm.	AOM decrease Phytoclasts increase Palynomorphs decrease PPI increase Log brown:black decrease Log biostuctured:non-biostructured decrease Corroded/non-biostructured decrease Black equant:lath increase Sporomorphs increase Marine plankton decrease *Botryococcus* increase Log spores:bisaccates increase
Deltaic Sandbody Fresh-brackish lagoon Fresh-brackish lagoon	E2 Valtos Sst. Fm. Lonfearn Mbr. Kildonnan Mbr.	AOM decrease Phytoclasts increase Palynomorphs decrease Log biostuctured:non-biostructured increase Log black equant:lath increase Marine plankton decrease Log spores:bisaccates increase Log unidentified pollen:bisaccates increase
Deltaic Sandbody Anoxic Basin Stagnating Basin	E1 Elgol Sst. Fm. Cullaidh Shale Fm. ?Garantiana Clay Mbr.	Palynomorphs increase PPI increase Log biostuctured:non-biostructured increase Log black equant:lath increase Marine plankton decrease *Botryococcus* increase Log unidentified pollen:bisaccates decrease
Open marine Open marine Open marine	D2 Rigg Sst. Mbr. Holm Sst. Mbr. Udaim Shales Mbr.	Palynomorphs decrease Log biostuctured:non-biostructured decrease Log black equant:lath increase Log unidentified pollen:bisaccates increase Log acritarchs:dinocysts increase
Open marine Open marine	D1 Ollach Sst. Mbr. Dun Caan Shales Mbr.	AOM decrease Palynomorphs increase Log brown:black decrease Log biostuctured:non-biostructured increase Log black equant:lath increase

Table 10.2. *Selected parameter variation through each regressive cycle in the sequence examined. Only those parameters showing greater than 25% relative change have been considered. Cycles after Morton.*

Environment	Boundary	Parameter change
Alluvial mudflat-transgressive lagoon-barrier bar complex	E3-F Skudiburgh–Staffin Bay fms.	AOM increase Phytoclasts decrease Palynomorphs increase PPI decrease Log brown:black increase Log biostuctured:non-biostructured increase Corroded/non-biostructured decrease Log black equant:lath decrease Marine plankton increase *Botryococcus* decrease Log spores:bisaccates increase Log unidentified pollen:bisaccates decrease
Deltaic sandbody transgressed by marine-brackish lagoon.	E2-E3 Valtos Sst.–Duntulm fms.	AOM increase Log brown:black increase Corroded/non-biostructured increase Log black equant:lath decrease Marine plankton increase *Botryococcus* decrease Log spores:bisaccates decrease Log unidentified pollen:bisaccates increase
Deltaic sandbody transgressed by fresh-brackish lagoon	E1-E2 Elgol Sst.–Lealt Shales fms.	AOM decrease Palynomorphs increase Log biostuctured:non-biostructured increase Marine plankton increase Log unidentified pollen:bisaccates increase Log acritarchs:dinocysts increase
Tidal-subtidal sand transgressed by basin stagnation sequence	D2-E1 Rigg Sst. Fm.–?Garantiana Clay Mbr.	AOM increase Phytoclasts decrease Palynomorphs decrease Log brown:black decrease Log black equant:lath decrease Marine plankton increase Log spores:bisaccates decrease Log unidentified pollen:bisaccates decrease Log acritarchs:dinocysts decrease
Tidal-subtidal sand transgressed by marine shale	D1-D2 Ollach Sst.–Udairn Shales mbrs.	AOM increase Palynomorphs increase PPI decrease Log black equant:lath decrease

Table 10.3. *Selected parameter variation through each transgressive boundary of the sequence examined. Only those parameters showing greater than 25% relative variation have been considered. Boundaries after Morton.*

Parameter	Relative change
AOM/kerogen	increase / very large
Phytoclasts/kerogen	decrease / moderate
Palynomorphs/kerogen	increase / very large
Phytoclast Preservation Index	decrease / minor
Log biostructured:non-biostructured brown wood	increase / moderate
Corroded/non-biostructured brown wood	decrease / minor
Log black equant:lath wood	decrease / large
Sporomorphs/palynomorphs	decrease / minor
Marine plankton/palynomorphs	increase / very large

Table 10.4. *Parameters which most commonly (4/5 cases) show consistent changes over transgressive sequence boundaries. Their average relative changes have been ranked as follows: >100% = very large, 50-99% = large, 25-49% = moderate, <25% = minor.*

10.1.2 Trends in Parameters

Some of the parameters show trends that are independent of the sequences (Fig. 10.1). Within the E3 regressive cycle the percentage of AOM first increases between the Duntulm and Kilmaluag formations, reflecting the change to a restricted lacustrine facies. The percentage of phytoclasts shows an overall decrease from the Dunn Caan Shales Member to the Lonfearn Member in the middle of the Great Estuarine Group; values then increase to the Belemnite Sands Member, reflecting the more coarse grained nature of the units which are present in the upper half of the section. In the case of the percentage of palynomorphs, the increase seen through minor sequence E1 continues into the overlying Kildonnan Member which forms the base of the subsequent E2 cycle.

Within the phytoclast fraction the phytoclast preservation index (PPI) shows an overall increase from the Kildonnan Member to Skudiburgh Formation, reflecting the overall regressive trend, although the values are reasonably stable apart from these two units. A similar trend can be seen in the biostructured:non-biostructured brown wood ratio, which shows a sharp decrease between the Udairn Shales and Holm Sandstone members (Bearreraig Sandstone Formation). There is a significant increase in the range of the PPI in the Lealt-Kilmaluag interval; this corresponds to an increased variability in the %corroded/non-biostructured brown wood, but the decrease after the Kilmaluag Formation is not reflected in the %corroded non-biostructured wood. The increased variation in the PPI also seems to be correlated with greater variation in the %sporomorphs/palynomorphs. The percentage of corroded non-biostructured brown wood shows a decrease from the Rigg Sandstone Member (which marks the top of regressive cycle D2) to the Lonfearn Member of the Lealt Shales Formation (middle of cycle E2), reflecting an increased input of fresh undegraded wood in the more proximal facies which characterise the middle part of the Great Estuarine Group.

Within the palynomorph fraction the percentage of sporomorphs decreases from the Dun Caan Shales to the Lonfearn Member, reflecting the increased contribution from other palynomorph types (especially marine plankton and *Botryococcus*) in the more marginal environments of the lower to middle Great Estuarine Group. The %sporomorphs/palynomorphs then shows an overall increase through the rest of the units examined.

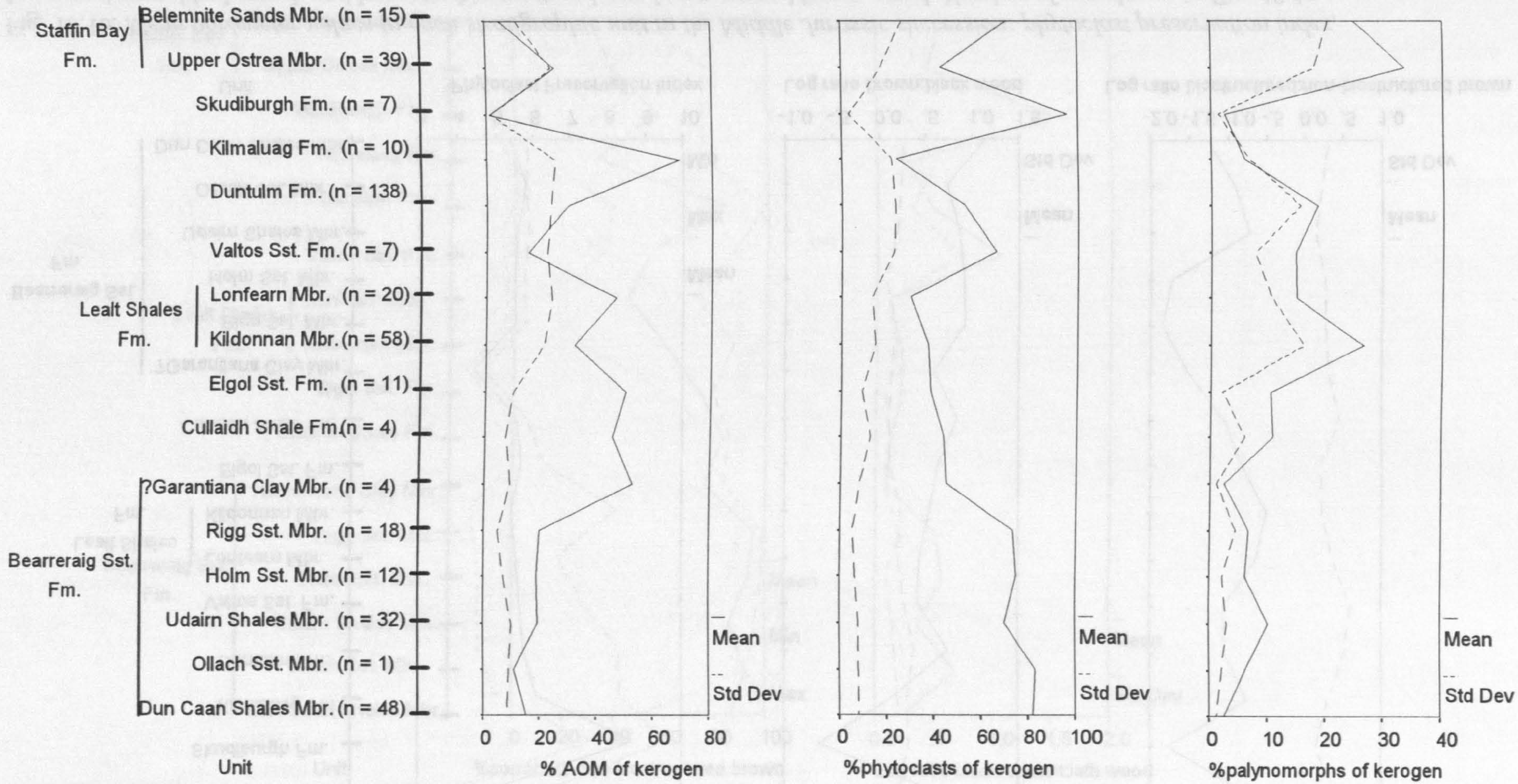


Fig. 10.1a. *Mean parameter values for each stratigraphic unit in the Middle Jurassic succession: major kerogen groups.*

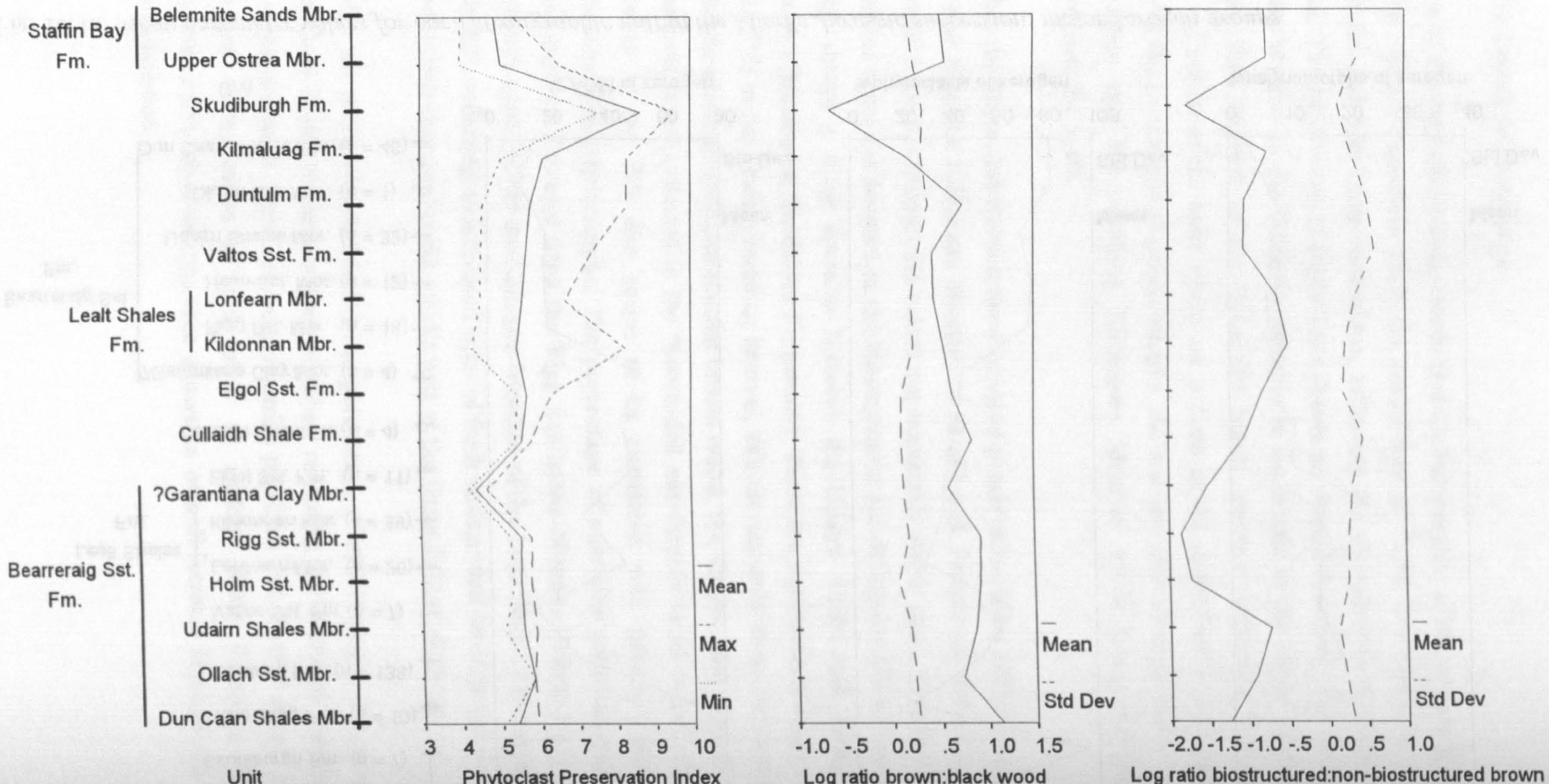


Fig. 10.1b. *Mean parameter values in each stratigraphic unit in the Middle Jurassic succession: phytoclast preservation index, log ratio brown:black wood, and log ratio biostructured:non-biostructured brown wood. Number of samples as in Fig. 10.1a.*

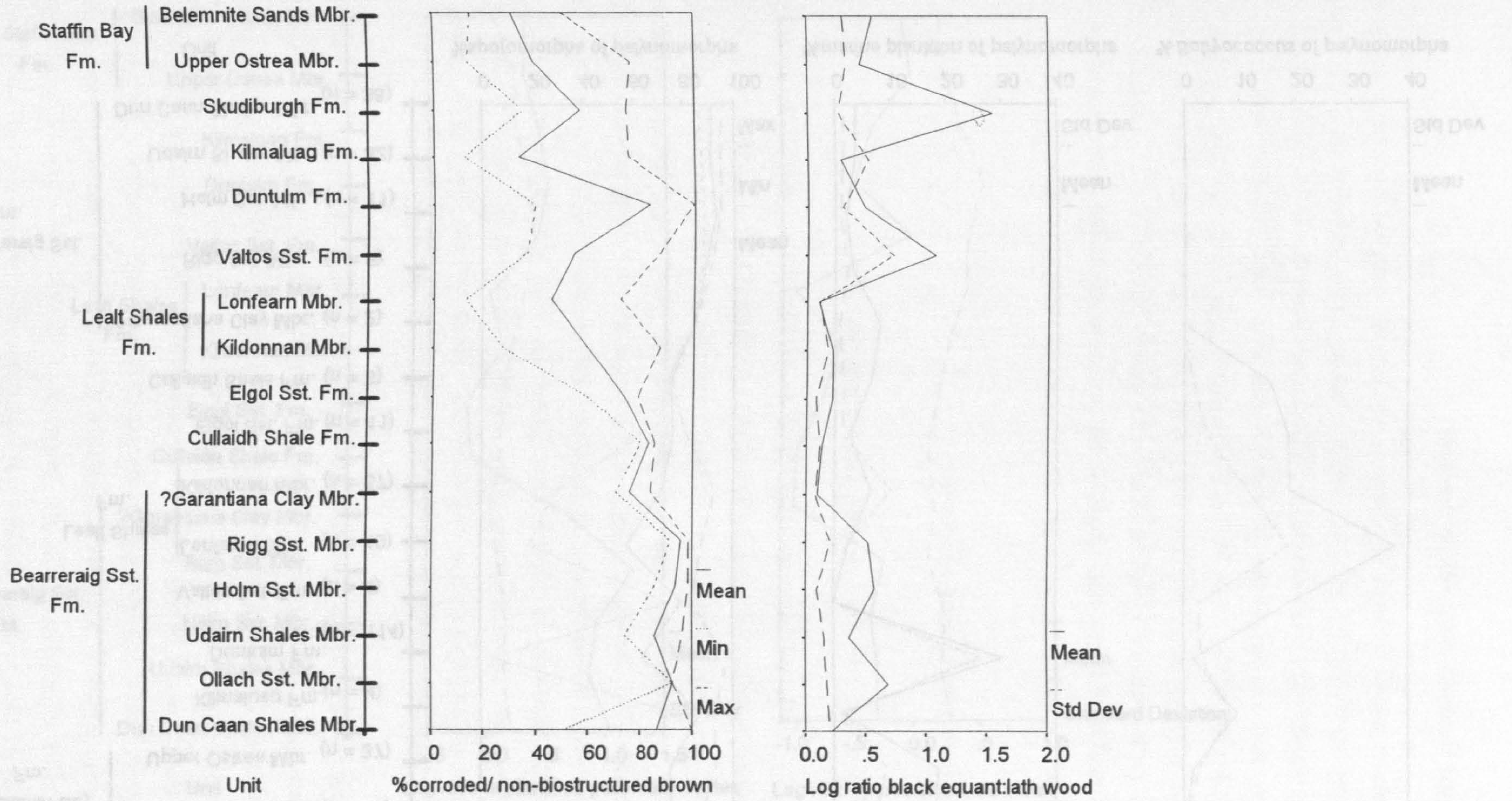


Fig. 10.1c. *Mean parameter values in each stratigraphic unit in the Middle Jurassic succession; %corroded/non-biostructured wood, and log black equant:lath wood. Number of samples as in Fig. 10.1a.*

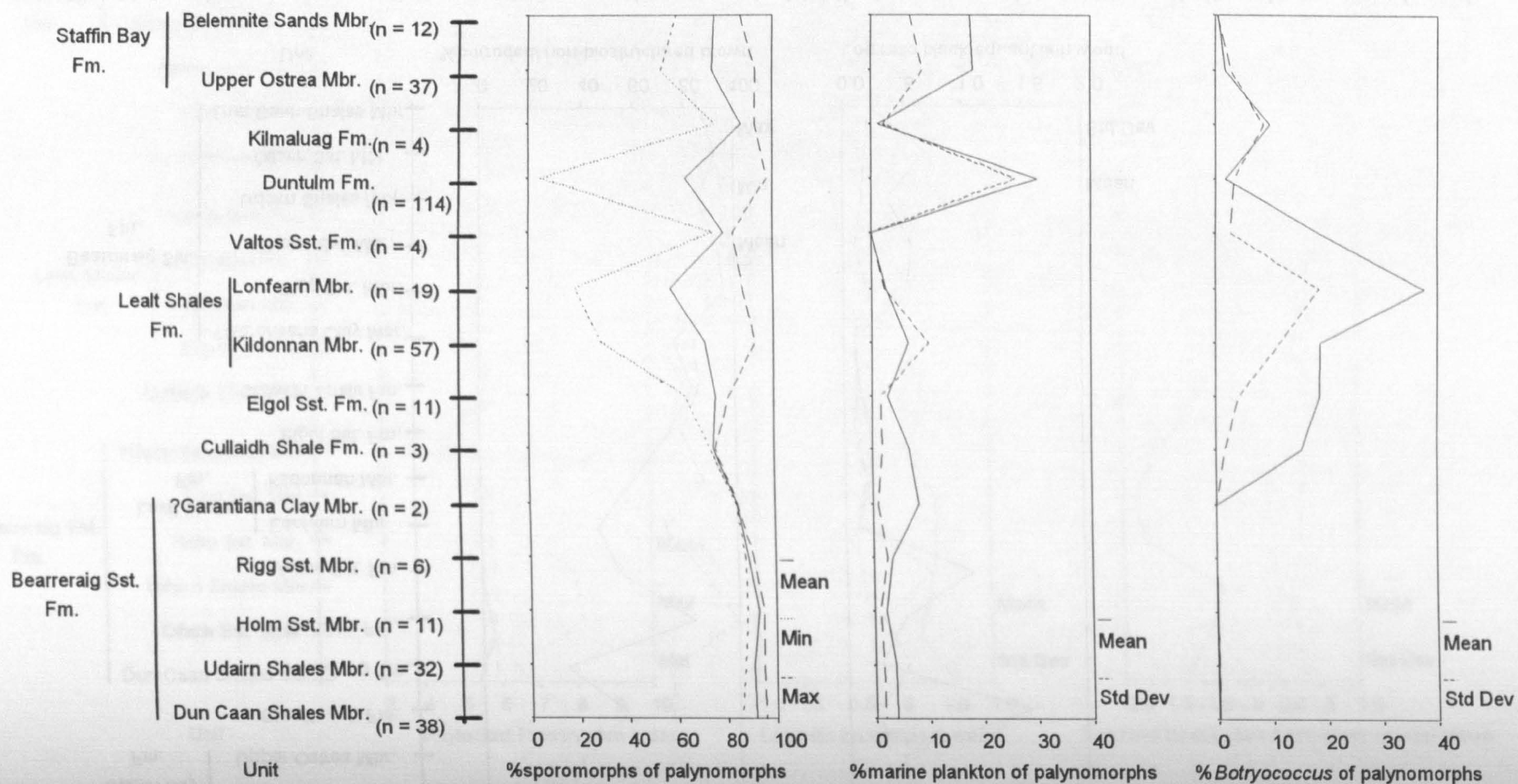


Fig. 10.1d. *Mean parameter values in each stratigraphic unit in the Middle Jurassic succession: major palynomorph groups.*

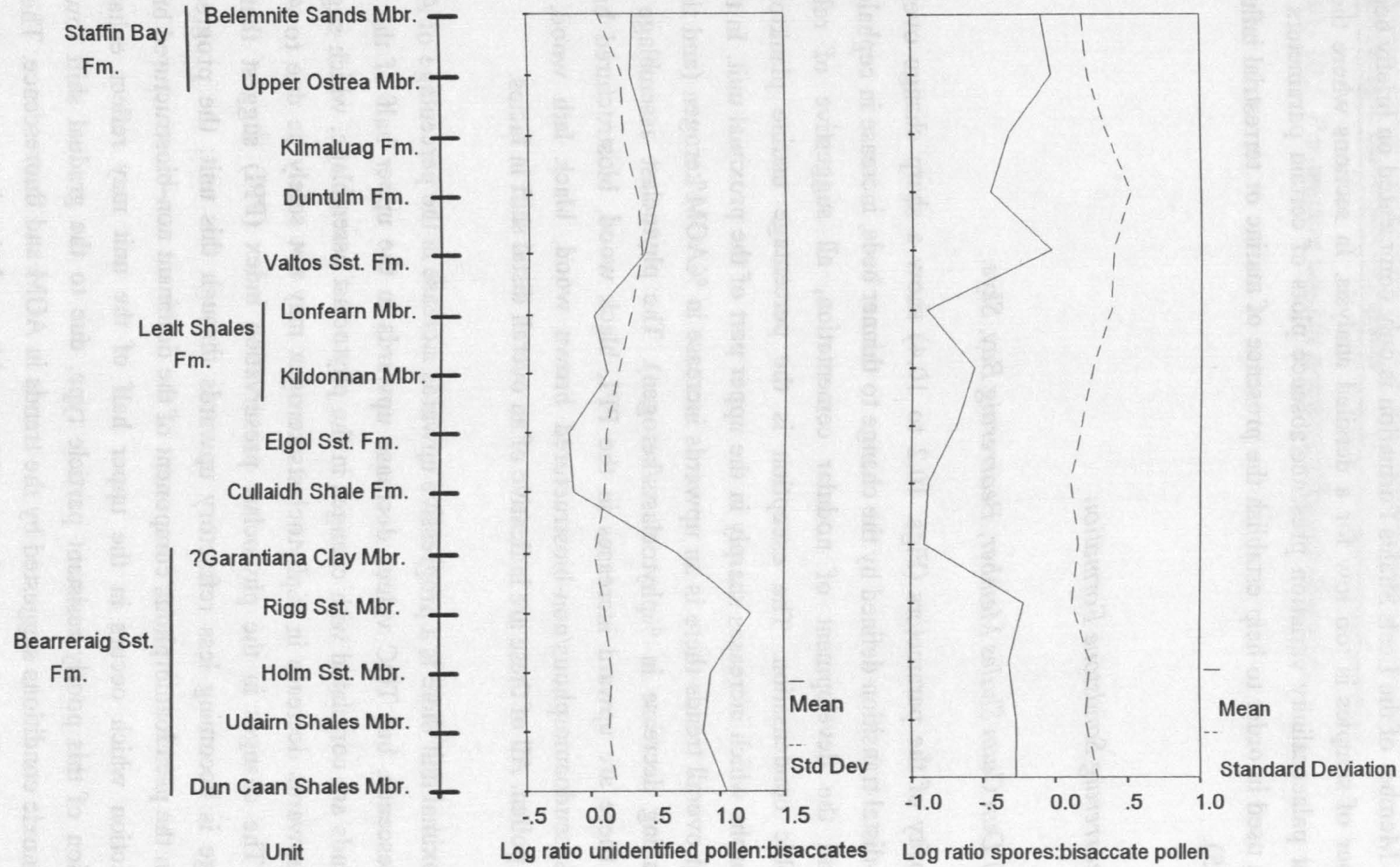


Fig. 10.1e. *Mean parameter values in each stratigraphic unit in the Middle Jurassic succession: log ratio unidentified pollen:bisaccates, and log ratio spores:bisaccates. Number of samples as in Fig. 10.1d.*

10.2 Trends through each Major Section

The parameter trends through the five major sections sampled have been examined in the form of stratigraphic plots of sample values. This includes the two from the Bearreraig Sandstone, one composite section each from the Duntulm and Staffin Bay formations, and one from the Kildonnan Member (Lealt Shales Formation). The Lonfearn Member of the Lealt Shales Formation is only commented on briefly because the number of samples is too low for a detailed analysis. In sections where there is significant palaeosalinity variation presence/absence plots of certain parameters have also been used in order to help establish the presence of marine or terrestrial influence (Table 1.5).

10.2.1 Bearreraig Sandstone Formation

10.2.1 (a) Dun Caan Shales Member, Bearreraig Bay, Skye.

The majority of the parameters (Figs. 10.2 to 10.4) show a sharp change over the proximal-distal transition defined by the change to thinner beds, increase in cephalopod fossils and the development of nodular cementation, all suggestive of relative stratigraphic condensation. The exception is the percentage marine plankton of palynomorphs which increases sharply in the upper part of the proximal unit. In terms of general overall trends there is an upwards increase in %AOM/kerogen (and thus a corresponding decrease in %phytoclasts/kerogen). The phytoclast assemblage also changes: there are upward increases in the PPI, black wood, biostructured brown wood, %pseudoamorphous/non-biostructured brown wood, black lath wood, and bisaccate pollen. All of these are indicative of an overall distal shift in facies.

In the proximal unit there is a progressive upwards increase in the percentage of AOM and fluorescence, but TOC values decrease upwards in the upper half of the unit. These trends are correlated with changes in the phytoclast assemblage, which suggest that the upwards decrease in %phytoclasts/kerogen may not solely be due to AOM dilution. The changes in the phytoclast preservation index (PPI) suggest that the assemblage is becoming less refractory upwards through this unit; the progressive increase in the pseudoamorphous component of the dominant non-biostructured brown wood fraction which occurs in the upper half of the unit may reflect enhanced preservation of this poorly resistant particle type, due to the gradual shift towards dysoxic-anoxic conditions suggested by the trends in AOM and fluorescence. There is also a change in the palynomorph assemblage with a relative increase in bisaccate

Botryococcus	Acritarchs
Pollen clusters	Leiospheres
Spore tetrads	*Tasmanites* type algae
Well preserved cuticle	Foraminiferal linings
Macroscopic plant fragments	Dinocysts
Lignite	?Dinocysts
Macroscopic carbonaceous grains	

Table 10.5. *Parameters used in presence/absence diagrams.*

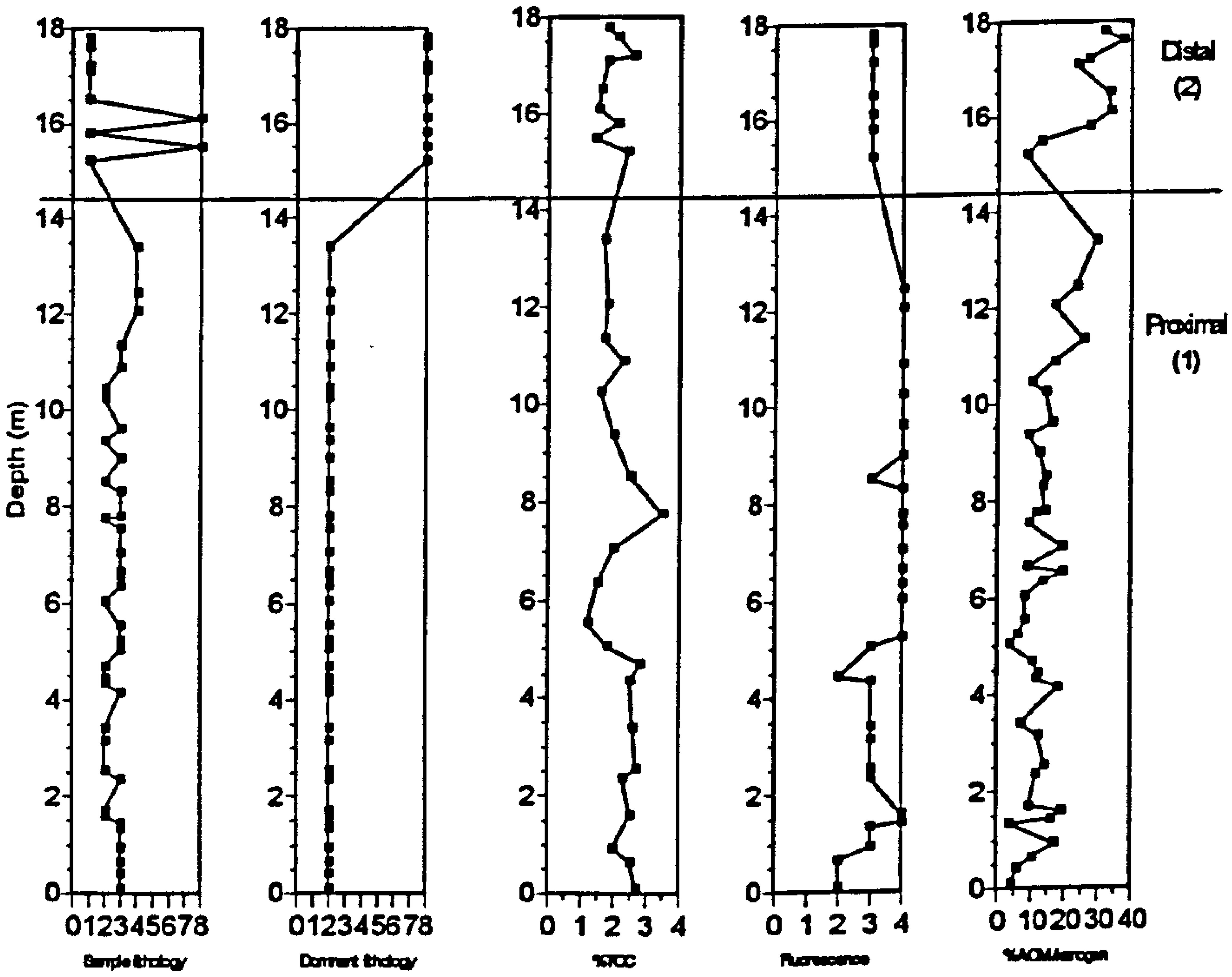


Fig. 10.2. *Selected parameter values through the Dun Caan Shales Member (Bearreraig Sst. Fm.) type section.*

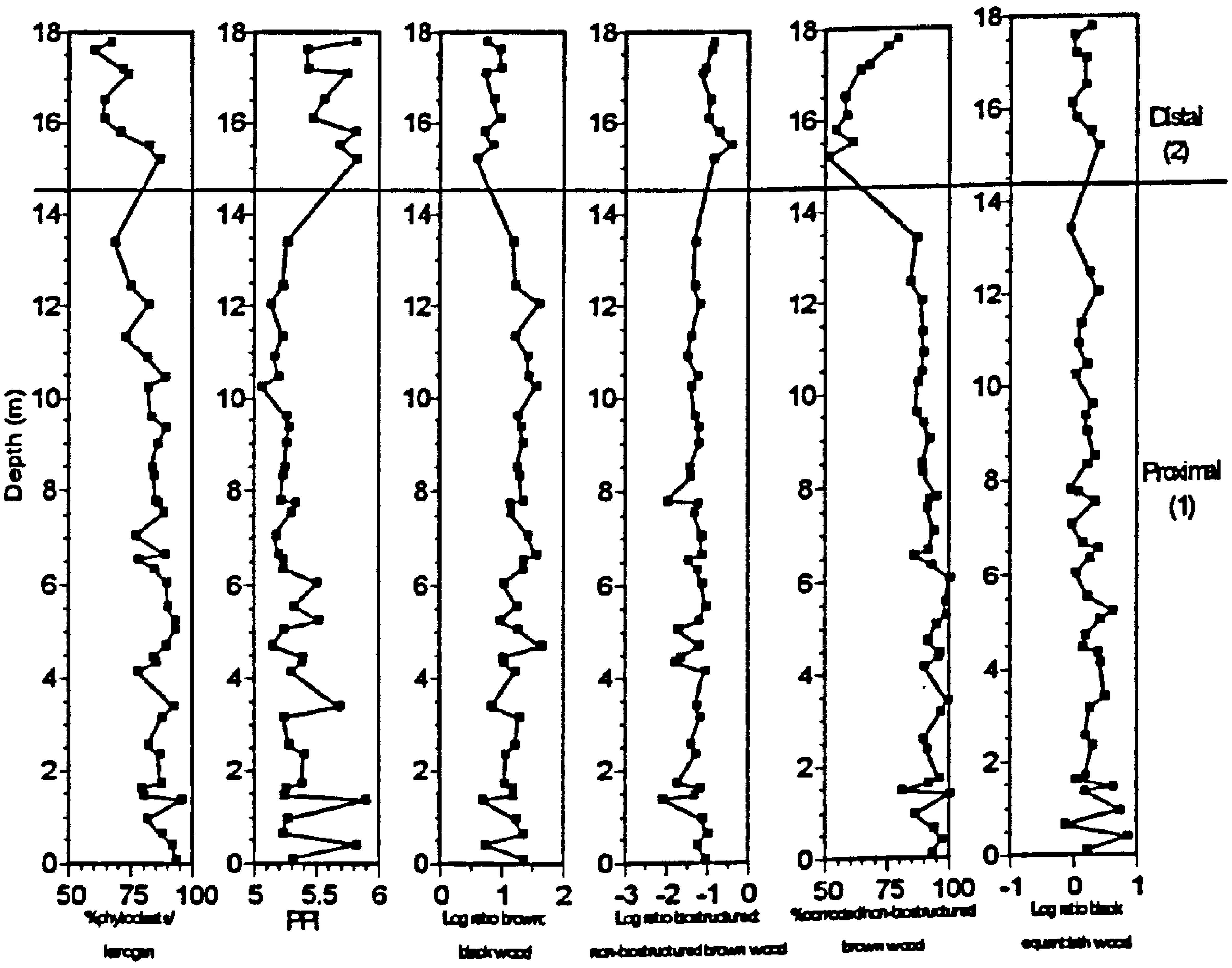


Fig. 10.3. *Selected parameter values from the phytoclast group through the Dun Caan Shales Member (Bearreraig Sst. Fm.) type section.*

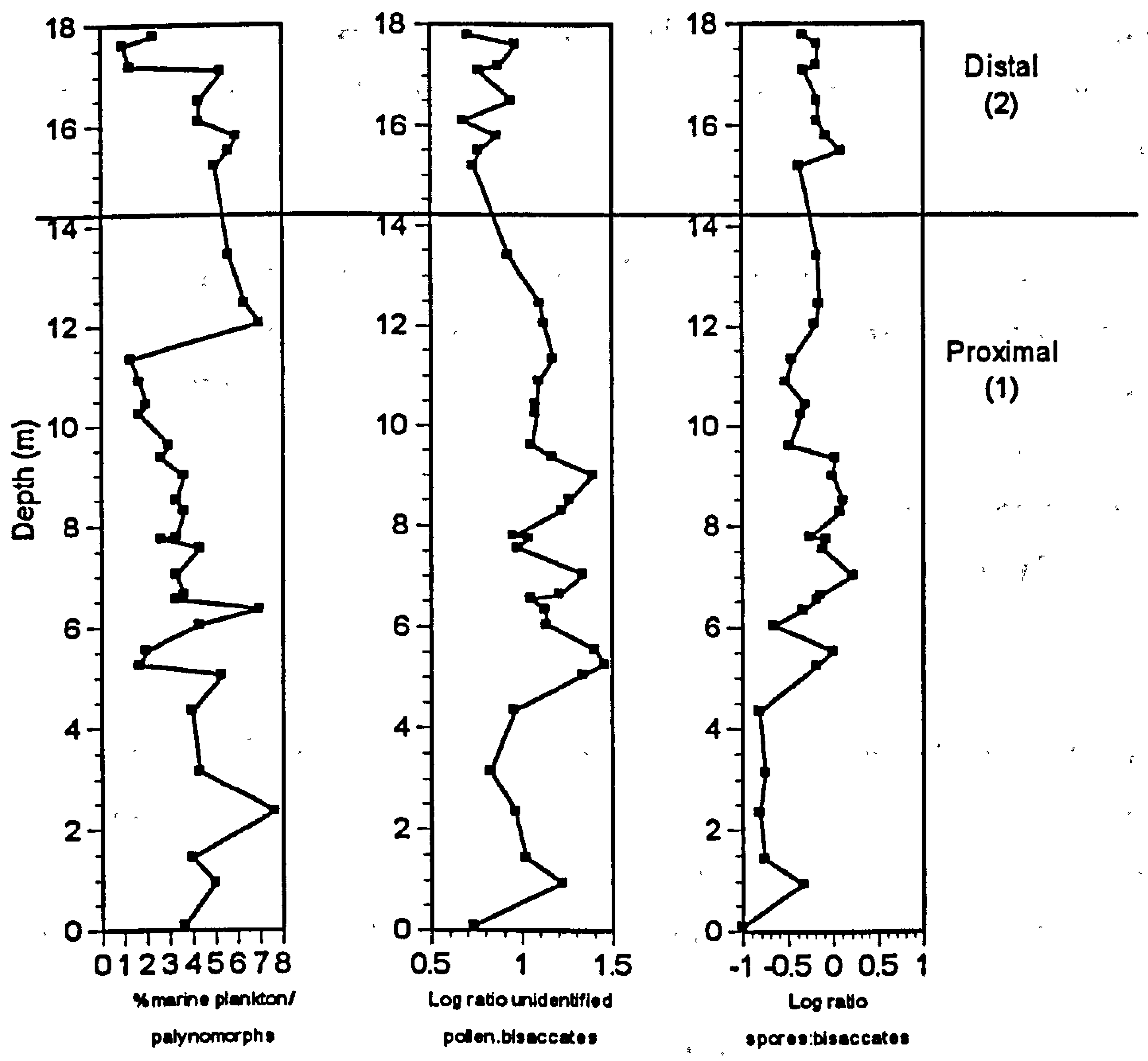


Fig. 10.4. *Selected parameter values from the palynomorph group through the Dun Caan Shales Member (Bearreraig Sst. Fm.) type section.*

pollen grains through the unit, particularly the mid-upper part. Together with the AOM and fluorescence changes, this may suggest a gradual shift to more distal conditions through this unit.

In the distal unit AOM percentages are higher, but fluorescence values are lower than those in the upper part of the proximal unit (perhaps due to more prolonged degradation at lower sediment accumulation rates). The increased PPI suggests a more refractory phytoclast assemblage, but pseudoamorphous percentages are also increased possibly reflecting increased transport distance from the phytoclast source or increased preservation. The more distal setting is also reflected in the relatively increased levels of bisaccates and marine plankton.

This proximal unit can be internally divided into two or possibly three palynofacies units, a lower unit from 0-2m characterised by large variability in parameter values, a middle unit (2 to 5-7m) in which the parameters are mostly stable, but do show some significant variability, and an upper unit from 5-7 to 14-15m, where the parameters are more uniform, but show progressive change. Combining these with the distal unit characterised by a major step from the unit below, and stable or progressive change within the unit, gives a total of four palynofacies units for this section. The palynofacies units are considered further in section 10.3.

10.2.1 (b) Udairn Shales-Holm Sandstone Member, Bearreraig Bay, Skye.

The regressive coarsening-upward nature of this section is reflected in the upward decrease in TOC and the increase in percentage phytoclasts, non-biostructured brown wood, corroded of non-biostructured brown wood, black equant wood, and unidentified pollen (Figs. 10.5 to 10.7). The unit boundaries are generally not marked by sharp changes in parameter values, apart from the boundary between the two members where there is a sharp increase in non-biostructured brown wood, and the corroded fraction of this component; this suggests that although the lithological change here is gradational, the shift to more proximal conditions is marked by a sharp change in some aspects of the phytoclast assemblage.

The section can be divided into four possible palynofacies units: a lower unit from the base to 87-89m characterised by progressive change combined with significant variability in the parameters, a unit from 87-89 to 92m where parameter values are variable, a unit from 92 to 104m (the base of which is often characterised by a sharp

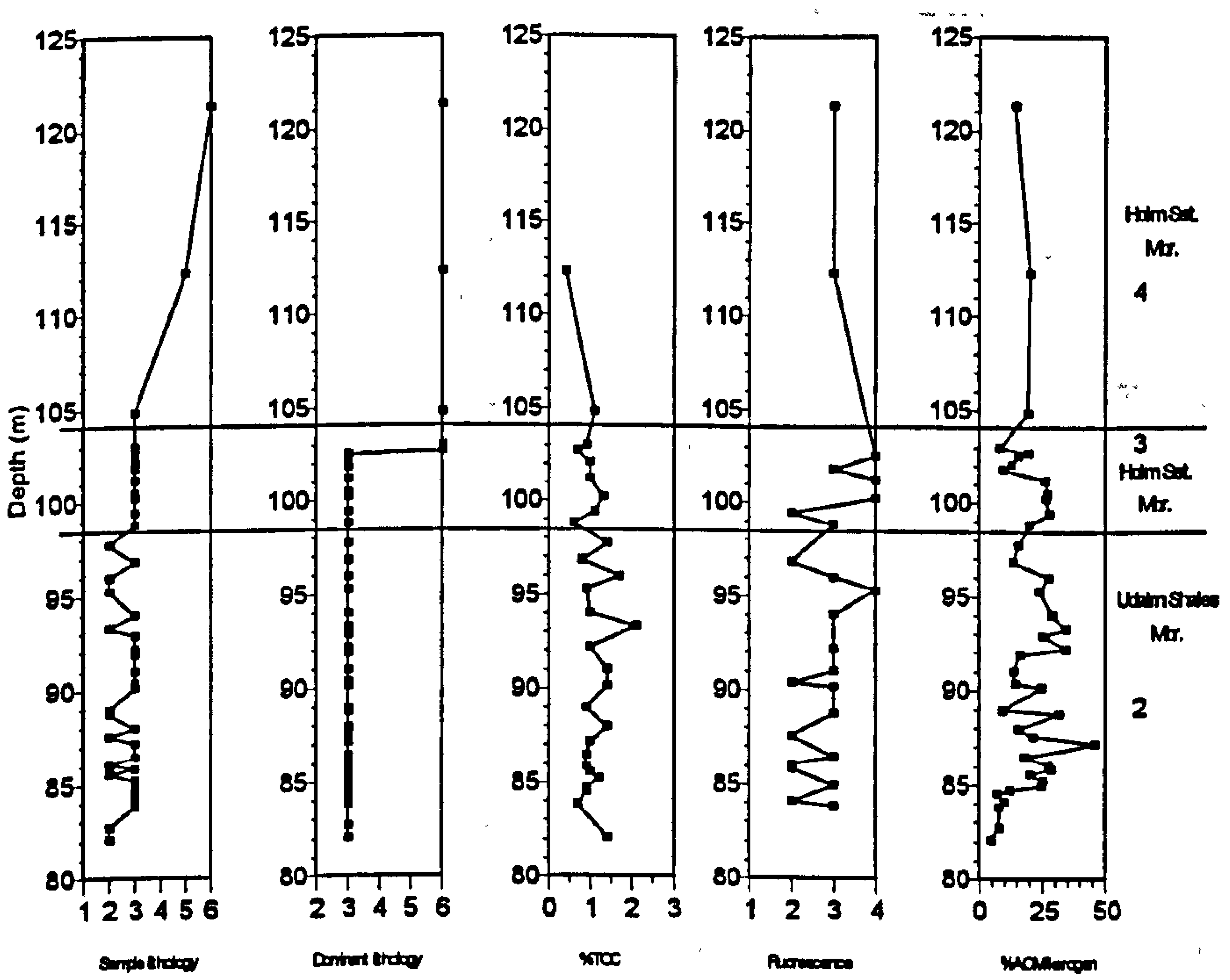


Fig. 10.5. *Selected parameter values through the middle-upper Udairn Shales to lower Holm Sandstone members (Bearreraig Sst. Fm.) type section. The number on the right represents the proximal-distal unit, 2 = most distal, 4 = most proximal.*

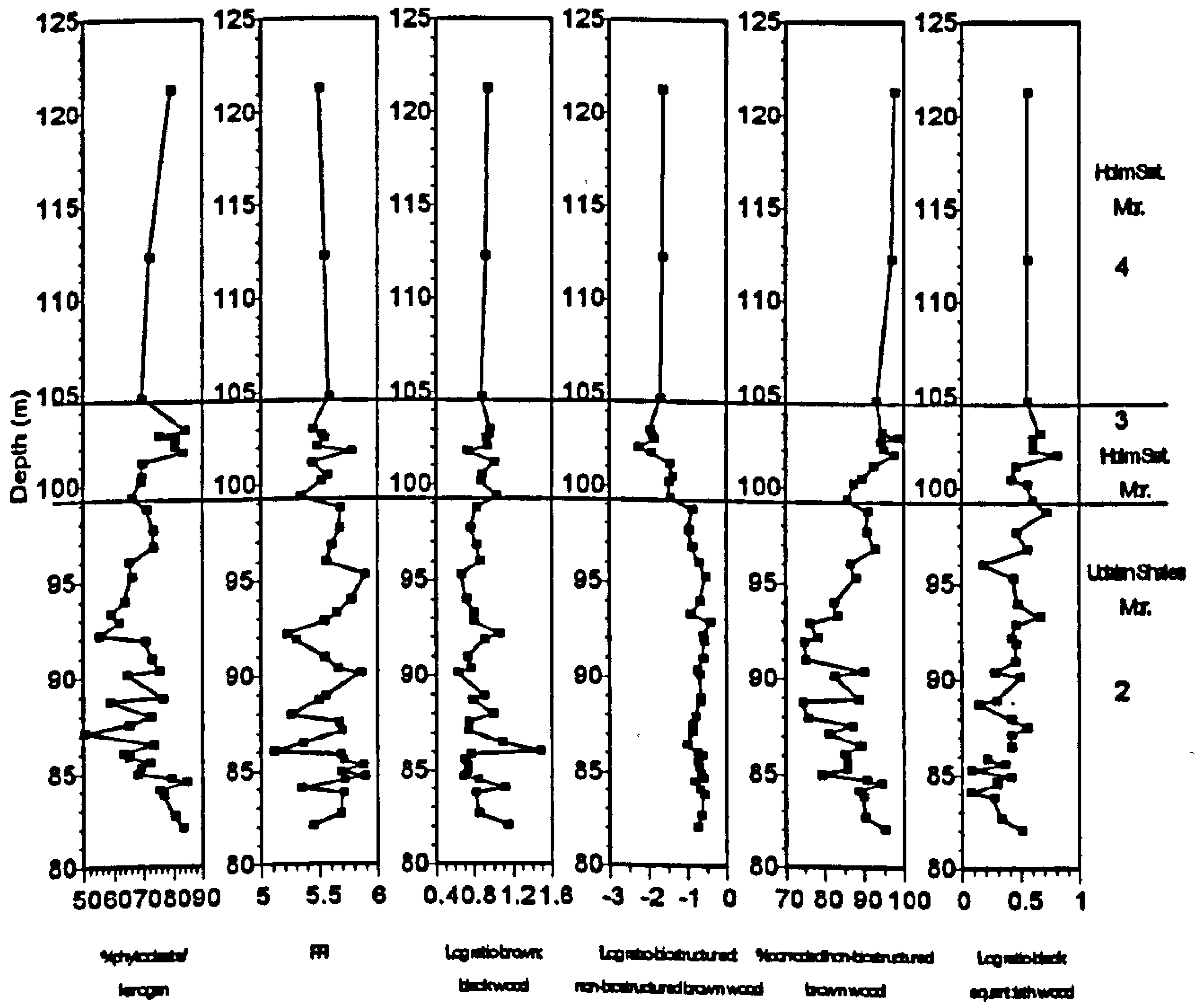


Fig. 10.6. *Selected parameter values from the phytoclast group through the middle-upper Udairn Shales to lower Holm Sandstone members (Bearreraig Sst. Fm.) type section. The number on the right represents the proximal-distal unit, 2 = most distal, 4 = most proximal.*

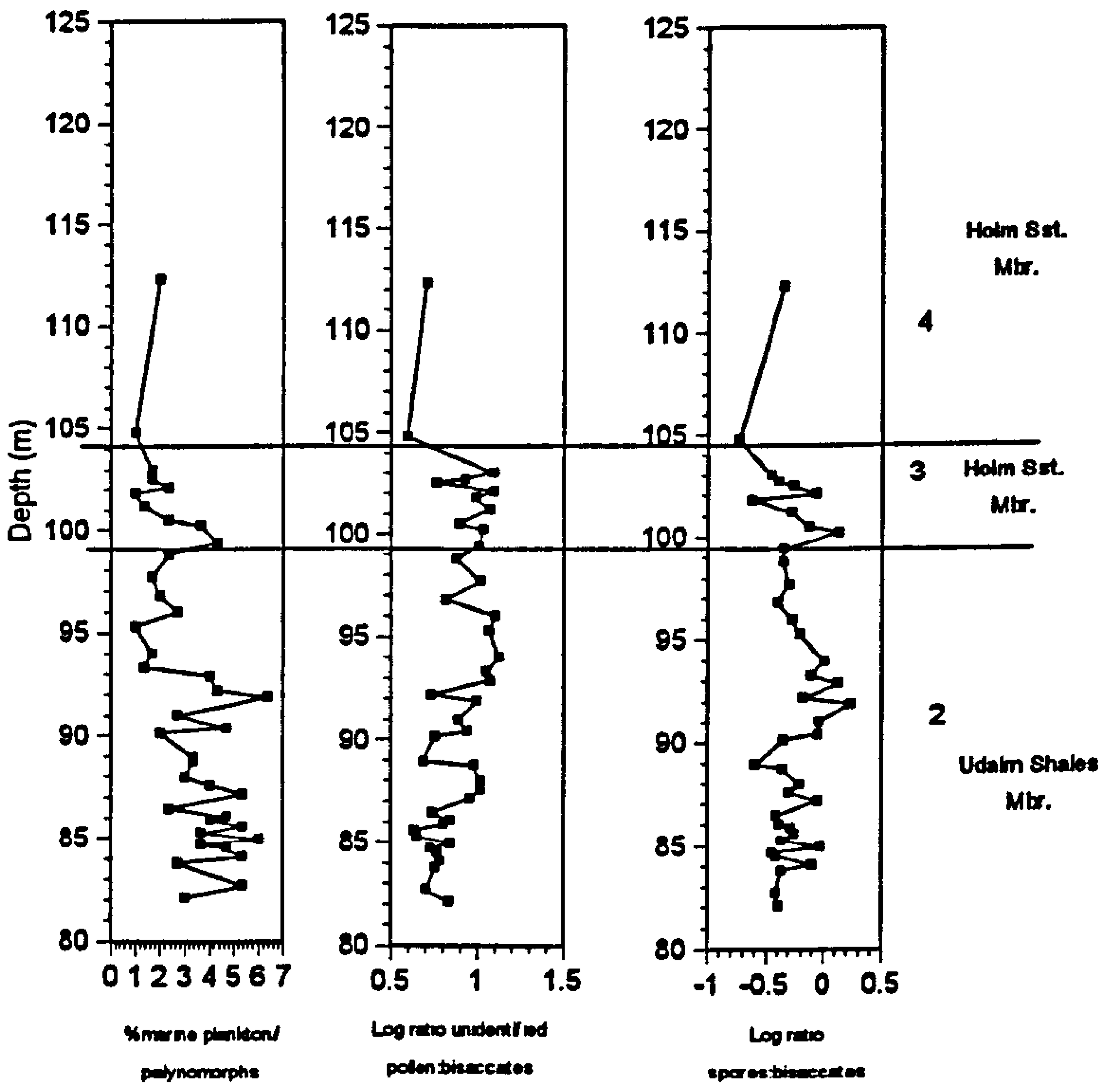


Fig. 10.7. *Selected parameter values from the palynomorph group through the middle-upper Udairn Shales to lower Holm Sandstone members (Bearreraig Sst. Fm.) type section. The number on the right represents the proximal-distal unit, 2 = most distal, 4 = most proximal.*

change in parameter values, and within which they show progressive change), and an upper unit, the base of which is again sometimes characterised by a sharp step.

10.2.2 Lealt Shales Formation

10.2.2 (a) Kildonnan Member, Kildonnan, Eigg.

In the lower part of the section the limestones and shaley limestones have lower AOM percentages and more refractory phytoclast assemblages, but there are also changes in the environment category of these beds so it is difficult to be sure whether these are only lithological effects (Figs. 10.8 to 10.12). There are also rapid variations in parameter values correlated with similar lithogical changes in the upper part of the section, but again the changes in lithology also represent changes in environment. The sandstone-dominated lithology of the 'complex bed' (at 7m) is reflected in increased percentages of palynomorphs of kerogen and sporomorphs of palynomorphs in the thin shales within the sands; the sharp increase in the percentage of membranes of phytoclasts in the upper sample from this bed can perhaps be related to the 'dominant lithology' effect of the overlying limestone which caps this unit.

The changes in environment category are generally reflected in sharp changes in certain parameters; however, this 'sharpness' could be exaggerated because of the large numbers of environment/salinity changes relative to the number of samples. In the lower part of the section the freshwater-brackish to brackish transition is reflected in a sharp increase in AOM; the %AOM and fluorescence also show a sharp change (decrease) at the brackish to marine-brackish transition further up the section, and the marine-brackish interval is characterised by low AOM and TOC values throughout. At the upper transition from marine-brackish to freshwater-brackish/freshwater there are sharp increases in the phytoc parameter, the %phytoclasts/kerogen, biostructured/brown wood, and *Botryococcus*/palynomorphs; there are corresponding decreases in the percentage membranes of phytoclasts and marine plankton of palynomorphs.

The marine plankton assemblage has only been examined in detail in the marine-brackish environment interval (beds 6a to lower 6f) where dinocysts achieve 100% dominance of marine plankton; in the rest of the section the data on assemblages (and marine plankton levels) is unreliable due to AOM masking of acritarchs leading to significant underestimation of their abundance (evident from fluorescence observations). Within the marine interval there is a progressive increase then decrease

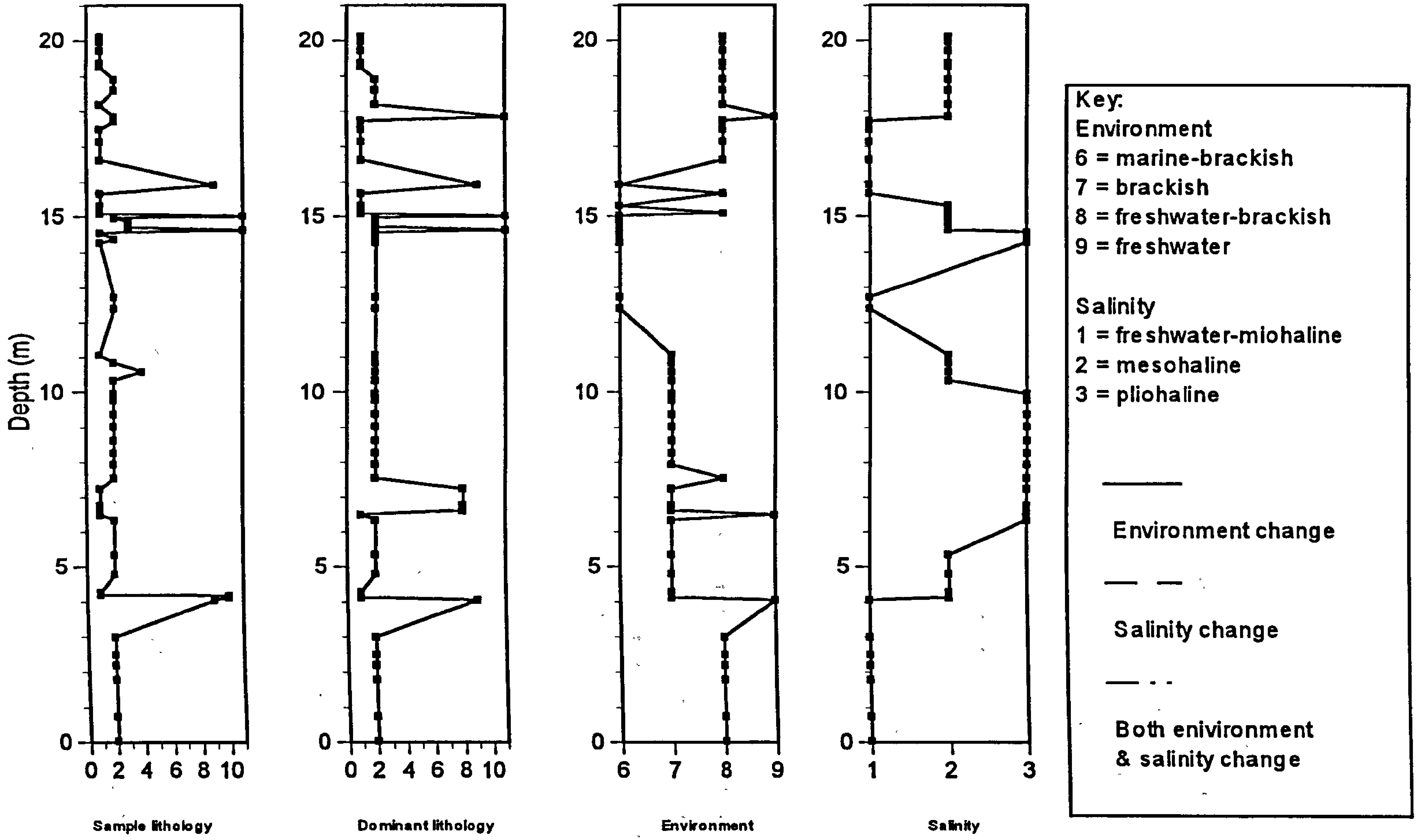


Fig. 10.8. *Selected parameter variation through the type section of the Kildonnan Member (Lealt Shales Fm.). The environment classification is that of Hudson and Harris (1979), the ostracod-salinity classification is based on Wakefield (1991).*

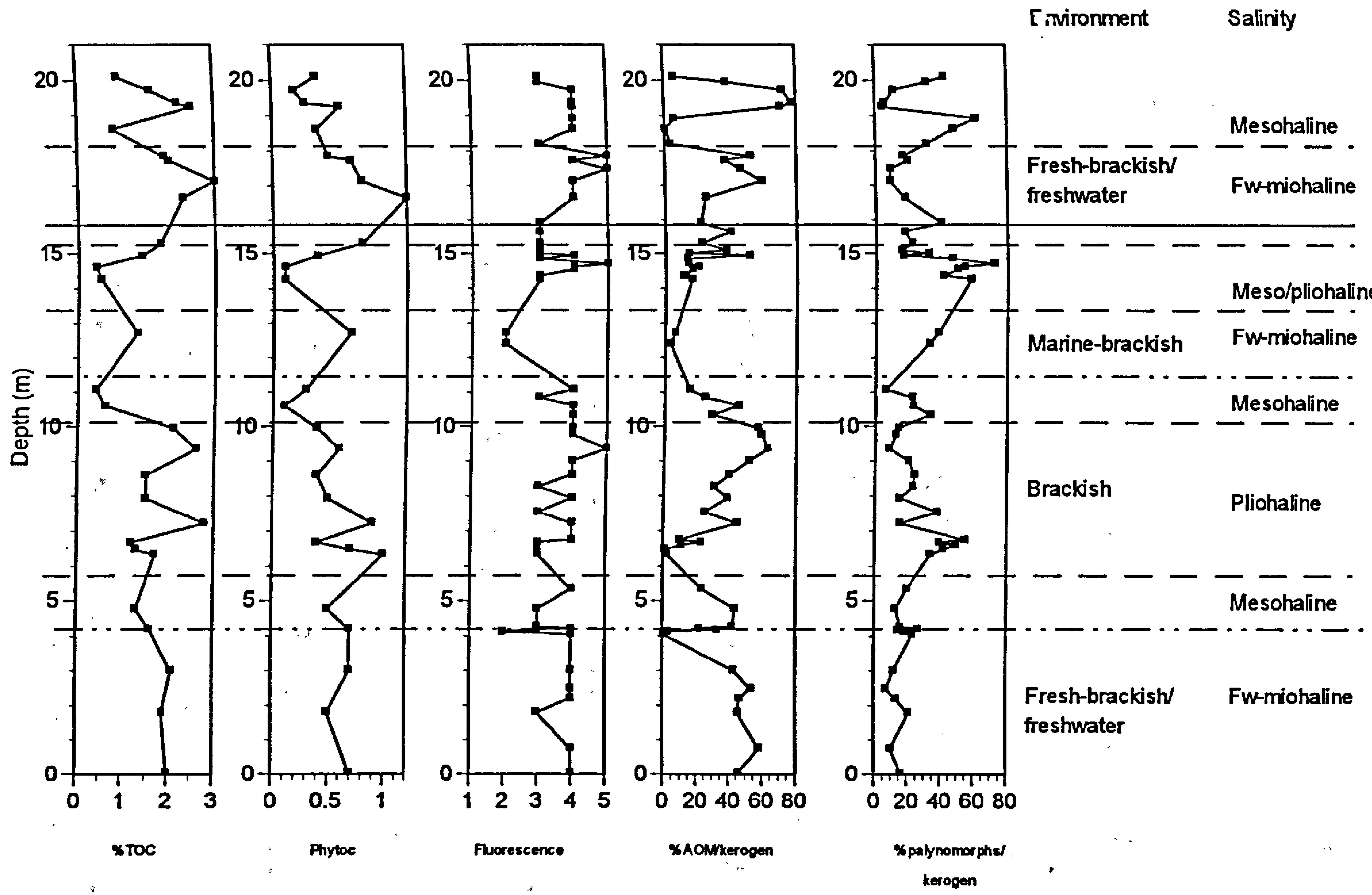


Fig. 10.9. *Selected parameter variation through the type section of the Kildonnan Member (Lealt Shales Fm.). The environment classification is that of Hudson and Harris (1979), the ostracod-salinity classification is based on Wakefield (1991).*

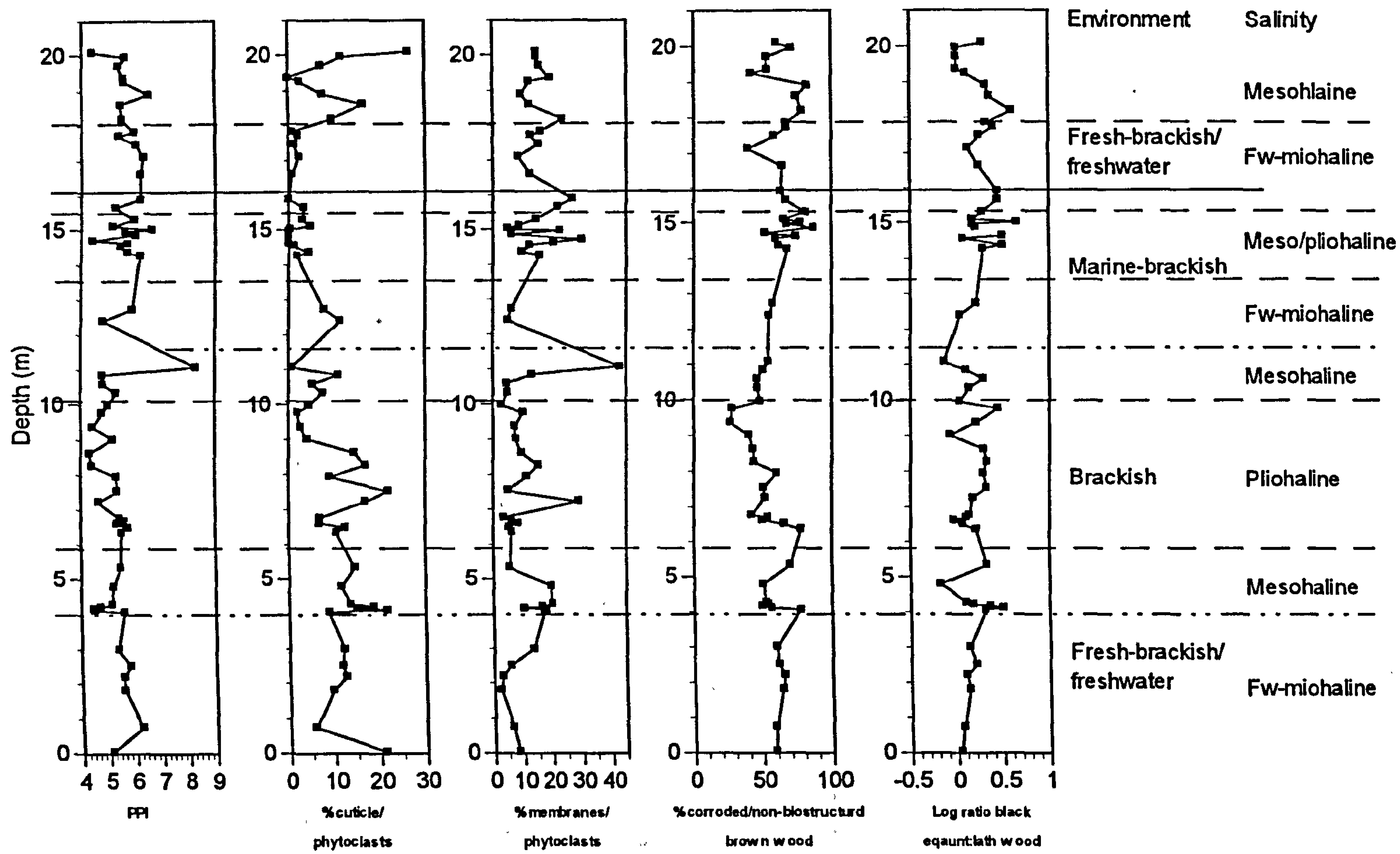


Fig. 10.10. *Selected phytoclast group parameter variation through the type section of the Kildonnan Member (Lealt Shales Fm.). The environment classification is that of Hudson and Harris (1979), the ostracod-salinity classification is based on Wakefield (1991).*

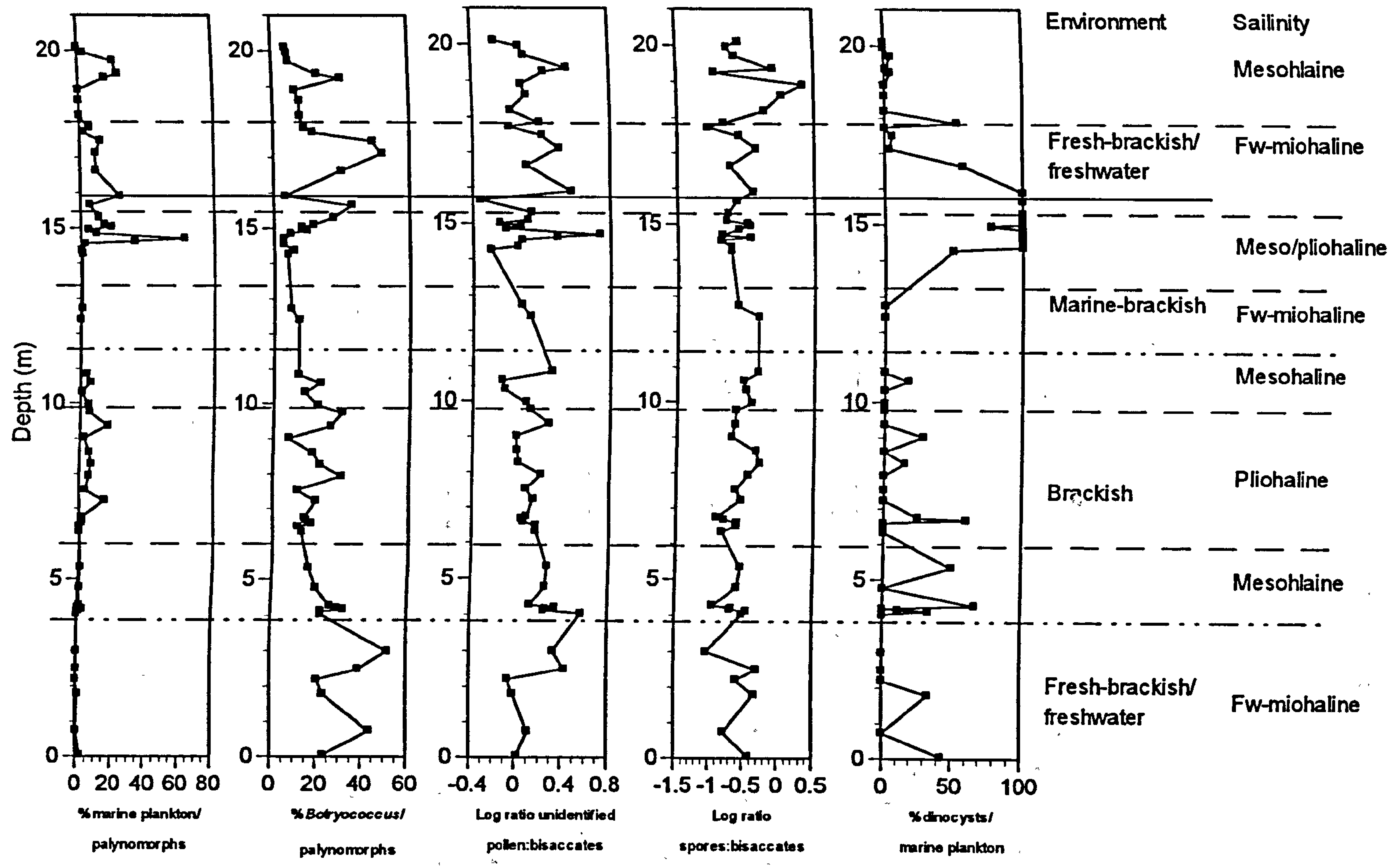


Fig. 10.11. *Selected palynomorph group parameter variation through the type section of the Kildonnan Member (Lealt Shales Fm.). The environment classification is that of Hudson and Harris (1979), the ostracod-salinity classification is based on Wakefield (1991).*

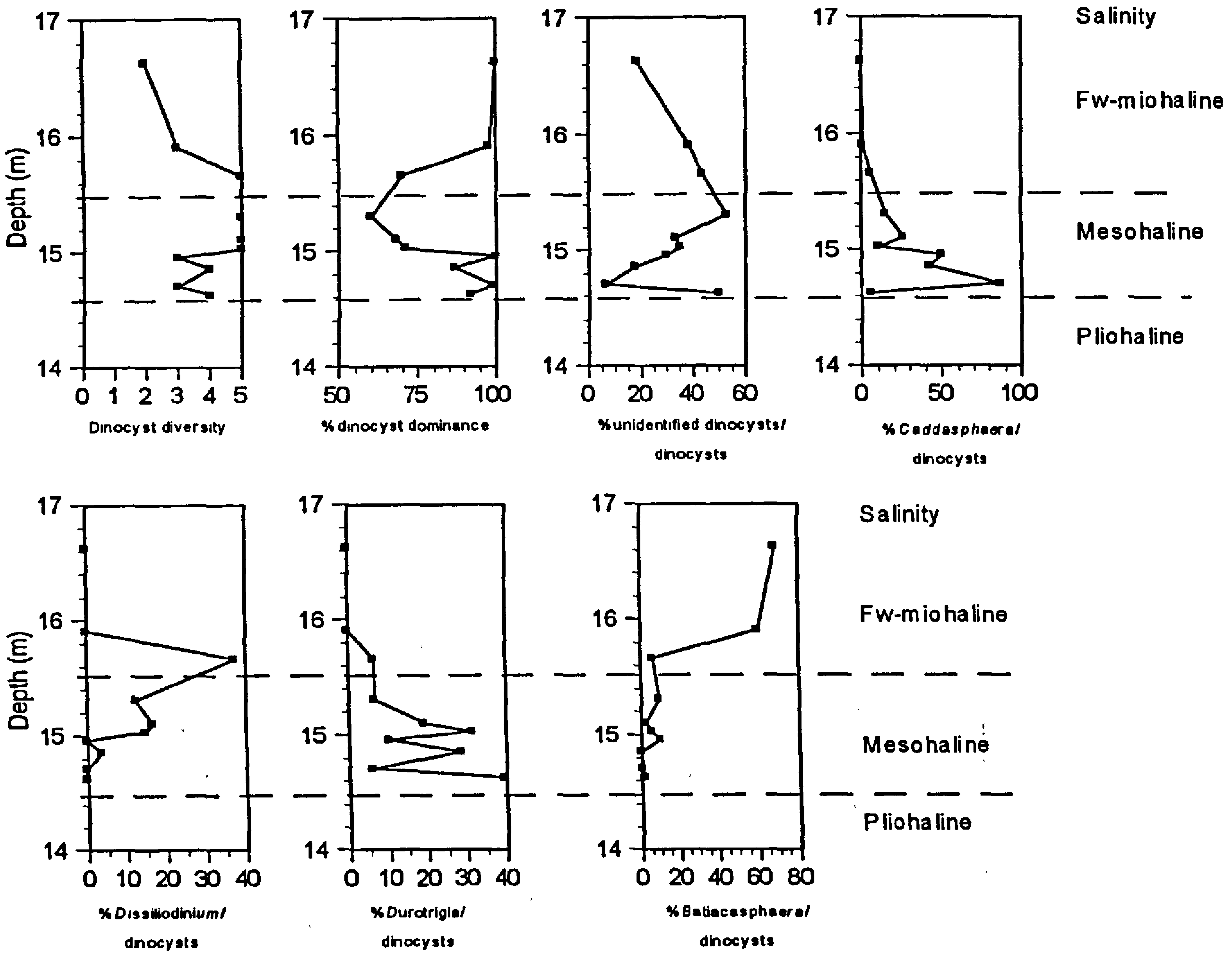


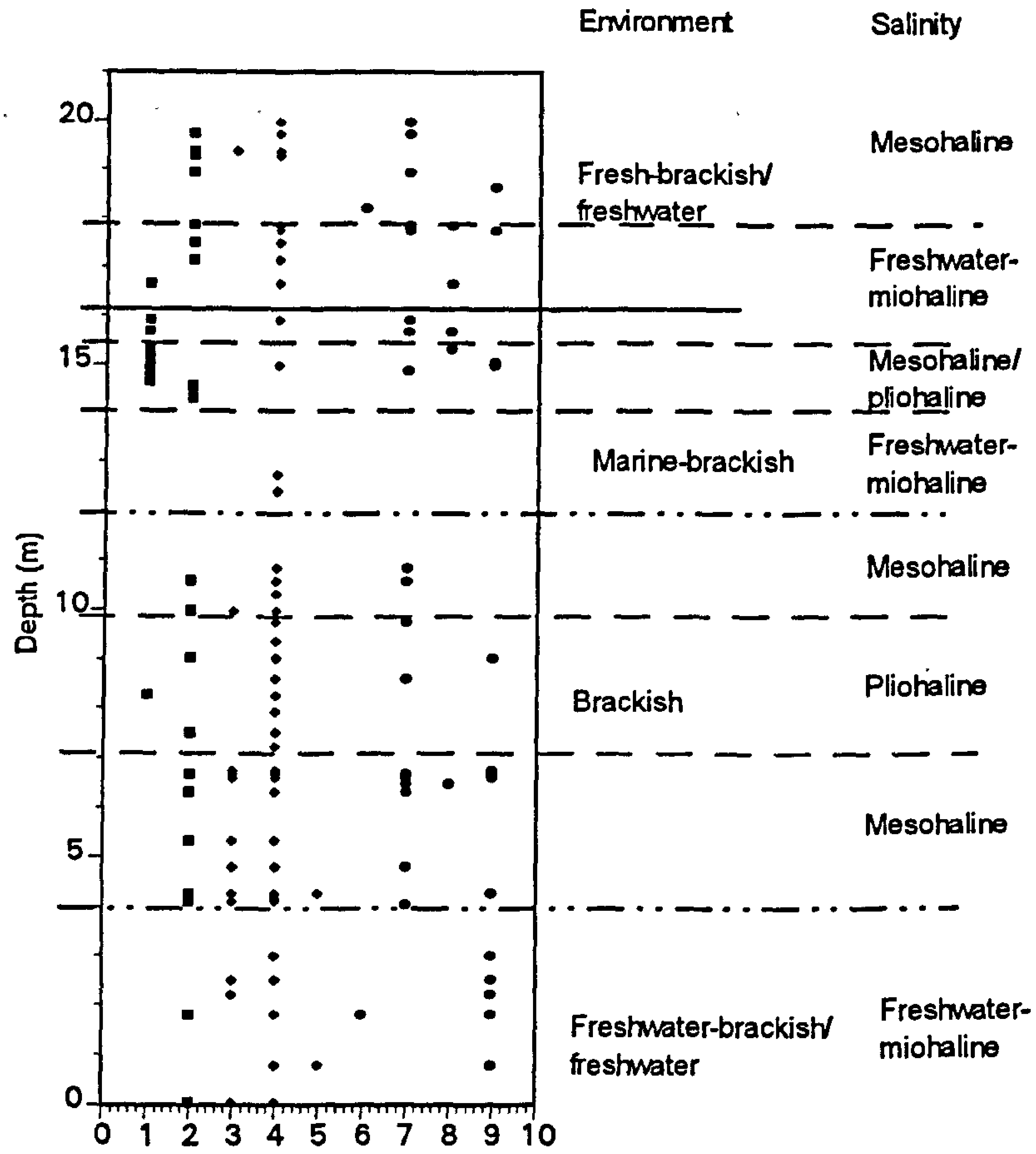
Fig. 10.12. *Selected dinocyst assemblage parameter variation through the marine-brackish environment part of the type section of the Kildonnan Member (Lealt Shales Fm.). The environment classification is that of Hudson and Harris (1979), the ostracod-salinity classification is based on Wakefield (1991).*

in dinocyst diversity; as would be expected, dinocyst dominance values show the opposite pattern (Fig. 10.12). These trends suggest that the change both to and from marine conditions was gradational rather than abrupt. The ostracod-salinity classification suggests a one way salinity gradient of pliohaline to freshwater-miohaline. The dinocyst taxa identified show three potential 'phases': a lower phase dominated by *Durotrigia* and *Caddasphaera*, a second phase where dominance values are low and the most abundant dinocyst is *Dissiliodinium*, and a final phase dominated by *Batiacasphaera*. These changes are not symmetrical like diversity and dominance, but show more similarity with the ostracod salinity gradient.

The presence/absence diagram for the section (Fig. 10.13) shows that outside of the marine interval most dinocysts are only tentatively identified ('?dinocysts'), short-spined acritarchs are ubiquitous and abundant, and long-spined acritarchs are restricted (mostly) to the lower part of the section. Pollen clusters are apparently restricted in their occurrence to zones dominated by freshwater and freshwater-brackish environments.

The changes in salinity category are often correlated with the environment changes, but there are variations in salinity that are independent of environment, i.e. they are not differentiated by the environment classification. At the three boundaries where salinity increases (3-7m, 14m, and 18m), there is an increase in %palynomorphs of kerogen; in two cases this is correlated with a decline in %AOM, in the other it is %phytoclasts that decreases. There are decreases in %*Botryococcus* at or about two of the boundaries (3-7m and 18m), and these are correlated with decreases in TOC and phytoc. At the middle boundary (14m) there is an increase in %marine plankton/palynomorphs.

At the two boundaries over which salinity declines (10-13m and 15m), there are changes in different parameters. At the lower boundary there is a decline in the %AOM; the %AOM is thus clearly independent of salinity, as it can either increase or decrease to or from the pliohaline category. In this case TOC shows a sharp decline at the pliohaline to mesohaline transition, but at the upper boundary TOC increases, suggesting that it too is independent of salinity. There are progressive increases in the percentage phytoclasts and palynomorphs of kerogen, biostructured brown wood, corroded of non-biostructured brown wood, and bisaccate pollen over the lower boundary. The changes in parameter values over the upper boundary are also progressive, with increases in %membranes of phytoclasts, and %*Botryococcus* of palynomorphs.



Key:
1 = dinocysts
2 = ?dinocysts

3 = long spined acritarchs
4 = short spined acritarchs
5 = *Tasmanites* type algae

6 = Pollen clusters
7 = Well preserved cuticle
8 = Plant fragments
9 = Macroscopic carbonaceous grains

Fig. 10.13. *Presence-absence diagram for the type section of the Kildonnan Member (Lealt Shales Fm.). The environment and ostracod-salinity units of Hudson and Harris (1979) and Wakefield (1991) are shown on the right of the diagram; see also Fig. 10.8.*

There are eight possible palynofacies units present in the section, a lower unit from 0-4m where the parameters show significant variation, but an overall trend is present, and a unit from 4 to 6m characterised by less variation and where some of the parameters show progressive change and some are stable. There is then a series of five units from 6 to 10m, 10 to 12m, 12-15m, 15-18m, and 18 to 19m which are all characterised by progressive change in some parameters with others remaining stable. A final unit (19m to top of section) is characterised by a sharp base, followed by progressive change in parameter values.

10.2.2 (b) Lonfearn Member, Ruhda Nam Braithairean, Skye.

In the lower part of this section the changes in parameter values can be related to lithological variation, while in the upper part changes related to environmental variation become more important. The change in dominant lithology from limestone to shale in the lower part of the section is reflected in sharp increases in the percentages AOM and palynomorphs of kerogen, and in biostructured brown wood. The rapid variation in sample lithology between shale and limestone is reflected in similar rapid variation in parameter values, particularly the phytoclast preservation index (PPI), the ratio of brown:black wood, and the percentage membranes of phytoclasts. In the upper part of the section there is a sharp decline in TOC and AOM percentages at the freshwater-brackish to brackish environment transition, with corresponding increases in the percentages of phytoclasts and palynomorphs (the former sharp, the latter progressive).

10.2.3 Duntulm Formation, Cairidh Ghlumaig and Lon Ostatoin, Skye.

The overall regressive, coarsening-upwards, and decreasing salinity trend through the Duntulm Formation composite type section (Figs. 10.14 to 10.30) is reflected in an increase in the percentage phytoclasts of kerogen values, and a decrease in AOM. Palynomorph percentages increase in the middle of the section. Within the phytoclast fraction there is a slight relative increase in biostructured over non-biostructured brown wood; cuticle is only a significant component of assemblages in the uppermost part of the composite section. The biostructured brown wood fraction is characterised by decreasing striate and striped and increasing refractory banded and pitted material; in the non-biostructured fraction, pseudoamorphous material is only significant in the lowest part of the composite section, while undegraded particles increase in their percentage frequencies between the lower and middle part of the section. The character of the black wood only really changes in the uppermost sand-dominated section where equant particles become more dominant. Within the palynomorph fraction sporomorphs increase upwards. *Botryococcus* is only present at significant levels in the upper part of the section. Spores increase in the upper part of the section and in the lower sandstone-dominated interval; thin-walled spores also increase upwards, most of the increase taking place in the lower part of the section. Pollen assemblages show no overall change, but, there is a relative increase in bisaccates near the lower-middle boundary and at the top of the composite section.

In the presence/absence diagrams (Figs. 10.29 &10.30) the regressive trend is reflected in the decrease in the occurrence of foraminiferal linings, and a greater frequency of pollen clusters and spore tetrads in the upper part of the section. *Tasmanites* type algae and leiospheres are rare, and restricted mostly to the lower and central section; two marine intervals are recorded by dinocyst occurrences in the upper section, and the occurrence of acritarchs at the very top of the section suggests brackish water influence at this point. The presence of *Scenedesmus* and *Pediastrum* type hydrodictyale algae in this upper section suggests very low salinities of less than 5‰ if the modern analogy is correct (cf. Tyson, 1995).

In the lower (foreshore) section (Figs. 10.14 to 10.18) there are two transitions from *Praeexogyra* limestone-shale to sandstone lithofacies; these represent the flooding of delta mouth sands, while the opposite transition represents the progradation of these sands into the normal lagoonal facies (Andrews & Walton, 1990). At the lowermost transition (2.4m) there is a sharp decrease in AOM percentages and a progressive decrease in fluorescence suggesting a change to more oxic conditions; however, the percentage of palynomorphs does not increase until the biofacies changes to the 'marine' community after the lithofacies transition. There are also sharp relative increases in black wood, biostructured brown wood, and thick-walled spores at this biofacies transition. Therefore, it is interesting to note that the changes within the palynomorph assemblage take place at the aforementioned lithofacies transition, with sharp relative increases in bisaccates and marine plankton, and changes in the marine plankton assemblage (sharply increasing dinocyst diversity, decreasing dominance, increasing *Ctenidodinium* spp., and progressive increases in *Pareodinia* spp. and *Sentusidinium* spp.). At the upper sandstone to *Praeexogyra* limestone-shale transition (5.4m) the parameter changes are different; there is only a sharp relative increase in dinocyst dominance, but immediately above the transition the %AOM initially increases sharply, as do the %palynomorphs, the PPI, black wood, and thin-walled spores.

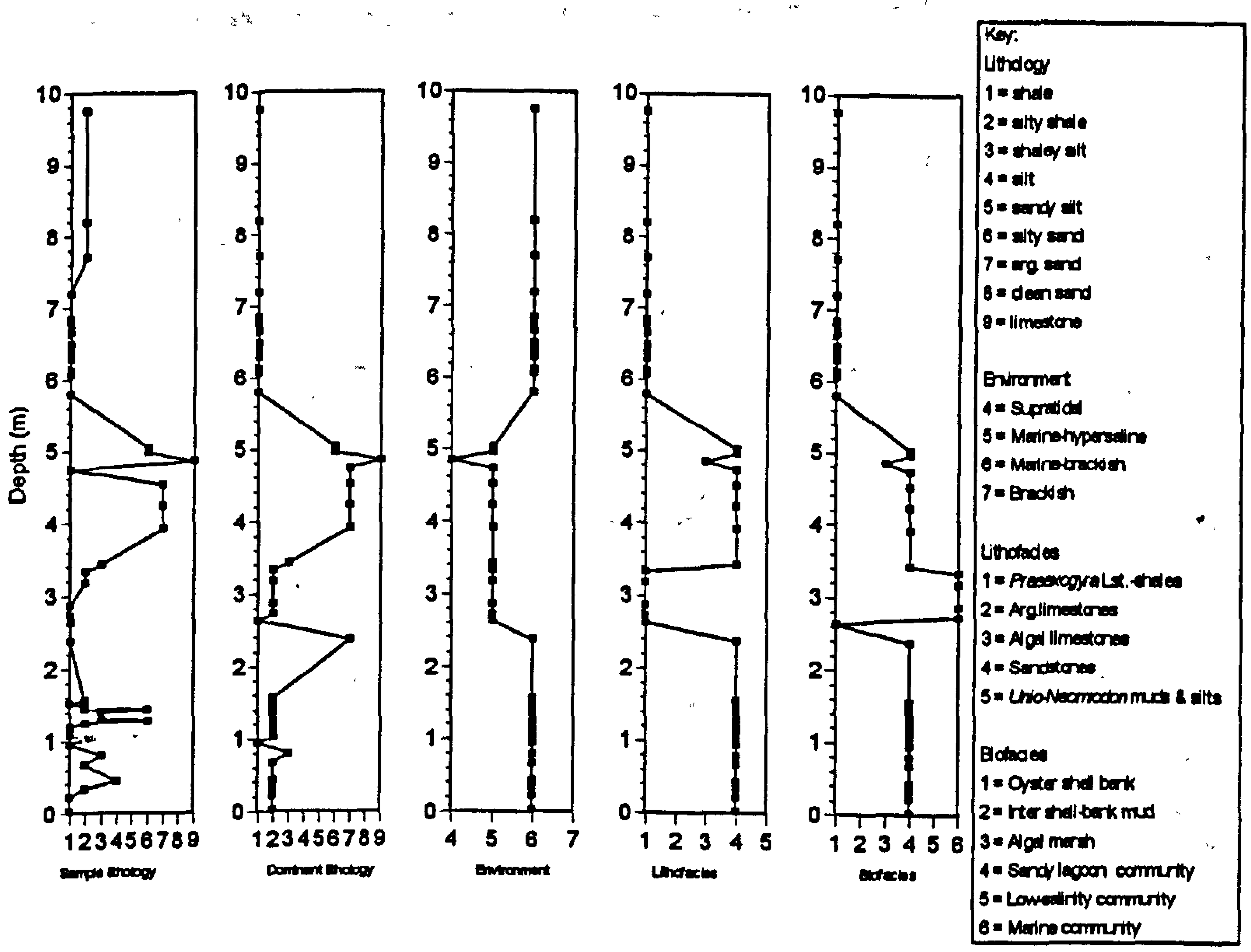


Fig. 10.14. *Selected parameter values through the lower (foreshore) part of the Duntulm Formation type section. The environment classification is that of Hudson and Harris (1979), the litho- and biofacies are those of Andrews and Walton (1990).*

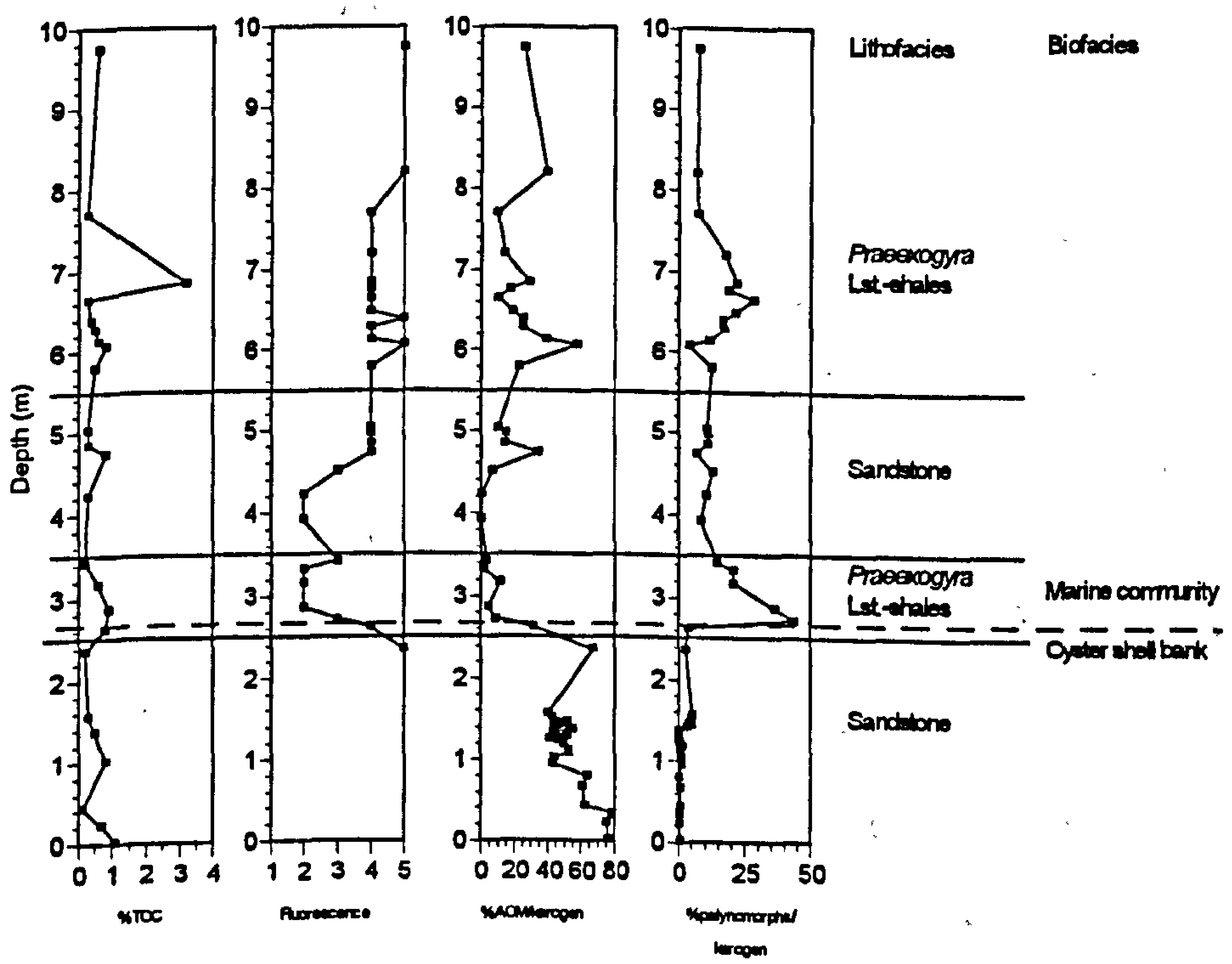


Fig. 10.15. *Selected parameter values through the lower (foreshore) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

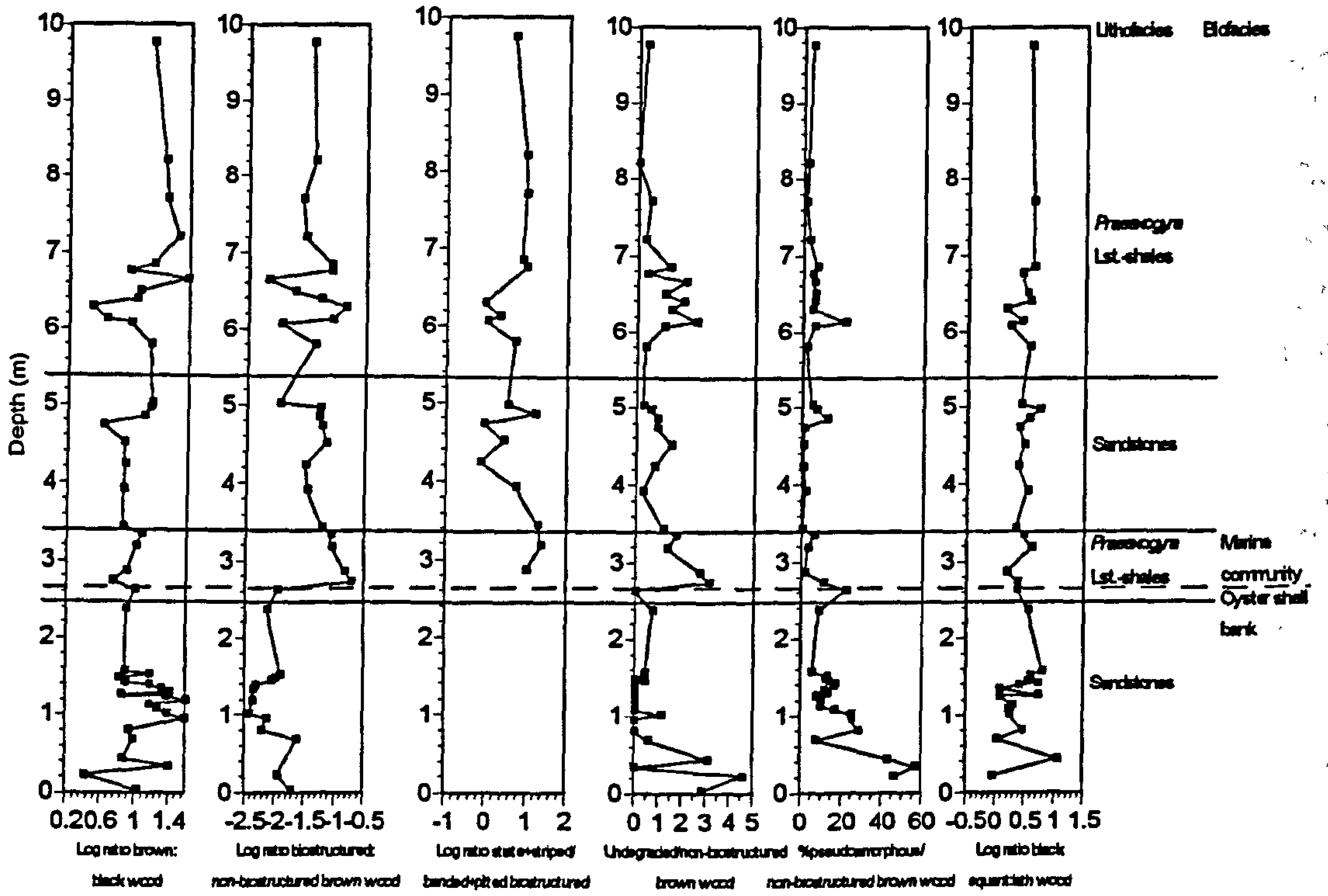


Fig. 10.16. *Selected phytoclast assemblage parameter values through the lower (foreshore) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

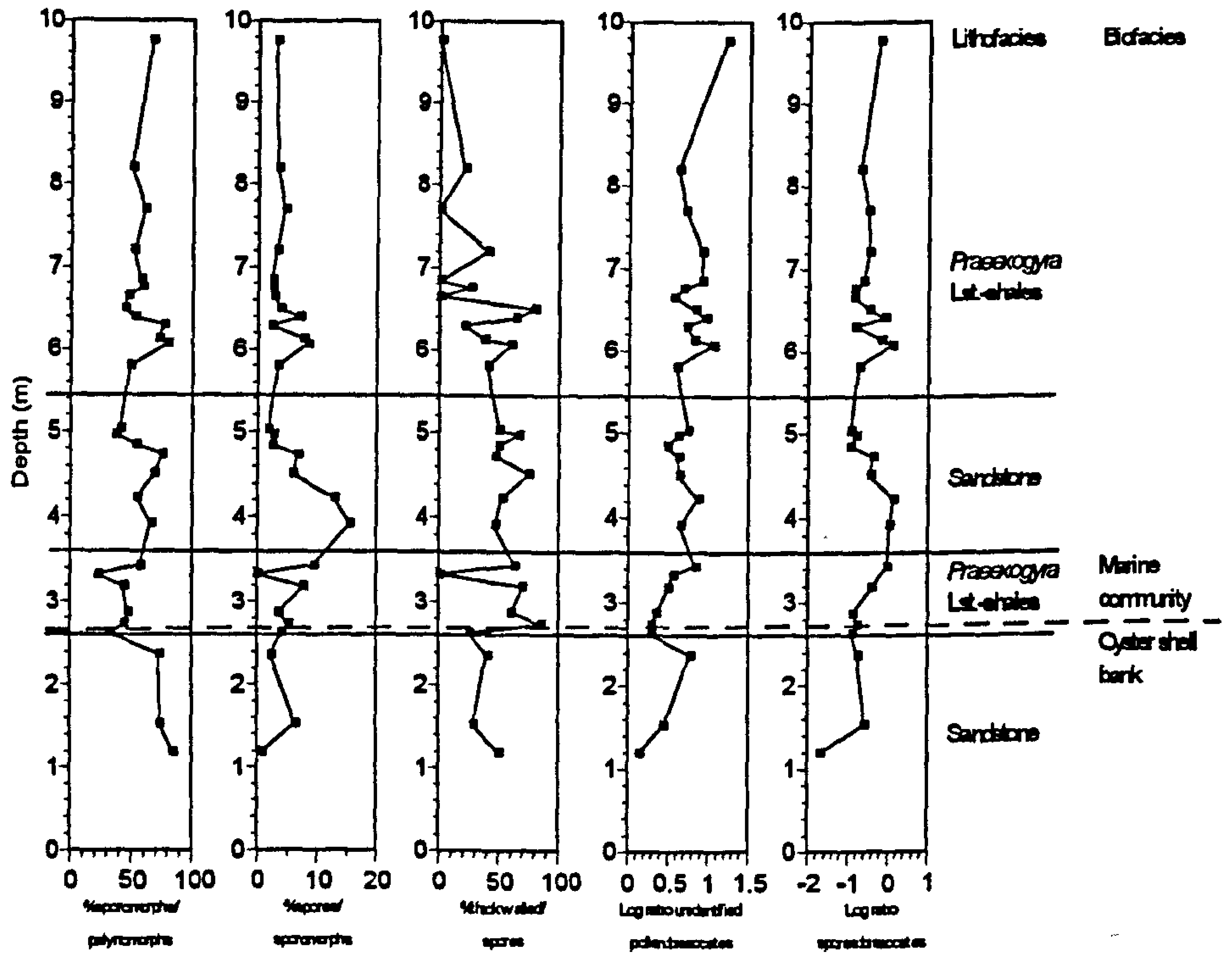


Fig. 10.17. *Selected palynomorph assemblage parameter values through the lower (foreshore) part of the Duntulm Formation type section. The litho- and biofacies are those of An. 'rews and Walton (1990).*

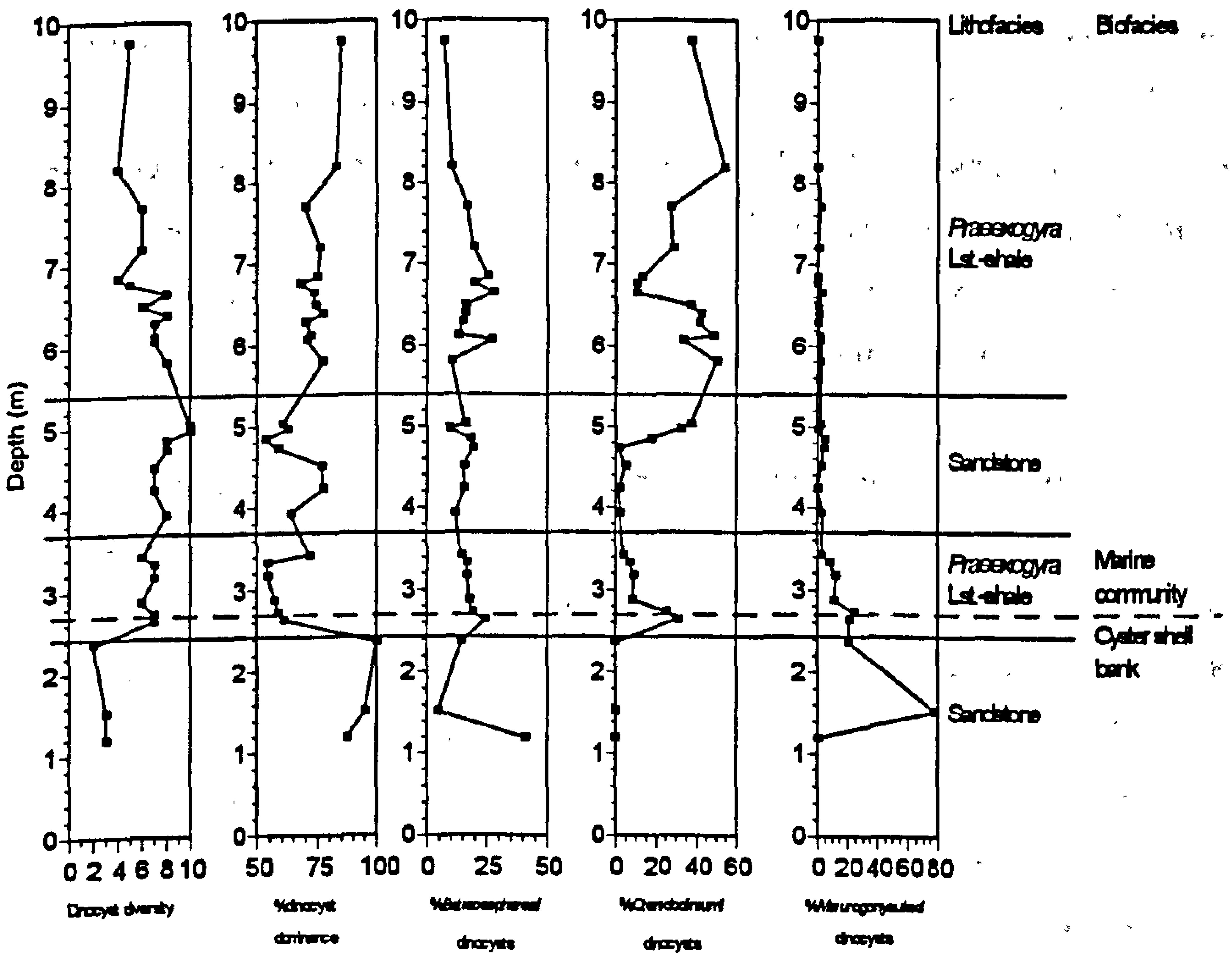


Fig. 10.18a. *Selected dinocyst assemblage parameter values through the lower (foreshore) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

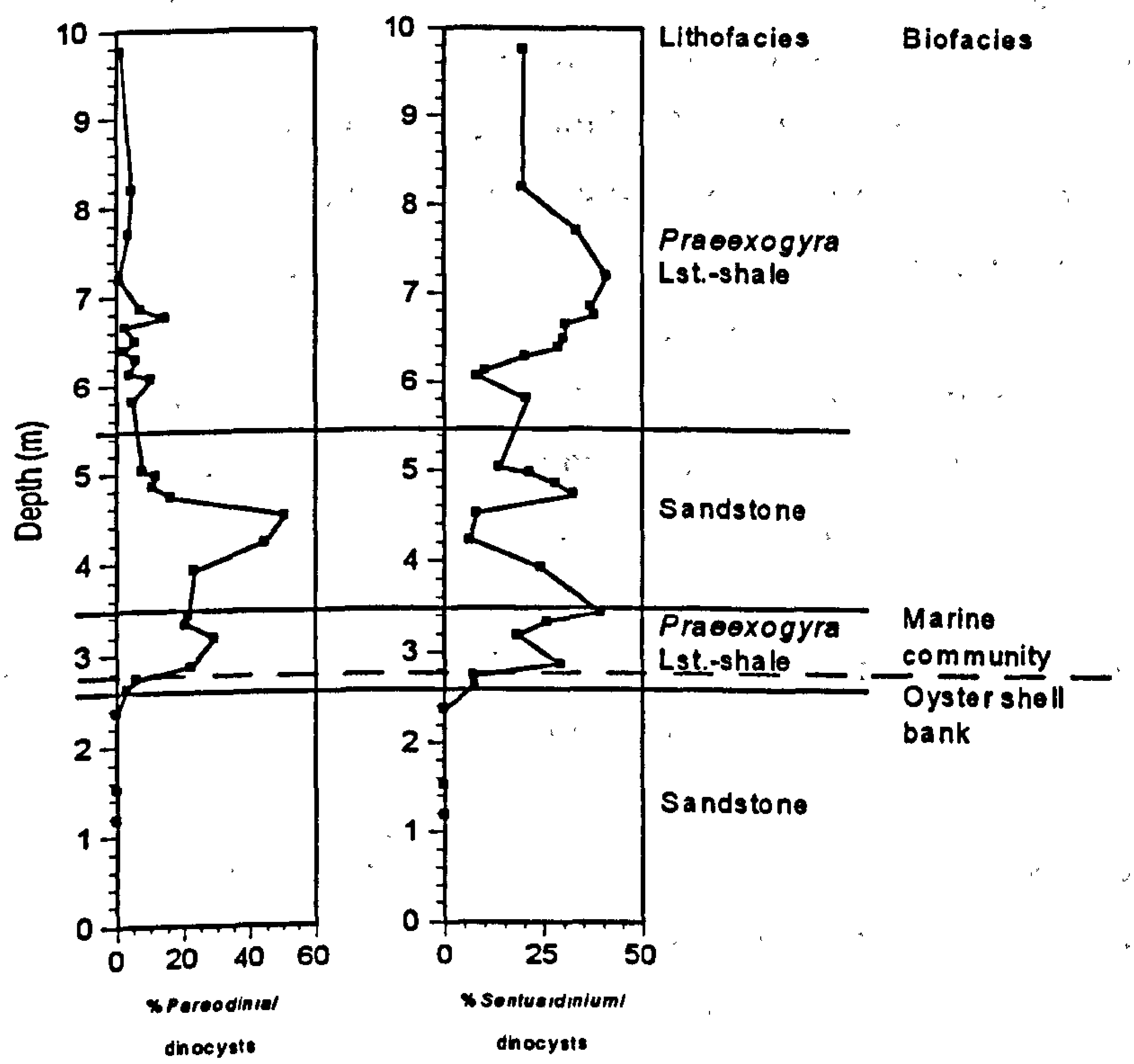


Fig. 10.18b. *Selected dinocyst assemblage parameter values through the lower (foreshore) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

At the *Praeexogyra* limestone-shale to sandstone lithofacies transition (4m) there is a progressive increase in the percentage of phytoclasts and its non-biostructured brown wood component; sharp increases in banded and pitted biostructured brown wood and sporomorphs occur above and below the boundary respectively. Within the dinocyst assemblage the proportion of *Sentusidinium* spp. decreases progressively through the boundary, and *Pareodinia* spp. reaches an acme in the sandstone lithofacies.

The effect of lithology in this lower section can be seen in the parameter changes through the coarsening upwards sequence at the 3-4m level: progressive increases in the percentages of phytoclasts, spores, dinocyst dominance, and *Pareodinia* spp., and a decrease in the striate and striped component of the biostructured brown wood assemblage. In general terms, the sands have increased phytoclast percentages, banded and pitted wood, spores, dinocyst dominance, and *Pareodinia* spp. dinocysts compared to the shales. The thin shale within the sands at the 4.8m level is characterised by increased AOM, PPI, black wood, and *Sentusidinium* spp., and the dinocyst dominance level is sharply decreased from the underlying sands.

The lower part of the type section can be divided into five palynofacies units. A lower unit from 0 to 2m in which the parameters show progressive change, but significant variability, is followed by a unit from 2 to 4.5m which is characterised by progressive change. The next two units from 4.5 to 6m and 6 to 7m are both characterised by progressive change and significant variability. A final unit from 7 to 10m is also present in which some parameters show progressive change, but others are stable. Eight dinocyst phases are present in this lower part of the type section, some of which correlate with palynofacies units or their boundaries. The lower sandstone lithofacies unit (= sandy lagoon community biofacies) is characterised by a dominance of first *Batiacasphaera*, then *Meiurogonyaulax*; the following *Praeexogyra* limestone-shale unit is dominated first by *Ctenidodinium*, then *Sentusidinium* and *Pareodinia*. The upper sandstone unit is dominated by *Pareodinia* followed by *Ctenidodinium*, and the final *Praeexogyra* limestone shale unit is characterised first by a dominance of *Ctenidodinum*, followed by a combination of *Ctenidodinium* and *Sentusidinium*.

In the middle (cliff) section (Figs. 10.19 to 10.23) the lithofacies present are *Praeexogyra* limestone-shales and cryptalgal-rippled siltstones; the lower transition from the latter to the former (13.1m) is characterised by sharply increasing TOC, percentage palynomorphs, black equant wood, and bisaccates. There is also a progressive increase in marine plankton which continues above the transition as the biofacies changes to the 'marine' community. These increases are correlated

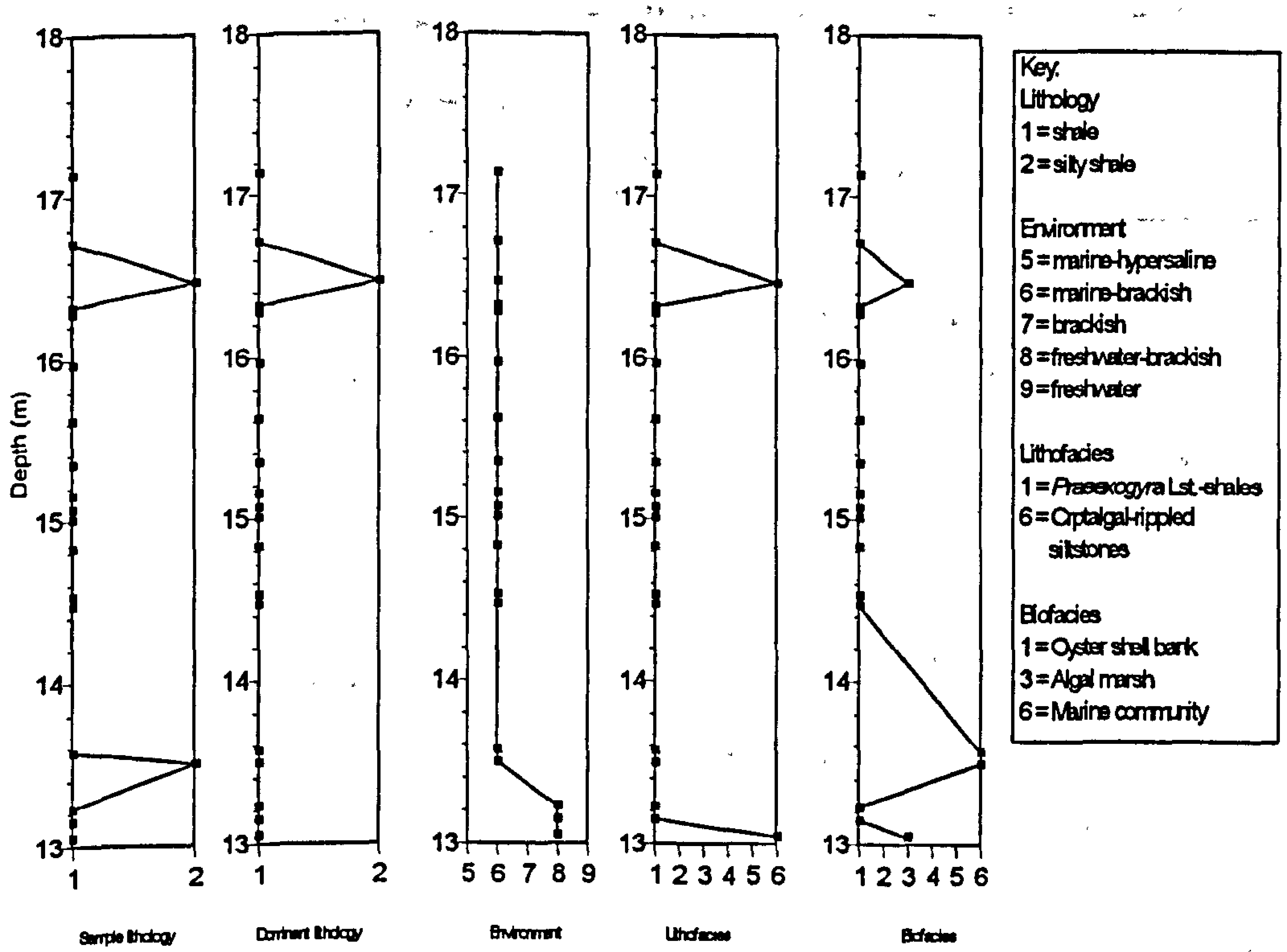


Fig. 10.19. *Selected parameters through the middle (cliff) part of the Duntulm Formation type section. The environment classification is that of Hudson and Harris (1979), the litho- and biofacies are those of Andrews and Walton (1990).*

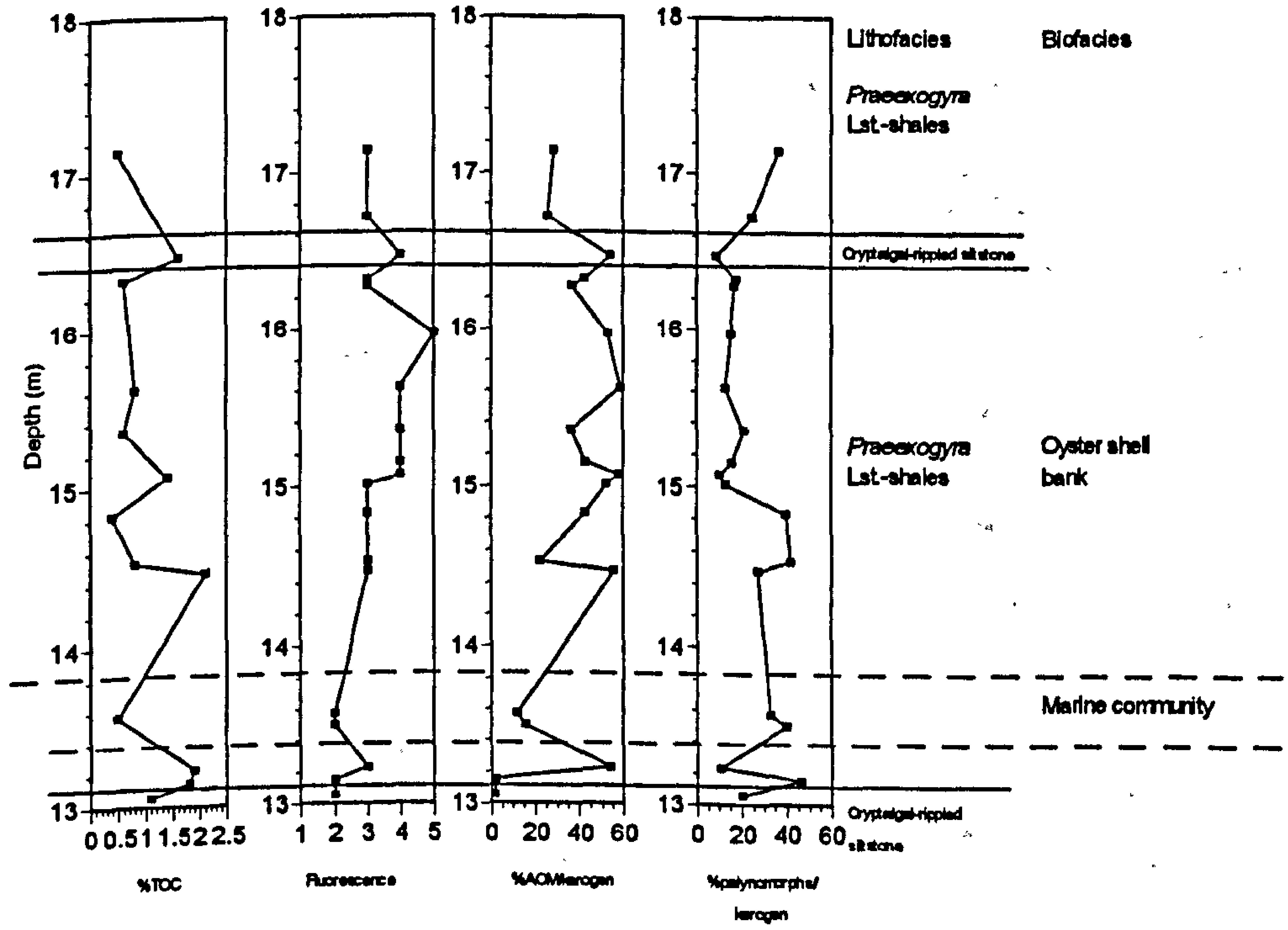


Fig. 10.20. *Selected parameters variation through the middle (cliff) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

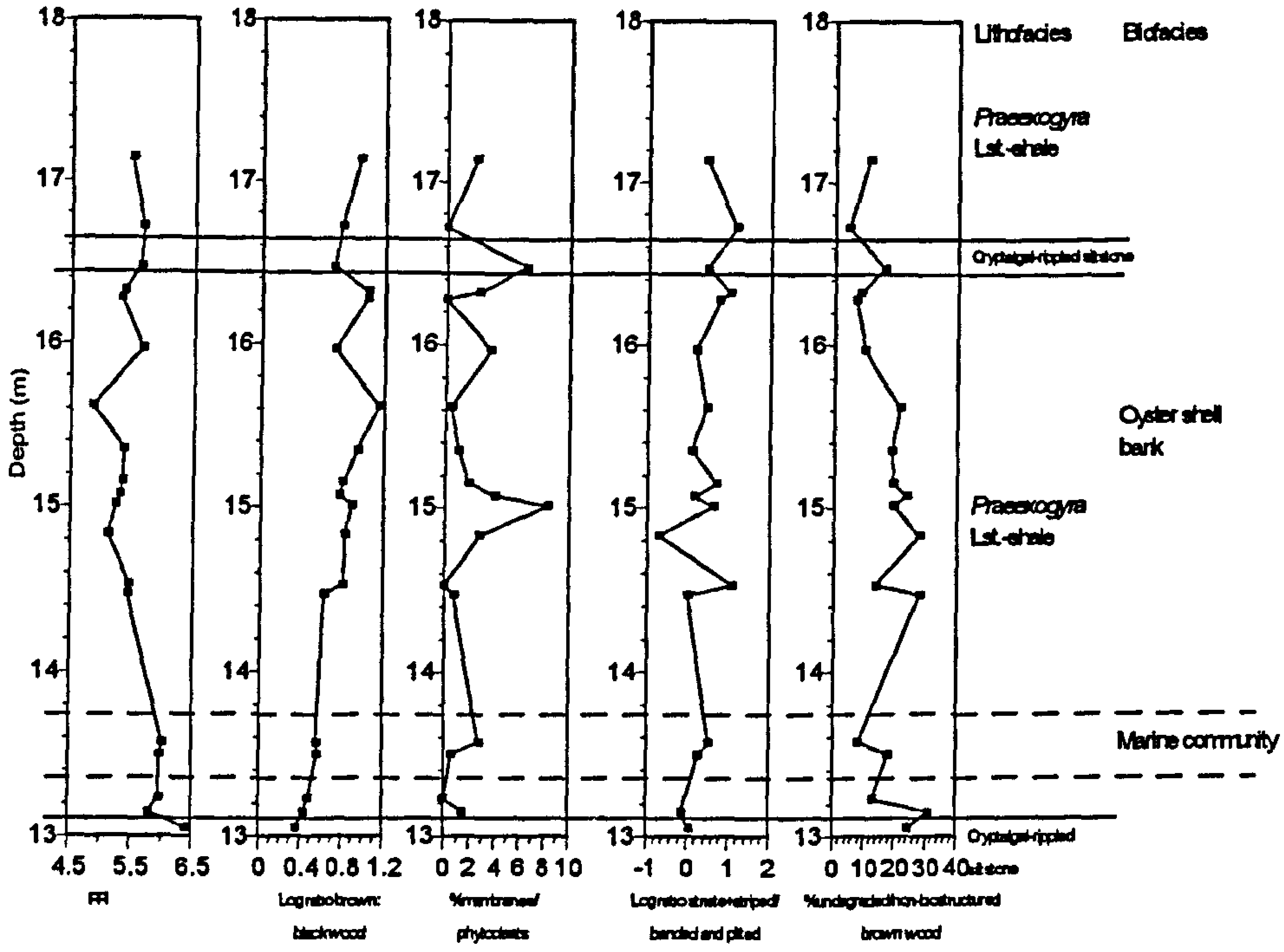


Fig. 10.21. *Selected phytoclast assemblage parameter variation through the middle (cliff) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

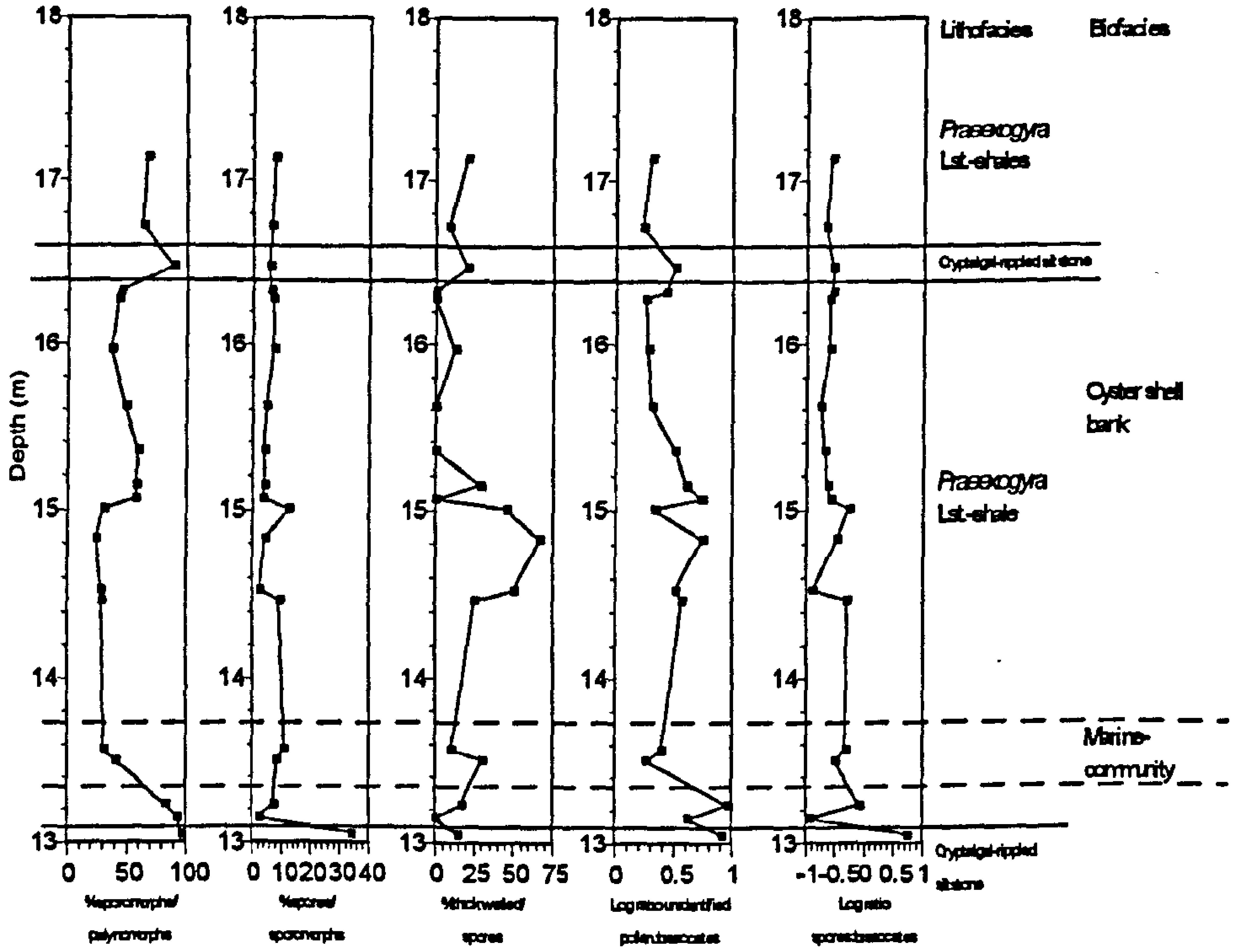


Fig. 10.22. *Selected palynomorph assemblage parameter variation through the middle (cliff) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

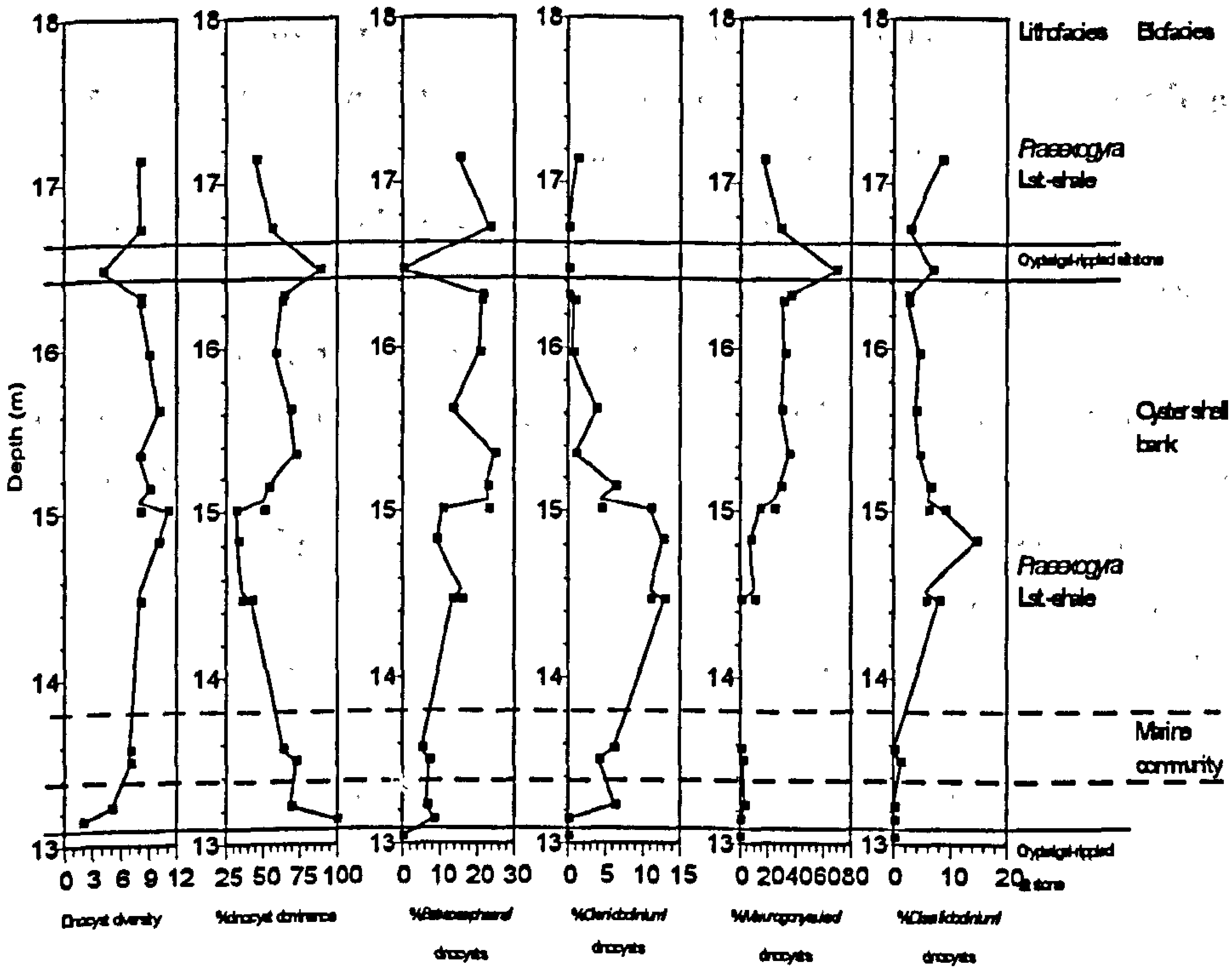


Fig. 10.23a. *Selected dinocyst assemblage parameter variation through the middle (cliff) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

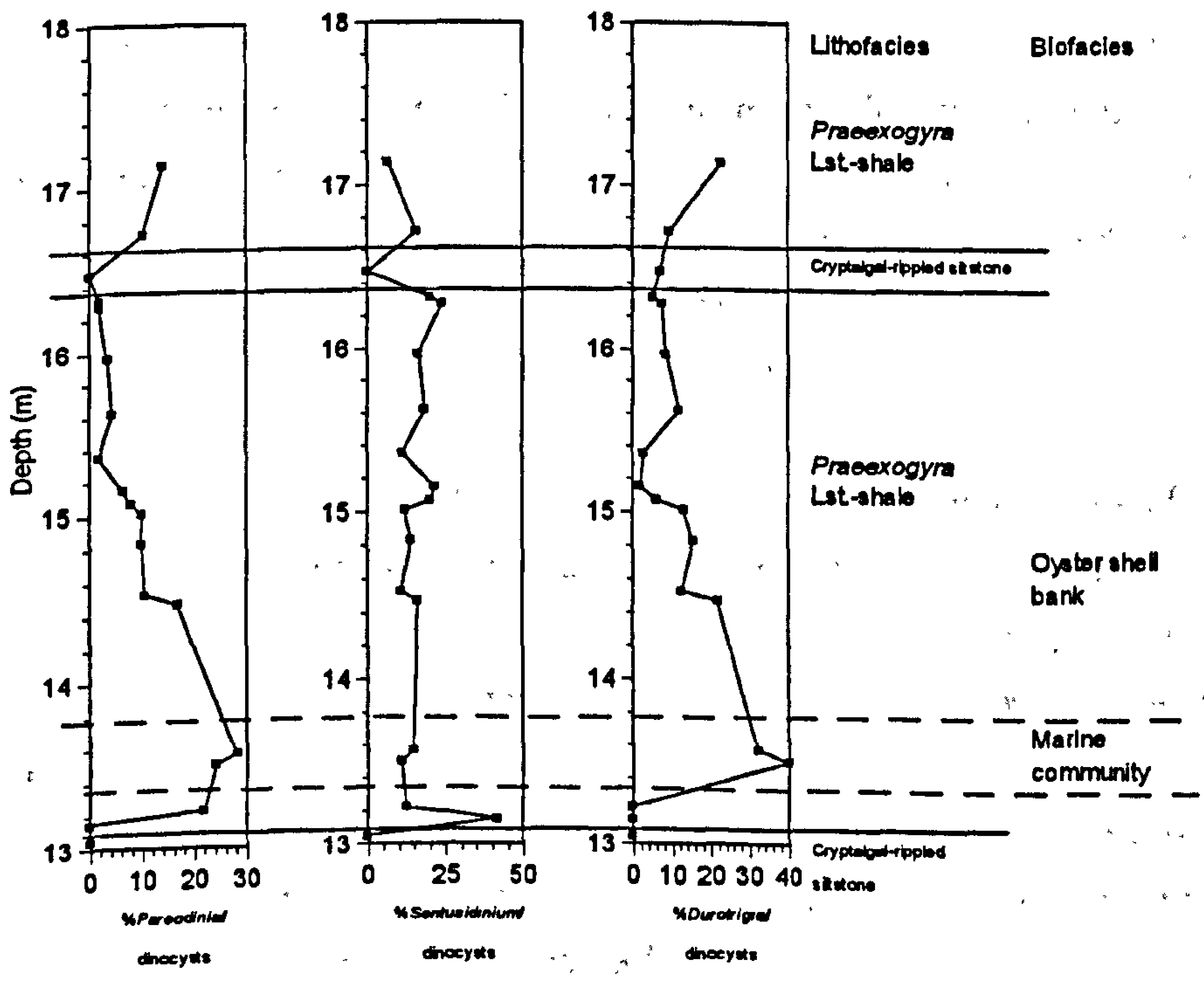


Fig. 10.23b. *Selected dinocyst assemblage parameter variation through the middle (cliff) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

with sharp decreases in the percentage of phytoclasts (which subsequently increases progressively), and the PPI. There is also a sharp increase in the percentage AOM and *Pareodinia* spp. dinocysts; the latter parameter increases in the marine community biofacies, then declines progressively. The upper cryptalgal-rippled siltstone lithofacies sample (silty shale) is characterised by increased TOC, fluorescence, membranes, and sporomorphs; it also has a low diversity-high dominance dinocyst assemblage dominated by *Meiurogonyaulax* spp.. The only other facies change in this section is the presence of the 'marine' community biofacies, which, in comparison with the normal oyster shell bank facies, has lowered TOC and AOM percentages and increased black lath wood (not shown), bisaccates, and marine plankton (= dinocysts); the dinocyst assemblage here is characterised by increased *Durotrigia* and *Pareodinia* spp..

The middle section can be divided into two possible palynofacies units: a lower unit from 13 to 15.5 m and an upper unit from 15.5m to the top of the section; both are characterised by progressive change, mainly in the major kerogen group parameters. The dinocyst distribution through the middle section shows an excellent succession of acmes with *Sentusidinium* at the base, changing to a combination of *Pareodinia* and *Sentusidinium* in the marine biofacies unit. The rest of this *Praeexogyra* limestone-shale unit is characterised by successive dominance of *Dissiliodinium*, *Ctenidodinium*, and *Batiacasphaera*, which changes to *Meiurogonyaulax* in the cryptalgal-rippled siltstone, before returning to *Batiacasphaera* in the upper *Praeexogyra* limestone-shale unit. Comparison with the dinocyst phases in the lower (foreshore) section shows that in both cases *Pareodinia* and *Sentusidinium* dominate in the 'marine' community biofacies, suggesting that they may represent a high salinity association in this formation. The only other similarity is that *Meiurogonyaulax* does not achieve dominance in the *Praeexogyra* limestone-shales lithofacies.

In the upper (Lon Ostatoin) section (Figs. 10.24 to 10.28) the parameter variation in the lower part of the section is closely related to changes in lithofacies and sample and dominant lithology, while that in the upper part is related to lithological changes. The transition from *Unio-Neomiodon* muds and sands to *Praeexogyra* limestone-shales is characterised by sharp increases in AOM, palynomorphs, and biostructured brown wood, and a progressive increase in the % undegraded/non-biostructured brown wood. The percentage of palynomorphs continue to increase as the environment changes to marine-hypersaline; a similar pattern is shown by the percentage of marine plankton. At the transition back to the *Unio-Neomiodon* muds and sands lithofacies there is a sharp increase in the percentage of phytoclasts (especially in banded and pitted of

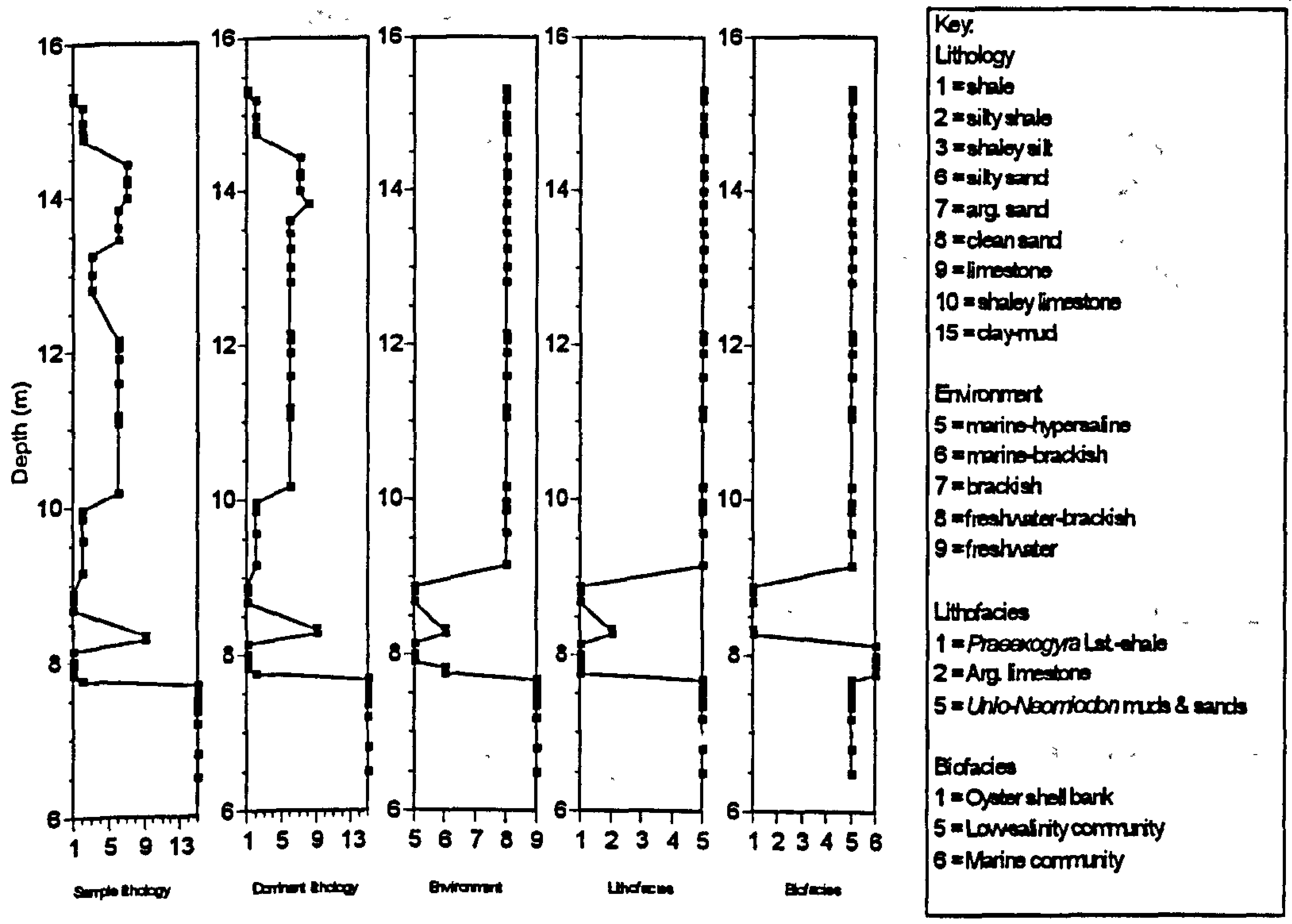


Fig. 10.24. *Selected parameters through the upper (Lon Ostatoin) part of the Duntulm Formation type section. The environment classification is that of Hudson and Harris (1979), the litho- and biofacies are those of Andrews and Walton (1990).*

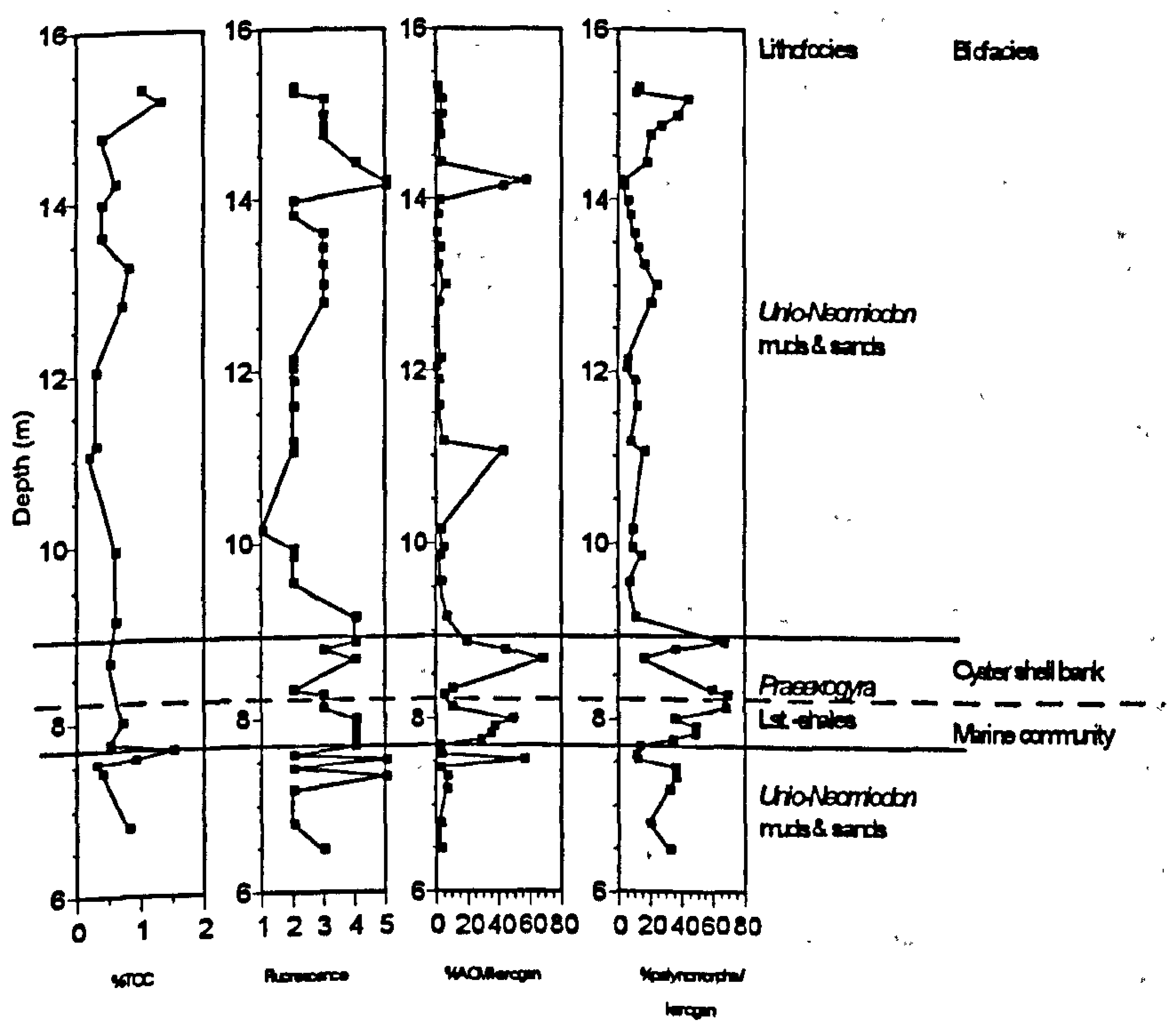


Fig. 10.25. *Selected parameter values through the upper (Lon Ostatoin) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

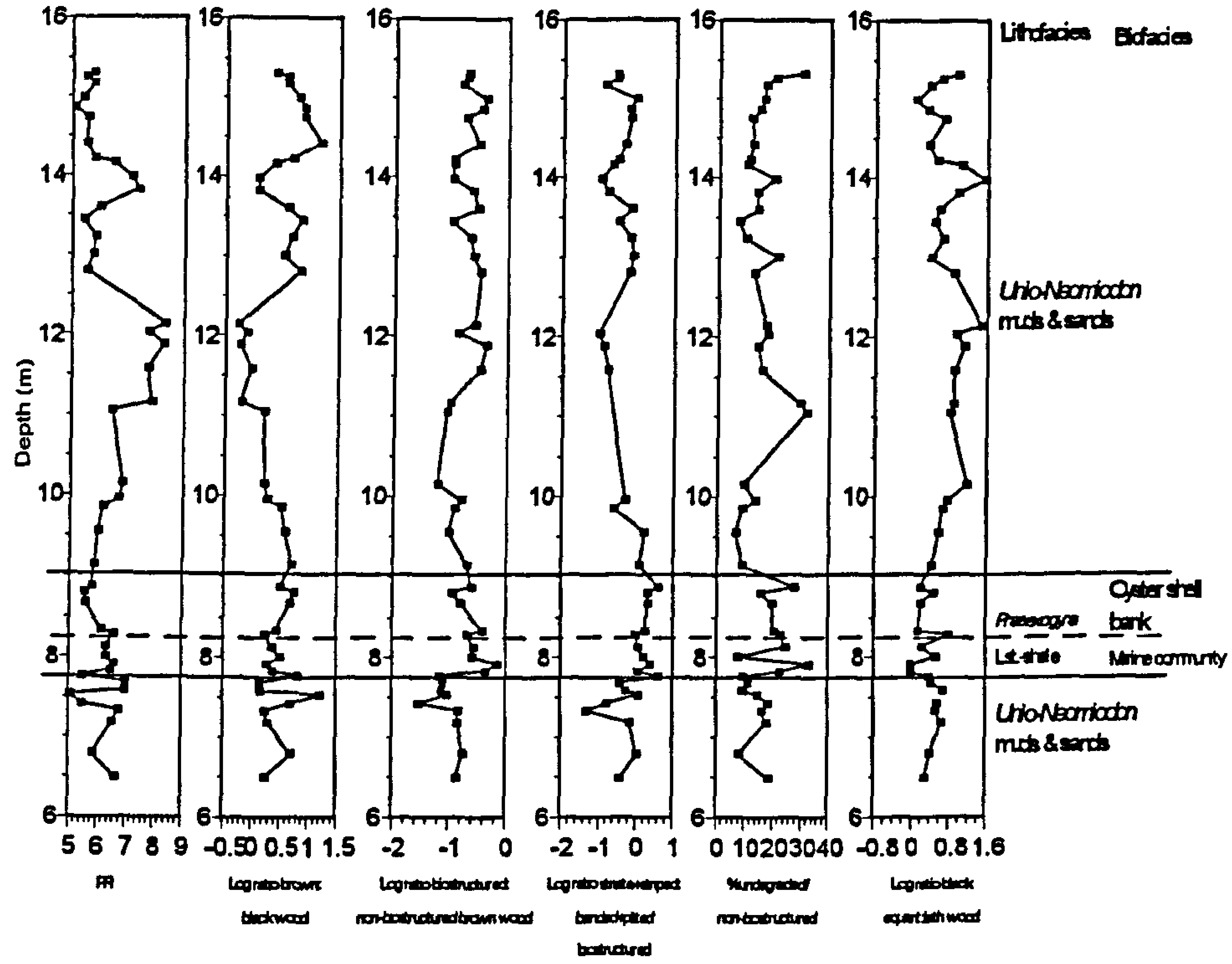


Fig. 10.26. *Selected phytoclast assemblage parameter values through the upper (Lon Ostatoin) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

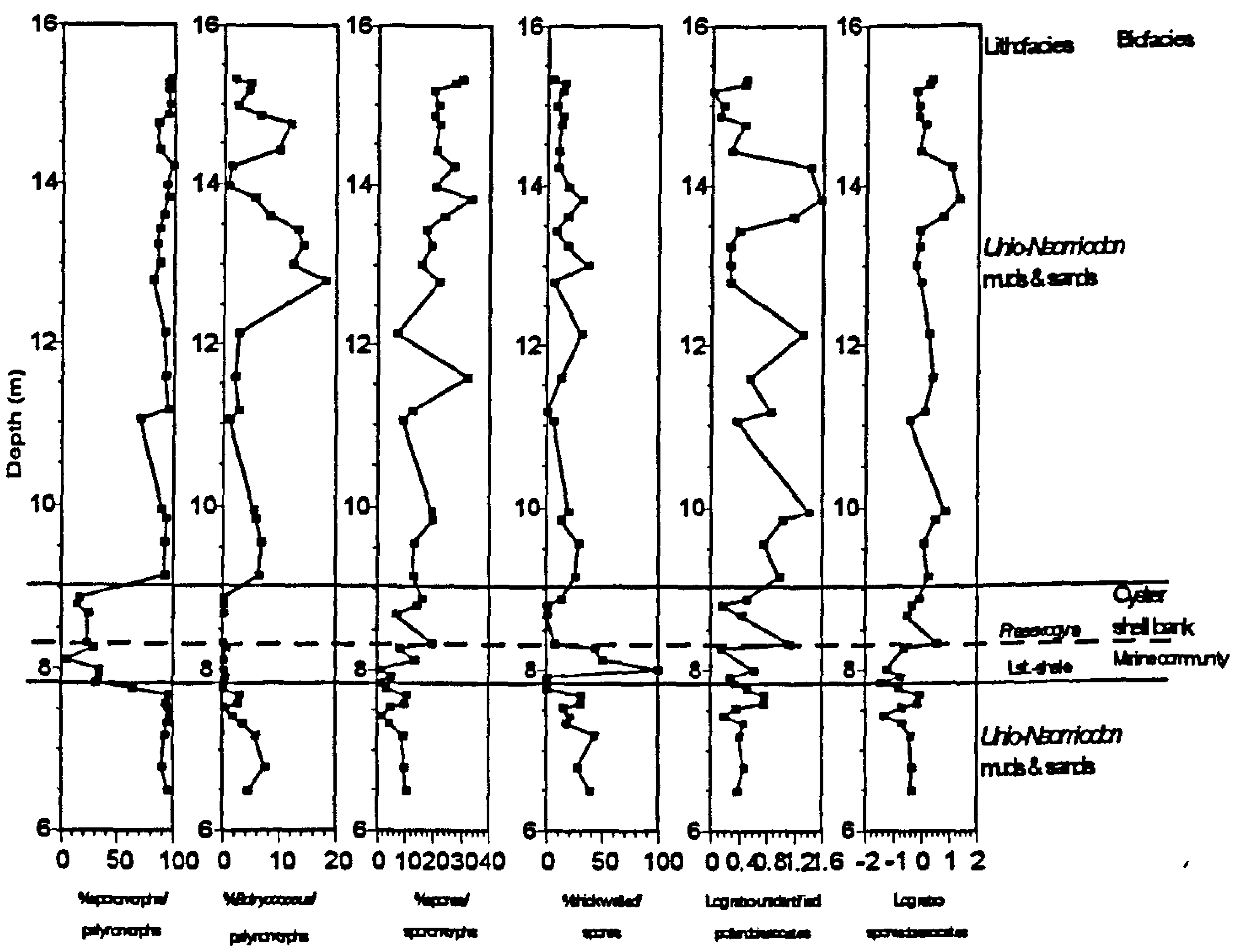


Fig. 10.27. *Selected palynomorph assemblage parameter values through the upper (Lon Ostatoin) part of the Duntulm Formation type section. The litho- and biofacies are those of Andrews and Walton (1990).*

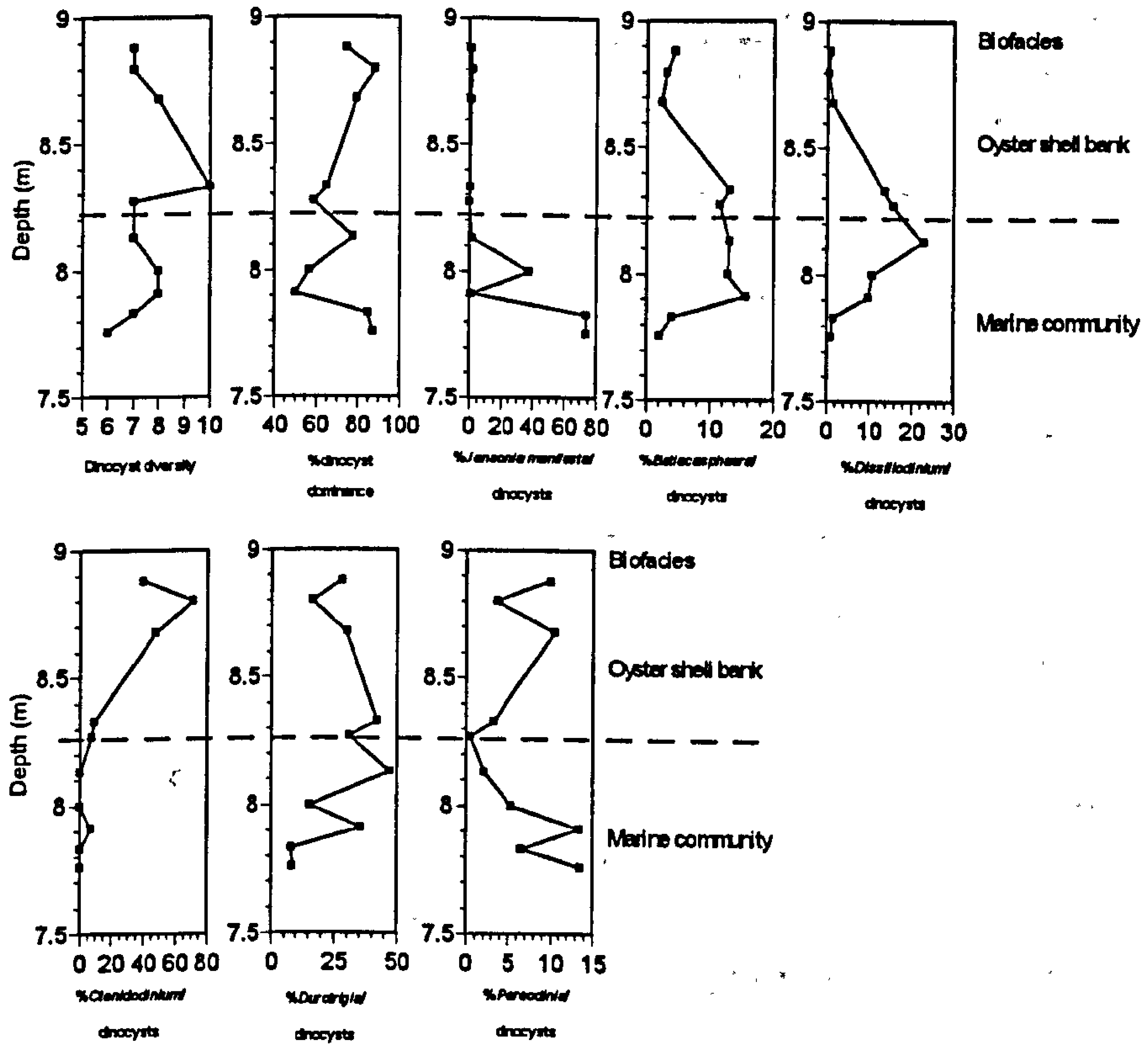


Fig. 10.28. *Selected dinocyst assemblage parameter values through the* Praeexogyra *limestone-shales lithofacies unit of the upper (Lon Ostatoin) part of the Duntulm Formation type section.*

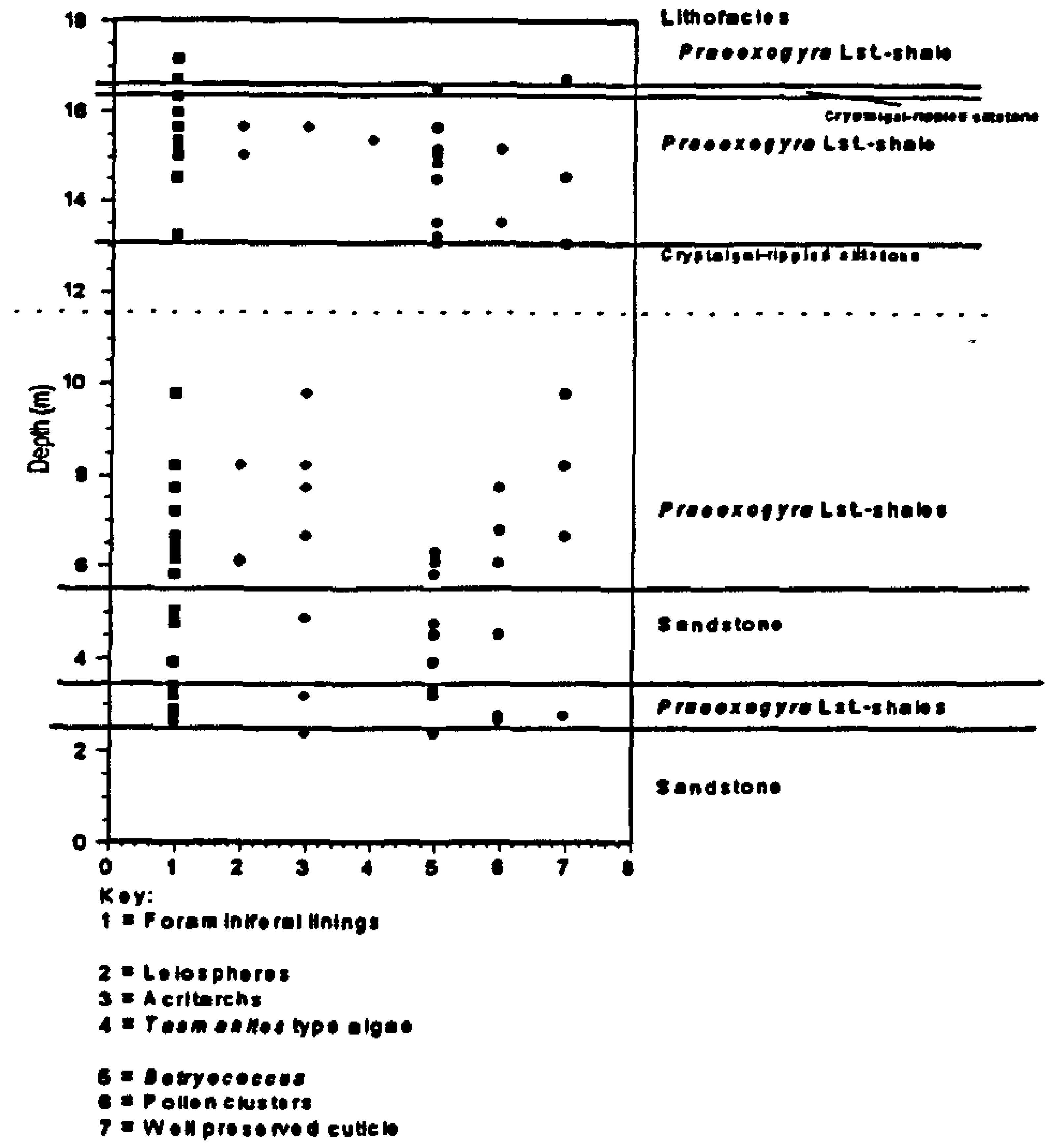


Fig. 10.29. *Presence-absence diagram for the lower and middle (Cairidh Glumaig) parts of the Duntulm Formation type section. The lithofacies are those of Andrews and Walton (1990).*

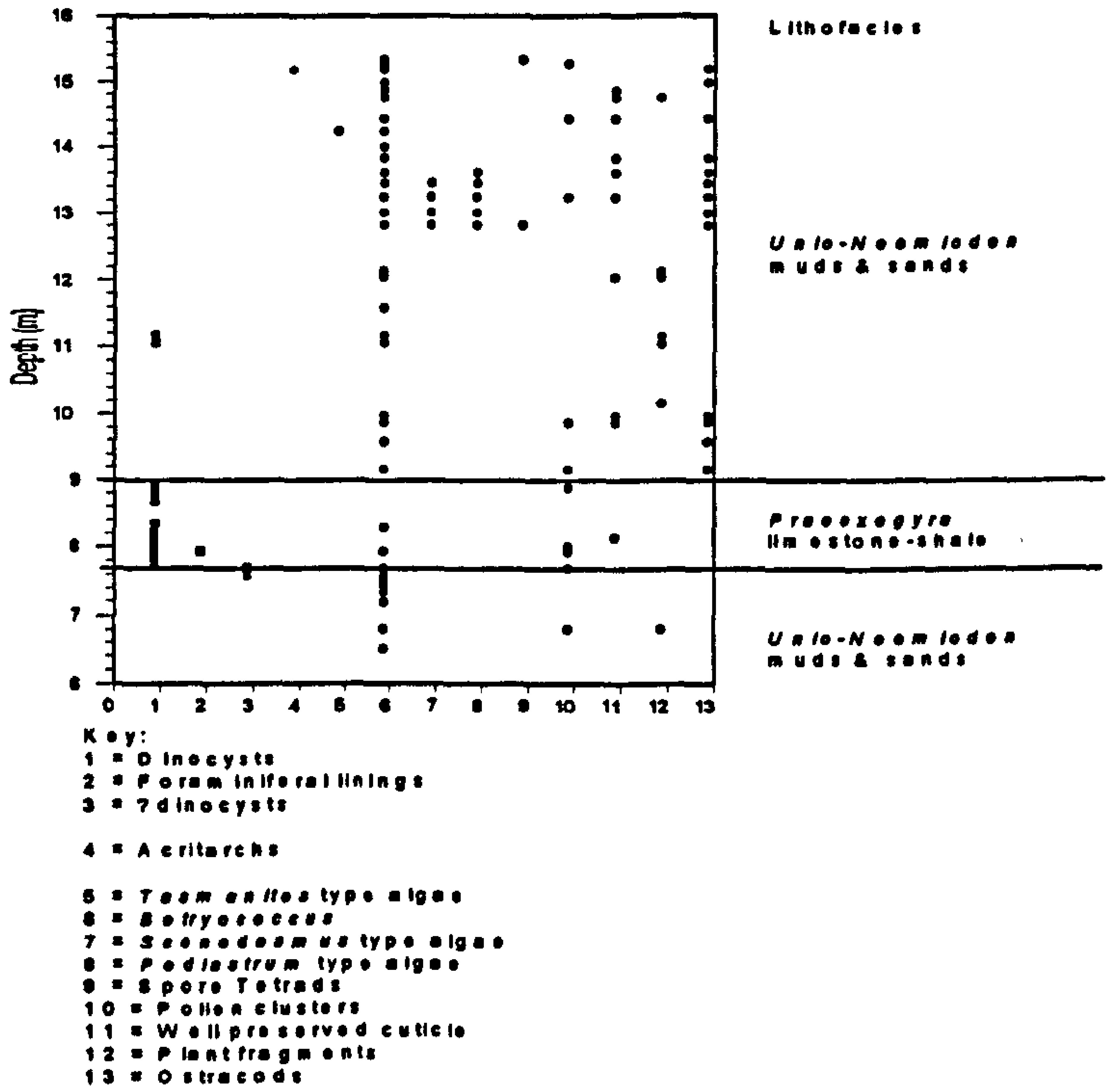


Fig. 10.30. *Presence-absence diagram for the upper (Lon Ostatoin) part of the Duntulm Formation type section. The lithofacies are those of Andrews and Walton (1990).*

biostructured and corroded of non-biostructured brown wood), and also in sporomorphs and *Botryococcus*.

Within the marine interval dinocyst diversity increases towards the centre of the interval, then decreases; dominance values show the usual opposite pattern. The opportunistic dinocyst *Jansonia manifesta* (Riding *et al.*, 1991) dominates the assemblages in the lower part of the interval, but this is followed by a sharp decrease in the abundance of this taxon correlated with a sharp decrease in dominance values. The high dominance assemblages in the upper part of the interval are characterised by high percentages of the *Ctenidodinium*, whilst in the middle of the interval the low dominance assemblage is characterised by increased proportions of *Durotrigia*, *Batiacasphaera*, and *Dissiliodinium*.

In the middle and upper part of this section the effect of lithology can be seen in the increased TOC values in the silty shales at the top of the section. The phytoclast assemblage becomes more refractory and *Botryococcus* percentages decrease through the lower coarsening upward sequence (8.5-11m); in the upper coarsening-upward sequence (13-14m) the percentage phytoclasts increases progressively, then decreases as lithology fines towards the top of the section. At 12.5m there are sharp changes in many parameters correlated with the sharp fining of lithology: kerogen fluorescence levels increase, as do the percentage of palynomorphs, *Botryococcus*, and bisaccate pollen; there are also changes in the phytoclast assemblage (brown wood, banded and pitted of biostructured, cuticle, and membranes all increase).

The upper section can be divided into six palynofacies units, a lower unit from 6 to 7.6m in which the parameters are stable, or show progressive change, a unit from 7.6 to 9m which is characterised by a sharp base and large variability, a unit from 9 to 12.5m which again has a sharp base and is characterised by progressive change (but some significant variability in parameter values), and a unit from 12.5 to 14m which also generally has a sharp step in values at the base before progressive change within the unit. There are two upper units, one from 14-15m in which the parameters show progressive change, and the other from 15 to 15.5m in which some parameters are stable, but others show progressive change.

10.2.4 Staffin Bay Formation, Staffin Bay, Skye.

Within this section (Figs. 10.31 to 10.35) the coarsening-upwards, proximal-distal trend through the section (defined by the change from a lagoonal to barrier bar environment) is reflected in the upwards increase in the percentage of phytoclasts and in the undegraded component of the non-biostructured brown wood. Other noticeable upward trends are the decreases in the percentage of poorly preserved dinocysts (not shown) and *Durotrigia* spp., and upward increase in other gonyaulacacean dinocysts. The phytoc parameter also increases upwards until the clean sands in the middle-upper Belemnite Sandstone Member are reached, and is noticeably smoother than the TOC curve.

At the Skudiburgh-Staffin Bay Formation transgression the change in facies and lithology is reflected in a decrease in the percentage of phytoclasts and a corresponding progressive increase in the percentage of palynomorphs. There are also changes in the phytoclast assemblage with increases in brown wood, biostructured brown wood, and all undegraded brown wood suggesting a change to a more refractory assemblage. There is also a sharp increase in the black lath wood content of the Staffin Bay Formation sediments.

In the type section the changes in parameters are mostly related to variations in lithofacies and lithology. Within the main lithofacies units the bituminous shales facies is characterised by relatively high TOC, AOM, black wood, and undegraded of non-biostructured brown wood; the silts-fine sands facies have high phytoclasts, palynomorphs, brown wood, and corroded non-biostructured wood. The argillaceous sands facies is dominated by phytoclasts, the assemblage of which is characterised by high black equant wood and undegraded non-biostructured brown wood. In the dinocyst assemblage poorly preserved dinocysts are low and gonyaulacacean dinocysts dominate; notes made during counting show that these are mostly robust proximate forms. In this facies the coarser sands are characterised by higher non-biostructured brown and banded and pitted biostructured brown wood.

The changes in parameters do not always occur at the lithofacies boundaries, for example at the transition from the silt-fine sands to bituminous shales at 6m there are sharp increases in TOC, and fluorescence, but the increase in AOM does not occur until lithology changes to shale above the transition. The change in the biostructured brown wood assemblage also correlates with the change in lithology whereas the non-biostructured brown wood component changes at the lithofacies boundary. There is

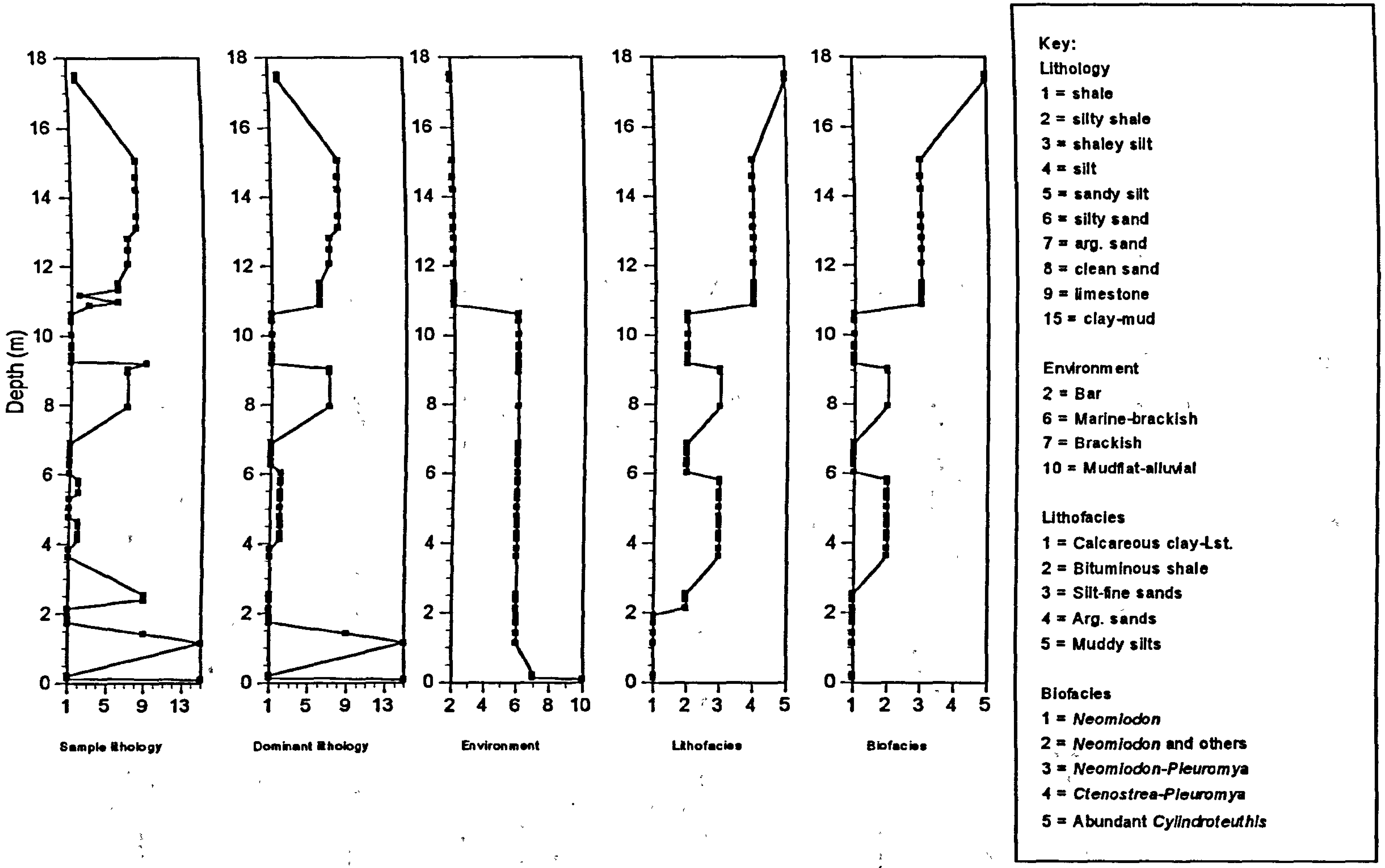


Fig. 10.31. *Selected parameters through the Staffin Bay Formation composite type section. The environment classification is that of Hudson and Harris (1979), the lithofacies are those of Sykes (1975a), the biofacies are derived from Sykes (ibid.) and Hudson and Morton (1969).*

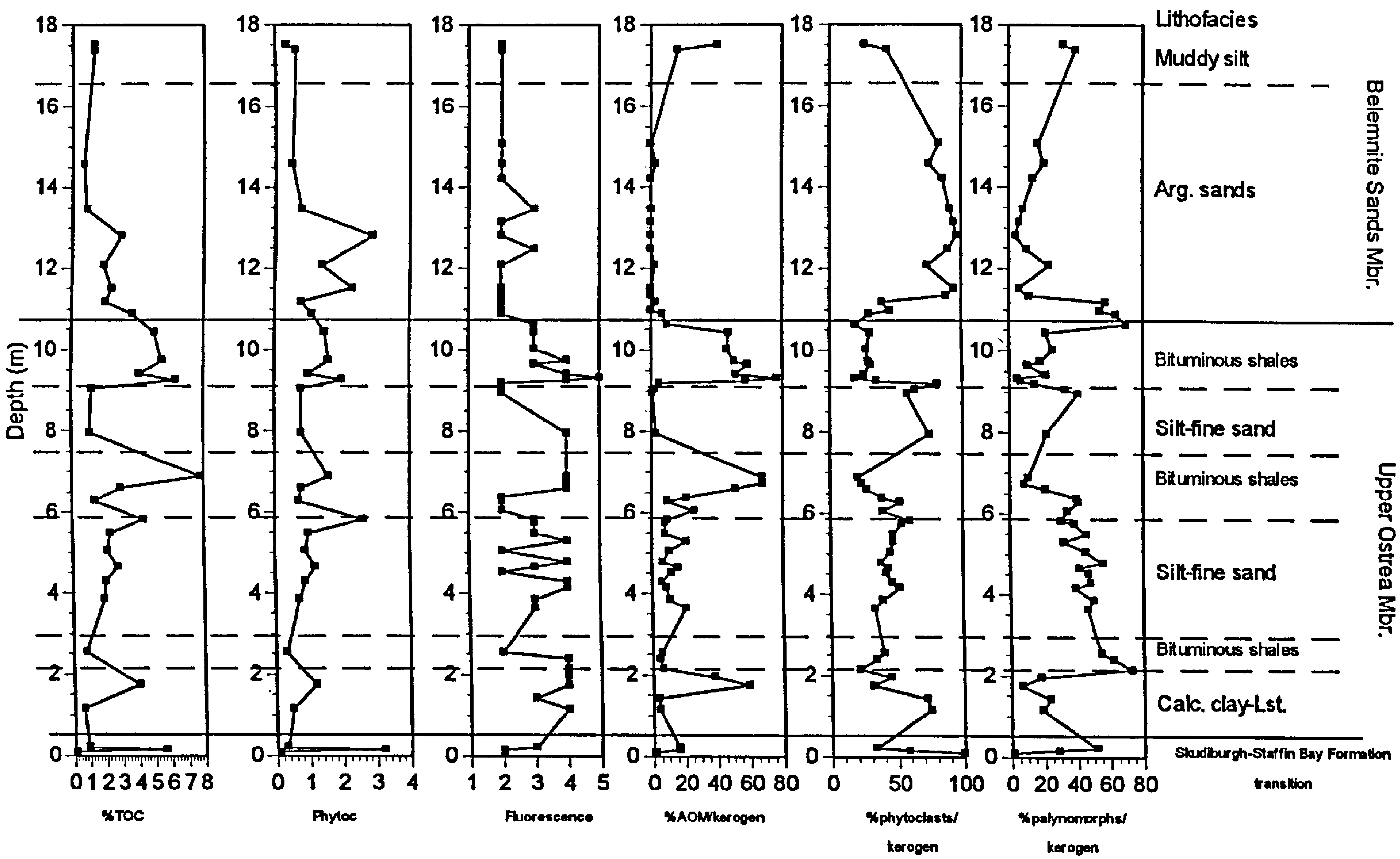


Fig. 10.32. *Selected parameter values through the Staffin Bay Formation composite type section. The lithofacies are those of Sykes (1975a).*

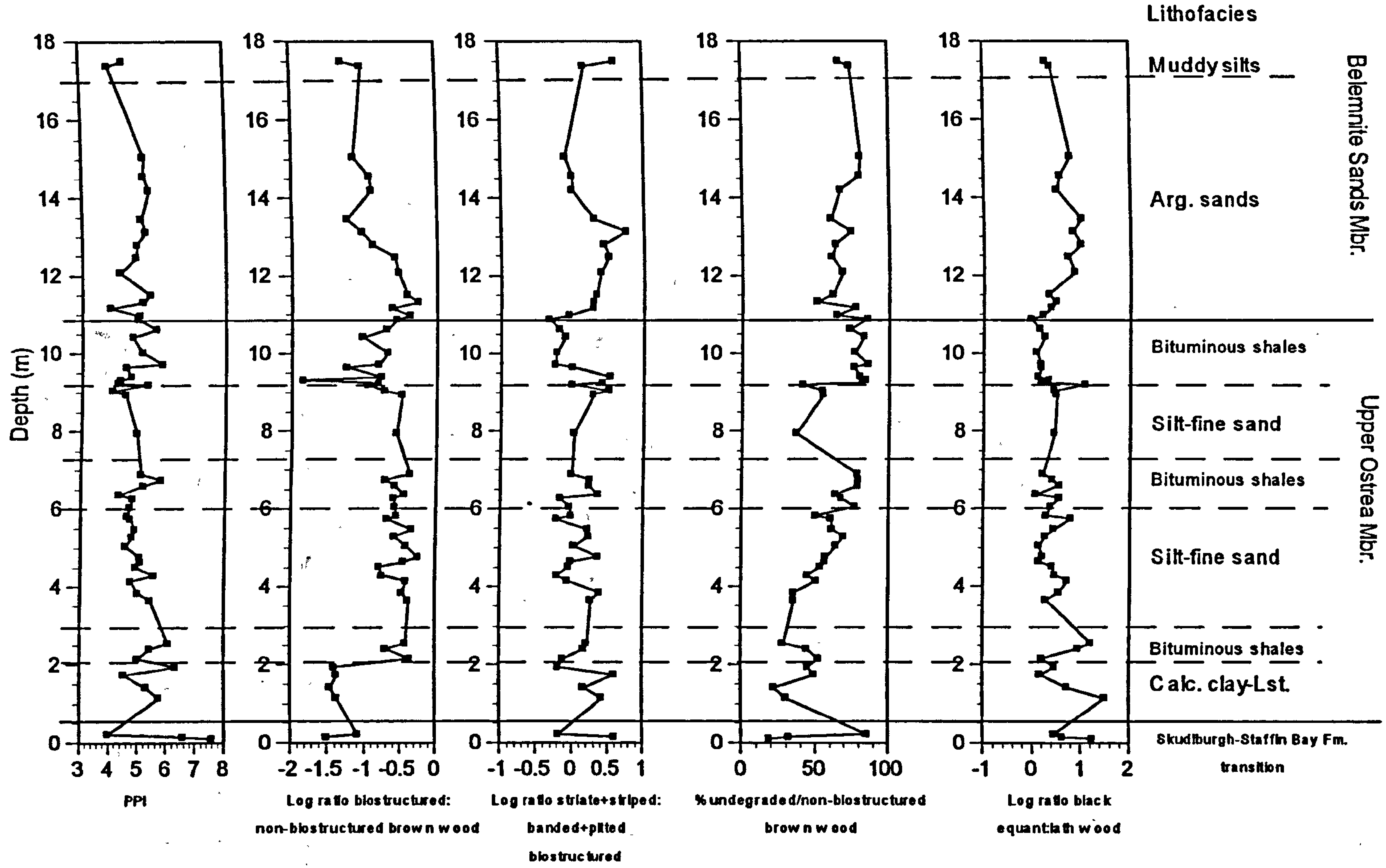


Fig. 10.33. *Selected phytoclast assemblage parameter values through the Staffin Bay Formation composite type section. The lithofacies are those of Sykes (1975a).*

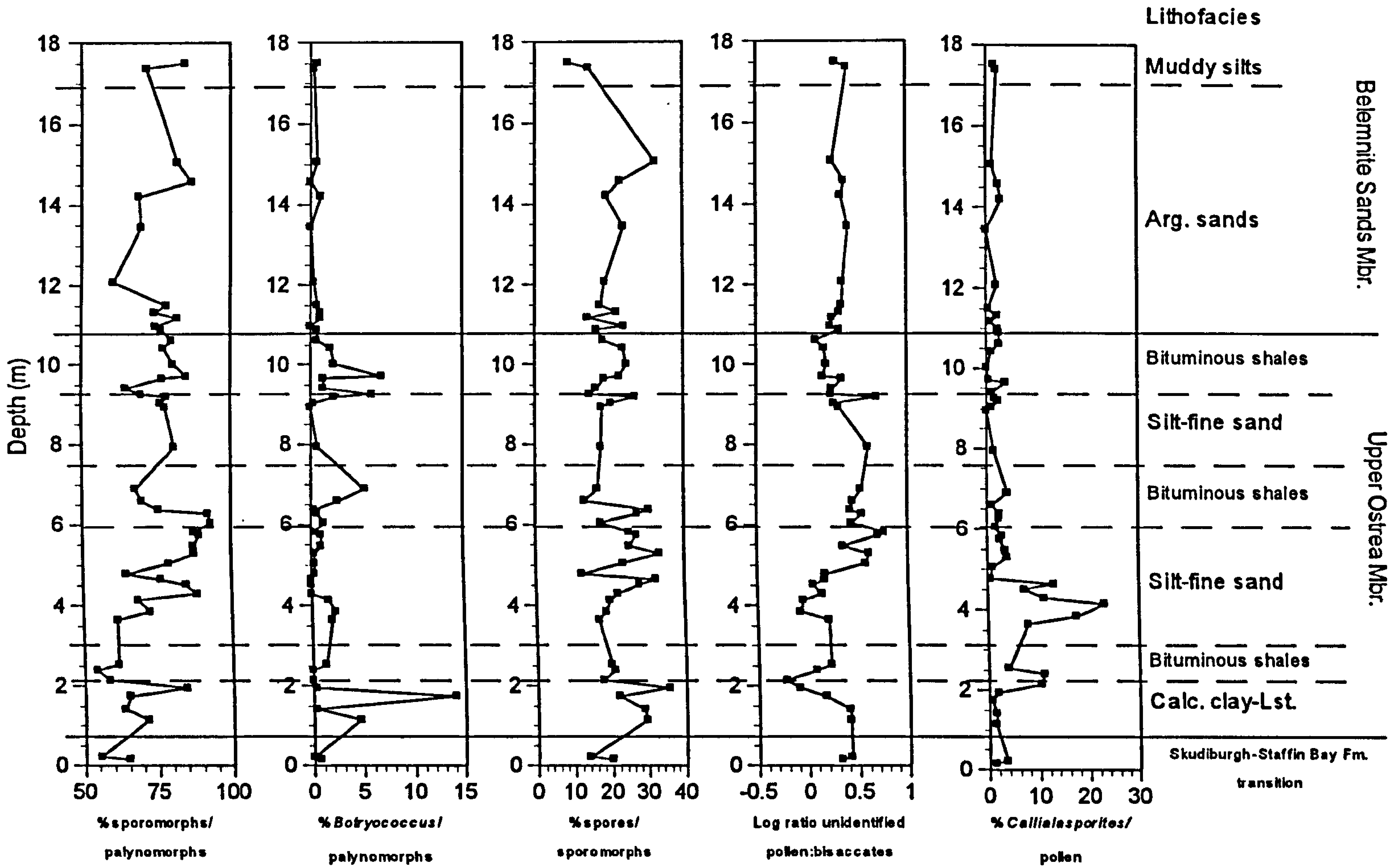


Fig. 10.34. *Selected palynomorph assemblage parameter values through the Staffin Bay Formation composite type section. The lithofacies are those of Sykes (1975a).*

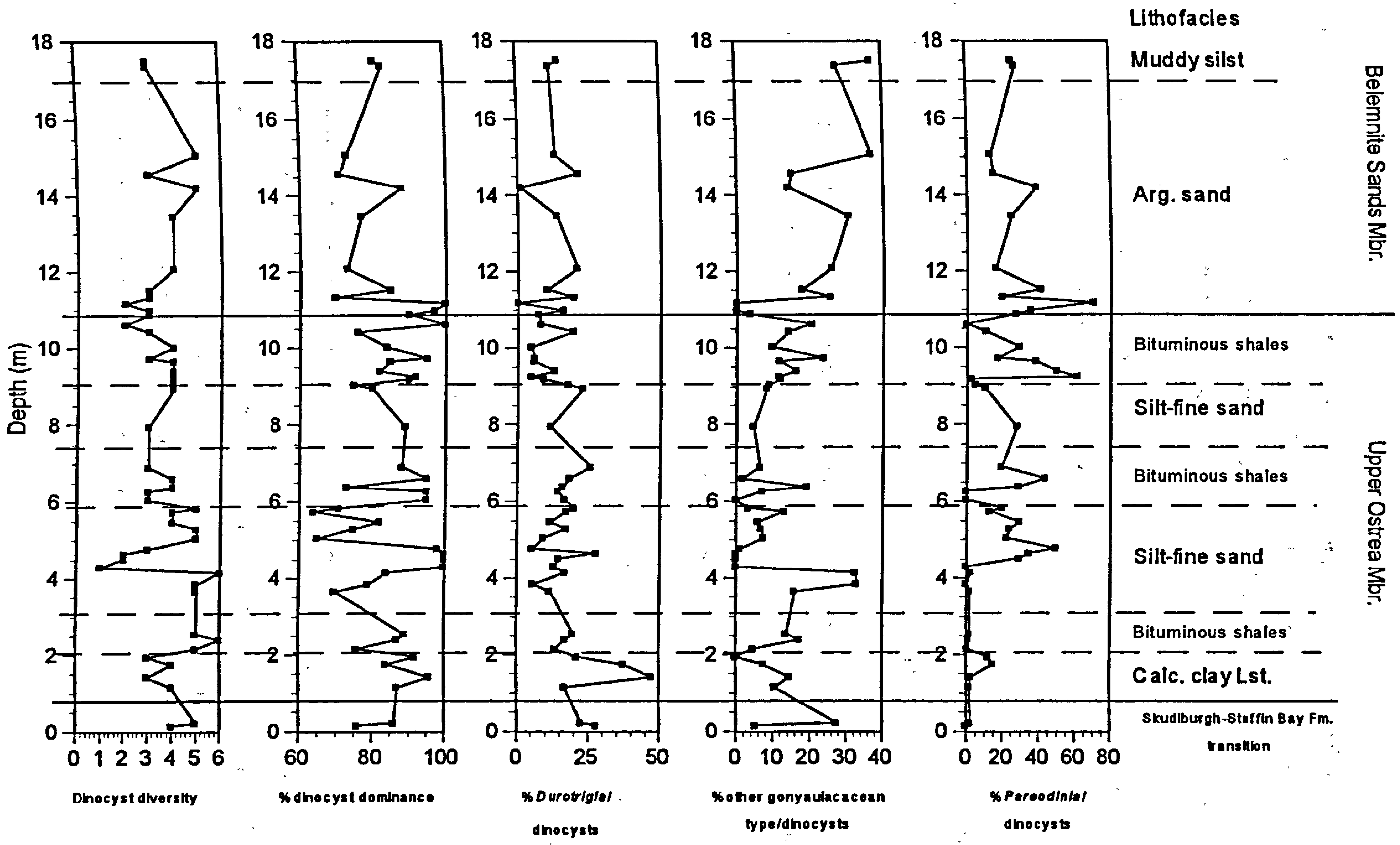


Fig. 10.35. *Selected dinocyst assemblage parameter values through the Staffin Bay Formation composite type section. The lithofacies are those of Sykes (1975a).*

also variability in the point of change in the palynomorph assemblage: the palynomorph fraction of the kerogen assemblage shows a sharp decrease at the lithofacies boundary, but changes within the palynomorph assemblage correlate with the change in lithology above the boundary.

The transition to the argillaceous sands facies which marks the base of the Belemnite Sands Member is marked by a sharp decline in fluorescence, but some of the parameters do not change until lithology coarsens significantly above this contact. There is a progressive decline in %TOC and an increase in phytoc and %phytoclasts, and a sharp increase in the proportion of gonyaulacacean dinocysts correlated with the coarsening lithology, but the decrease in the %AOM occurs below the member boundary. There is a progressive increase in biostructured brown wood over the boundary.

There are five possible playnofacies units relating to the total kerogen plots, but only four are visible in the palynomorph data. A lower unit from 0 to 2m is visible in both, being characterised by large variability in the kerogen parameters, but progressive change in some of the palynomorph parameters. There is then a unit from 2 to 7m in the kerogen plots which has a sharp base, and in which the parameters show progressive change; in the palynomorph parameters the top of this unit is at 6m, and it is followed by a unit from 6 to 11m characterised by stability in most of the parameters and occasional progressive change. There are two units in the kerogen parameters over this part of the section, one from 7 to 10m characterised by progressive change, and one from 10 to 11m in which the parameters are mostly stable, but there is some progressive change. Finally, there is a unit in both the kerogen and palynomorph parameters from 11m to the top of the section, which in the case of the kerogen parameters is characterised by progressive change or stability, the palynomorph parameters are mostly stable, but some show significant variability.

The presence/absence diagram (Fig. 10.36) shows the change to marine-brackish conditions in the Staffin Bay Formation with the incoming of acritarchs, but no foraminiferal linings occur until well into the Upper Ostrea Member suggesting that conditions remained at least partly brackish for some time following the transgression. The diagram also shows that acritarchs are not present in the coarser sands, and that there is no cuticle in the upper lithofacies unit, possibly reflecting the more distal site of deposition.

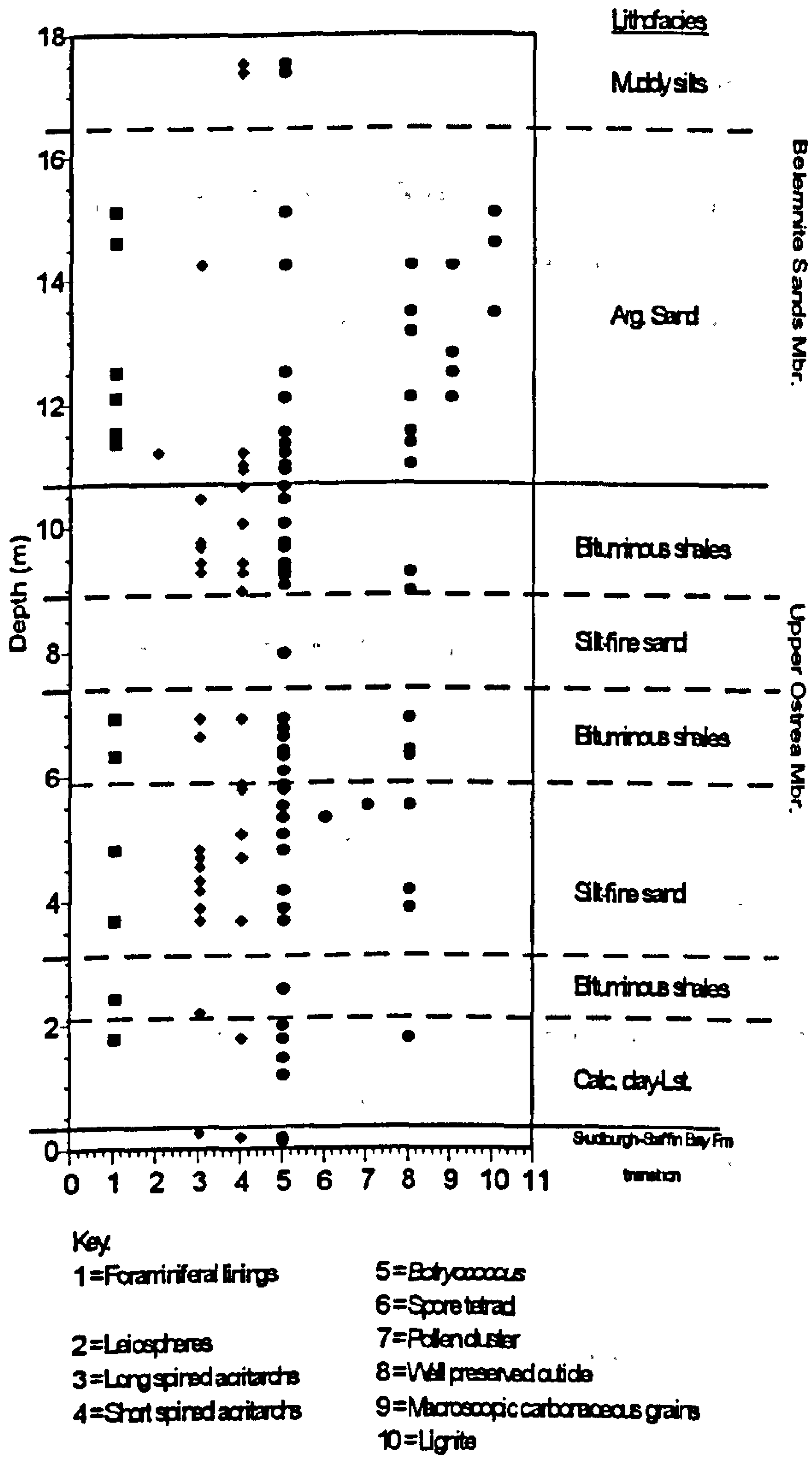


Fig. 10.36. *Presence-absence diagram for the Staffin Bay Formation composite type section. The lowermost sample represents the top of the Skudiburgh Formation. The lithofacies are those of Sykes (1975a).*

10.2.5 Overall Controls

In each section the parameter variations are a product of the interactions between a number of potential controls on assemblages such as lithology, dominant lithology, lithofacies, and environment. In many cases the changes in these factors are often correlated, making it difficult to assess a major single controlling factor on any variation. However, it has been possible to try to establish the relative strengths of lithology versus other factors.

In the Dun Caan Shales Member (Bearreraig Sandstone Formation) the main control appears to be the proximal-distal variation, although this is partly lithologically based with the upper distal unit consisting primarily of shales (as opposed to the silty shales and shaley silts of the section below). In the Udairn Shales-Holm Sandstone members section there appears to be a strong lithological control with many parameters showing changes correlated with the coarsening-upward nature of the section. In the lower (Kildonnan Member) of the two sections from the Lealt Shales Formation much of the variation in lithology and environment is correlated, but where lithology is stable, variation in environment category does result in parameter changes, suggesting that all the variability is not accounted for by lithology.

In terms of environment versus salinity the changes are again often correlated, but when either salinity or environment vary independently there are also parameter changes suggesting that both these variables are influential. It also appears that environment changes seem to be reflected in sharp variations in some of the parameters, whilst variation over salinity changes appear more gradual. Where the variations in lithology and environment are independent the parameters show a strong correlation with both, suggesting that they both exert a strong control on assemblages. The Duntulm Formation composite section provide a similar problem to the Kildonnan Member, but on occasions where variation takes place independently there is parameter variation due to lithology and due to litho- and biofacies. In the Staffin Bay Formation the parameters seem to be more strongly correlated with lithology, although again there is a correlation between lithologic and lithofacies variation. For example, the sharp increase in the percentage of phytoclasts in the lower part of the argillaceous sands lithofacies occurs after the transition and is correlated with significantly coarsening lithology.

10.2.6 Parameters Most Responsive to Controlling Factor Variation

In each of the sections the parameters most responsive to variation have been compared (Table 10.6). Where possible they have been divided into those which best reflect lithological variation and those which respond most to variations in other factors (proximal-distal, environment, salinity, lithofacies). The majority of parameters show both gradual and sharp changes at unit boundaries, but AOM in particular is characterised in the most part by sharp increases or decreases, which may reflect the potential for the rapid establishment of dysoxic-anoxic conditions in shallow water.

Examination of Table 10.6 shows that the most common parameters are the three main kerogen groups (AOM, phytoclasts, palynomorphs), with the brown:black and biostructured:non-biostructured brown wood ratios from the phytoclast assemblage. The sporomorph:marine plankton ratio is important in the lagoonal sections where there is significant palaeosalinity variation.

10.3 Constrained Cluster Analysis

The objective of using constrained cluster analysis was to examine the natural relationships of the samples when constrained in stratigraphic order. It was carried out using only the combined variables group. The distance measure used was the squared euclidean distance, the clustering algorithm was Wards' method. This technique has been applied to all of the sections examined in the previous section, apart from the Lonfearn Member section which has a relatively low number of samples. Summary diagrams are provided of the cluster memberships versus potential controlling factors such as lithofacies and environment; the dendrograms (not shown) have been divided into relatively high order clusters (A, B, C, etc.) which represent major divisions, and minor sub-clusters (A1, A2, etc., numbered from the base upwards) which are subdivisions of these. The clusters have been compared with the palynofacies units defined by visual inspection of the stratigraphic plots of parameters; also shown are the stratigraphic plots of the scores of each sample on the first two factors from the factor analysis, these factor scores summarise the variation through the sections. A high positive score reflects high percentages of the variables which plot on the positive side of the factor (positively loaded variables), a high negative score thus reflects high percentages of the negative variables (negatively loaded variables). The factors are fully described in Chapter 9.0.

Section	Unit change	Lithological change
Dun Caan Shales Mbr.	%AOM/kerogen	
	PPI	
	%pseudomorphous/ non-biostructured brown wood	
	Unidentified pollen:bisaccates	
Udairn Shales &	%phytoclasts/kerogen	%AOM/kerogen
Holm Sst. mbrs.	Biostructured:non-biostructured brown wood	
	%corroded/non-biostructured brown wood	
	Black equant:lath wood	
	PPI	
Kildonnan Mbr.	%AOM/kerogen	%AOM/kerogen
	%palynomorphs/kerogen	%palynomorphs/kerogen
	%phytoclasts/kerogen	%phytoclasts/kerogen
	Fluorescence	Fluorescence
	Biostructured:non-biostructured brown wood	Biostructured:non-biostructured brown wood
	%*Botryococcus*/ palynomorphs	PPI
	%marine plankton/palynomorphs	
Lonfearn Mbr.	%AOM/kerogen	Brown:black wood
	%palynomorphs/kerogen	%membranes/phytoclasts
		PPI
Duntulm Fm.	%AOM/kerogen	%phytoclasts/kerogen
	Fluorescence	%spores/sporomorphs
	%palynomorphs/kerogen	PPI
	Biostructured:non-biostructured brown wood	Brown:black wood
	Sporomorph:marine plankton	
	Unidenitified pollen:bisaccates	
Staffin Bay Fm.	%palynomorphs/kerogen	Black equant:lath wood
	%AOM/kerogen	%AOM/kerogen
	Brown:black wood	%phytoclasts/kerogen
	Biostructured:non-biostructured brown wood	
	Sporomorph:marine plankton	

Table 10.6. *Parameters most responsive to change in unit or lithology, unit refers to variation in proximal-distal, environment, salinity, or lithofacies unit.*

10.3.1 Dun Caan Shales Member Type Section

There is a good correlation between the major clusters and proximal-distal units; there is also a reasonable agreement between the clusters and palynofacies units (Fig. 10.37). The factor loadings suggest a proximal trend defines subcluster A1, whilst sub-cluster A2 show a distal shift. There also appears to be a proximal shift towards the top of the section, which together with a decrease in selective preservation may be defining sub-cluster B2.

10.3.2 Udairn Shales-Holm Sandstone Members Type Section

Three major clusters are present (Fig. 10.38), the lowermost (A) suggests that the lower main Udairn Shales section samples are more similar to those from the section below which represent the most distal unit (1). This suggests that the lower part of this main section may also represent a part of the more distal facies; this is partly evidenced in the Factor 1 scores, which suggest a distal shift through this cluster. The second cluster (B) incorporates the rest of the Udairn Shales and the lower part of the Holm Sandstone Member; the position of the sub-cluster B2 suggests that the transitional unit (3) may begin below the top of the Udairn Shales Member, and that the upper part of this unit (which falls into cluster C) is significantly different from the lower-middle part of the section. The subdivision of cluster C agrees precisely with the distal-proximal unit boundary, suggesting that there is a change in palynofacies here also. As the cluster B-C boundary occurs below the one for units 3 and 4, this may suggest that the palynofacies assemblage is reflecting a significant proximal change before the sedimentological evidence on which the 3/4 boundary is based; this change is evident in the Factor 1 scores. There is generally poor agreement between the palynofacies units and the constrained clusters: only one boundary occurs at the same level.

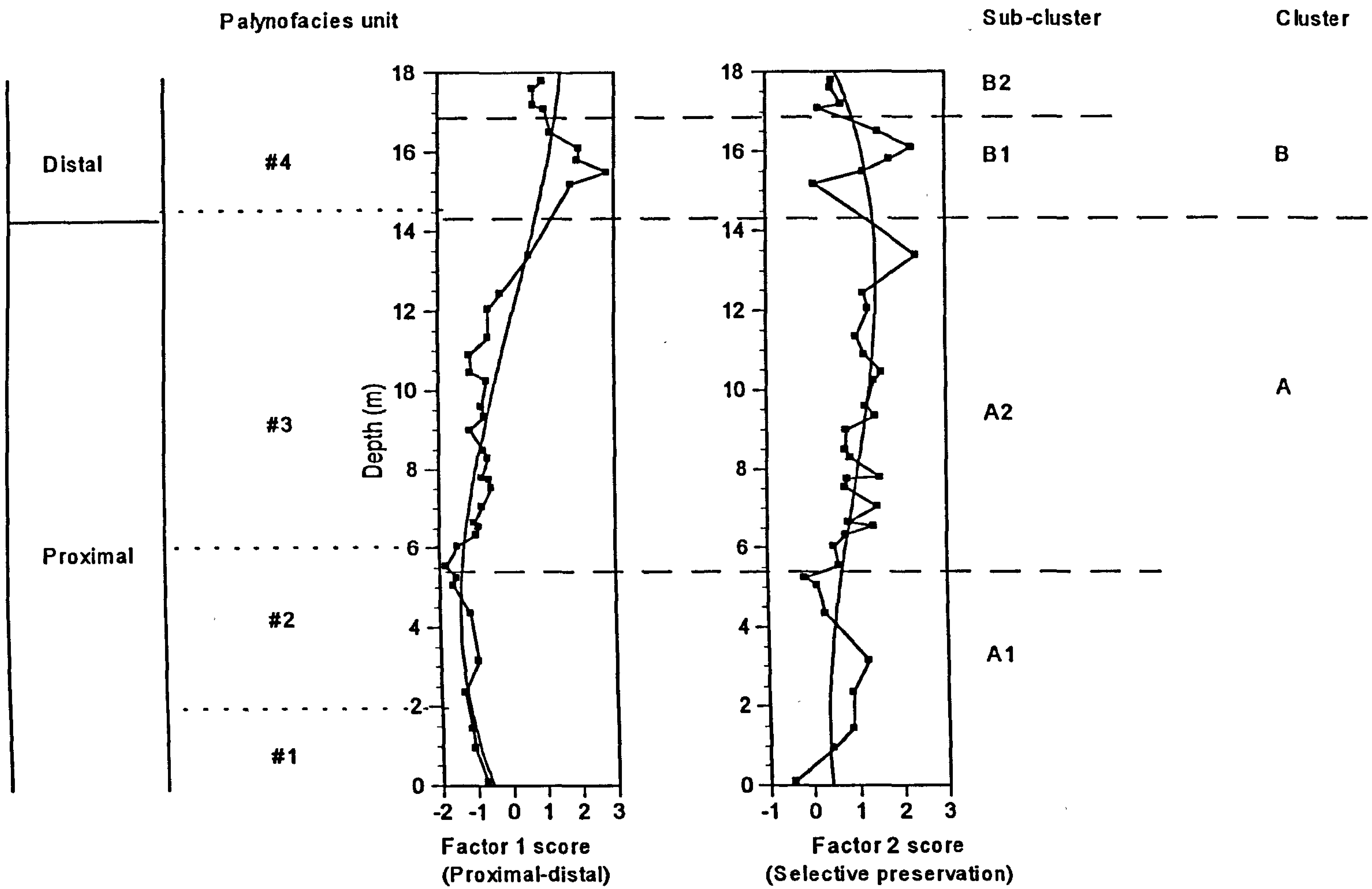


Fig. 10.37. *Constrained clusters, factor scores, and palynofacies units from the Dun Caan Shales Member (Bearreraig Sandstone Fm.) type section. Smoothed curve derived from polynomial of degree curve fitting function.*

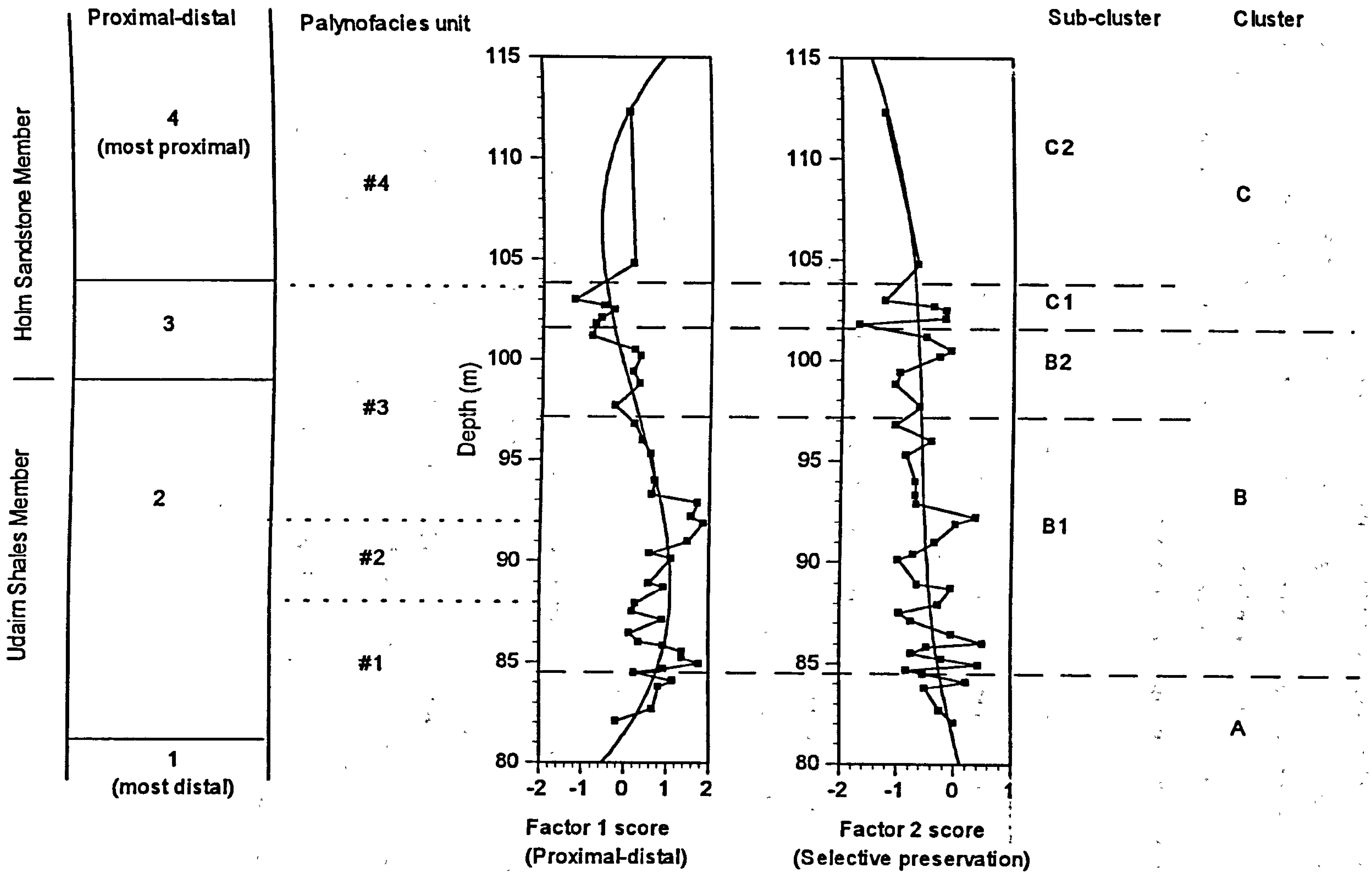


Fig. 10.38. *Constrained clusters, factor scores, and palynofacies units from the Udairn Shales-Holm Sandstone members (Bearreraig Sandstone Fm.) type section. Smoothed curve derived from polynomial of degree curve fitting function.*

10.3.3 Kildonnan Member Type Section

The clusters and sub-clusters generally relate very well to both the palynofacies units, and changes in environment and salinity (Fig. 10.39). There are eight palynofacies units and eight clusters and they are virtually identical in their position and make-up; on many occasions the factor scores can be seen to be varying between the clusters and palynofacies units. Nearly every change in environment or salinity is reflected in a cluster or sub-cluster boundary, suggesting that these are well defined by the palynofacies data, but the cluster or sub-cluster membership is sometimes not exactly the same as the environment/salinity unit.

10.3.4 Duntulm Formation Composite Type Section.

There are 13 palynofacies units and only 11 clusters and sub-clusters, but there is reasonable agreement between their boundaries, particularly those which reflect major lithofacies variation (Fig. 10.40). The major lithofacies changes and the variation between the different sections is generally picked up by both the clusters and the palynofacies units, and the cluster and unit memberships are often exactly the same as the lithofacies units. The factor scores often change between clusters and palynofacies units.

10.3.5 Staffin Bay Formation Composite Type Section

In this section the number of clusters and palynofacies units is the same, but there are also may sub-clusters which have been defined, leading to poor agreement between the number of units and clusters (Fig. 10.41). However, there is relatively good agreement between the positions of the boundaries of units and clusters which are nearly always similar, suggesting that changes that are evident in the limited number of parameters examined as stratigraphic plots are also present in the variable group as a whole. The clusters show a reasonably good correlation with the lithofacies present, but the cluster memberships are not exactly the same as those of the lithofacies units, often reflecting lithological rather than lithofacies changes.

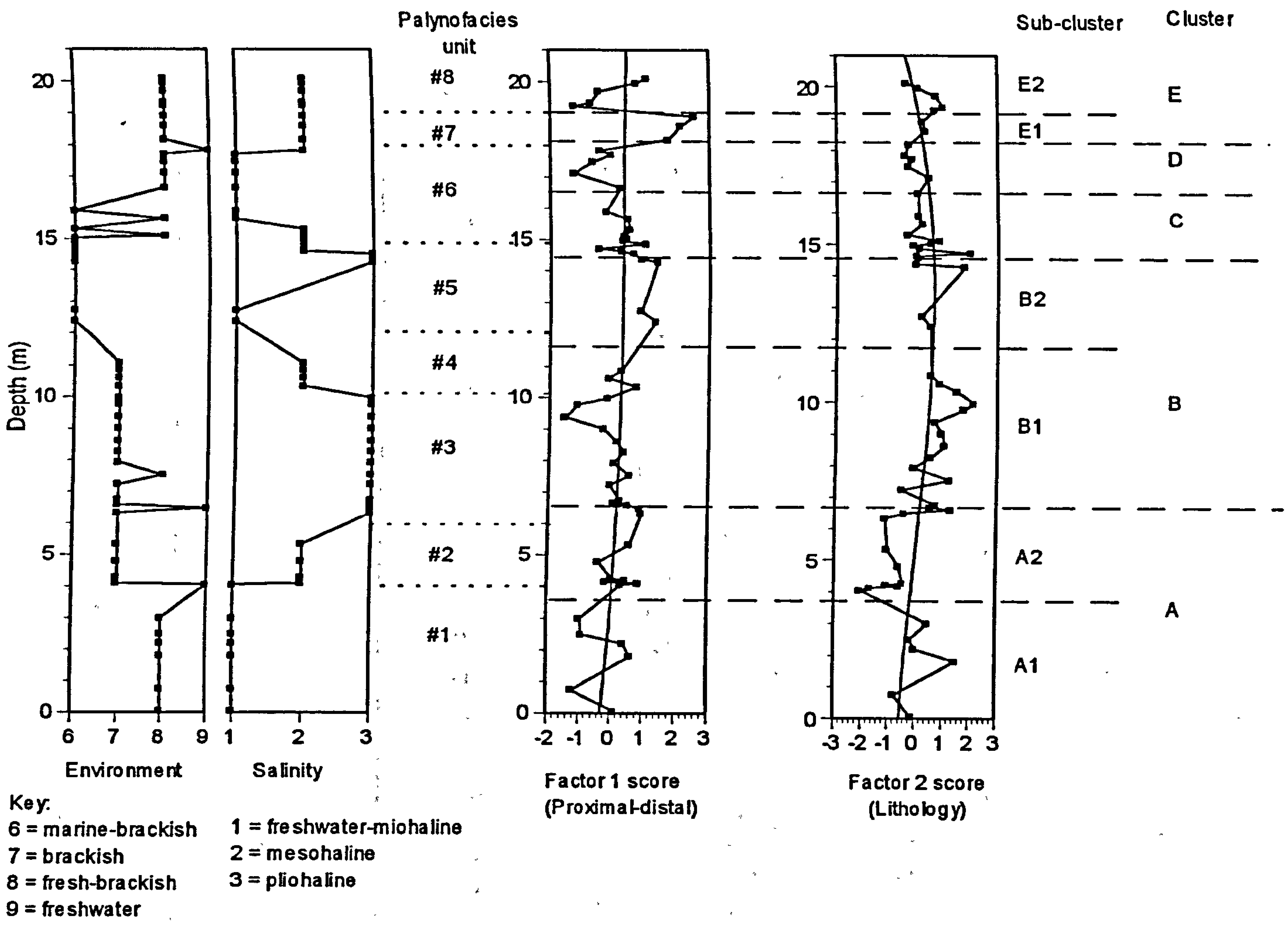


Fig. 10.39. *Constrained clusters, factor scores, and palynofacies units from the Kildonnan Member (Lealt Shales Fm.) type section. Smoothed curve derived from polynomial of degree curve fitting function.*

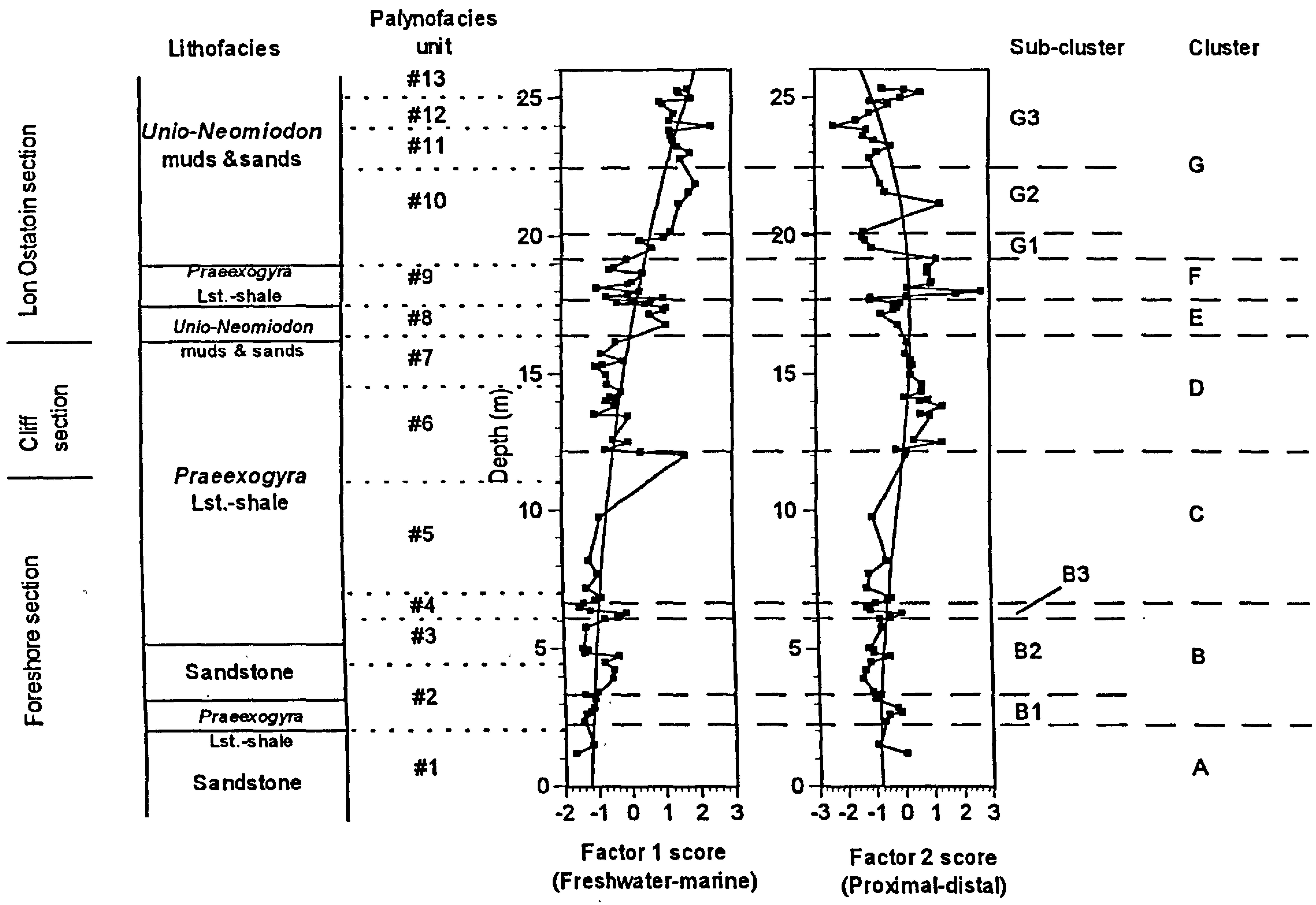


Fig. 10.40. *Constrained clusters, factor scores, and palynofacies units from the Duntulm Formation type section. Smoothed curve derived from polynomial of degree curve fitting function.*

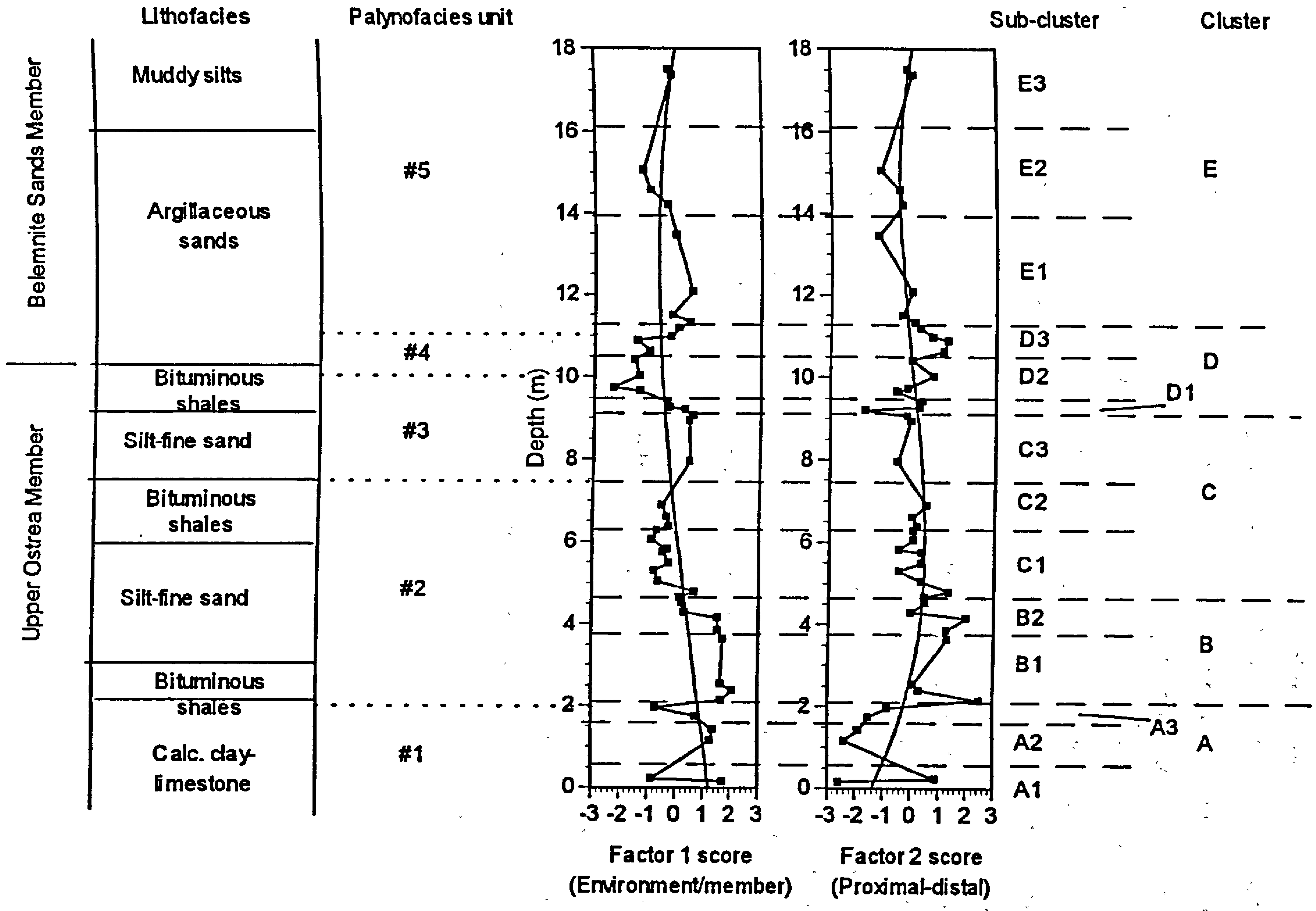


Fig. 10.41. *Constrained clusters, factor scores, and palynofacies units from the Staffin Bay Formation type section. Smoothed curve derived from polynomial of degree curve fitting function.*

10.3.6 Summary

The constrained clustering technique is useful for comparison between the palynofacies assemblages and the changes in potential controlling factors (lithofacies, environment, salinity). The clusters should (theoretically) reflect the prevalent control on each section, but this is difficult to define when the changes taking place in the controlling factors are often auto-correlated. Within the sections examined the variation in the Dun Caan Shales Member seems to be based on relative proximal-distal position. The Udairn Shales-Holm Sandstone member section shows a proximal-distal control, but this classification is based primarily on lithological changes. The Kildonnan Member section shows a strong environment/salinity control on assemblages, but lithologic and dominant lithology effects can also be seen. Similarly, lithofacies exert a relatively strong control in the Duntulm Formation, but lithology also appears to be an important factor. The Staffin Bay Formation section shows a stronger lithological control with a contribution from lithofacies. To summarise, where there is relatively little lithological variation changes in the assemblage can be related to other factors (e.g. Dun Caan Shales and Kildonnan members), but if lithology does vary then it clearly has a strong influence (e.g. Duntulm and Staffin Bay formations).

This technique also shows that changes in the palynofacies assemblage may not be precisely correlated with environment/salinity/lithofacies boundaries. This suggests the palynofacies technique may pick up these changes before they are evidenced in other ways, or that the changes are not shown by the assemblages until some time after they have taken place.

CHAPTER 11.0
CONCLUSIONS

11.0 CONCLUSIONS

11.1 Overall Controls and Most Useful Variables

In each of the major formations the controls on the palynofacies data derived from a variety of methods have been compared (Table 11.1). In the Bearreraig Sandstone Formation proximal-distal position appears to be the strongest control on palynofacies assemblages, followed by a lithological effect. Comparison of the variables derived from the multivariate statistical techniques with those showing the most variability in the stratigraphic plots reveals that the non-biostructured brown wood fraction (and its constituent particle types) and the unidentified pollen component of the palynomorph assemblage are common to both. This suggests that these variables show the most systematic variation with regard to proximal-distal position.

In the Lealt Shales Formation the primary control on assemblages appears to be more ambiguous; however, the proximal-distal name attributed to Factor 1 may be related to the environmental control suggested by constrained cluster analysis and the stratigraphic plots, as freshwater environments are likely to be more proximal than more marine environments. There certainly appears to be a strong lithological control which is picked up by all the techniques. Comparison of the variables which characterise this (lithological) effect shows that %membranes/phytoclasts is common to all the analyses. The %*Botryococcus*/palynomorphs parameter is common to all the environment/proximal-distal analyses. This suggests that the latter two variables best characterise any lithological (membranes) and palaeosalinity (*Botryococcus*) variations within this formation.

The primary control in the Duntulm Formation appears to be based on lithofacies/environment (which are generally closely related to each other); the freshwater-marine identity attributed to Factor 1 also relates partly to the lithofacies/environment units, as the major difference in facies is the freshwater intercalation. The variables which occur in all these analyses are %sporomorphs and %marine plankton (both of palynomorphs), which suggests that these variables show the most systematic variation through the lithofacies and environment units.

Formation	Factor analysis	Discriminant function	Constrained cluster analysis	Stratigraphic plots
Bearreraig Sandstone	Proximal-distal Selective preservation	Proximal-distal Dominant lithology	Proximal-distal Lithology	Proximal-distal Lithology
Lealt Shales	Proximal-distal Lithology	Dominant lithology Sample lithology	Environment Lithology	Environment Lithology
Duntulm	Freshwater-marine Proximal-distal	Environment Lithofacies	Lithofacies Lithology	Lithofacies Lithology
Staffin Bay	Facies/member Proximal-distal	Environment Lithofacies	Lithology Lithofacies	Lithology Lithofacies

Table 11.1. *The two major controls on palynofacies assemblages derived from a variety of techniques for each of the four main formations examined.*

In the case of the Staffin Bay Formation the primary control is ambiguous: member and environment are both suggested by factor analysis and DFA (note the environment categories of this formation relate almost perfectly to the members), but the techniques examining the data stratigraphically suggest lithology as the prime control. Comparison of the variables derived from each of these techniques shows that in the case of the primary controls there is no variable which is common to them all; however, when the secondary controls are compared the percentage phytoclasts of kerogen and non-biostructured of brown wood are common throughout. This suggests that these variables show the most systematic variation in this formation.

The best variable overall is perhaps %AOM/kerogen: it is strongly dependent on lithology, shows a good correlation with environment, salinity, lithofacies, and proximal-distal variation, and also varies systematically in relation to sequence stratigraphic changes. This parameter has the added advantage of being geochemically significant, being correlated with the hydrogen index and in some cases with TOC.

11.2 Conclusions Regarding the Main Aims

The aims stated in the preface of this work will now be briefly addressed and discussed in the light of the previous chapters.

a) Influence of sediment grain size on organic matter character.

It has been shown that both major and subtle lithological changes (e.g. the change from shale to sand versus the change from shale to silty shale), have an appreciable effect on the organic matter assemblage. In terms of their kerogen content the most characteristic lithologies are the sands and limestones. The lithological effects are apparent not only in the large scale statistical summaries of the data, but also in the stratigraphic plots of individual parameters. Sub-division of the main lithologies present has shown that the sample lithology categories (e.g. argillaceous, silty, and clean sands) which make up the gross lithologies (e.g. in this case 'sands') generally have similar characteristics despite some detailed differences. Some lithologies seem to be better characterised by their palynomorph content rather than by their kerogen assemblage (e.g. argillaceous sands), whilst other lithologies show the opposite pattern (e.g. silty sands). However, in the majority of lithologies both the kerogen and palynomorph components are reasonably distinct.

The effect of dominant lithology on organic matter assemblages has also been shown to be important; this is particularly clear where the sections are sand-dominated, but limestone-dominated sections may also be effected (although this is less clear due to a lack of appropriate samples). Dominant lithology effects can also be seen in the individual section plots.

b) Facies, stratigraphic, and spatial variations in organic matter assemblages.
Interfacies variation is characterised by sharp or gradational changes in some parameters over the facies boundaries, but in some cases the changes do not correlate exactly with the conventional position of the boundary. Other parameters show no change between facies suggesting that their distribution is independent of these variables; variations in these parameters may be linked to supply (input) rather than changes (e.g. sorting and preservation) that are taking place within the depositional system.

Intrafacies variation can often be related to lithological changes or changes in one of the other potential controlling factors, e.g. palaeosalinity variation within a lithofacies unit. However, there are occasions when neither of these seems to be the case; where this occurs it would appear that the organic matter assemblage is reflecting changes which are not evident in those factors which were used to define the facies.

Vertical variation within an individual section can be related mostly to changes in one or more of the controlling factors (e.g. lithofacies changes) or to lithology (lith and dlith). However, significant variation can also occur, apparently independent of these controlling factors, and sometimes over intervals as small as 5-10cm; this again suggests that the organic matter assemblage is reflecting changes which are not readily apparent in other criteria (e.g. sedimentology). Overall trends through sections, and the Middle Jurassic succession in general, appear to be mostly related to sea level changes, and the lithological and facies variation they bring about. Some of these changes are evidenced by sharp changes in aspects of the organic matter assemblage values; others show more gradual changes, and some show no change at all. Part of the variation through the Middle Jurassic succession thus appears to be largely independent of sea level variation (i.e. of sequences and minor sequences) and relate more to the specific lithological characteristics of the units.

c) Correlation between the optical and geochemical data.

The correlation between the optical and geochemical data varies from very poor to very good, but in the majority of cases the data show a reasonable correlation. However, the correlation will never be 'perfect' due to complex nature of the controls on TOC and HI and the percentage particle frequency nature of the optical data. Multiple regression has proved useful in determining the nature of the correlation between the HI and the liptinitic fraction of the organic matter assemblage, and in determining the variables which exert the most influence on the HI. It has also allowed the production of a predicted HI value for those samples for which this parameter was not measured.

d) Usefulness of multivariate statistical techniques in the interpretation of quantitative palynofacies data.

The multivariate techniques have proved useful, particularly DFA and constrained cluster analysis. Factor analysis was also helpful in reducing the main sources of variance in the dataset down to a manageable level, but the data closure effects inherent in the dataset makes some of the interpretation of the results of this technique difficult. Discriminant function analysis provides good and easily comparable results, and the stepwise version of this technique is particularly useful as it gives an idea of the most important variables. This has shown that in many cases relatively minor components of the organic matter assemblage are important in differentiating the different categories. Cluster analysis is less easily interpreted and is more subjective in approach, but it does allow natural correlation amongst the samples. Clustering using the stepwise DFA variables has shown that in some cases DFA is forcing samples together that are not actually that similar. Constrained clustering is particularly useful as it allows the examination of all the variables together in a stratigraphic context, this would be extremely time consuming and difficult to achieve through the visual examination of stratigraphic plots of parameters.

In general, the results of the multivariate statistical techniques were often what was expected because the geological rationale for the controls on this kind of data has been well established previously (cf. Tyson 1995). This means that the multivariate techniques are probably not as useful here as they are in studies where there is no known logic that controls or describes the inter-relationships within the dataset (e.g. in taxonomic or molecular biomarker studies). Similar results would probably have been obtained using trivariate, bivariate, and visual assessments of the data (cf. Tyson, 1989). The main theoretical advantage of the multivariate techniques over the latter methods is that they allow a more objective consideration of all the data, rather than just a more subjective consideration of parts of it (Kovach & Batten, 1994).

e) Relative usefulness and resolution of total kerogen versus palynomorph parameters.

In general terms the kerogen data is probably better as it contains information on a wider range of particle types. As utilised here, the kerogen data includes some major palynomorph categories; there appears to be little difference in the trends indicated by the equivalent palynomorph parameters regardless of whether the data were derived from the kerogen or palynomorph counts (although the statistical accuracy of the latter is greater due to the larger sample sizes). The palynomorph data is generally not as good at characterising the variation in the potential controlling factors on its own, but (as expected) it is more useful when there is significant palaeosalinity variation; it also characterises certain lithologies better than the kerogen data, possibly due to the differences in the sorting of the palynomorphs (cf. Tyson, 1989). Ideally, both datasets should be used, but given limited time the kerogen data is perhaps the most useful, although this would depend partly on the type of facies being analysed. In facies where there is the possibility of palaeosalinity variation considerable resolution would be lost if only the kerogen data was available.

f) Agreement with previous interpretations of the sediments studied.

There is a generally good agreement between the organic matter assemblages and the previous interpretations of the sediments studied, although there are sometimes slight differences between the stratigraphic position of the boundaries based on these criteria and the 'corresponding' palynofacies unit boundaries. This suggests that the organic matter assemblage is picking up these changes either before or after they are evident in the sedimentological or macropalaeontological record. There is also evidence that relatively sharp changes in the sedimentological or macropalaeontological record can be manifested as longer term changes in the organic matter assemblage. The examination of the organic matter assemblage has also provided some new information which may help to refine the models for the depositional environments of the succession studied.

g) Potential usefulness of the palynofacies technique in sub-surface reservoir studies.

The palynofacies technique can be useful in dividing up sequences for which there is very little other information (i.e. studies carried out on cuttings samples). It has been shown that the derived 'palynofacies units' ought to show a broad general agreement with the variation in the potential controlling factors (e.g. depositional environment, proximal-distal variation). The use of the constrained clustering technique may be particularly useful in these cases as the resulting clusters have been shown to be well related to the environment, lithofacies, and proximal-distal units in the majority of cases. This can be termed 'low resolution' palynofacies. In order to provide meaningful 'high resolution' interpretations the sampling needs to be intensive (probably in the order of every 10cm maximum in productive lithologies), particularly in 'deltaic' settings where there is the potential for particularly rapid variations in facies and palaeosalinity. If less intensive sampling is carried out then the interpretations may be limited to a general overview of any potential variation; the amount of variation may well relate to the number of samples rather than to the actual changes that are occurring.

11.3 Strengths and Weaknesses of the Palynofacies Technique

The strengths of the technique lie in its ability to integrate with sedimentological and palaeontological criteria, so where these data are not available or limited the palynofacies units defined will relate reasonably well to the variability in the sedimentological and palaeontological record. The technique also allows the subdivision of sediments (particularly those which are lithologically uniform) at levels of resolution that are often above lithofacies or palaeosalinity subdivisions. Another strength of the quantitative technique is that it provides measurable differences between lithologies and environments, and allows the nature of the correlation with geochemical parameters to be tested statistically.

The main weakness of the technique lies in its strong dependence on lithology which, if not properly considered, can lead to incorrect interpretations of changes based only on lithological variation. Another weakness of the technique lies in the nature of the data; percentage data means that there will always be strong closure effects which can also lead to incorrect interpretations unless this problem is carefully considered. The use of percentage data also means that it is often only possible to establish the effect of a change in one of the controlling factors on the dataset; the cause can often not be established with any certainty, although it can often be reasonably inferred from arguments based on general geological logic and complimentary parameters.

11.4 Further Work

Further advances in the understanding of the effect of lithology on organic matter assemblages may be derived from full grain size analysis of the sediments studied (or at least a fraction thereof) and the correlation of these results with the palynofacies parameter proportions. The study of this, and many other aspects of the nature of the organic matter assemblages may be aided by the additional use of absolute abundance data for the components of the organic matter assemblage (by counting slides where the organic matter has been spiked using *Lycopodium* spores); this has proved useful in Quaternary palynology, but has been relatively little used in ancient palynofacies work. This type of absolute abundance data would help to remove the problem of data closure and would be useful in correlation with the geochemical parameters as it would provide a measure of the absolute abundance of the particle types rather than just a proportion. However, this data would still not be size/volume corrected, so the correlation with the geochemistry may well prove to be imperfect. Perhaps the best way to achieve better correlation with the geochemistry (through particle size data) is through the use of image analysis, as manual measuring of particles is time consuming and less accurate (although potentially more discriminating). This would also allow more detailed examination of sorting criteria in terms of palaeoenvironments. Previous work on this subject has shown that the differences in sorting can be very subtle and difficult to interpret (Tyson, 1995), although recent work carried out in the Fossil Fuels and Environmental Geochemistry Postgraduate Institute, has shown that phytoclast size and sorting data can produce coherent results (Tuweni & Tyson, 1994; Frank & Tyson, 1995; A.T. Piper, pers. comm.).

The distribution of the different biostructured brown phytoclasts, which appears to merit further study, may be better understood if extra counts were performed on these components, similar to those carried out for the black wood category. This would allow the more confident interpretation of the distribution of these particles, which in this study has often been limited by low percentage abundances.

Further benefits may be derived from the refinement of the statistical techniques employed in this study, particularly factor and discriminant function analysis. It may prove beneficial to logratio transform the whole dataset before applying any multivariate statistical techniques, but this would have to be examined carefully as there are subjective aspects of this logratio transformation procedure which can effect the results produced (Kovach, 1993). In the case of factor analysis it is possible to rotate the factors to produce the 'best' results, but again this introduces a degree of subjectivity into the procedure. It is also possible to derive from discriminant function analysis the relative weighting of the variables used in the discrimination each of the categories giving, for example, a list of the variables and their loadings *in* each depositional environment (as opposed to the stepwise variables and Wilks' lambda values which show the variables which discriminate best *between* the different categories) following the approach of Hart (1994) and Darby and Hart (1994). This iterative approach also involves the removal of mis-classified samples until 100% classification accuracy is achieved overall and in each category, allowing the generation of a perfect algorithm; it is from this algorithm that the variable loadings which characterise each category are derived.

There are many other multivariate techniques that could be applied to the dataset, some of these may prove useful, particularly those which have been used successfully in ecology, e.g. correspondence analysis.

Other possibilities for further work include the taxonomic study of the palynomorphs, and the multivariate correlation of this information with the palynofacies data in order to try and better establish the environmental preferences of different taxa. The use of polished palynological slides (allowing examination in both transmitted and reflected light) may result in the better discrimination and characterisation of black vs. brown phytoclasts using additional reflectance criteria; it may also prove useful to subdivide the light and dark brown phytoclasts in order to add extra palaeoenvironmental and geochemical information (cf. Tuweni & Tyson, 1994). A study of the molecular biomarker geochemistry of the samples used in this study would allow an interesting comparison and correlation of biomarker data with the detailed palynofacies data presented here.

REFERENCES

AFIFI, A.A. & CLARK, V. 1984. *Computer Aided Multivariate Analysis.* Lifetime Learning Publications, California, 458pp.

AMBLER, J. 1989. *The Organic Geochemistry of the Minch Basin Jurassic Shales.* Unpublished Ph.D. thesis, University of Aberdeen.

ANDERSON, F.W. & DUNHAM, K.C. 1966. *The Geology of Northern Skye, Memoirs of the Geological Survey of Scotland,* HMSO, Edinburgh, 216pp.

ANDREWS, J.E. 1985. The sedimentary facies of a late Bathonian regressive episode: the Kilmaluag and Skudiburgh Formations of the Great Estuarine Group, Inner Hebrides, Scotland. *Journal of the Geological Society London*, **142**, 1119-1137.

ANDREWS, J.E. 1986. Microfacies and geochemistry of Middle Jurassic algal limestones from Scotland. *Sedimentology*, **33**, 499-520.

ANDREWS, J.E., & WALTON,W. 1990. Depositional environments within Middle Jurassic oyster-dominated lagoons: an integrated litho-, bio- and palynofacies study of the Duntulm Formation (Great Estuarine Group, Inner Hebrides). *Transactions of the Royal Society of Edinburgh: Earth Sciences*, **81**, 1-22.

BARSS, M.S. & WILLIAMS, G.L. 1973. Palynology and nannofossil processing techniques. *Geological Survey of Canada, Paper* **73-26**, 1-25.

BATTEN, D.J. 1973. Use of palynologic assemblage types in Wealden correlation. *Palaeontology*, **16**, 1-40.

BATTEN, D.J. 1982. Palynofacies, palaeoenvironments, and petroleum. *Journal of Micropalaeontology*, **1**, 107-114.

BATTEN, D.J. & MORRISON, L. 1983. Methods of palynological preparation for palaeoenvironmental, source potential, and organic maturation studies. *Norewegian Petroleum Directorate Bulletin*, **2**, 35-53.

BINNS, P.E., McQUILLAN, R., FANNIN, N.G.T., KENOLTY, N., & ARDUS, D.A. 1975. Structure and stratigraphy of sedimentary basins in the Sea of the Hebrides and the Minches. *In*: WOODLAND, A.W. (ed.) *Petroleum and the Continental Shelf of North West Europe*, **1**, *Geology*, Applied Science Publishers, Barking, 93-102.

BISHOP, A.N., & ABBOT, G.D. 1995. Vitrinite reflectance and molecular geochemistry of Jurassic sediments: the influence of heating by Tertiary dykes (northwest Scotland). *Organic Geochemistry*, **22**, 165-177.

BORDENAVE, M.L., ESPITALIÉ, J., LEPLAT, P., OUDIN, J.L., & VAN DEN BROUCKE, M. 1993. Screening techniques for source rock evaluation. *In*: BORDENAVE, M.L. (ed.) *Applied Petroleum Geochemistry*, Editions Technip, Paris, 217-279.

BOULTER, M.C. 1994. An approach to a standard terminology for palynodebris. *In*: TRAVERSE, A. (ed.) *Sedimentation of Organic Particles*, Cambridge University Press, Cambridge, 199-216.

BOULTER, M.C. & RIDDICK, A. 1986. Classification and analysis of palynodebris from the Palaeocene sediments of the Forties Field. *Sedimentology*, 33, 871-886.

BRADSHAW, M.J. & FENTON, J. 1982. The Bajocian "Cornbrash" of Raasay, Inner Hebrides: palynology, facies analysis and a revised geological map. *Scottish Journal of Geology*, 18, 131-145.

BRADSHAW, M.J., COPE, J.C.W., CRIPPS, D.W., DONOVAN, D.T., HOWARTH, M.K., RAWSON, P.F., WEST, I.M., & WIMBLEDON, W.A. 1992. Jurassic. *In*: COPE, J.C.W., INGHAM, J.K., & RAWSON, P.F. (eds) *Atlas of Palaeogeography and Lithofacies, Memoir of the Geological Society of London*, 13, 107-129.

BUSTIN, R.M. 1988. Sedimentology and characteristics of dispersed organic matter in the Tertiary Niger Delta: origin of source rocks in a deltaic environment. *American Association of Petroleum Geologists Bulletin*, 72, 277-298.

CHEN, P.J. & HUDSON, J.D. 1991. The Conchostracon fauna of the Great Estuarine Group, Middle Jurassic, Scotland. *Palaeontology*, 34, 515-545.

COMBAZ, A. 1964. Les palynofaciès. *Revue de Micropaléontologie*, 7, 205-218.

COPE, J.C.W., DUFF, K.L., PARSONS, C.F., TORRENS, H.S., WIMBLEDON, W.A., & WRIGHT, J.K. 1980. *A Correlation of Jurassic Rocks of the British Isles. Part 2: Middle and Upper Jurassic. Geological Society of London Special Report* 15, 109pp.

CROKER, P.F. & SHANNON, P.M. 1987. The evolution and hydrocarbon prospectivety of the Porcupine Basin, offshore Ireland. *In:* BROOKS, J. & GLENNIE, K. (eds) *Petroleum Geology of Northwest Europe*, 2, Graham & Trotman, London, 633-642.

CROSS, A.T., THOMPSON, G.G., & ZAITZEFF, J.B. 1966. Source and distribution of palynomorphs in bottom sediments, southern part of Gulf of California. *Marine Geology*, 4, 467-524.

DARBY, J.D. & HART, G.F. 1994. Organic sedimentation in a carbonate region. *In*: TRAVERSE, A. (ed.) *Sedimentation of Organic Particles*, Cambridge University Press, Cambridge, 177-198.

DARRELL II, J.H. & HART G.F. 1970. Environmental determinations using absolute miospore frequency, Mississippi River Delta. *Geological Society of America Bulletin*, 81, 2513-2518.

DAVEY, R.J., & ROGERS, J. 1975. Palynomorph distribution in Recent offshore sediments along two traverses off South West Africa. *Marine Geology*, **18**, 213-225.

DAVIS, J.C. 1986. *Statistics and Data Analysis in Geology*, 2nd Edition, Wiley, New York, 646pp.

DENISON, C. & FOWLER, R.M. 1980. Palynological identification of facies in a deltaic environment. *In: Proceedings of the Meeting on the Sedimentation of the North Sea Reservoir Rocks, Geilo 1980, Norsk Petroleumsforening, Paper XII*, 1-22.

DYBKJÆR, K. 1991. Palynological zonation and palynofacies investigation of the Fjerritslev Formation (Lower Jurassic-basal Middle Jurassic) in the Danish Subbasin. *Danmarks Geologiske Undersøgelese*, **A30**, 150pp.

FISHER, M.J. 1980. Kerogen distribution and depositional environments in the Middle Jurassic of Yorkshire U.K. *In*: BHARADWAJ, D.C., SINGH, H.P., & TIWARI, R.S. (eds) *Proceedings of the 4th International Palynological Conference, Lucknow 1976-1977*, **2**, 574-580.

FISHER, M.J., & HANCOCK, N.J. 1985. The Scalby Formation (Middle Jurassic, Ravenscar Group) of Yorkshire: reassesment of age and depositional environment. *Proceedings of the Yorkshire Geological Society*, **45**, 293-298.

FORSYTH, I.H. 1960. A marine shell bed near the base of the Great Estuarine Series on Raasay. *Transactions of the Edinburgh Geological Society*, **17**, 273-275.

FRANK, M.C. & TYSON, R.V. 1995. Parasequence-scale organic facies variations through an Early Carboniferous Yoredale cyclothem, Middle Limestone Group, Scremerston, Northumberland. *Journal of the Geological Society London*, **152**, 41-50.

GOODMAN, D.K. 1979. Dinoflagellate "communties" from the Lower Eocene Nanjemoy Formation of Maryland, USA. *Palynology*, **3**, 169-190.

GORIN, G.E. & STEFFEN, D. 1991. Organic facies as a tool for recording eustatic variations in marine fine-grained carbonates - example of the Berriasian stratotype at Berrias (Ardèche, SE France). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **85**, 303-320.

GREGORY, W.A. Jr. & HART, G.F. 1990. Sudivision of the Wilcox Group (Sabinian) argillaceous sediments using particulate organic matter. *Palynology*, **14**, 105-121.

HABIB, D. 1982. Sedimentary supply origin of Cretaceous black shales. *In*: SCHLANGER, S.O. & CITA, M.B. (eds) *Nature and origin of Cretaceous Carbon-Rich Facies*, Academic Press, London, 113-127.

HAIR, J.F. Jr, ANDERSON, R.E., & TATHAM, R.L. 1987. *Multivariate Data Analysis*, (2nd edition), Macmillan, New York, 449pp.

HALLAM, A. 1978. Eustatic cycles in the Jurassic. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 23, 1-32.

HANCOCK, N.J. & FISHER, M.J. 1981. Middle Jurassic North Sea deltas with particular reference to Yorkshire. *In*: ILLING, L.V. & HOBSON, G.D. (eds) *Petroleum Geology of the Continental Shelf of North-West Europe*, Heyden, London, 186-195.

HARRIS, J.P. 1989. The sedimentology of a Middle Jurassic lagoonal delta system: Elgol Formation (Great Estuarine Group), NW Scotland. *In*: WHATELY, M.K.G. & PICKERING, K.T. (eds) *Deltas: Sites and Traps for Fossil Fuels, Geological Society of London Special Publications*, 41, 147-166.

HARRIS, J.P. 1992. Mid-Jurassic lagoonal delta systems in the Hebridean basins: thickness and facies distribution patterns of potential reservoir sand bodies. *In*: PARNELL, J. (ed.) *Basins on the Atlantic Seaboard: Petroleum Geology, Sedimentology, and Basin Evolution, Geological Society of London Special Publications*, 62, 111-145.

HARRIS, J.P. & HUDSON, J.D. 1980. Lithostratigraphy of the Great Estuarine Group (Middle Jurassic), Inner Hebrides. *Scottish Journal of Geology*, 16, 231-250.

HART, G.F. 1986. Origin and classification of organic matter in clastic systems. *Palynology*, 10, 1-23.

HART, G.F. 1994. Maceral palynofacies of the Louisiana deltaic plain in terms of organic constituents and hydrocarbon potential. *In*: TRAVERSE, A. (ed.) *Sedimentation of Organic Particles*, Cambridge University Press, Cambridge, 141-176.

HARTMAN-STROUP, C. 1987. The effect of organic matter type and organic carbon content on Rock-Eval hydrogen index in oil shales and source rocks. *Organic Geochemistry*, 11, 352-369.

HEUSSER, L.E. 1983. Pollen distribution in the bottom sediments of the western North Atlantic Ocean. *Marine Micropalaeontology*, 8, 77-88.

HONIGSTEIN, A., LIPSON-BENITAH, S., CONWAY, B., FLEXER, A., & ROSENFELD, A. 1989. Mid-Turonian anoxic event in Israel - a multidisciplinary approach. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 69, 103-112.

HOPKINS, J.S. 1950. Differential flotation and deposition of coniferous and deciduous tree pollen. *Ecology*, 31, 633-641.

HUDSON, J.D. 1962. The stratigraphy of the Great Estuarine Series (Middle Jurassic), Inner Hebrides. *Transactions of the Edinburgh Geological Society*, 19, 139-165.

HUDSON, J.D. 1963a. The recognition of salinity-controlled mollusc assemblages in the Great Estuarine Series (Middle Jurassic) of the Inner Hebrides. *Palaeontology*, 6, 318-326.

HUDSON, J.D. 1963b. The ecology and stratigraphical distribution of the invertebrate fauna of the Great Estuarine Series. *Palaeontology*, 6, 327-348.

HUDSON, J.D. 1964. The petrology of the sandstones of the Great Estuarine Series, and the Jurassic palaeogeography of Scotland. *Proceedings of the Geologist's Association*, 75, 499-527.

HUDSON, J.D. 1968. The microstructure and mineralogy of a Jurassic mytilid (Bivalvia). *Palaeontology*, 11, 168-182.

HUDSON, J.D. 1970. Algal limestones with pseudomorphs after gypsum from the Middle Jurassic of Scotland. *Lethaia*, 3, 11-40.

HUDSON, J.D. 1980. Aspects of brackish-water facies and faunas from north-west Scotland. *Proceedings of the Geologist's Association*, 91, 99-105.

HUDSON, J.D. 1983. Mesozoic sedimentation and sedimentary rocks in the Inner Hebrides. *Proceedings of the Royal Society of Edinburgh*, 83B, 47-63.

HUDSON, J.D. & ANDREWS, J.E. 1987. The diagenesis of the Great Estuarine Group, Middle Jurassic, Inner Hebrides. *In*: MARSHALL, J.D. (ed.) *Diagenesis of Sedimentary Sequences, Geological Society of London Special Publication*, 36, 259-276.

HUDSON, J.D. & HARRIS, J.P. 1979. Sedimentology of the Great Estuarine Group (Middle Jurassic) of north-west Scotland. *Symposium sur la Sédimentation de Jurrassique Western Européen, Paris, 9-10 may, 1977*. Association des Sédimentologists Français, 1-13.

HUDSON, J.D. & MORTON, N. 1969. *International Field Symposium on the British Jurassic, Excursion No. 4, Guide for Western Scotland*, Keele University, Keele.

JONES, R.W. 1987. Organic facies. *In*: BROOKS, J. & WELTE, D. (eds) *Advances in Petroleum Geochemistry*, 2, 1-90.

KATZ, B.J. 1983. Limitations of 'Rock-Eval' pyrolysis for typing organic matter. *Organic Geochemistry*, 4, 195-199.

KOVACH, W.L. 1989. Comparisons of multivariate analytical techniques for use in pre-Quaternary plant palaeoecology. *Review of Palaeobotany and Palynology*, 60, 255-282.

KOVACH, W.L. 1993. *MVSP - A MultiVariate Statistical Package for IBM-PC's, Version 2.1*, Kovach Computing Services, Pentraeth, Wales, UK.

KOVACH, W.L. & BATTEN, D.J. 1994. Association of palynomorphs and palynodebris with depositional environments: quantitative approaches. *In*: TRAVERSE, A. (ed.) *Sedimentation of Organic Particles*, Cambridge University Press, Cambridge, 391-408.

LANGFORD, F.F., & BLANC-VALLERON, M-M. 1990. Interpreting Rock-Eval Pyrolysis data using graphs of pyrolizable hydrocarbons vs. total organic carbon. *American Association of Petroleum Geologists Bulletin*, 74, 799-804.

LENOIR, E.A. & HART, G.F. 1988. Palynofacies of some Miocene sands from the Gulf of Mexico, offshore Louisiana, USA. *Palynology*, 12, 151-165.

MORTON, N. 1965. The Bearreraig Sandstone Series (Middle Jurassic) of Skye and Raasay. *Scottish Journal of Geology*, 1, 189-216.

MORTON, N. 1976. Bajocian (Jurassic) stratigraphy in Skye, Western Scotland, Scotland. *Scottish Journal of Geology*, 12, 23-33.

MORTON, N. 1983. Palaeocurrents and palaeo-environment of part of the Bearreraig Sandstone (Middle Jurassic) of Skye and Raasay, Inner Hebrides. *Scottish Journal of Geology*, 19, 87-95.

MORTON, N. 1987. Jurassic subsidence history in the Hebrides, N.W. Scotland. *Marine and Petroleum Geology*, 4, 226-242.

MORTON, N. 1989. Jurassic sequence stratigraphy in the Hebrides Basin, NW Scotland. *Marine and Petroleum Geology*, 6, 243-260.

MORTON, N. 1990a. Bearreraig (Isle of Skye, NW Scotland) as boundary stratotype for the base of the Bajocian stage. *Memoirie Descrittive della Carta Geologica d'Italia*, 40, 23-48.

MORTON, N. 1990b. Tectonic and eustatic controls of Jurassic genetic sequences in the Hebrides Basin, NW Scotland. *Bulletin Sociètè Géologique de France, serie 8*, 6, 1001-1009.

MORTON, N. 1992a. Late Triassic to Middle Jurassic stratigraphy, palaeogeography and tectonics west of the British Isles. *In*: PARNELL, J. (ed.) *Basins on the Atlantic Seaboard: Petroleum Geology, Sedimentology, and Basin Evolution, Geological Society of London Special Publication*, 62, 53-68.

MORTON, N. 1992b. Dynamic stratigraphy of the Triassic and Jurassic of the Hebrides Basin, NW Scotland. *In*: PARNELL, J. (ed.) *Basins on the Atlantic Seaboard: Petroleum Geology, Sedimentology, and Basin Evolution, Geological Society of London Special Publication*, 62, 97-110.

MORTON, N. 1993. Potential reservoir and source rocks in relation to Upper Triassic to Middle Jurassic sequence stratigraphy, Atlantic margin basins of the British Isles. *In*: PARKER, J.R. (ed.) *Petroleum Geology of Northwest Europe: Proceedings of the 4th Conference*, 1, Geological Society London, 285-297.

MORTON, N. & HUDSON, J.D. 1964. The stratigraphical nomenclature of the Lower and Middle Jurassic rocks of the Hebrides. *Geological Magazine*, 101, 531-534.

MORTON, N., SMITH, R.M., & JAMES, A.V. 1987. Comparative study of Triassic-Jurassic sedimentation and basin evolution in the northern North Sea and NW of the British Isles. *In*: BROOKS, J., & GLENNIE, K. (eds) *The Petroleum Geology of NW Europe*, Graham & Trotman, London, 2, 697-709.

MULLER, J. 1959. Palynology of Recent Orinoco delta and shelf sediments: Reports of the Orinoco Shelf expedition; volume 5. *Micropalaeontology*, 5, 1-32.

NAGY, J., DYPVIK, H., & BJAERKE, T. 1984. Sedimentological and palaeontological analyses of Jurassic North Sea deposits from deltaic environments. *Journal of Petroleum Geology*, 7, 169-188.

OBOH, F.E. 1992. Middle Miocene palaeoenvironments of the Niger Delta. *Palaeogeography, Palaeoclimatology, and Palaeoecology*, 92, 55-84.

ORR, W.L. 1981. Comments on pyrolytic hydrocarbon yields in source-rock evaluation. *In*: BJOROY, M. *et al.* (eds) *Advances in Organic Geochemistry 1981*, Wiley, London, 775-787.

PARRY, C.C., WHITELY, P.K.J., & SIMPSON, R.D.H. 1981. Integration of palynological and sedimentological methods in facies anaysis of the Brent Formation. *In*: ILLING, L.V. & HOBSON, G.D. (eds) *Petroleum Geology of the Continental Shelf of North-West Europe*, Heyden, London, 205-215.

PASLEY, M.A., GREGORY, W.A., & HART, G.F. 1991. Organic matter variations in transgressive and regressive shales. *Organic Geochemistry*, 17, 483-509.

PETERS, K.E. 1986. Guidelines for evaluating petroleum source rocks using programmed pyrolysis. *American Association of Petroleum Geologists Bulletin*, 70, 318-329.

RIDING, J.B. 1992. On the age of the Upper Ostrea Member, Staffin Bay Formation (Middle Jurassic) of north-west Skye. *Scottish Journal of Geology*, 28, 155-158.

RIDING, J.B., WALTON, W., & SHAW, D. 1991. Toarcian to Bathonian (Jurassic) palynology of the Inner Hebrides, NW Scotland. *Palynology*, 15, 115-179.

SCHWARZBACH, M. 1963. *Climates of the Past. An Introduction to Palaeoclimatology*, Van Nostrand, New York 328pp.

SMITH, A.G., BRIDEN, J.L., & DEWRY, G.E. 1973. Phanerozoic world maps. *Special Papers in Palaeontology*, 12, 1-42.

STEEL, R.J. 1977. Triassic rift basins of northwest Scotland - their configuration, infilling and development. MNNSS/7. *In*: FINSTAD, K.G. & SELLEY, R.C. (eds) *Proceedings: Mesozoic NORTHERN North Sea Symposium, Oslo 1977, Norsk Petroleumforening*, 1-18.

SWAN, A.R.H., & SANDILANDS, M. 1995. *Introduction to Geological Data Analysis*, Blackwell, Oxford, 446pp.

SYKES, R.M. 1975a. *Facies and Faunal Analysis of the Callovain and Oxfordian Stages (Middle-Upper Jurassic) in Northern Scotland and East Greenland.* Unpublished Ph.D. thesis, University of Oxford, 285pp.

SYKES, R.M. 1975b. The stratigraphy of the Callovian-Oxfordian stages (Middle-Upper Jurassic) in Northern Scotland. *Scottish Journal of Geology*, 11, 51-78.

TAN, F.C. & HUDSON, J.D. 1974. Isotopic studies of palaeoecology and diagenesis of the Great Estuarine Series (Jurassic) of Scotland. *Scottish Journal of Geology*, 10, 91-128.

TAN, F.C., HUDSON, J.D., & KEITH, M.L. 1970. Jurassic (Callovian) palaeotemperatures from Scotland. *Earth and Planetary Science Letters*, 9, 421-426.

THRASHER, J. 1992. Thermal effect of the Tertiary Cuillins Intrusive Complex in the Jurassic of the Hebrides: an organic geochemical study. *In*: PARNELL, J. (ed.) *Basins on the Atlantic Seaboard: Petroleum Geology, Sedimentology, and Basin Evolution, Geological Society of London Special Publication*, 62, 35-49.

TRAVESE, A. 1988. *Palaeopalynology*, Unwin Hyman, Boston, 600pp.

TRAVERSE, A. 1994. Sedimentation of palynomorphs and palynodebris: an introduction. *In*: TRAVERSE, A. (ed.) *Sedimentation of Organic Particles*, Cambridge University Press, Cambridge, 1-8.

TRUEBLOOD, S. & MORTON, N. 1991. Comparitive sequence stratigraphy and structural styles of the Slyne Trough and Hebrides Basin. *Journal of the Geological Society London*, 148, 197-201.

TSCHUDY, R.H. 1969. Relationship of palynomorphs to sedimentation. *In*: TSCHUDY, R.H. & SCOTT, R.A. (eds) *Aspects of Palynology*, Wiley, New York, 79-96.

TUCKER, M.E. 1982. *The Field Description of Sedimentary Rocks*, Open University Press, Milton Keynes, 112pp.

TUWENI, A.O. & TYSON, R.V. 1994. Organic facies variations in the Westbury Formation (Rhaetic, Bristol Channel, SW England). *Organic Geochemistry*, **21**, 1001-1014.

TYSON, R.V. 1984. Palynofacies ivestigation of Callovian (Middle Jurassic) Sediments from DSDP Site534, Blake-Bahama Basin, western Central Atlantic. *Marine and Petroleum Geology*, **1**, 3-13.

TYSON, R.V. 1987. The genesis and palynofacies characteristics of marine petroleum source rocks. *In*: BROOKS, J. & FLEET, A.J. (eds) *Marine Petroleum Source Rocks, Geological Society of London Special Publication*, **26**, 47-67.

TYSON, R.V. 1989. Late Jurassic palynofacies trends, Piper and Kimmeridge Clay Formations, UK onshore and northern North Sea. *In*: BATTEN, D.J. & KEEN, M.C. (eds) *Northwest European Micropalaeontology and Palynology, British Micropalaeontological Society Series*, Ellis Horwood, Chichester, 135-172.

TYSON, R.V. 1993. Palynofacies analysis, *In*: JENKINS, D.G. (ed) *Applied Micropalaeontology*, Kluwer, Dordrecht, 153-191.

TYSON, R.V. 1995. *Sedimentary Organic Matter. Organic Facies and Palynofacies*, Chapman and Hall, London, 625pp.

VAN DER ZWAN, C.J. 1990. Palynostratigraphy and palynofacies reconstruction of the Upper Jurassic to lowermost Cretaceous of the Draugen Field, offshore mid Norway. *Review of Palaeobotany and Palynology*, **62**, 157-186.

WAKEFIELD, M.I. 1991. *Ostracoda (Crustacea) of the Great Estuarine Group (Bathonian, Middle Jurassic), Inner Hebrides, Scotland*, Unpublished Ph.D. thesis, University of Leicester.

WALL, D. 1965. Microplankton pollen and spores from the Lower Jurassic in Britain. *Micropaleontology*, **11**, 151-190.

WALL, D., DALE, B., LOHMANN, G.P., & SMITH, W.K. 1977. The environmental and climatic distribution of dinoflagellate cysts in modern marine sediments from regions in the North and South Atlantic Oceans and adjacent seas. *Marine Micropalaeontology*, **2**, 121-200.

WHITAKER, M.F., GILES, M.R., & CANNON, S.J.C. 1992. Palynological review of the Brent Group, U.K. sector, North sea. *In*: MORTON, A.C., HAZELDINE, R.S., GILES, M.R., & BROWN, S. (eds) *The Geology of the Brent Group, Geological Society of London Special Publication*, **61**, 169-202.

WOLLAST, R. 1983. Interactions in estuaries and coastal waters. *In*: BOLIN, B. & COOK, R.B. (eds) *The Major Biogeochemical Cycles and Their Interactions*, Wiley, New York, 385-407.

APPENDICES

APPENDIX I

Appendix I: 'Dummy' variables

Key to abbreviations used in column headers:

Tnum	= total number
Samno	= sample number
Basin	= basin of deposition
Sequence	= major sequence of Morton
Cycle	= minor sequence of Morton
Strat	= stratigraphic order
Lith	= lithology
Dlith	= dominant lithology
Shells	= shell abundance
Bioturb	= bioturbation level
Colour	= shale colour
shaleT	= shale type
Env	= environment
Lithofac	= lithofacies
Biofac	= biofacies
Palyfac	= palynofacies
Salinity	= ostracod-derived salinity
Prox-dist	= proximal-distal unit

The keys to the numbers in each of the categories can be found in Tables 2.23 to 2.27.

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
1	BBE1	1	1	1	1	16	1	1	0.1	3	2	1	3	3		1
2	BBE2	1	1	1	1	16	1	1	0.4	3	2	1	3	3		1
3	BBE3	1	1	1	1	16	1	1	0.65	3	2	1	3	4		1
4	BBE4	1	1	1	1	16	1	1	0.95	3	2	1	3	4		1
5	BBE5	1	1	1	1	16	1	1	1.35	3	2	1	3	9		1
6	BBE6	1	1	1	1	16	1	1	1.45	3	2	1	3	11		1
7	BBE7	1	1	1	1	16	1	1	1.6	2	2	1	3	4		1
8	BBE8	1	1	1	1	16	1	1	1.7	2	2	1	3	5		1
9	BBE9	1	1	1	1	16	1	1	2.35	3	2	1	3	5		1
10	BBE10	1	1	1	1	16	1	1	2.55	2	2	1	3	3		1
11	BBE11	1	1	1	1	16	1	1	3.15	2	2	1	3	9		1
12	BBE12	1	1	1	1	16	1	1	3.4	2	2	1	3	4		1
13	BBE13	1	1	1	1	16	1	1	4.15	3	2	1	3	5		1
14	BBE14	1	1	1	1	16	1	1	4.35	2	2	1	3	3		1
15	BBE15	1	1	1	1	16	1	1	4.45	2	2	1	3	3		1
16	BBE16	1	1	1	1	16	1	1	4.7	2	2	1	3	4		1
17	BBE17	1	1	1	1	16	1	1	5.05	3	2	1	3	5		1
18	BBE18	1	1	1	1	16	1	1	5.25	3	2	1	3	5		1
19	BBE19	1	1	1	1	16	1	1	5.55	3	2	1	3	4		1
20	BBE20	1	1	1	1	16	1	1	6.05	2	2	1	3	3		1
21	BBE21	1	1	1	1	16	1	1	6.35	3	2	1	3	6		1
22	BBE22	1	1	1	1	16	1	1	6.55	3	2	1	3	11		1
23	BBE23	1	1	1	1	16	1	1	6.65	3	2	1	3	11		1
24	BBE24	1	1	1	1	16	1	1	7.05	3	2	1	3	3		1
25	BBE25	1	1	1	1	16	1	1	7.55	3	2	1	3	4		1
26	BBE26	1	1	1	1	16	1	1	7.75	2	2	1	3	3		1
27	BBE27	1	1	1	1	16	1	1	7.8	3	2	1	3	5		1
28	BBE28	1	1	1	1	16	1	1	8.3	3	2	1	3	5		1
29	BBE29	1	1	1	1	16	1	1	8.5	2	2	2	3	4		1
30	BBE30	1	1	1	1	16	1	1	9	3	2	1	3	3		1
31	BBE31	1	1	1	1	16	1	1	9.35	2	2	2	3	5		1
32	BBE32	1	1	1	1	16	1	1	9.6	3	2	1	3	4		1
33	BBE33	1	1	1	1	16	1	1	10.25	2	2	1	3	5		1
34	BBE34	1	1	1	1	16	1	1	10.45	2	2	1	3	5		1
35	BBE35	1	1	1	1	16	1	1	10.9	3	2	1	3	11		1
36	BBE36	1	1	1	1	16	1	1	11.35	3	2	1	3	11		1
37	BBE37	1	1	1	1	16	1	1	12.05	4	2	1	3	9		1
38	BBE38	1	1	1	1	16	1	1	12.45	4	2	1	3	9		1
39	BBE39	1	1	1	1	16	1	1	13.4	4	2	1	3	9		1

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
40	BBE40	1	1	1	1	16	1	1	15.2	1	8	1	2	3		1
41	BBE41	1	1	1	1	16	1	1	15.5	8	8	1	2	3		1
42	BBE42	1	1	1	1	16	1	1	15.8	1	8	1	2	3		1
43	BBE43	1	1	1	1	16	1	1	16.1	8	8	1	2	4		1
44	BBE44	1	1	1	1	16	1	1	16.5	1	8	1	2	9		1
45	BBE45	1	1	1	1	16	1	1	17.1	1	8	1	2	9		1
46	BBE46	1	1	1	1	16	1	1	17.2	1	8	1	2	3		1
47	BBE47	1	1	1	1	16	1	1	17.6	1	8	1	2	3		1
48	BBE48	1	1	1	1	16	1	1	17.8	1	8	1	2	9		1
49	BBE49	1	1	1	1	15	1	2	22.1	6	8	1	2			1
50	BBO1	1	1	1	2	14	1	3	60.1	2	2	1	3	3		1
51	BBO2	1	1	1	2	14	1	3	60.8	2	2	1	3	3		1
52	BBU1	1	1	1	2	14	1	3	82.1	2	3	1	3	2		1
53	BBU2	1	1	1	2	14	1	3	82.7	2	3	1	3	3		1
54	BBU3	1	1	1	2	14	1	3	83.8	3	3	1	3	5		1
55	BBU4	1	1	1	2	14	1	3	84.1	3	3	1	3	4		1
56	BBU5	1	1	1	2	14	1	3	84.5	3	3	1	3	9		1
57	BBU6	1	1	1	2	14	1	3	84.7	3	3	1	3	9		1
58	BBU7	1	1	1	2	14	1	3	84.95	3	3	1	3	9		1
59	BBU8	1	1	1	2	14	1	3	85.25	3	3	1	3	9		1
60	BBU9	1	1	1	2	14	1	3	85.55	2	3	1	3	2		1
61	BBU10	1	1	1	2	14	1	3	85.85	3	3	1	3	9		1
62	BBU11	1	1	1	2	14	1	3	86.05	2	3	1	3	9		1
63	BBU12	1	1	1	2	14	1	3	86.45	3	3	1	3	4		1
64	BBU13	1	1	1	2	14	1	3	87.15	3	3	1	3	5		1
65	BBU14	1	1	1	2	14	1	3	87.55	2	3	1	3	4		1
66	BBU15	1	1	1	2	14	1	3	87.95	3	3	1	3	2		1
67	BBU16	1	1	1	2	14	1	3	88.75	2	3	1	3	2		1
68	BBU17	1	1	1	2	14	1	3	88.95	2	3	1	3	3		1
69	BBU18	1	1	1	2	14	1	3	90.15	3	3	1	3	9		1
70	BBU19	1	1	1	2	14	1	3	90.4	3	3	1	3	8		1
71	BBU20	1	1	1	2	14	1	3	91	3	3	1	3	1		1
72	BBU21	1	1	1	2	14	1	3	91.9	3	3	1	3	9		1
73	BBU22	1	1	1	2	14	1	3	92.2	3	3	1	3	9		1
74	BBU23	1	1	1	2	14	1	3	92.9	3	3	1	3	4		1
75	BBU24	1	1	1	2	14	1	3	93.3	2	3	1	3	2		1
76	BBU25	1	1	1	2	14	1	3	94	3	3	1	3	9		1
77	BBU26	1	1	1	2	14	1	3	95.3	2	3	1	3	8		1
78	BBU27	1	1	1	2	14	1	3	96	2	3	1	3	8		1

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
79	BBU28	1	1	1	2	14	1	3	96.8	3	3	1	3	9		1
80	BBU29	1	1	1	2	14	1	3	97.7	2	3	1	3	8		1
81	BBU30	1	1	1	2	14	1	3	98.8	3	3	1	3	3		1
82	BBH1	1	1	1	2	13	1	4	99.4	3	3	1	3	9		1
83	BBH2	1	1	1	2	13	1	4	100.2	3	3	1	3	4		1
84	BBH3	1	1	1	2	13	1	4	100.5	3	3	1	3	5		1
85	BBH4	1	1	1	2	13	1	4	101.2	3	3	1	3	9		1
86	BBH5	1	1	1	2	13	1	4	101.8	3	3	1	3	5		1
87	BBH6	1	1	1	2	13	1	4	102.1	3	3	1	3	5		1
88	BBH7	1	1	1	2	13	1	4	102.5	3	3	1	3	5		1
89	BBH8	1	1	1	2	13	1	4	102.7	3	6	1	3	9		1
90	BBH9	1	1	1	2	13	1	4	103	3	6	1	3	4		1
91	BBH10	1	1	1	2	13	1	4	104.8	3	6	1	3	4		1
92	BBH11	1	1	1	2	13	1	4	112.3	5	6	1	3	5		1
93	BBH12	1	1	1	2	13	1	4	121.3	6	6	1	3			1
94	BBR1	1	1	1	2	12	1	5	139.05	6	8	1	3			1
95	BBR2	1	1	1	2	12	1	5	139.25	6	8	1	3			1
96	BBR3	1	1	1	2	12	1	5	139.45	6	8	1	3			1
97	BBR4	1	1	1	2	12	1	5	140.55	6	8	1	3			1
98	BBR13	1	1	1	2	12	1	5	144.45	7	7	1	3			1
99	BBR14	1	1	1	2	12	1	5	145.38	7	7	1	3			1
100	BBR15	1	1	1	2	12	1	5	146.28	7	7	1	3			1
101	BBR16	1	1	1	2	12	1	5	146.38	7	7	1	3			1
102	BBR17	1	1	1	2	12	1	5	146.48	7	7	1	3			1
103	BBR18	1	1	1	2	12	1	5	146.81	7	7	1	3			1
104	BBR19	1	1	1	2	12	1	5	146.98	7	7	1	3			1
105	BBR5	1	1	1	2	12	1	5	157.78	6	8	1	3			1
106	BBR6	1	1	1	2	12	1	5	158.88	6	8	1	3			1
107	BBR7	1	1	1	2	12	1	5	158.88	6	8	1	3			1
108	BBR8	1	1	1	2	12	1	5	158.98	6	8	1	3			1
109	BBR9	1	1	1	2	12	1	5	159.08	6	8	1	3			1
110	BBR10	1	1	1	2	12	1	5	159.58	6	8	1	3			1
111	BBR11	1	1	1	2	12	1	5	159.68	6	8	1	3	2		1
112	BNL17	3	1	1	3		1	6	0.1	2	2	2	3	9		1
113	BNL16	3	1	1	3		1	6	3	2	2	1	3	8		1
114	BNL1	3	1	1	3		1	6	6	2	2	1	3	3		1
115	BNL2	3	1	1	3		1	6	6.15	2	2	1	3	3		1
116	BNL3	3	1	1	3		1	6	6.35	2	2	1	3	3		1
117	BNL4	3	1	1	3		1	6	6.65	2	2	1	3	3		1

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
118	BNL5	3	1	1	3		1	7	6.8	2	12	1	3	3		1
119	BNL6	3	1	1	3		1	7	7.43	2	12	1	3	3		1
120	BNL7	3	1	1	3		1	7	7.96	2	12	1	3	3		1
121	BNL8	3	1	1	3		1	7	8.61	2	12	1	3	3		1
122	BNL9	3	1	1	3		1	7	9.96	2	12	1	3	3		1
123	BNL10	3	1	1	3		1	7	13.25	2	12	1	3	3		1
124	BNL11	3	1	1	3		1	7	14.53	2	12	1	3	4		1
125	BNL12	3	1	1	3		1	7	14.63	2	12	1	3	3		1
126	BNL13	3	1	1	3		1	7	15.28	2	12	1	3	3		1
127	BNL15	3	1	1	3		1	7	18.08	8	8	1	3			1
128	RGC1	3	1	2	4	11	1	8	0.02	2	2	3	1	4		1
129	RGC2	3	1	2	4	11	1	8	0.17	2	2	3	1	4		1
130	RGC3	3	1	2	4	11	1	8	0.32	2	2	3	1	4		1
131	RGC4	3	1	2	4	11	1	8	0.62	2	2	3	1	4		1
132	RCS1	3	1	2	4	10	2		3.07	1	1	1	1	2	2	3
133	RCS2	3	1	2	4	10	2		3.22	1	1	1	1	2	2	3
134	RCS3	3	1	2	4	10	2		3.32	1	1	1	1	2	2	3
135	RCS4	3	1	2	4	10	2		3.42	1	1	1	1	2	2	3
136	RCS5	3	1	2	4	9	3		3.55	2	2	1	1	11		6
137	RCS6	3	1	2	4	9	3		3.82	2	2	1	1	11		6
138	RCS7	3	1	2	4	9	3		4.02	13	7	1	1			6
139	RCS8	3	1	2	4	9	3		4.17	13	7	1	1			6
140	RCS9	3	1	2	4	9	3		4.32	13	7	1	1			6
141	RCS10	3	1	2	4	9	3		4.47	13	7	1	2			6
142	RCS11	3	1	2	4	9	3		4.62	14	7	1	2			6
143	RCS12	3	1	2	4	9	3		4.72	14	7	1	2			6
144	RCS13	3	1	2	4	9	3		4.87	14	7	1	2			6
145	RCS14	3	1	2	4	9	3		5.02	7	7	1	2			6
146	RCS15	3	1	2	4	9	3		5.17	7	7	1	2			6
147	KE26	4	2	2	5	8	4	9	0.05	2	2	2	1	9		8
148	KE27	4	2	2	5	8	4	9	0.75	2	2	1	1	7		8
149	KE28	4	2	2	5	8	4	9	1.8	2	2	1	1	6		8
150	KE29	4	2	2	5	8	4	9	2.2	2	2	2	1	6		8
151	KE30	4	2	2	5	8	4	9	2.5	2	2	1	1	6		8
152	KE31	4	2	2	5	8	4	9	3	2	2	1	1	6		8
153	KE32	4	2	2	5	8	4	9	4.05	9	9	3	1			9
154	KE33	4	2	2	5	8	4	9	4.12	10	1	3	1			7
155	KE34	4	2	2	5	8	4	9	4.17	10	1	3	1			7
156	KE35	4	2	2	5	8	4	9	4.21	1	1	3	1	4	3	7

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
157	KE36	4	2	2	5	8	4	9	4.28	1	1	3	1	5	2	7
158	KE37	4	2	2	5	8	4	9	4.79	2	2	2	1	5		7
159	KE38	4	2	2	5	8	4	9	5.34	2	2	2	1	5		7
160	KE39	4	2	2	5	8	4	9	6.34	2	2	2	1	5		7
161	KE40	4	2	2	5	8	4	9	6.49	1	1	3	1	5		9
162	KE41	4	2	2	5	8	4	9	6.6	1	8	3	1	7	2	7
163	KE42	4	2	2	5	8	4	9	6.68	1	8	3	1	7	3	7
164	KE43	4	2	2	5	8	4	9	6.75	1	8	3	1	7	3	7
165	KE44	4	2	2	5	8	4	9	7.23	1	8	3	1	3		7
166	KE45	4	2	2	5	8	4	9	7.53	2	2	2	1	11		8
167	KE46	4	2	2	5	8	4	9	7.94	2	2	2	1	5		7
168	KE47	4	2	2	5	8	4	9	8.27	2	2	2	1	5		7
169	KE48	4	2	2	5	8	4	9	8.62	2	2	2	1	5		7
170	KE49	4	2	2	5	8	4	9	9.02	2	2	2	1	5		7
171	KE50	4	2	2	5	8	4	9	9.37	2	2	2	1	3		7
172	KE51	4	2	2	5	8	4	9	9.77	2	2	2	1	3		7
173	KE52	4	2	2	5	8	4	9	9.97	2	2	2	1	3		7
174	KE53	4	2	2	5	8	4	9	10.34	2	2	2	1	4		7
175	KE54	4	2	2	5	8	4	9	10.6	4	2	2	1	11		7
176	KE55	4	2	2	5	8	4	9	10.85	2	2	2	1	4		7
177	KE56	4	2	2	5	8	4	9	11.07	1	2	4	1			7
178	KE57	4	2	2	5	8	4	9	12.4	2	2	2	1	4		6
179	KE58	4	2	2	5	8	4	9	12.73	2	2	2	1	4		6
180	KE1	4	2	2	5	8	4	9	14.27	1	2	2	1	11		6
181	KE2	4	2	2	5	8	4	9	14.37	2	2	2	1	5		6
182	KE3	4	2	2	5	8	4	9	14.55	1	2	3	1	5	3	6
183	KE4	4	2	2	5	8	4	9	14.63	11	11	3	2			6
184	KE5	4	2	2	5	8	4	9	14.71	3	2	3	2	11		6
185	KE6	4	2	2	5	8	4	9	14.86	3	2	1	1	11		6
186	KE7	4	2	2	5	8	4	9	14.96	2	2	1	1	5		6
187	KE8	4	2	2	5	8	4	9	15.03	11	11	3	1			6
188	KE9	4	2	2	5	8	4	9	15.11	1	1	3	1	3		8
189	KE10	4	2	2	5	8	4	9	15.31	1	1	3	1	3	2	6
190	KE11	4	2	2	5	8	4	9	15.66	1	1	3	1	3	2	8
191	KE12	4	2	2	5	8	4	9	15.91	9	9	4	1			6
192	KE13	4	2	2	5	8	4	9	16.63	1	1	3	1	9		8
193	KE14	4	2	2	5	8	4	9	17.13	1	1	3	1	9		8
194	KE15	4	2	2	5	8	4	9	17.48	1	1	3	1	9		8
195	KE16	4	2	2	5	8	4	9	17.72	2	1	3	1	11		8

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
196	KE17	4	2	2	5	8	4	9	17.84	2	11	3	1	11		9
197	KE18	4	2	2	5	8	4	9	18.19	1	2	1	1	3		8
198	KE19	4	2	2	5	8	4	9	18.61	2	2	1	1	5		8
199	KE20	4	2	2	5	8	4	9	18.91	2	2	2	1	9		8
200	KE21	4	2	2	5	8	4	9	19.26	1	1	3	1	3		8
201	KE22	4	2	2	5	8	4	9	19.36	1	1	3	1	9		8
202	KE23	4	2	2	5	8	4	9	19.71	1	1	3	1	3		8
203	KE24	4	2	2	5	8	4	9	19.96	1	1	3	1	3		8
204	KE25	4	2	2	5	8	4	9	20.11	1	1	3	1	3		8
205	RNB1	1	1	2	5	7	4	10	0.04	1	1	2	1	5		8
206	RNB2	1	1	2	5	7	4	10	0.1	1	1	2	1	5		8
207	RNB3	1	1	2	5	7	4	10	0.35	1	1	2	1	5		8
208	RNB4	1	1	2	5	7	4	10	0.5	1	1	2	1	5		8
209	RNB5	1	1	2	5	7	4	10	0.76	1	1	2	1	5		8
210	RNB6	1	1	2	5	7	4	10	0.85	9	9	3	1			8
211	RNB7	1	1	2	5	7	4	10	0.91	1	9	3	1	5		8
212	RNB8	1	1	2	5	7	4	10	0.96	10	9	3	1	6		8
213	RNB9	1	1	2	5	7	4	10	1.01	1	9	3	1	5		8
214	RNB10	1	1	2	5	7	4	10	1.06	10	9	3	1	6		8
215	RNB11	1	1	2	5	7	4	10	1.15	1	1	2	1	3		8
216	RNB12	1	1	2	5	7	4	10	1.55	1	1	3	1	3		8
217	RNB13	1	1	2	5	7	4	10	1.85	1	1	2	1	3		8
218	RNB14	1	1	2	5	7	4	10	2.05	1	1	3	1	3		8
219	RNB15	1	1	2	5	7	4	10	5.49	1	1	3	1	3		8
220	RNB16	1	1	2	5	7	4	10	5.78	1	1	2	1	2		6
221	RNB17	1	1	2	5	7	4	10	6.93	1	1	2	1	2		8
222	RNB18	1	1	2	5	7	4	10	7.45	1	1	3	1	3		8
223	RNB19	1	1	2	5	7	4	10	7.85	1	1	2	1	3		7
224	RNB20	1	1	2	5	7	4	10	8.81	1	1	2	1	2		7
225	VS2	1	1	2	5	6	5		0.85	1	7	1	2	10		7
226	VS3	1	1	2	5	6	5		0.98	1	7	1	2	10		7
227	VS4	1	1	2	5	6	5		1.18	1	7	1	2			7
228	VS5	1	1	2	5	6	5		1.3	7	7	1	2			7
229	VS7	1	1	2	5	6	5		11.05	7	7	1	3			7
230	VS8	1	1	2	5	6	5		11.55	7	7	1	3			7
231	VS9	1	1	2	5	6	5		11.58	7	7	1	3			7
232	CGD1	1	1	2	6	5	6		0.03	1	2	1	3	4		6
233	CGD2	1	1	2	6	5	6		0.22	1	2	2	3	3		6
234	CGD3	1	1	2	6	5	6		0.33	2	2	2	3	3	3	6

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
235	CGD4	1	1	2	6	5	6		0.43	4	2	1	3	5		6
236	CGD5	1	1	2	6	5	6		0.68	2	2	1	3	10		6
237	CGD6	1	1	2	6	5	6		0.8	3	3	1	3	9		6
238	CGD7	1	1	2	6	5	6		0.95	1	1	1	3	9		6
239	CGD8	1	1	2	6	5	6		1.02	2	2	1	3	9		6
240	CGD9	1	1	2	6	5	6		1.08	1	2	1	3	9		6
241	CGD10	1	1	2	6	5	6		1.13	1	2	1	3	9		6
242	CGD11	1	1	2	6	5	6		1.19	1	2	1	3	9		6
243	CGD12	1	1	2	6	5	6		1.24	2	2	1	3	4		6
244	CGD13	1	1	2	6	5	6		1.26	6	2	1	3			6
245	CGD14	1	1	2	6	5	6		1.29	3	2	1	3	6		6
246	CGD15	1	1	2	6	5	6		1.33	3	2	1	3	6		6
247	CGD16	1	1	2	6	5	6		1.38	3	2	1	3	6		6
248	CGD17	1	1	2	6	5	6		1.42	6	2	1	3	4		6
249	CGD18	1	1	2	6	5	6		1.44	2	2	1	3	4		6
250	CGD19	1	1	2	6	5	6		1.47	2	2	1	3	4		6
251	CGD20	1	1	2	6	5	6		1.52	1	2	1	3	3		6
252	CGD21	1	1	2	6	5	6		1.56	2	2	1	3	4		6
253	CGD23	1	1	2	6	5	6		2.37	1	7	2	3	3		6
254	CGD24	1	1	2	6	5	6		2.63	1	1	3	1	3		5
255	CGD25	1	1	2	6	5	6		2.73	1	2	3	1	4		5
256	CGD26	1	1	2	6	5	6		2.87	1	2	3	1	4		5
257	CGD27	1	1	2	6	5	6		3.18	2	2	3	1	4		5
258	CGD28	1	1	2	6	5	6		3.33	2	2	3	1	4		5
259	CGD29	1	1	2	6	5	6		3.43	3	3	3	1	4		5
260	CGD30	1	1	2	6	5	6		3.92	7	7	2	3			5
261	CGD31	1	1	2	6	5	6		4.23	7	7	2	3			5
262	CGD32	1	1	2	6	5	6		4.51	7	7	2	3			5
263	CGD33	1	1	2	6	5	6		4.73	1	7	1	1	4	3	5
264	CGD34	1	1	2	6	5	6		4.85	9	9	1	1			4
265	CGD35	1	1	2	6	5	6		4.97	6	6	3	1			5
266	CGD36	1	1	2	6	5	6		5.03	6	6	3	1			5
267	CGD37	1	1	2	6	5	6		5.8	1	1	3	2	4		6
268	CGD38	1	1	2	6	5	6		6.07	1	1	2	1	3		6
269	CGD39	1	1	2	6	5	6		6.13	1	1	2	1	3		6
270	CGD40	1	1	2	6	5	6		6.29	1	1	2	1	3		6
271	CGD41	1	1	2	6	5	6		6.39	1	1	3	1	3		6
272	CGD42	1	1	2	6	5	6		6.49	1	1	3	1	3		6
273	CGD43	1	1	2	6	5	6		6.65	1	1	4	1	3		6

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
274	CGD44	1	1	2	6	5	6		6.76	1	1	2	1	9	3	6
275	CGD45	1	1	2	6	5	6		6.85	1	1	2	1	9	3	6
276	CGD46	1	1	2	6	5	6		7.2	1	1	4	1	9		6
277	CGD47	1	1	2	6	5	6		7.7	2	1	4	1	9		6
278	CGD48	1	1	2	6	5	6		8.2	2	1	4	1	9		6
279	CGD49	1	1	2	6	5	6		9.75	2	1	4	1	9		6
280	CGD50	1	1	2	6	5	6		0.05	1	1	1	1	1		8
281	CGD51	1	1	2	6	5	6		0.15	1	1	3	1	10		8
282	CGD52	1	1	2	6	5	6		0.23	1	1	3	1	9	2	8
283	CGD53	1	1	2	6	5	6		0.5	2	1	2	1	9		6
284	CGD54	1	1	2	6	5	6		0.57	1	1	3	1	4		6
285	CGD55	1	1	2	6	5	6		1.47	1	1	3	1	9		6
286	CGD56	1	1	2	6	5	6		1.53	1	1	3	1	9		6
287	CGD57	1	1	2	6	5	6		1.83	1	1	4	1	9		6
288	CGD58	1	1	2	6	5	6		2.01	1	1	3	1	9		6
289	CGD59	1	1	2	6	5	6		2.07	1	1	2	1	9		6
290	CGD60	1	1	2	6	5	6		2.15	1	1	2	1	9		6
291	CGD61	1	1	2	6	5	6		2.35	1	1	2	1	9		6
292	CGD62	1	1	2	6	5	6		2.62	1	1	2	1	9		6
293	CGD63	1	1	2	6	5	6		2.97	1	1	2	1	9		6
294	CGD64	1	1	2	6	5	6		3.28	1	1	2	1	9		6
295	CGD65	1	1	2	6	5	6		3.32	1	1	2	1	9		6
296	CGD66	1	1	2	6	5	6		3.47	2	2	1	1	6		6
297	CGD67	1	1	2	6	5	6		3.72	1	1	4	1	9		6
298	CGD68	1	1	2	6	5	6		4.14	1	1	4	1	9		6
299	LOD1*	1	1	2	6	5	6		0.13	1	1	2	1	9		6
300	LOS4	1	1	2	6	5	6		6.49	15	15	1	1	8		9
301	LOD2	1	1	2	6	5	6		6.79	15	15	3	1	9		9
302	LOD3	1	1	2	6	5	6		7.18	15	15	3	1	4		9
303	LOD4	1	1	2	6	5	6		7.33	15	15	3	1	3		9
304	LOD5	1	1	2	6	5	6		7.43	15	15	3	1	8		9
305	LOS5	1	1	2	6	5	6		7.53	15	15	3	1	8		9
306	LOD5A	1	1	2	6	5	6		7.58	15	15	3	1	8		9
307	LOD6	1	1	2	6	5	6		7.68	15	15	3	1	8		9
308	LOD7	1	1	2	6	5	6		7.76	2	2	4	1	8		6
309	LOD8	1	1	2	6	5	6		7.83	1	1	3	1	3		6
310	LOD9	1	1	2	6	5	6		7.91	1	1	3	1	3		5
311	LOD10	1	1	2	6	5	6		8	1	1	3	1	3		5
312	LOK6	1	1	2	6	5	6		8.13	1	1	3	1	9		5

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
313	LOK7	1	1	2	6	5	6		8.27	9	9	2	1	4		6
314	LOK8	1	1	2	6	5	6		8.33	9	9	2	1			6
315	LOD11	1	1	2	6	5	6		8.68	1	1	4	1	3		5
316	LOD12	1	1	2	6	5	6		8.8	1	1	4	1	3		5
317	LOK11	1	1	2	6	5	6		8.88	1	1	4	1	9		5
318	LOD13	1	1	2	6	5	6		9.15	2	2	1	1	9		8
319	LOD14	1	1	2	6	5	6		9.56	2	2	1	1	9		8
320	LOD15	1	1	2	6	5	6		9.85	2	2	1	1	9		8
321	LOD16	1	1	2	6	5	6		9.95	2	2	3	1	9		8
322	LOK15	1	1	2	6	5	6		10.15	6	6	1	1			8
323	LOK16	1	1	2	6	5	6		11.05	6	6	1	1			8
324	LOK17	1	1	2	6	5	6		11.16	6	6	1	1			8
325	LOK20	1	1	2	6	5	6		11.58	6	6	1	1			8
326	LOK21	1	1	2	6	5	6		11.89	6	6	1	1			8
327	LOK22	1	1	2	6	5	6		12.04	6	6	1	1			8
328	LOK23	1	1	2	6	5	6		12.14	6	6	1	1			8
329	LOK24	1	1	2	6	5	6		12.8	3	6	3	1			8
330	LOK25	1	1	2	6	5	6		13	3	6	3	1			8
331	LOK26	1	1	2	6	5	6		13.24	3	6	2	1			8
332	LOK27	1	1	2	6	5	6		13.44	6	6	2	1			8
333	LOK28	1	1	2	6	5	6		13.6	6	6	2	1			8
334	LOK29	1	1	2	6	5	6		13.82	6	8	2	1			8
335	LOK30	1	1	2	6	5	6		13.98	7	7	1	1			8
336	LOK31	1	1	2	6	5	6		14.16	7	7	1	1			8
337	LOK32	1	1	2	6	5	6		14.22	7	7	2	1			8
338	LOK33	1	1	2	6	5	6		14.42	7	7	2	1	3		8
339	LOK34	1	1	2	6	5	6		14.75	2	2	2	1	9		8
340	LOK35	1	1	2	6	5	6		14.86	2	2	1	1	3		8
341	LOK36	1	1	2	6	5	6		14.98	2	2	2	1	3		8
342	LOK37	1	1	2	6	5	6		15.18	2	2	2	1	3		8
343	LOK38	1	1	2	6	5	6		15.26	1	1	1	1	2	3	8
344	LOK39	1	1	2	6	5	6		15.32	1	1	1	1	2	3	8
345	LBT1	2	1	2	6	5	6		0.03	1	1	4	1	9		6
346	LBT2	2	1	2	6	5	6		0.2	1	1	4	1	9		6
347	LBT3	2	1	2	6	5	6		0.27	1	1	3	1	4		6
348	LBT4	2	1	2	6	5	6		0.35	1	1	3	1	4		6
349	LBT5	2	1	2	6	5	6		0.44	1	1	3	1	4		6
350	LBT6	2	1	2	6	5	6		0.53	1	1	4	1	3		6
351	LBT7	2	1	2	6	5	6		0.83	1	1	4	1	3		6

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
352	LBT8	2	1	2	6	5	6		1.07	1	1	4	1	3		6
353	LBT9	2	1	2	6	5	6		1.14	1	1	1	1	2	3	6
354	LBT10	2	1	2	6	5	6		1.23	1	1	2	1	2	3	6
355	LBT11	2	1	2	6	5	6		1.35	1	1	1	1	2	3	6
356	LBT12	2	1	2	6	5	6		1.49	10	10	1	1	4		6
357	LBT13	2	1	2	6	5	6		1.56	1	10	1	1	5		6
358	LBT14	2	1	2	6	5	6		1.64	2	10	1	1	5		6
359	LBT15	2	1	2	6	5	6		1.75	10	10	1	1	9		6
360	LBT16	2	1	2	6	5	6		1.83	10	10	1	1	9		6
361	LBT17	2	1	2	6	5	6		2.02	1	10	4	1	9		6
362	LBM1	2	1	2	6	5	6		0.08	1	1	4	1	9		6
363	LBM2	2	1	2	6	5	6		0.14	1	1	4	1	9		6
364	LBM3	2	1	2	6	5	6		0.35	1	1	1	1	9		6
365	LBM4	2	1	2	6	5	6		0.48	1	1	1	1	3		6
366	LBM5	2	1	2	6	5	6		0.56	10	1	3	1	11		6
367	LBM6	2	1	2	6	5	6		0.85	6	6	1	1			6
368	LBM7	2	1	2	6	5	6		1.29	10	9	3	1			6
369	KBD1	1	1	2	6	5	6		0.42	10	9	3	1	2		6
370	KBK1	1	1	2	6	4	7		3.22	2	2	1	1	11		9
371	KBK2	1	1	2	6	4	7		4.72	2	2	2	1	11		9
372	KBK3	1	1	2	6	4	7		5.22	2	2	2	1	11		9
373	KBK4	1	1	2	6	4	7		5.72	2	2	2	1	11		9
374	KBK5	1	1	2	6	4	7		6.22	2	2	2	1	11		9
375	KBK7	1	1	2	6	4	7		6.72	1	1	2	1	9		9
376	KBK8	1	1	2	6	4	7		7.22	2	2	1	1	11		9
377	KBK9	1	1	2	6	4	7		7.72	2	2	1	1	11		9
378	KBK10	1	1	2	6	4	7		8.22	2	2	1	1	11		9
379	KBK11	1	1	2	6	4	7		8.72	2	2	1	1	11		9
380	SB1	1	1	2	6	3	8		0.05	7	7	1	1			10
381	SB4	1	1	2	6	3	8		0.26	7	7	1	1			10
382	SB7	1	1	2	6	3	8		0.4	7	7	1	1			10
383	SB10	1	1	2	6	3	8		0.73	7	7	1	1			10
384	SB14	1	1	2	6	3	8		0.85	7	7	1	1			10
385	SBS2	1	1	2	6	3	8		0.05	15	15	1	1			10
386	SBS4	1	1	2	6	3	8		3.05	15	15	1	1			10
387	SBS5	1	1	3		2	9	11	3.1	1	1	3	1			7
388	SBU1	1	1	3		2	9	11	3.12	1	1	3	1			7
389	UOB1	1	1	3		2	9	11	0.15	15	15	2	1	5		6
390	UOB2	1	1	3		2	9	11	0.42	9	9	4	1			6

Appendix I: 'Dummy' variables

Key to abbreviations used in column headers:

Tnum	= total number
Samno	= sample number
Basin	= basin of deposition
Sequence	= major sequence of Morton
Cycle	= minor sequence of Morton
Strat	= stratigraphic order
Lith	= lithology
Dlith	= dominant lithology
Shells	= shell abundance
Bioturb	= bioturbation level
Colour	= shale colour
shaleT	= shale type
Env	= environment
Lithofac	= lithofacies
Biofac	= biofacies
Palyfac	= palynofacies
Salinity	= ostracod-derived salinity
Prox-dist	= proximal-distal unit

The keys to the numbers in each of the categories can be found in Tables 2.23 to 2.27.

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
391	UOB3	1	1	3		2	9	11	0.75	1	1	3	1	2		6
392	UOB4	1	1	3		2	9	11	0.95	1	1	3	1	2	3	6
393	UOB5	1	1	3		2	9	11	1.15	1	1	3	1	9	3	6
394	UOB6	1	1	3		2	9	11	1.4	9	1	4	1			6
395	UOB7	1	1	3		2	9	11	1.55	9	1	4	1	9		6
396	UOB8	1	1	3		2	9	11	2.65	1	1	3	2	3		6
397	UOB9	1	1	3		2	9	11	2.85	1	1	3	2	9		6
398	UOB10	1	1	3		2	9	11	3.15	2	2	2	1	9		6
399	UOB11	1	1	3		2	9	11	3.3	2	2	3	1	9		6
400	UOB12	1	1	3		2	9	11	3.52	2	2	3	1	9		6
401	UOB13	1	1	3		2	9	11	3.65	2	2	2	1	9		6
402	UOB14	1	1	3		2	9	11	3.78	1	2	3	1	9	3	6
403	UOB15	1	1	3		2	9	11	4.05	1	2	3	1	9		6
404	UOB16	1	1	3		2	9	11	4.3	1	2	3	1	9		6
405	UOB17	1	1	3		2	9	11	4.48	2	2	2	1	9		6
406	UOB18	1	1	3		2	9	11	4.75	2	2	3	1	9		6
407	UOB19	1	1	3		2	9	11	4.83	2	2	2	1	9		6
408	UOB20	1	1	3		2	9	11	5.05	1	2	2	1	9	3	6
409	UOB21	1	1	3		2	9	11	5.28	1	1	3	1	9	3	6
410	UOB22	1	1	3		2	9	11	5.38	1	1	2	1	9		6
411	UOB23	1	1	3		2	9	11	5.6	1	1	3	1	1	1	6
412	UOB24	1	1	3		2	9	11	5.75	1	1	4	1	1		6
413	UOB25	1	1	3		2	9	11	5.9	1	1	4	1	1		6
414	UOB26	1	1	3		2	9	11	6.95	7	7	2	2			6
415	UOB27	1	1	3		2	9	11	7.95	7	7	3	2			6
416	UOB28	1	1	3		2	9	11	8.05	7	7	1	1			6
417	UOB29	1	1	3		2	9	11	8.2	9	1	4	1			6
418	UOB30	1	1	3		2	9	11	8.26	1	1	2	1	1	1	6
419	UOB31	1	1	3		2	9	11	8.32	1	1	2	1	10	1	6
420	UOB32	1	1	3		2	9	11	8.41	1	1	3	1	10	1	6
421	UOB33	1	1	3		2	9	11	8.66	1	1	3	1	10	1	6
422	UOB34	1	1	3		2	9	11	8.73	1	1	3	1	10	1	6
423	UOB35	1	1	3		2	9	11	9.03	1	1	2	1	10	1	6
424	UOB36	1	1	3		2	9	11	9.43	1	1	3	1	10	1	6
425	UOB37	1	1	3		2	9	11	9.63	1	1	3	1	10	1	6
426	BS1	1	1	3		1	9	12	9.89	3	6	3	1	1		2
427	BS2	1	1	3		1	9	12	9.98	6	6	3	2			2
428	BS3	1	1	3		1	9	12	10.18	2	6	2	2			2
429	BS4	1	1	3		1	9	12	10.33	6	6	2	2			2

Tnum	Samno	Location	Basin	Sequence	Cycle	Strat	Formation	Member	Depth	Lith	Dlith	Shells	Bioturb	Colour	shaleT	Env
430	BS5	1	1	3		1	9	12	10.51	6	6	3	2			2
431	BS6	1	1	3		1	9	12	11.08	7	7	1	2			2
432	BS7	1	1	3		1	9	12	11.48	7	7	1	2			2
433	BS8	1	1	3		1	9	12	11.81	7	7	2	2			2
434	BS9	1	1	3		1	9	12	12.13	8	8	2	2			2
435	BS10	1	1	3		1	9	12	12.46	8	8	3	2			2
436	BS11	1	1	3		1	9	12	13.21	8	8	3	2			2
437	BS12	1	1	3		1	9	12	13.58	8	8	1	2			2
438	BS13	1	1	3		1	9	12	14.07	8	8	1	3			2
439	BS14	1	1	3		1	9	12	16.38	2	2	3	2	9		2
440	BS15	1	1	3		1	9	12	16.51	2	2	3	2	9		2

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
BBE1					1
BBE2					1
BBE3					1
BBE4					1
BBE5					1
BBE6					1
BBE7					1
BBE8					1
BBE9					1
BBE10					1
BBE11					1
BBE12					1
BBE13					1
BBE14					1
BBE15					1
BBE16					1
BBE17					1
BBE18					1
BBE19					1
BBE20					1
BBE21					1
BBE22					1
BBE23					1
BBE24					1
BBE25					1
BBE26					1
BBE27					1
BBE28					1
BBE29					1
BBE30					1
BBE31					1
BBE32					1
BBE33					1
BBE34					1
BBE35					1
BBE36					1
BBE37					1
BBE38					1
BBE39					1

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
BBE40					2
BBE41					2
BBE42					2
BBE43					2
BBE44					2
BBE45					2
BBE46					2
BBE47					2
BBE48					2
BBE49					
BBO1					1
BBO2					1
BBU1					2
BBU2					2
BBU3					2
BBU4					2
BBU5					2
BBU6					2
BBU7					2
BBU8					2
BBU9					2
BBU10					2
BBU11					2
BBU12					2
BBU13					2
BBU14					2
BBU15					2
BBU16					2
BBU17					2
BBU18					2
BBU19					2
BBU20					2
BBU21					2
BBU22					2
BBU23					2
BBU24					2
BBU25					2
BBU26					2
BBU27					2

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
BBU28					2
BBU29					2
BBU30					2
BBH1					3
BBH2					3
BBH3					3
BBH4					3
BBH5					3
BBH6					3
BBH7					3
BBH8					3
BBH9					3
BBH10					4
BBH11					4
BBH12					4
BBR1					
BBR2					
BBR3					
BBR4					
BBR13					
BBR14					
BBR15					
BBR16					
BBR17					
BBR18					
BBR19					
BBR5					
BBR6					
BBR7					
BBR8					
BBR9					
BBR10					
BBR11					
BNL17					1
BNL16					1
BNL1					1
BNL2					1
BNL3					1
BNL4					1

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
BNL5					2
BNL6					2
BNL7					2
BNL8					2
BNL9					2
BNL10					2
BNL11					2
BNL12					2
BNL13					2
BNL15					3
RGC1					1
RGC2					1
RGC3					1
RGC4					1
RCS1					2
RCS2					2
RCS3					2
RCS4					2
RCS5					3
RCS6					3
RCS7					4
RCS8					4
RCS9					4
RCS10					4
RCS11					4
RCS12					4
RCS13					4
RCS14					5
RCS15					5
KE26				1	
KE27				1	
KE28				1	
KE29				1	
KE30				1	
KE31				1	
KE32				1	
KE33				2	
KE34				2	
KE35				2	

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
KE36				2	
KE37				2	
KE38				2	
KE39				3	
KE40				3	
KE41				3	
KE42				3	
KE43				3	
KE44				3	
KE45				3	
KE46				3	
KE47				3	
KE48				3	
KE49				3	
KE50				3	
KE51				3	
KE52				3	
KE53				2	
KE54				2	
KE55				2	
KE56				2	
KE57				1	
KE58				1	
KE1				3	
KE2				3	
KE3				3	
KE4				2	
KE5				2	
KE6				2	
KE7				2	
KE8				2	
KE9				2	
KE10				2	
KE11				1	
KE12				1	
KE13				1	
KE14				1	
KE15				1	
KE16				1	

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
KE17				2	
KE18				2	
KE19				2	
KE20				2	
KE21				2	
KE22				2	
KE23				2	
KE24				2	
KE25				2	
RNB1				1	
RNB2				1	
RNB3				1	
RNB4				1	
RNB5				1	
RNB6				1	
RNB7				1	
RNB8				1	
RNB9				1	
RNB10				1	
RNB11				1	
RNB12				1	
RNB13				1	
RNB14				1	
RNB15				1	
RNB16				1	
RNB17				1	
RNB18				1	
RNB19				1	
RNB20				1	
VS2					
VS3					
VS4					
VS5					
VS7					
VS8					
VS9					
CGD1	4	4	1		
CGD2	4	4	1		
CGD3	4	4	1		

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
CGD4	4	4	1		
CGD5	4	4	1		
CGD6	4	4	1		
CGD7	4	4	1		
CGD8	4	4	1		
CGD9	4	4	1		
CGD10	4	4	1		
CGD11	4	4	1		
CGD12	4	4	1		
CGD13	4	4	1		
CGD14	4	4	1		
CGD15	4	4	1		
CGD16	4	4	1		
CGD17	4	4	1		
CGD18	4	4	1		
CGD19	4	4	1		
CGD20	4	4	1		
CGD21	4	4	1		
CGD23	4	4	1		
CGD24	1	1	1		
CGD25	1	6	1		
CGD26	1	6	1		
CGD27	1	6	1		
CGD28	1	6	1		
CGD29	4	4	1		
CGD30	4	4	1		
CGD31	4	4	1		
CGD32	4	4	1		
CGD33	4	4	1		
CGD34	3	3	1		
CGD35	4	4	1		
CGD36	4	4	1		
CGD37	1	1	1		
CGD38	1	1	1		
CGD39	1	1	1		
CGD40	1	1	1		
CGD41	1	1	1		
CGD42	1	1	1		
CGD43	1	1	1		

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
CGD44	1	1	1		
CGD45	1	1	1		
CGD46	1	1	1		
CGD47	1	1	1		
CGD48	1	1	1		
CGD49	1	1	1		
CGD50	6	3	2		
CGD51	1	1	1		
CGD52	1	1	1		
CGD53	1	6	1		
CGD54	1	6	1		
CGD55	1	1	1		
CGD56	1	1	1		
CGD57	1	1	1		
CGD58	1	1	1		
CGD59	1	1	1		
CGD60	1	1	1		
CGD61	1	1	1		
CGD62	1	1	1		
CGD63	1	1	1		
CGD64	1	1	1		
CGD65	1	1	1		
CGD66	6	3	2		
CGD67	1	1	1		
CGD68	1	1	1		
LOD1*	1	1	1		
LOS4	5	5	3		
LOD2	5	5	3		
LOD3	5	5	3		
LOD4	5	5	3		
LOD5	5	5	3		
LOS5	5	5	3		
LOD5A	5	5	3		
LOD6	5	5	3		
LOD7	1	6	1		
LOD8	1	6	1		
LOD9	1	6	1		
LOD10	1	6	1		
LOK6	1	6	1		

Appendix I: 'Dummy' variables

Key to abbreviations used in column headers:

Tnum	= total number
Samno	= sample number
Basin	= basin of deposition
Sequence	= major sequence of Morton
Cycle	= minor sequence of Morton
Strat	= stratigraphic order
Lith	= lithology
Dlith	= dominant lithology
Shells	= shell abundance
Bioturb	= bioturbation level
Colour	= shale colour
shaleT	= shale type
Env	= environment
Lithofac	= lithofacies
Biofac	= biofacies
Palyfac	= palynofacies
Salinity	= ostracod-derived salinity
Prox-dist	= proximal-distal unit

The keys to the numbers in each of the categories can be found in Tables 2.23 to 2.27.

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
LOK7	2	1	1		
LOK8	2	1	1		
LOD11	1	1	1		
LOD12	1	1	1		
LOK11	1	1	1		
LOD13	5	5	3		
LOD14	5	5	3		
LOD15	5	5	3		
LOD16	5	5	3		
LOK15	5	5	3		
LOK16	5	5	3		
LOK17	5	5	3		
LOK20	5	5	3		
LOK21	5	5	3		
LOK22	5	5	3		
LOK23	5	5	3		
LOK24	5	5	3		
LOK25	5	5	3		
LOK26	5	5	3		
LOK27	5	5	3		
LOK28	5	5	3		
LOK29	5	5	3		
LOK30	5	5	3		
LOK31	5	5	3		
LOK32	5	5	3		
LOK33	5	5	3		
LOK34	5	5	3		
LOK35	5	5	3		
LOK36	5	5	3		
LOK37	5	5	3		
LOK38	5	5	3		
LOK39	5	5	3		
LBT1	1	1	1		
LBT2	1	1	1		
LBT3	1	1	1		
LBT4	1	1	1		
LBT5	1	1	1		
LBT6	1	1	1		
LBT7	1	1	1		

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
LBT8	1	1	1		
LBT9	1	1	1		
LBT10	1	1	1		
LBT11	1	1	1		
LBT12	1	1	1		
LBT13	1	1	1		
LBT14	1	1	1		
LBT15	1	1	1		
LBT16	1	1	1		
LBT17	1	1	1		
LBM1	6	3	2		
LBM2	6	3	2		
LBM3	6	3	2		
LBM4	3	3	1		
LBM5	3	3	1		
LBM6	6	3	2		
LBM7	1	1	1		
KBD1	1	1	1		
KBK1					
KBK2					
KBK3					
KBK4					
KBK5					
KBK7					
KBK8					
KBK9					
KBK10					
KBK11					
SB1					
SB4					
SB7					
SB10					
SB14					
SBS2					
SBS4					
SBS5	1	1			
SBU1	1	1			
UOB1	1	1			
UOB2	1	1			

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
UOB3	1	1			
UOB4	1	1			
UOB5	2	1			
UOB6	2	1			
UOB7	2	1			
UOB8	3	2			
UOB9	3	2			
UOB10	3	2			
UOB11	3	2			
UOB12	3	2			
UOB13	3	2			
UOB14	3	2			
UOB15	3	2			
UOB16	3	2			
UOB17	3	2			
UOB18	3	2			
UOB19	3	2			
UOB20	2	1			
UOB21	2	1			
UOB22	2	1			
UOB23	2	1			
UOB24	2	1			
UOB25	2	1			
UOB26	3	2			
UOB27	3	2			
UOB28	3	2			
UOB29	2	1			
UOB30	2	1			
UOB31	2	1			
UOB32	2	1			
UOB33	2	1			
UOB34	2	1			
UOB35	2	1			
UOB36	2	1			
UOB37	2	1			
BS1	4	3			
BS2	4	3			
BS3	4	3			
BS4	4	3			

Samno	Lithofac	Biofac	palyfac	Salinity	Prox-dist
BS5	4	3			
BS6	4	3			
BS7	4	3			
BS8	4	3			
BS9	4	3			
BS10	4	3			
BS11	4	3			
BS12	4	3			
BS13	4	3			
BS14	5	5			
BS15	5	5			

APPENDIX II

Appendix II: Simple percentages of the kerogen count categories

Key to abbreviations used in column headers (parameters all percentages based on 500 counts per sample):

SAMNO = sample number
UNDIF% = undifferentiated palynomorphs
BOT% = *Botryococcus*
FORAM% = Foraminiferal linings
PLANK% = marine plankton
SPORO% = sporomorphs
AOM% = AOM
FUNG% = fungal hyphae
MEM% = membranes
CUTIC% = cuticle
USPSU% = pseudoamorphous non-biostructured brown wood
USCO% = corroded non-biostructured brown wood
USUN% = undegraded non-biostructured brown wood
SDPT% = degraded pitted biostructured brown wood
SDBN% = degraded banded biostructured brown wood
SDSP% = degraded striped biostructured brown wood
SDSR% = degraded striate biostructured brown wood
STDEG% = total degraded biostructured brown wood
SUPT% = undegraded pitted biostructured brown wood
SUBN% = undegraded banded biostructured brown wood
SUSP% = undegraded striped biostructured brown wood
SUST% = undegraded striate biostructured brown wood
STUND% = total undegraded biostructured brown wood
BLKLAT% = lath shaped black wood
BLKEQUI% = equant shaped black wood

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
BBE1	1.2	0.0	0.0	0.2	1.2	4.0	0.0	0.0	0.0	5.0	76.4	0.8	0.0	2.0	0.8	4.0
BBE2	1.2	0.0	0.0	0.4	1.2	5.6	0.0	0.4	0.0	0.8	70.0	1.4	0.0	0.0	1.2	2.8
BBE3	0.4	0.0	0.0	0.2	2.0	10.2	0.0	1.0	0.0	2.6	69.8	2.4	0.0	0.0	0.2	7.4
BBE4	0.8	0.0	0.0	0.6	2.0	17.0	0.0	1.0	0.0	8.2	60.0	2.4	0.0	0.0	0.2	5.0
BBE5	0.0	0.0	0.0	0.0	1.0	3.6	0.0	0.0	0.0	0.0	78.0	0.0	0.0	0.2	0.4	0.0
BBE6	0.8	0.0	0.0	0.8	2.4	16.0	0.0	0.8	0.0	10.4	56.8	3.6	0.0	0.0	0.4	2.8
BBE7	0.0	0.0	0.2	0.4	1.6	19.0	0.0	0.4	0.2	2.8	62.8	3.2	0.0	0.2	0.4	3.6
BBE8	0.0	0.0	0.0	0.6	3.2	9.4	0.0	0.0	0.0	1.2	74.8	2.0	0.0	0.0	0.2	1.2
BBE9	0.4	0.0	0.0	0.4	1.6	11.4	0.0	0.8	0.2	5.4	67.4	1.6	0.0	0.0	0.0	3.8
BBE10	0.4	0.0	0.0	0.4	3.6	14.2	0.0	0.6	0.0	6.6	65.6	1.4	0.0	0.0	0.0	2.8
BBE11	0.0	0.0	0.0	0.0	2.0	12.2	0.0	1.4	0.2	0.6	73.6	2.0	0.0	0.0	0.4	4.4
BBE12	0.0	0.0	0.0	0.0	0.6	6.8	0.0	0.0	0.0	0.0	76.0	0.4	0.0	0.0	0.0	3.8
BBE13	0.4	0.0	0.0	0.6	3.4	18.0	0.0	2.0	0.0	5.2	58.4	2.0	0.0	0.2	0.2	5.2
BBE14	0.0	0.0	0.0	0.8	3.0	11.4	0.0	0.0	0.0	1.2	72.8	2.2	0.0	0.0	0.0	1.2
BBE15	0.0	0.0	0.0	0.4	3.4	12.2	0.0	0.0	0.0	0.8	72.0	2.2	0.0	0.0	0.0	1.6
BBE16	0.0	0.0	0.0	0.2	0.2	10.4	0.0	0.8	0.0	6.6	74.0	0.8	0.0	0.0	0.0	5.0
BBE17	0.6	0.0	0.0	0.6	2.4	3.4	0.0	0.2	0.0	2.8	81.6	1.8	0.0	0.2	0.0	1.4
BBE18	0.6	0.0	0.0	0.0	0.6	6.0	0.0	0.2	0.0	0.2	77.4	1.0	0.0	0.0	0.4	4.4
BBE19	1.2	0.0	0.0	0.2	0.8	8.0	0.0	0.2	0.0	0.0	76.2	1.2	0.0	0.0	0.2	7.0
BBE20	0.8	0.0	0.0	0.2	1.6	8.0	0.0	0.0	0.0	0.0	76.0	0.0	0.0	0.0	0.4	5.2
BBE21	0.8	0.0	0.0	0.2	1.4	13.4	0.0	0.8	0.0	4.4	69.6	1.4	0.0	0.0	0.2	4.0
BBE22	0.6	0.0	0.0	0.4	2.0	19.2	0.0	0.2	0.2	10.0	61.2	0.4	0.0	0.0	0.0	2.4
BBE23	0.4	0.0	0.0	0.2	1.8	8.8	0.0	2.0	0.0	6.8	71.6	0.4	0.0	0.0	0.0	5.6
BBE24	0.4	0.0	0.0	0.8	2.6	19.4	0.0	1.0	0.0	2.4	63.8	2.0	0.0	0.0	0.2	4.6
BBE25	0.4	0.0	0.0	0.2	2.0	9.4	0.0	1.0	0.0	4.4	70.2	2.8	0.0	0.0	0.2	3.4
BBE26	0.4	0.0	0.0	0.4	1.8	11.4	0.0	1.0	0.0	4.2	68.2	2.2	0.0	0.0	0.4	4.0
BBE27	0.0	0.0	0.0	0.4	0.6	14.0	0.0	1.4	0.0	3.6	74.8	0.6	0.0	0.0	0.0	0.8
BBE28	0.4	0.0	0.0	0.2	1.6	13.4	0.0	0.8	0.0	7.0	67.8	1.6	0.0	0.0	0.0	3.0
BBE29	0.0	0.0	0.0	0.2	2.0	14.4	0.0	0.6	0.0	6.6	66.8	2.0	0.0	0.2	0.0	2.6
BBE30	0.4	0.0	0.0	0.2	0.8	12.4	0.0	1.8	0.0	5.6	69.0	0.8	0.0	0.2	0.0	4.4
BBE31	0.2	0.0	0.0	0.2	1.4	9.0	0.0	0.8	0.0	7.6	70.4	1.2	0.2	0.8	0.0	4.0
BBE32	0.0	0.0	0.0	0.0	0.6	16.2	0.0	1.4	0.0	8.6	63.6	1.6	0.0	0.0	0.0	3.6
BBE33	0.6	0.0	0.0	0.8	2.6	14.4	0.0	1.6	0.0	6.6	65.0	3.2	0.0	0.0	0.0	3.0
BBE34	0.0	0.0	0.0	0.2	1.2	10.0	0.0	1.4	0.0	8.0	70.0	1.2	0.0	0.0	0.2	4.6
BBE35	0.2	0.0	0.2	0.2	1.2	16.8	0.0	0.8	0.0	6.4	67.2	1.6	0.0	0.2	0.0	2.2
BBE36	0.4	0.0	0.0	0.8	2.2	25.4	0.0	1.4	0.0	4.8	57.2	2.4	0.0	0.0	0.0	2.6
BBE37	0.0	0.0	0.0	0.0	1.0	16.8	0.0	1.2	0.0	7.2	65.6	1.4	0.0	0.0	0.0	4.8
BBE38	0.4	0.0	0.0	0.2	1.4	23.2	0.0	1.0	0.0	8.0	55.4	2.8	0.0	0.0	0.4	2.8
BBE39	0.2	0.0	0.0	0.4	1.6	29.2	0.0	1.8	0.0	6.0	51.4	2.2	0.0	0.0	0.0	3.0

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
BBE40	2.2	0.0	0.2	1.0	2.0	8.4	0.0	0.8	0.0	22.4	26.6	10.0	0.0	0.6	0.2	7.0
BBE41	2.4	0.0	0.0	0.6	2.4	12.6	0.0	0.8	0.0	21.4	25.2	5.6	0.4	1.0	0.6	16.0
BBE42	1.2	0.0	0.0	0.4	0.4	27.4	0.0	1.0	0.0	23.0	22.0	3.8	0.0	0.6	0.2	8.6
BBE43	1.0	0.0	0.0	0.6	1.0	33.6	0.0	0.8	0.0	20.6	27.6	3.0	0.0	0.4	0.6	4.4
BBE44	1.4	0.0	0.0	0.4	1.0	33.2	0.0	1.4	0.0	19.6	26.0	3.6	0.0	0.4	0.6	4.6
BBE45	1.0	0.0	0.0	0.8	1.2	23.4	0.0	0.8	0.0	18.8	35.0	3.2	0.4	0.2	1.2	2.2
BBE46	0.6	0.0	0.0	0.4	0.6	26.6	0.0	0.2	0.0	17.8	38.2	3.4	0.0	0.2	2.0	3.0
BBE47	1.0	0.0	0.0	0.4	1.2	37.2	0.0	0.4	0.0	9.4	34.2	4.0	0.2	0.2	2.0	3.8
BBE48	0.6	0.0	0.0	0.2	0.6	31.8	0.0	0.6	0.0	10.0	37.4	1.8	0.4	0.0	1.6	4.8
BBE49	1.6	0.0	0.0	0.6	4.0	10.8	0.0	0.8	0.2	3.0	57.0	1.6	0.4	0.0	3.6	2.8
BBO1	2.0	0.0	0.0	2.0	12.2	8.0	0.0	0.4	0.0	1.2	59.0	1.0	0.2	0.0	3.0	4.0
BBO2	1.2	0.0	0.0	0.4	8.8	9.4	0.0	1.6	0.0	2.0	55.6	3.2	1.0	0.0	4.4	8.4
BBU1	1.8	0.0	0.0	1.2	9.2	4.4	0.2	0.4	0.0	2.2	62.0	1.6	1.0	0.0	4.2	6.2
BBU2	1.4	0.0	0.0	0.6	10.0	7.6	0.0	0.2	0.0	3.2	50.8	3.4	0.2	1.0	4.2	7.2
BBU3	3.2	1.0	0.0	1.8	9.4	7.8	0.0	0.6	0.0	2.4	43.0	4.0	0.2	0.4	5.4	7.2
BBU4	1.0	0.0	0.0	1.0	10.6	9.8	0.2	0.4	0.0	2.6	49.6	5.4	1.0	0.6	3.8	6.6
BBU5	1.6	0.0	0.0	0.6	6.2	7.0	0.0	0.0	0.0	2.0	60.2	2.0	0.8	0.6	3.8	4.2
BBU6	0.4	0.0	0.0	0.4	7.8	12.0	0.0	0.0	0.0	2.0	47.2	3.6	0.0	0.4	2.8	9.2
BBU7	0.8	0.0	0.2	0.0	6.0	24.6	0.2	1.0	0.0	5.8	34.6	6.0	0.4	0.0	1.2	8.6
BBU8	0.6	0.0	0.4	1.2	3.6	25.2	0.0	0.0	0.0	5.2	40.2	3.0	0.6	1.8	1.8	5.2
BBU9	0.0	0.0	0.0	1.6	6.0	20.4	0.0	0.8	0.0	1.6	42.6	6.4	0.6	0.2	3.2	4.4
BBU10	0.2	0.0	0.0	1.0	5.2	28.4	0.2	0.0	0.0	3.0	36.8	5.0	0.2	0.2	4.4	5.8
BBU11	2.4	0.2	0.0	0.6	5.6	27.2	0.6	0.6	0.0	4.6	42.8	4.4	0.0	0.4	2.0	6.4
BBU12	1.0	0.0	0.0	0.6	5.0	18.0	0.2	0.4	0.0	4.6	53.8	2.8	0.0	0.4	1.6	4.0
BBU13	0.2	0.2	0.0	0.2	2.8	46.0	0.2	0.0	0.0	5.0	29.4	3.2	0.0	0.2	1.8	3.0
BBU14	0.8	0.0	0.0	1.6	10.8	21.4	0.0	0.2	0.0	2.6	41.6	4.6	0.4	0.0	2.0	4.0
BBU15	1.0	0.0	0.0	1.8	8.8	15.8	0.0	0.4	0.0	7.2	40.6	8.6	0.4	0.2	3.2	5.2
BBU16	1.0	0.0	0.0	1.6	7.4	31.2	0.2	0.6	0.0	5.6	28.4	7.2	0.0	0.4	2.2	6.0
BBU17	0.6	0.0	0.0	2.2	11.6	9.2	0.0	0.4	0.0	2.0	48.0	5.2	0.2	1.0	4.0	6.6
BBU18	0.8	0.0	0.0	1.2	8.8	24.6	0.0	0.4	0.0	3.0	34.2	6.0	0.4	1.0	2.6	4.6
BBU19	0.8	0.0	0.0	1.6	9.6	14.6	0.0	0.0	0.0	1.4	47.8	5.2	0.0	0.2	5.4	4.0
BBU20	1.6	0.0	0.0	0.8	11.0	13.8	0.0	0.4	0.0	5.0	34.0	10.0	0.0	0.2	4.0	7.6
BBU21	1.0	0.0	0.0	0.4	12.0	16.2	0.0	0.4	0.0	5.0	33.8	10.4	0.0	0.0	4.0	8.8
BBU22	1.6	0.0	0.0	1.4	7.8	34.2	0.0	1.0	0.0	3.8	29.2	6.8	0.2	0.2	1.2	8.0
BBU23	1.0	0.0	0.2	1.4	10.4	25.2	0.0	0.2	0.0	4.0	26.0	8.4	0.0	0.4	5.8	8.2
BBU24	0.8	0.0	0.2	0.6	5.2	34.2	0.0	0.2	0.0	5.0	36.4	3.6	0.0	1.0	1.6	3.0
BBU25	1.4	0.0	0.0	0.2	6.0	28.8	0.0	0.6	0.0	5.0	34.6	4.2	0.2	0.4	2.4	5.8
BBU26	0.0	0.0	0.0	1.2	9.0	23.8	0.0	0.0	0.0	2.2	35.6	4.4	0.2	0.4	3.2	8.2
BBU27	0.2	0.0	0.0	0.6	6.4	27.4	0.0	0.0	0.0	2.8	40.6	4.6	0.0	0.4	0.6	8.0

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
BBU28	1.8	0.0	0.0	1.4	11.4	13.6	0.0	0.0	0.0	0.4	51.6	4.0	0.0	0.2	1.6	5.6
BBU29	1.0	0.0	0.0	1.2	8.8	15.8	0.0	0.0	0.0	2.0	50.6	3.8	0.0	0.4	1.6	4.0
BBU30	0.6	0.0	0.0	0.2	8.0	20.0	0.0	0.0	0.0	2.8	49.0	2.6	0.2	0.8	1.8	4.4
BBH1	0.6	0.0	0.2	0.4	4.8	27.8	0.0	0.8	0.0	5.6	49.4	2.8	0.0	0.4	0.4	1.0
BBH2	0.8	0.0	0.0	0.6	3.4	26.4	0.0	0.8	0.0	4.8	50.4	2.8	0.2	0.0	0.6	1.0
BBH3	1.0	0.0	0.0	0.2	2.4	27.0	0.0	1.2	0.0	4.8	51.4	1.6	0.0	0.4	0.8	1.2
BBH4	0.4	0.0	0.0	0.4	3.6	26.0	0.0	0.2	0.0	3.4	56.2	1.4	0.4	0.0	0.4	1.2
BBH5	0.2	0.0	0.0	0.8	6.0	9.6	0.0	0.2	0.0	1.0	67.4	0.8	0.0	0.0	0.8	0.0
BBH6	0.8	0.0	0.0	1.0	5.2	12.6	0.0	0.4	0.0	2.2	67.6	1.4	0.0	0.0	0.0	0.4
BBH7	0.2	0.0	0.0	0.4	3.0	15.8	0.0	0.0	0.0	3.8	66.4	0.6	0.0	0.0	0.4	0.6
BBH8	0.8	0.0	0.0	0.4	3.6	19.6	0.2	0.2	0.0	0.8	65.8	0.2	0.2	0.0	0.0	0.6
BBH9	0.4	0.0	0.0	1.0	6.4	8.2	0.0	0.0	0.0	2.2	70.6	2.0	0.0	0.2	0.6	0.0
BBH10	1.8	0.0	0.0	0.6	8.8	19.4	0.0	0.2	0.0	3.4	55.6	0.8	0.0	0.0	0.6	0.6
BBH11	0.2	0.2	0.0	0.2	7.2	20.2	0.0	0.0	0.0	1.2	60.8	0.8	0.4	0.2	0.6	0.2
BBH12	0.4	0.2	0.0	0.8	5.0	14.4	0.0	0.2	0.2	0.4	67.6	1.0	0.2	0.0	0.6	0.6
BBR1	0.4	0.0	0.0	0.8	1.6	20.6	0.0	0.2	0.8	1.8	65.6	0.8	0.0	0.2	0.4	0.0
BBR2	1.4	0.0	0.0	1.0	3.2	21.8	0.0	0.2	0.0	1.6	58.6	0.4	0.0	0.2	0.4	0.4
BBR3	1.4	0.0	0.0	0.4	3.0	17.0	0.0	0.4	0.0	0.2	68.2	0.6	0.0	0.0	0.0	0.6
BBR4	1.6	0.0	0.0	1.2	3.6	12.4	0.0	0.0	0.0	0.8	71.2	1.2	0.0	0.0	0.2	1.0
BBR13	0.6	0.0	0.0	1.2	4.4	13.4	0.0	0.0	0.0	2.0	65.8	0.6	0.4	0.0	0.2	0.0
BBR14	0.0	0.0	0.0	1.2	6.8	19.2	0.0	0.2	0.0	1.6	56.8	1.2	0.0	0.2	0.4	0.2
BBR15	0.0	0.0	0.0	0.4	3.2	22.6	0.0	0.0	0.0	2.8	66.2	0.6	0.0	0.0	0.0	0.0
BBR16	1.0	0.0	0.0	0.6	3.8	21.6	0.6	0.4	0.0	2.2	64.2	0.4	0.2	0.6	0.0	0.2
BBR17	0.0	0.0	0.0	0.4	4.8	25.6	0.4	0.0	0.0	1.6	58.0	0.8	0.2	0.2	0.2	0.0
BBR18	1.0	0.0	0.2	0.2	4.0	21.0	0.0	0.0	0.0	2.2	66.0	0.2	0.2	0.0	0.2	0.0
BBR19	0.8	0.0	0.0	0.2	5.4	16.8	0.0	0.2	0.0	2.4	66.0	0.6	0.4	0.2	0.0	0.4
BBR5	0.4	0.0	0.0	0.4	5.8	17.2	0.0	0.2	0.0	1.8	61.6	0.8	0.0	0.4	0.2	1.4
BBR6	1.6	0.0	0.0	0.6	1.8	15.8	0.0	0.4	0.0	2.0	63.0	1.4	0.0	0.2	0.0	0.0
BBR7	2.0	0.0	0.0	0.4	3.4	25.6	0.0	0.6	0.0	1.6	56.4	0.4	0.2	0.0	0.6	0.6
BBR8	1.8	0.0	0.0	1.0	3.8	20.4	0.0	0.2	0.0	2.4	53.8	2.4	0.0	0.6	0.0	0.8
BBR9	1.0	0.0	0.0	0.2	2.6	32.2	0.0	0.8	0.0	2.4	50.2	0.8	0.0	0.4	0.0	0.6
BBR10	3.0	0.0	0.0	1.8	6.2	21.8	0.0	0.6	0.0	3.8	56.6	0.4	0.0	0.4	0.4	0.4
BBR11	1.8	0.0	0.0	2.0	19.0	13.8	0.2	0.0	0.0	0.8	53.8	1.0	0.0	0.6	1.4	0.2
BNL17	0.0	0.0	0.0	0.0	1.4	52.8	0.0	0.0	0.0	0.4	38.4	0.0	0.0	0.0	0.0	0.0
BNL16	0.2	0.0	0.0	1.0	4.4	34.0	0.0	0.0	0.0	6.4	43.8	0.4	0.0	0.4	0.0	0.0
BNL1	0.4	0.4	0.0	0.4	2.0	28.4	0.0	0.0	0.0	9.2	48.4	1.6	0.0	0.8	0.0	0.0
BNL2	0.0	0.0	0.0	0.8	5.8	20.0	0.0	0.2	0.0	7.4	55.6	0.4	0.0	0.0	0.8	0.0
BNL3	0.2	0.0	0.0	0.0	1.6	34.4	0.0	0.0	0.0	2.8	53.6	0.2	0.0	0.4	0.4	0.0
BNL4	0.0	0.0	0.0	0.4	5.6	26.6	0.0	0.0	0.0	3.8	56.0	0.2	0.0	0.2	0.4	0.0

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
BNL5	0.0	0.0	0.0	0.2	3.8	29.6	0.0	0.0	0.0	5.4	51.6	0.8	0.0	0.2	0.4	0.0
BNL6	0.0	0.0	0.0	0.2	1.0	16.6	0.0	0.0	0.0	4.2	70.6	0.2	0.0	0.0	0.2	0.0
BNL7	0.0	0.0	0.0	0.2	0.4	36.8	0.0	0.0	0.0	0.0	55.6	0.6	0.0	0.6	0.0	0.0
BNL8	0.0	0.0	0.0	0.0	2.4	34.4	0.0	0.0	0.0	5.8	49.6	0.0	0.0	0.0	0.4	0.0
BNL9	0.0	0.2	0.0	0.8	10.2	27.8	0.0	0.0	0.0	3.4	50.2	0.8	0.0	0.0	0.4	0.0
BNL10	0.0	0.0	0.0	0.4	2.4	35.0	0.0	0.0	0.0	7.6	46.4	0.6	0.0	0.0	0.2	0.2
BNL1:	0.2	0.0	0.0	0.2	5.0	38.0	0.0	0.0	0.0	3.6	39.2	0.6	0.4	0.2	0.6	0.0
BNL12	0.0	0.0	0.0	0.6	3.4	33.2	0.0	0.0	0.0	4.4	44.0	1.2	0.2	0.4	0.6	0.0
BNL13	0.8	0.0	0.0	1.4	5.6	23.6	0.0	0.0	0.0	0.8	47.6	0.4	0.0	0.6	0.6	0.0
BNL15	0.0	0.0	0.0	0.4	3.8	32.4	0.0	0.0	0.0	1.2	49.0	0.0	0.0	0.0	0.0	0.0
RGC1	0.4	0.0	0.0	0.0	1.6	48.4	0.0	10.6	20.0	1.2	10.4	3.2	0.2	0.0	0.0	0.0
RGC2	0.0	0.0	0.0	0.2	1.8	57.4	0.0	5.6	17.4	0.2	12.2	2.0	0.2	0.2	0.0	0.0
RGC3	0.0	0.0	0.0	0.0	1.4	62.6	0.0	4.6	14.2	1.4	9.8	1.4	0.0	0.0	0.0	0.0
RGC4	1.4	0.2	0.0	0.4	2.2	42.0	0.0	9.4	19.4	2.0	13.2	3.8	0.0	0.2	0.8	0.0
RCS1	0.2	0.6	0.0	1.8	12.4	42.8	0.0	1.0	0.2	3.0	24.8	2.0	0.8	1.2	2.2	0.6
RCS2	0.6	0.4	0.0	1.0	11.8	50.8	0.0	0.4	0.0	1.6	22.2	2.8	0.4	1.4	1.4	0.2
RCS3	1.0	0.2	0.0	0.2	12.2	51.4	0.0	0.2	0.0	1.2	21.0	4.2	0.0	1.6	2.6	0.2
RCS4	0.0	0.0	0.0	0.0	2.0	36.0	0.2	0.0	0.0	9.4	43.8	1.8	0.2	0.4	0.4	0.0
RCS5	0.6	1.4	0.0	0.6	8.6	50.0	0.0	0.8	0.0	1.6	22.4	5.6	0.2	1.0	1.0	0.0
RCS6	0.8	2.4	0.0	0.6	8.2	57.4	0.0	0.2	0.0	1.2	16.6	4.4	0.2	1.2	0.4	0.0
RCS7	1.0	1.4	0.0	0.6	8.0	63.0	0.0	0.2	0.2	0.6	13.6	3.4	0.4	0.8	0.2	0.0
RCS8	0.8	1.8	0.0	0.4	10.2	48.6	0.0	0.8	0.0	2.4	18.4	5.2	0.2	2.2	2.6	1.2
RCS9	1.2	1.6	0.0	0.4	7.2	57.4	0.0	0.2	0.4	2.0	17.6	3.8	0.2	2.2	0.8	0.8
RCS10	1.0	2.0	0.0	1.0	9.0	47.2	0.0	1.2	0.6	3.4	17.8	4.4	0.2	2.4	1.6	0.0
RCS11	1.0	2.4	0.0	0.4	5.8	54.0	0.0	0.4	0.0	2.2	14.8	6.2	0.2	2.8	2.6	0.4
RCS12	1.0	1.2	0.0	0.2	7.4	51.8	0.0	0.8	1.0	2.4	14.0	7.8	0.6	3.0	1.8	0.6
RCS13	0.6	2.0	0.0	0.2	12.0	51.6	0.0	1.2	0.2	1.6	15.6	6.0	0.0	2.2	1.4	0.0
RCS14	0.6	2.8	0.0	0.2	13.0	40.6	0.0	2.4	1.2	4.2	13.4	8.6	0.0	3.6	1.4	0.2
RCS15	0.4	1.6	0.0	0.2	11.4	26.4	0.0	1.4	0.2	7.2	28.0	2.6	0.2	3.2	2.0	0.4
KE26	0.4	4.0	0.0	0.2	15.6	46.4	0.0	2.8	7.0	0.6	6.2	6.6	0.2	2.0	1.4	0.8
KE27	0.8	7.0	0.0	0.0	9.2	58.4	0.0	1.6	1.4	0.0	6.0	5.2	0.0	0.6	0.8	0.2
KE28	0.8	4.0	0.0	0.2	20.0	46.2	0.0	0.6	2.8	0.4	8.4	5.4	0.4	1.2	2.2	0.2
KE29	0.4	4.6	0.0	0.4	12.6	47.2	0.0	1.0	4.4	0.4	9.8	6.6	1.2	2.4	0.8	0.4
KE30	1.2	6.8	0.0	0.0	6.2	53.8	0.0	1.8	3.8	0.4	8.6	6.0	0.0	0.6	0.8	0.4
KE31	1.0	10.2	0.0	0.0	11.0	43.4	0.0	4.6	4.2	0.8	9.4	6.2	0.2	0.4	0.8	0.4
KE32	1.6	9.0	0.0	0.0	21.6	0.6	0.0	11.6	6.0	0.2	23.6	8.2	0.4	3.2	1.8	0.4
KE33	0.6	5.4	0.0	0.0	17.8	3.2	0.0	13.0	15.8	2.0	8.0	15.0	1.2	4.4	7.2	2.0
KE34	0.2	6.6	0.0	0.0	13.8	33.4	0.0	4.8	7.0	1.0	8.4	14.0	0.8	3.8	1.2	1.2
KE35	0.6	7.4	0.0	0.0	26.0	22.4	0.0	7.2	8.2	0.8	5.4	9.4	1.2	2.8	3.4	0.6

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
KE36	0.6	9.6	0.0	0.4	15.0	42.4	0.0	6.4	4.4	0.6	4.4	6.8	1.0	1.6	1.6	0.2
KE37	0.6	7.0	0.0	0.0	12.2	44.2	0.0	7.0	4.2	1.0	5.6	8.2	0.8	2.6	0.4	0.4
KE38	0.6	4.4	0.0	0.2	18.8	23.8	0.0	2.8	7.6	1.4	15.0	8.2	1.0	3.4	2.8	0.6
KE39	1.4	3.2	0.0	0.2	32.4	2.4	0.0	3.8	6.4	0.2	22.0	8.6	2.4	2.8	3.6	0.8
KE40	0.8	2.8	0.0	0.0	41.0	1.2	0.0	2.8	6.8	0.4	11.6	10.0	0.8	2.8	3.8	1.6
KE41	0.8	4.0	0.0	0.0	49.0	11.0	0.0	3.0	2.4	0.2	6.6	9.8	1.0	1.4	1.8	0.6
KE42	2.2	5.2	0.0	1.0	36.2	22.8	0.0	2.0	2.2	1.6	6.6	7.6	0.8	2.0	2.2	0.0
KE43	1.4	6.4	0.0	0.0	53.8	9.8	0.0	1.0	2.0	1.8	4.4	8.2	0.8	1.4	1.6	0.0
KE44	0.2	7.4	0.0	1.4	13.8	45.4	0.0	9.2	5.4	0.2	4.2	6.0	0.2	1.2	1.8	0.0
KE45	1.0	4.8	0.0	0.6	36.4	25.2	0.0	1.6	7.0	1.0	4.2	6.0	0.6	1.8	1.6	0.4
KE46	0.8	8.8	0.0	0.6	13.8	39.2	0.0	4.2	3.4	2.0	8.6	6.8	1.2	2.0	2.6	0.4
KE47	0.8	9.2	0.0	0.4	22.2	31.0	0.0	5.4	6.0	1.6	4.6	9.2	0.6	1.0	2.2	0.8
KE48	0.8	6.6	0.0	0.6	22.8	40.2	0.0	2.8	4.2	0.0	5.2	10.4	0.6	1.4	0.8	0.2
KE49	1.2	3.6	0.0	1.0	18.2	52.2	0.0	1.8	1.0	0.0	2.8	9.0	0.6	1.0	2.0	0.0
KE50	0.6	6.6	0.0	0.8	7.0	63.2	0.0	1.6	0.6	0.8	3.0	10.6	0.0	0.4	0.8	0.0
KE51	0.6	8.4	0.0	1.0	10.8	59.2	0.4	2.0	0.4	0.0	2.8	9.0	0.0	0.6	0.2	0.0
KE52	0.8	7.4	0.0	1.8	11.4	57.4	0.0	0.6	1.0	0.2	5.2	7.2	0.0	0.8	1.4	0.2
KE53	2.2	8.2	0.0	0.4	31.0	29.2	0.0	1.4	2.2	0.2	3.4	9.0	1.2	1.0	3.0	0.4
KE54	1.6	5.2	0.0	0.8	21.0	45.8	0.0	1.2	1.4	0.2	5.6	9.6	0.8	0.4	1.8	0.2
KE55	0.8	5.2	0.0	0.4	21.4	25.0	0.0	6.2	5.2	1.0	9.6	12.6	0.8	0.4	3.6	0.4
KE56	1.0	4.6	0.0	0.0	5.2	15.4	0.0	31.8	0.6	0.0	4.0	5.0	0.0	0.4	1.2	0.4
KE57	1.0	2.4	0.0	0.2	31.8	3.2	0.0	3.0	7.0	1.2	11.8	17.0	1.4	3.8	7.0	0.8
KE58	3.4	4.8	0.0	1.0	34.0	6.2	0.2	3.2	4.0	1.0	7.0	10.4	0.8	3.0	5.4	1.6
KE1	1.8	3.8	0.0	0.0	56.4	16.2	0.2	3.4	0.4	0.4	5.8	2.4	1.6	1.0	1.0	0.2
KE2	1.8	3.4	0.0	0.0	39.2	11.2	0.0	4.4	2.0	1.0	11.0	8.8	0.4	1.6	3.6	1.2
KE3	1.8	2.4	0.0	2.0	46.4	16.8	0.0	3.8	0.4	2.0	7.2	6.4	1.0	2.2	2.4	0.8
KE4	5.2	2.0	0.0	29.0	20.0	20.4	0.0	4.8	0.0	0.4	7.4	3.0	0.0	0.2	1.2	2.4
KE5	3.4	1.6	0.0	56.0	12.6	14.4	0.0	3.6	0.0	0.0	3.4	3.4	0.2	0.2	0.2	0.0
KE6	3.0	2.2	0.0	7.0	37.0	13.6	0.0	2.4	0.0	0.6	19.2	2.8	0.2	2.0	2.2	0.8
KE7	1.2	2.6	0.0	2.0	13.4	51.6	0.2	6.6	0.0	0.4	7.8	5.0	0.2	1.8	2.6	0.2
KE8	2.4	2.0	0.0	4.6	25.6	14.8	0.0	2.6	0.2	0.2	20.6	6.0	0.4	2.0	0.6	0.0
KE9	1.2	5.8	0.0	2.4	12.0	37.8	0.0	3.6	2.0	0.0	13.8	8.8	0.8	2.8	3.0	0.0
KE10	1.2	11.8	0.0	1.6	19.2	22.6	0.0	6.4	1.4	0.4	15.6	4.2	1.0	2.8	3.4	0.6
KE11	2.0	7.8	0.0	1.2	14.4	40.4	0.0	7.6	1.2	0.4	9.6	5.8	0.8	0.8	2.6	0.8
KE12	4.6	1.2	0.0	8.2	27.4	22.2	0.0	9.6	0.0	0.4	9.4	5.8	0.6	1.8	0.0	0.2
KE13	1.6	4.2	0.0	0.8	15.4	25.4	0.0	6.6	0.4	1.2	12.2	8.8	1.0	4.0	4.0	0.6
KE14	0.8	6.6	0.0	0.0	8.0	59.6	0.0	2.2	0.6	0.6	2.2	7.2	0.0	2.0	1.0	0.2
KE15	0.8	10.8	0.0	0.4	7.8	46.8	0.0	5.2	0.4	0.6	6.6	7.0	0.6	1.4	1.6	1.2
KE16	0.6	7.6	0.0	0.0	19.0	37.0	0.0	4.6	0.8	0.8	13.4	7.0	0.2	2.0	1.0	0.4

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
KE17	2.4	1.8	0.0	0.8	13.2	53.0	0.0	4.6	0.2	0.2	8.6	5.4	0.2	1.2	1.6	0.0
KE18	0.6	2.4	0.0	0.0	30.6	3.6	0.0	14.8	6.0	1.2	17.6	5.2	1.6	3.8	5.0	0.6
KE19	2.0	3.6	0.0	0.0	45.6	0.4	0.0	6.0	8.0	0.6	12.6	4.8	1.0	2.2	4.2	0.8
KE20	1.8	4.2	0.0	0.6	58.8	5.8	0.0	2.8	2.2	0.0	5.4	2.8	1.2	3.6	3.0	1.0
KE21	0.4	2.4	0.0	1.2	2.6	71.0	0.0	2.8	0.6	0.2	2.6	7.2	0.0	1.4	1.6	0.0
KE22	0.4	3.0	0.0	1.0	4.4	77.8	0.0	2.6	0.0	0.0	2.6	3.6	0.2	1.0	0.4	0.2
KE23	0.4	2.6	0.0	1.2	9.6	72.2	0.0	2.2	1.0	0.2	2.6	3.4	0.2	0.6	1.0	0.0
KE24	0.4	2.6	0.0	0.2	31.0	38.2	0.4	4.0	3.2	0.0	5.6	3.8	0.4	2.2	3.2	0.0
KE25	0.8	4.8	0.0	0.0	41.4	6.0	0.0	7.0	12.4	1.0	9.2	8.2	0.4	2.0	2.4	1.0
RNB1	1.0	16.4	0.0	0.0	28.0	16.4	0.0	8.6	4.8	2.2	4.8	3.6	0.8	1.6	3.8	2.2
RNB2	0.2	26.8	0.0	0.2	6.6	45.8	0.0	3.6	0.2	1.2	2.8	3.8	0.2	1.0	1.0	0.2
RNB3	1.2	20.8	0.0	0.2	15.0	38.8	0.0	2.6	0.2	1.4	7.6	5.4	0.0	0.4	0.8	0.4
RNB4	0.4	13.8	0.0	0.0	12.6	51.6	0.0	1.0	0.4	1.2	3.8	7.0	0.2	0.8	0.6	0.0
RNB5	0.0	13.0	0.0	0.0	15.8	46.2	0.0	4.8	2.0	0.6	1.2	10.0	0.0	1.2	0.8	0.4
RNB6	0.8	4.4	0.0	0.8	4.8	49.6	0.0	15.4	0.2	2.8	6.0	6.6	0.2	0.8	0.0	0.0
RNB7	1.2	6.2	0.0	0.0	11.0	57.6	0.0	4.4	0.6	0.6	4.4	7.4	0.4	0.4	0.6	0.0
RNB8	0.8	4.8	0.0	0.0	2.2	78.4	0.2	3.0	0.0	0.6	1.0	3.2	0.0	0.2	0.2	0.0
RNB9	0.2	15.6	0.0	0.0	1.2	71.4	0.0	1.0	0.0	0.0	0.4	5.6	0.2	0.0	0.0	0.2
RNB10	0.6	6.8	0.0	0.0	2.6	67.8	0.0	7.2	0.0	0.8	2.0	4.4	0.0	0.0	0.6	0.0
RNB11	1.2	6.2	0.0	1.4	5.8	61.6	0.0	3.0	0.0	1.2	2.2	9.6	0.4	0.2	1.4	0.2
RNB12	2.2	9.2	0.0	1.4	15.2	39.6	0.0	9.4	1.6	2.2	3.2	4.6	0.6	1.4	2.6	0.0
RNB13	2.2	13.2	0.0	1.2	29.8	2.6	0.0	12.8	1.6	0.2	11.0	7.6	3.6	1.0	3.8	1.2
RNB14	1.6	8.8	0.0	0.4	34.6	1.4	0.0	10.4	2.0	0.8	8.0	12.6	1.8	3.6	6.0	2.2
RNB15	1.2	4.0	0.0	0.4	6.6	65.0	0.2	6.0	0.2	0.2	3.6	6.6	0.2	0.6	0.8	0.2
RNB16	0.4	6.2	0.0	0.4	10.6	53.2	0.0	3.0	1.0	1.0	4.8	8.0	0.4	1.2	2.4	0.6
RNB17	0.0	0.0	0.0	0.0	4.6	80.0	0.0	0.0	1.2	4.4	3.6	1.4	0.2	0.4	0.6	0.2
RNB18	1.2	3.8	0.0	0.0	15.2	57.4	0.0	8.6	1.8	0.4	0.6	5.4	1.0	0.8	1.4	0.2
RNB19	0.2	3.2	0.0	0.2	23.2	22.4	0.2	13.6	2.8	1.4	7.0	6.8	1.4	3.8	3.6	1.4
RNB20	0.6	10.4	0.0	0.4	25.6	16.8	0.2	8.0	2.0	2.2	6.8	12.0	1.4	0.4	4.2	1.2
VS2	0.2	5.6	0.0	0.0	14.0	5.4	0.0	5.4	1.2	0.4	16.6	18.6	4.6	5.0	5.4	0.8
VS3	1.0	4.6	0.0	0.0	12.8	6.8	0.2	4.8	1.0	0.2	17.6	24.8	1.0	4.6	4.6	0.2
VS4	1.6	8.8	0.0	0.0	18.6	7.6	0.0	5.6	0.8	0.8	13.0	21.8	1.6	3.4	3.6	0.4
VS5	0.2	1.2	0.0	0.0	2.0	1.8	0.0	1.2	0.0	0.2	39.2	5.8	0.2	0.4	0.0	0.0
VS7	0.4	4.4	0.0	0.0	9.2	63.6	0.0	1.4	0.0	1.4	6.0	9.4	0.4	0.2	0.2	0.0
VS8	0.0	5.2	0.0	0.0	26.0	8.4	0.0	1.0	0.4	2.6	20.6	12.0	0.6	0.6	0.4	0.0
VS9	0.0	5.0	0.0	0.0	16.0	9.8	0.0	0.2	1.4	2.0	14.2	25.8	0.2	0.4	0.6	0.2
CGD1	0.4	0.0	0.0	0.2	0.0	76.2	0.0	0.0	0.0	9.8	10.4	0.6	0.0	0.0	0.2	0.2
CGD2	0.4	0.0	0.0	0.0	0.0	75.2	0.0	0.0	0.2	10.0	6.6	0.8	0.0	0.0	0.2	0.0
CGD3	0.2	0.0	0.0	0.0	0.2	78.4	0.0	0.0	0.0	8.8	11.6	0.0	0.0	0.0	0.0	0.0

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
CGD4	0.4	0.0	0.0	0.0	0.4	62.2	0.0	0.0	0.2	2.4	29.0	1.0	0.0	0.0	0.0	0.0
CGD5	0.4	0.0	0.0	0.2	0.2	61.0	0.0	0.0	0.0	9.8	23.8	0.2	0.0	0.0	0.8	0.0
CGD6	0.2	0.0	0.0	0.0	0.0	63.2	0.0	0.0	0.0	8.2	24.4	0.0	0.0	0.0	0.2	0.0
CGD7	0.8	0.0	0.0	0.4	0.0	42.6	0.0	0.0	0.0	13.6	40.8	0.0	0.0	0.0	0.4	0.0
CGD8	0.2	0.0	0.0	0.2	0.2	43.6	0.0	0.0	0.0	9.0	43.8	0.6	0.2	0.0	0.0	0.0
CGD9	0.4	0.0	0.0	0.8	0.0	52.6	0.0	0.0	0.0	4.0	39.8	0.0	0.0	0.0	0.0	0.0
CGD10	0.8	0.0	0.0	0.0	0.0	52.4	0.0	0.0	0.0	4.2	39.6	0.0	0.0	0.0	0.0	0.0
CGD11	0.8	0.0	0.0	0.6	0.2	49.6	0.0	0.0	0.0	3.4	44.0	0.0	0.0	0.0	0.0	0.2
CGD12	0.4	0.0	0.0	0.0	0.4	46.6	0.0	0.0	0.0	4.0	46.4	0.0	0.0	0.0	0.0	0.0
CGD13	0.2	0.0	0.0	0.0	0.0	41.4	0.0	0.0	0.0	6.8	44.4	0.0	0.0	0.0	0.0	0.0
CGD14	0.0	0.0	0.0	0.0	0.0	51.4	0.0	0.0	0.0	5.2	41.6	0.0	0.0	0.0	0.0	0.0
CGD15	0.2	0.0	0.0	0.0	0.0	43.4	0.0	0.0	0.0	7.6	38.4	0.0	0.2	0.0	0.0	0.0
CGD16	0.0	0.0	0.0	0.0	0.0	55.0	0.0	0.0	0.0	7.2	34.8	0.0	0.2	0.0	0.0	0.0
CGD17	1.4	0.0	0.0	1.2	0.6	46.0	0.0	0.0	0.0	6.2	38.8	0.0	0.0	0.0	0.0	0.0
CGD18	3.2	0.2	0.0	0.8	0.8	44.0	0.0	0.0	0.0	5.4	39.4	0.2	0.0	0.0	0.4	0.0
CGD19	2.6	0.0	0.0	0.6	0.6	51.6	0.0	0.4	0.0	5.0	33.0	0.0	0.0	0.0	0.2	0.2
CGD20	2.0	0.4	0.0	0.6	2.4	42.8	0.0	0.0	0.0	2.6	45.2	0.2	0.0	0.0	0.0	0.6
CGD21	1.4	0.0	0.0	1.6	2.2	40.0	0.0	0.6	0.0	4.0	43.8	0.2	0.0	0.0	0.0	0.0
CGD23	1.4	0.2	0.0	0.4	0.8	66.8	0.0	0.0	0.0	6.0	20.6	0.2	0.0	0.0	0.0	0.2
CGD24	1.4	0.0	0.0	1.0	1.6	31.4	0.0	1.2	0.0	5.8	47.6	0.0	0.0	0.0	0.4	0.2
CGD25	8.0	0.2	1.0	20.2	15.4	8.6	0.0	0.6	0.4	0.6	31.2	0.6	0.0	0.0	3.4	2.2
CGD26	3.6	0.0	0.2	17.6	15.0	4.4	0.0	0.6	0.0	1.6	42.4	1.4	0.2	0.4	2.0	4.0
CGD27	2.8	0.0	0.0	9.6	8.4	11.4	0.0	1.0	0.0	3.6	51.4	0.8	0.2	0.0	2.0	2.8
CGD28	3.2	0.4	0.0	12.4	5.0	1.2	0.0	0.2	0.0	0.0	64.6	1.2	0.0	0.0	3.6	2.0
CGD29	2.0	0.2	0.0	5.6	6.8	3.0	0.0	0.8	0.0	1.0	65.8	0.8	0.0	0.2	2.6	1.2
CGD30	1.4	0.0	0.0	2.2	5.0	0.4	0.0	0.2	0.0	0.2	76.6	0.2	0.2	0.2	2.0	0.2
CGD31	1.2	0.6	0.0	1.0	8.2	0.2	0.0	0.0	0.0	0.2	75.0	0.6	0.2	1.2	1.0	0.0
CGD32	1.0	0.4	0.0	3.8	8.0	6.4	0.0	1.0	0.0	0.4	63.8	1.0	0.2	1.0	3.2	0.0
CGD33	1.2	0.0	0.0	0.8	5.0	34.0	0.0	0.2	0.0	5.6	38.6	0.4	0.8	0.6	1.2	0.0
CGD34	1.4	0.0	0.8	4.0	5.4	13.6	0.0	0.6	0.0	4.4	60.2	0.6	0.2	0.0	2.8	0.4
CGD35	1.6	0.0	0.0	6.2	3.2	14.8	0.0	1.2	0.0	2.8	61.6	0.4	0.4	0.4	1.0	1.6
CGD36	1.2	0.0	0.0	6.6	3.0	10.2	0.0	0.2	0.0	1.2	71.6	0.2	0.0	0.0	0.8	0.0
CGD37	2.0	0.0	0.6	6.2	4.0	22.4	0.0	1.2	0.0	3.2	53.6	0.2	0.0	0.4	1.0	1.0
CGD38	0.0	0.0	0.0	1.2	2.6	57.0	0.0	0.0	0.0	7.2	27.0	0.4	0.0	0.2	0.2	0.0
CGD39	1.6	0.0	0.0	4.4	5.4	38.8	0.0	0.2	0.0	1.6	35.0	0.6	0.2	0.4	1.4	0.6
CGD40	3.0	0.0	0.0	7.2	7.0	25.4	0.0	0.0	0.0	2.2	35.0	0.2	1.0	1.4	1.6	0.8
CGD41	2.6	0.0	0.0	9.4	5.0	25.4	0.0	0.2	0.0	2.8	45.6	1.0	0.0	0.0	1.2	1.4
CGD42	3.4	0.0	0.0	11.8	6.4	19.0	0.0	0.4	0.0	2.6	49.6	0.6	0.0	0.0	0.2	0.8
CGD43	2.4	0.0	0.6	19.6	6.4	10.0	0.0	0.0	0.2	2.2	55.4	1.2	0.0	0.0	0.2	0.2

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
CGD44	3.0	0.2	0.0	12.0	4.0	17.6	0.0	0.4	0.0	3.4	48.2	0.2	0.4	0.0	1.2	2.4
CGD45	4.4	0.0	0.0	14.0	3.6	28.8	0.0	0.2	0.0	1.2	41.0	0.2	0.0	0.0	1.0	1.8
CGD46	4.0	0.2	0.0	12.0	1.8	14.0	0.0	1.6	0.0	0.6	61.6	0.2	0.0	0.0	1.2	0.6
CGD47	1.2	0.0	0.2	4.6	1.8	9.8	0.0	0.8	0.0	1.4	74.2	0.4	0.0	0.2	1.2	0.6
CGD48	1.4	0.2	0.2	4.2	1.4	39.0	0.0	1.2	0.2	2.0	45.8	0.0	0.0	0.2	1.4	0.4
CGD49	2.2	0.0	0.0	3.4	1.8	25.6	0.0	1.8	0.2	1.4	57.0	0.2	0.0	0.4	1.6	0.2
CGD50	0.6	0.0	0.0	1.4	18.4	1.6	0.0	1.2	0.4	0.8	31.8	9.4	1.4	2.6	3.6	0.2
CGD51	3.6	0.2	0.0	3.0	39.8	1.8	0.0	0.0	0.0	1.4	20.6	11.8	0.4	2.0	1.2	0.6
CGD52	1.4	0.4	0.0	2.2	7.0	54.2	0.0	0.2	0.0	5.2	14.4	3.0	0.0	0.0	0.2	0.2
CGD53	4.0	0.4	0.0	22.0	14.2	15.8	0.0	1.2	0.0	1.8	20.4	4.4	0.0	1.4	2.8	1.0
CGD54	2.2	1.2	0.0	18.4	12.2	12.0	0.0	0.4	0.0	2.0	32.6	3.2	0.2	0.6	3.2	0.0
CGD55	2.4	0.6	0.0	17.2	7.6	55.4	0.0	0.0	0.0	1.6	7.4	3.4	0.4	0.0	0.4	0.0
CGD56	4.0	0.4	0.2	26.8	10.8	21.8	0.0	1.0	0.2	1.2	19.8	4.0	0.4	0.0	3.0	1.6
CGD57	4.0	0.4	0.0	24.4	11.6	42.4	0.2	1.4	0.0	2.0	6.8	3.6	0.2	0.6	0.2	0.0
CGD58	4.0	0.6	0.0	0.2	8.6	52.0	0.0	1.4	0.0	1.0	19.0	5.6	0.0	0.8	2.4	0.6
CGD59	2.2	0.6	0.0	4.2	4.0	57.8	0.0	0.6	0.0	1.8	14.8	6.2	0.2	1.2	2.0	0.0
CGD60	1.8	0.2	0.0	5.6	8.2	42.6	0.0	0.4	0.0	0.8	20.6	6.0	0.0	0.6	3.2	0.8
CGD61	1.2	0.6	0.2	10.4	9.6	36.4	0.0	0.2	0.0	2.0	21.0	6.4	0.0	3.0	3.4	0.6
CGD62	2.0	0.2	0.0	6.0	5.0	58.8	0.0	1.0	0.0	0.6	17.0	5.4	0.0	0.6	1.6	0.0
CGD63	2.2	0.4	0.0	7.6	5.4	53.0	0.0	0.0	0.0	1.8	20.0	2.6	0.2	0.6	1.0	0.2
CGD64	2.4	0.0	0.4	8.4	6.2	36.8	0.0	1.2	0.0	2.0	33.2	2.8	0.0	0.4	1.4	0.8
CGD65	2.0	0.2	0.2	10.6	5.0	42.0	0.0	2.6	0.0	1.6	25.6	2.6	0.2	0.2	3.4	0.4
CGD66	0.4	0.2	0.0	1.8	6.4	54.0	0.0	0.0	0.0	1.6	20.2	4.8	0.6	0.4	3.0	0.2
CGD67	2.0	0.0	0.2	5.6	17.2	25.8	0.0	1.2	0.2	0.6	35.6	1.8	0.0	0.2	2.8	0.0
CGD68	3.8	0.2	0.2	5.0	28.0	28.6	0.0	0.0	0.0	0.0	21.8	3.2	0.0	1.6	4.0	0.0
LOD1*	3.6	0.0	0.2	0.4	1.2	64.4	0.0	3.4	2.6	4.6	16.0	1.4	0.0	0.6	0.0	0.4
LOS4	0.4	0.0	0.0	0.6	31.2	2.4	0.0	0.0	0.0	0.6	29.6	6.8	0.6	2.0	0.8	0.6
LOD2	0.2	1.0	0.0	0.0	19.4	2.2	0.0	0.4	0.4	0.2	49.4	4.2	1.4	2.4	4.4	0.6
LOD3	0.8	1.0	0.0	0.0	31.0	6.2	0.0	0.2	0.2	1.0	28.2	6.0	0.8	1.4	1.6	0.0
LOD4	0.4	1.4	0.0	0.4	35.4	6.6	0.0	0.0	0.0	1.4	24.6	5.0	0.6	3.0	0.2	0.0
LOD5	1.6	2.8	0.0	0.2	34.0	2.6	0.0	0.0	0.0	1.0	37.6	8.8	0.2	0.8	0.2	0.0
LOS5	1.4	0.2	0.0	0.8	9.6	55.6	0.0	0.6	0.0	2.0	21.0	4.4	0.2	1.0	0.6	0.8
LOD5A	0.0	0.8	0.0	0.0	10.6	3.2	0.0	0.0	0.0	0.6	42.2	4.4	0.6	1.4	1.0	0.0
LOD6	0.6	1.0	0.0	0.0	12.2	2.0	0.0	0.0	0.0	1.0	39.6	5.0	0.4	2.0	0.8	0.0
LOD7	0.2	0.0	0.0	15.2	18.2	27.8	0.0	1.6	0.0	0.8	26.4	3.0	0.2	0.2	1.2	0.4
LOD8	4.4	0.2	0.0	42.2	1.0	34.2	0.0	0.0	0.0	0.4	5.8	2.6	0.8	0.8	1.0	1.0
LOD9	4.8	0.2	0.0	38.4	5.0	36.4	0.0	0.2	0.0	0.6	2.4	2.8	0.2	0.8	2.0	0.6
LOD10	3.0	0.0	0.2	27.6	4.0	48.0	0.0	0.2	0.0	0.6	9.0	0.8	0.0	1.0	0.8	0.6
LOK6	4.4	0.0	0.0	59.0	4.2	10.2	1.0	1.2	0.0	1.0	7.0	3.0	0.0	1.0	1.4	0.2

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
LOK7	2.6	0.0	0.2	58.8	7.6	4.8	0.2	8.0	0.0	0.2	6.6	2.6	0.4	0.6	0.0	1.0
LOK8	6.0	0.0	0.0	41.4	11.6	10.0	0.2	3.8	0.6	1.6	8.6	3.8	0.2	1.6	2.4	1.0
LOD11	2.2	0.4	0.0	10.0	3.6	67.8	0.0	0.0	0.0	0.0	8.8	2.6	0.0	0.6	0.8	0.4
LOD12	3.6	0.2	0.0	24.0	7.6	43.6	0.0	0.0	0.0	0.0	13.4	2.6	0.2	0.4	0.6	0.4
LOK11	4.4	0.0	0.0	54.2	8.2	18.8	0.4	0.6	0.0	0.6	5.0	2.6	0.0	0.2	1.0	0.6
LOD13	0.8	0.0	0.0	0.0	9.4	6.0	0.0	0.0	0.0	0.4	51.8	5.6	2.0	2.8	4.6	2.0
LOD14	0.2	0.8	0.0	0.0	6.2	3.0	0.0	0.0	0.0	0.8	59.8	4.4	0.8	1.6	2.4	1.2
LOD15	0.2	1.2	0.0	0.6	13.2	2.2	0.4	0.4	0.0	0.6	50.2	5.0	0.6	4.4	1.2	0.2
LOD16	0.0	1.0	0.0	0.2	8.2	4.2	0.0	0.0	0.0	0.6	40.0	7.4	2.4	2.6	2.4	0.2
LOK15	1.6	1.0	0.0	0.8	6.2	2.2	0.0	1.0	0.0	1.4	44.4	5.0	0.0	3.0	0.0	0.0
LOK16	2.4	0.4	0.0	1.2	12.8	42.2	1.2	1.4	1.0	2.2	13.0	5.8	0.4	0.0	0.0	0.0
LOK17	0.0	0.2	0.0	0.0	7.2	4.2	0.0	0.0	0.0	0.8	20.2	9.4	0.8	1.8	0.0	0.0
LOK20	0.6	0.2	0.0	0.4	10.4	1.4	0.2	0.6	0.0	0.8	24.4	5.6	1.6	6.4	1.2	0.2
LOK21	0.4	0.4	0.0	0.2	9.6	1.4	0.2	0.8	0.0	0.8	17.8	4.2	0.8	7.2	1.0	0.0
LOK22	0.2	0.4	0.0	0.0	4.4	0.2	0.0	0.8	0.2	1.4	28.0	6.4	0.0	3.6	0.2	0.2
LOK23	0.2	0.0	0.0	0.2	5.4	3.0	0.0	0.4	0.0	0.8	19.6	4.6	0.0	5.8	0.0	0.0
LOK24	0.0	2.0	0.0	0.0	20.8	1.2	0.0	8.4	7.0	1.8	31.4	6.4	1.4	6.4	5.0	0.0
LOK25	0.2	0.6	0.0	0.0	23.6	5.2	0.0	5.2	6.0	0.0	27.0	9.4	0.8	4.2	3.8	0.0
LOK26	0.0	2.8	0.0	0.6	16.0	1.0	0.0	3.0	4.2	1.0	42.2	5.2	0.4	5.6	4.0	0.0
LOK27	0.2	2.6	0.0	0.0	12.2	2.4	0.0	1.2	8.0	1.4	52.2	4.4	0.2	4.2	1.4	0.0
LOK28	1.4	0.4	0.0	0.2	8.4	0.2	0.0	2.4	2.4	1.0	41.8	9.0	1.0	8.0	5.2	1.0
LOK29	0.2	0.2	0.0	0.0	6.8	0.6	0.0	0.6	0.6	1.2	32.2	6.2	0.6	7.0	1.0	0.2
LOK30	0.8	0.2	0.0	0.4	4.2	2.0	0.0	2.0	0.0	1.8	32.8	9.8	0.4	3.8	0.4	0.0
LOK31	0.4	0.0	0.0	0.0	2.8	42.0	0.0	2.6	0.0	0.6	28.6	3.6	0.0	3.0	0.6	0.0
LOK32	0.2	0.2	0.0	0.0	2.2	56.6	0.2	8.8	0.2	0.2	20.8	2.6	0.2	1.6	0.6	0.0
LOK33	0.4	0.6	0.0	0.0	17.2	2.6	0.0	1.2	0.6	1.2	47.8	6.6	1.6	8.0	5.0	0.2
LOK34	0.6	0.2	0.0	0.0	19.6	2.2	0.0	2.8	1.6	0.6	46.6	7.4	0.4	5.4	3.6	0.0
LOK35	1.0	0.8	0.0	0.2	25.4	1.2	0.0	7.0	15.2	1.0	25.6	5.8	1.4	5.0	3.8	0.2
LOK36	1.8	0.2	0.0	1.8	33.6	3.2	0.2	5.6	8.6	0.2	23.0	4.4	1.0	3.4	4.6	0.2
LOK37	0.6	0.4	0.0	0.0	43.0	3.2	0.4	2.8	3.2	0.4	25.2	6.0	1.2	3.4	0.6	0.0
LOK38	0.2	0.0	0.0	0.4	10.2	0.6	0.0	5.6	12.4	1.0	35.4	10.6	1.0	5.2	1.8	0.0
LOK39	0.2	0.2	0.0	0.4	12.0	0.4	0.0	6.6	11.6	0.0	27.0	13.0	0.4	5.2	0.8	0.2
LBT1	1.0	0.0	0.0	6.0	3.2	50.8	0.0	1.4	0.0	1.6	30.2	3.0	0.0	0.0	0.0	0.2
LBT2	3.4	0.2	0.0	17.4	10.2	47.8	0.2	4.0	0.2	0.2	11.8	1.2	0.2	0.0	0.8	0.0
LBT3	2.2	0.0	0.0	6.2	10.4	36.6	0.6	1.2	0.0	0.8	27.8	1.8	0.4	1.6	3.4	1.2
LBT4	3.8	0.0	0.0	14.6	7.4	50.4	0.2	1.6	0.0	0.4	13.6	5.0	0.0	0.4	0.2	0.2
LBT5	3.2	0.2	0.0	10.8	13.4	27.2	0.0	0.6	0.0	0.0	31.0	1.4	0.2	1.4	3.8	0.8
LBT6	1.6	1.4	0.0	11.4	15.2	17.2	0.2	0.0	0.4	0.6	30.8	5.4	0.4	2.0	4.8	0.0
LBT7	3.0	0.0	0.0	11.8	13.8	36.2	0.6	1.4	0.0	0.4	21.0	4.2	0.2	0.8	3.0	0.4

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
LBT8	3.4	0.2	0.0	8.2	12.4	48.6	0.8	2.8	0.0	0.6	10.6	2.4	0.0	0.8	2.4	0.4
LBT9	0.8	0.0	0.0	5.0	10.2	53.8	0.4	0.8	0.4	0.2	12.8	3.2	1.6	2.2	3.2	0.0
LBT10	1.6	0.0	0.0	7.2	13.6	41.4	0.2	1.2	0.0	0.8	16.0	3.4	0.6	2.2	6.0	0.0
LBT11	2.2	0.0	0.0	11.8	10.8	36.4	0.0	0.4	0.0	0.8	17.8	2.8	0.4	0.8	4.8	0.2
LBT12	0.2	0.0	0.0	0.6	4.6	80.4	0.0	1.6	0.0	0.0	6.2	0.6	0.2	0.2	1.4	0.0
LBT13	0.8	0.0	0.0	1.2	4.6	54.6	0.0	0.2	0.0	1.2	11.0	6.6	1.2	1.8	1.8	0.0
LBT14	0.6	0.0	0.0	0.2	6.4	71.0	0.0	1.2	0.0	0.4	2.8	6.8	1.0	0.6	1.2	0.0
LBT15	2.0	0.0	0.0	2.6	17.2	59.4	0.8	0.8	0.0	0.0	5.8	3.6	0.6	0.8	1.6	0.0
LBT16	1.4	0.0	0.0	9.0	3.2	63.6	0.4	0.6	0.0	0.2	9.0	4.4	0.6	0.8	1.2	0.4
LBT17	2.4	0.0	0.4	6.4	7.6	49.6	0.8	2.0	0.0	0.0	13.6	5.2	0.8	1.6	2.8	0.4
LBM1	4.2	0.0	0.0	9.6	28.0	15.8	0.0	2.0	0.0	0.8	26.4	3.4	0.4	1.2	3.4	0.0
LBM2	4.4	0.0	0.6	14.0	18.6	32.2	0.0	0.8	0.0	0.6	15.4	4.6	0.2	0.4	1.6	0.6
LBM3	1.0	0.0	0.0	0.8	13.4	16.6	0.0	0.8	0.2	2.2	27.0	7.0	2.0	4.0	2.8	1.0
LBM4	0.4	0.0	0.0	0.6	15.0	54.0	0.2	1.0	0.0	0.4	11.4	4.4	2.2	0.8	1.0	0.0
LBM5	3.0	0.2	0.2	13.2	22.8	20.0	0.0	2.0	0.0	0.8	27.8	2.0	0.2	1.6	1.4	0.2
LBM6	1.4	1.2	0.0	1.6	18.2	46.8	0.2	0.4	0.0	0.4	16.2	2.8	0.0	2.8	1.4	0.4
LBM7	4.8	0.8	0.0	19.2	10.0	23.6	2.2	3.4	0.2	0.0	26.0	2.0	0.0	1.0	1.2	0.2
KBD1	4.6	0.8	0.0	8.2	47.6	7.2	0.0	1.2	0.2	1.0	12.8	10.6	0.2	0.2	2.2	0.0
KBK1	2.8	1.0	0.0	1.4	16.4	60.0	0.2	5.2	0.0	1.4	2.0	3.4	0.2	0.2	1.0	0.2
KBK2	0.4	3.6	0.0	0.0	3.2	75.8	0.0	0.6	0.2	0.8	2.6	6.8	0.0	0.8	0.4	0.2
KBK3	0.0	3.8	0.0	0.0	4.0	75.2	0.0	1.2	0.6	0.0	1.4	7.0	0.2	0.4	0.6	0.2
KBK4	0.0	2.8	0.0	0.0	2.8	68.2	0.0	0.8	0.6	0.8	2.4	9.6	0.0	0.4	1.0	0.0
KBK5	0.2	5.0	0.0	0.0	2.4	79.0	0.0	0.4	0.2	0.2	0.8	5.6	0.0	0.0	0.0	0.0
KBK7	0.2	2.0	0.0	0.0	14.8	1.8	0.0	1.2	8.2	1.8	26.4	11.8	0.0	5.8	7.0	1.2
KBK8	0.0	2.0	0.0	0.0	4.0	78.0	0.0	0.6	0.2	0.2	0.4	7.0	0.4	0.2	0.6	0.4
KBK9	0.2	2.0	0.0	0.0	2.0	79.4	0.0	0.2	0.0	0.4	0.8	7.0	0.2	0.2	0.4	0.2
KBK10	0.0	3.8	0.0	0.0	0.2	81.0	0.0	0.4	0.0	0.0	0.8	4.0	0.0	0.4	0.0	0.4
KBK11	0.2	3.4	0.0	0.0	2.2	86.6	0.0	0.0	0.2	0.0	0.4	1.0	0.2	0.0	0.0	0.2
SB1	0.2	0.8	0.0	0.0	1.6	0.0	0.0	0.8	0.0	1.0	6.6	12.0	0.2	0.0	0.0	0.0
SB4	0.2	0.8	0.0	0.0	2.8	1.6	0.0	4.0	0.2	0.0	7.4	3.6	0.0	0.0	0.2	0.0
SB7	0.2	1.2	0.0	0.0	2.2	4.4	0.0	0.4	0.0	0.6	9.8	9.6	0.0	0.0	0.2	0.2
SB10	1.0	2.4	0.0	0.0	2.6	0.6	0.0	0.4	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0
SB14	0.4	2.4	0.0	0.0	3.8	0.0	0.0	8.8	0.2	1.4	7.0	4.4	0.0	0.0	0.0	0.0
SBS2	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.2	15.8	10.2	0.0	0.0	0.6	0.0
SBS4	0.2	0.0	0.0	0.0	0.8	1.2	0.0	0.0	0.0	3.4	31.8	8.0	0.0	0.0	0.0	0.0
SBS5	3.6	0.6	0.0	3.0	21.8	16.2	0.0	0.4	0.0	7.6	13.8	10.6	0.0	0.2	0.6	0.2
SBU1	3.2	0.0	0.0	23.4	25.0	15.8	0.0	0.2	0.0	0.4	2.8	21.0	0.0	0.2	0.4	0.0
UOB1	3.2	2.0	0.0	3.6	12.0	4.2	0.0	1.4	0.0	1.2	34.0	16.2	0.0	0.6	1.2	0.4
UOB2	6.0	1.2	0.0	6.0	11.6	3.4	0.0	1.4	0.0	1.6	42.2	13.0	0.0	0.8	1.0	0.2

Appendix II: Simple percentages of the kerogen count categories

Key to abbreviations used in column headers (parameters all percentages based on 500 counts per sample):

SAMNO = sample number
UNDIF% = undifferentiated palynomorphs
BOT% = *Botryococcus*
FORAM% = Foraminiferal linings
PLANK% = marine plankton
SPORO% = sporomorphs
AOM% = AOM
FUNG% = fungal hyphae
MEM% = membranes
CUTIC% = cuticle
USPSU% = pseudoamorphous non-biostructured brown wood
USCO% = corroded non-biostructured brown wood
USUN% = undegraded non-biostructured brown wood
SDPT% = degraded pitted biostructured brown wood
SDBN% = degraded banded biostructured brown wood
SDSP% = degraded striped biostructured brown wood
SDSR% = degraded striate biostructured brown wood
STDEG% = total degraded biostructured brown wood
SUPT% = undegraded pitted biostructured brown wood
SUBN% = undegraded banded biostructured brown wood
SUSP% = undegraded striped biostructured brown wood
SUST% = undegraded striate biostructured brown wood
STUND% = total undegraded biostructured brown wood
BLKLAT% = lath shaped black wood
BLKEQUI% = equant shaped black wood

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
UOB3	1.8	2.8	0.0	0.8	4.2	59.4	0.0	2.0	0.2	2.2	9.4	11.8	0.0	0.0	0.4	0.4
UOB4	5.6	0.0	0.0	2.4	9.8	38.0	0.0	0.2	0.0	1.8	11.8	11.2	0.2	0.2	0.2	0.0
UOB5	8.0	0.0	0.0	33.8	31.2	6.2	0.0	0.8	0.4	0.0	3.2	8.2	1.6	1.0	2.0	0.0
UOB6	8.8	0.0	0.2	23.4	29.8	4.2	0.0	1.4	0.8	1.0	8.6	10.0	0.2	1.0	2.2	0.2
UOB7	7.8	0.4	0.0	16.8	30.2	5.4	0.0	1.0	1.2	1.4	11.4	6.6	0.2	2.0	4.2	0.0
UOB8	4.8	0.0	0.4	17.0	24.8	20.4	0.0	1.2	0.8	1.2	8.4	8.0	0.4	1.6	4.4	0.2
UOB9	3.6	0.4	0.0	13.8	32.4	11.2	0.0	0.6	1.0	1.8	11.8	10.6	0.0	2.0	5.0	0.4
UOB10	2.4	0.4	0.2	9.8	27.0	9.0	0.0	1.4	0.8	1.2	9.8	19.4	0.4	3.2	4.2	0.0
UOB11	1.4	0.0	0.0	5.4	41.4	5.8	0.0	0.2	0.4	2.6	11.4	14.4	0.6	2.2	1.8	0.0
UOB12	2.8	0.0	0.0	3.0	41.0	12.0	0.0	0.2	0.4	2.4	9.0	16.6	0.2	1.6	1.8	0.2
UOB13	3.4	0.0	0.0	6.4	31.4	16.0	0.0	0.6	0.0	0.8	6.2	17.8	0.4	3.0	4.2	0.0
UOB14	6.0	0.2	0.0	16.6	33.2	6.8	0.0	0.8	0.4	0.2	5.2	13.4	0.4	0.8	6.0	0.0
UOB15	5.4	0.2	0.0	5.2	34.6	10.6	0.0	0.0	0.0	0.8	6.8	19.6	0.0	1.8	4.2	0.0
UOB16	2.0	0.0	0.0	1.6	28.6	21.2	0.0	0.0	0.0	1.0	4.8	23.0	0.2	1.4	3.8	0.0
UOB17	5.0	0.0	0.0	9.0	31.4	8.2	0.0	0.4	0.0	0.6	5.4	19.8	0.0	2.0	6.6	0.0
UOB18	3.2	0.2	0.0	3.4	31.8	8.2	0.0	0.2	0.2	1.6	10.8	23.2	1.0	1.0	2.0	0.0
UOB19	1.0	0.0	0.0	3.0	26.4	9.8	0.0	0.0	0.0	0.8	16.8	23.8	0.2	3.2	5.4	0.0
UOB20	2.2	0.2	0.2	2.4	29.8	26.4	0.0	0.0	0.0	0.0	2.6	21.0	0.4	1.0	2.8	0.0
UOB21	2.0	0.0	0.0	4.2	34.6	9.6	0.0	0.0	2.6	0.2	7.2	22.8	0.6	1.6	2.8	0.0
UOB22	4.6	0.2	0.0	7.6	27.6	21.8	0.0	0.4	0.0	1.0	5.0	18.4	0.2	0.6	5.2	0.0
UOB23	3.2	0.4	0.0	2.6	15.4	51.8	0.0	0.2	0.0	0.2	0.6	13.6	0.0	0.8	2.2	0.0
UOB24	1.6	0.4	0.0	0.6	6.4	68.0	0.0	0.6	0.0	0.2	1.4	9.8	0.0	0.4	0.8	0.0
UOB25	1.0	0.6	0.2	1.4	8.8	67.8	0.0	0.0	0.0	0.0	0.2	10.2	0.2	1.0	1.8	0.0
UOB26	2.0	0.2	0.0	1.2	18.6	3.0	0.0	0.8	0.4	0.6	28.2	22.8	0.0	6.2	6.8	0.0
UOB27	2.8	0.6	0.0	3.4	34.6	0.8	0.0	0.8	0.0	0.2	13.4	24.2	0.2	2.0	6.8	0.0
UOB28	3.4	0.4	0.0	3.8	26.0	2.4	0.0	0.4	0.2	0.4	17.8	30.8	0.2	1.2	6.8	0.0
UOB29	0.8	0.4	0.0	1.4	12.8	4.8	0.0	0.2	0.8	0.2	30.8	24.4	0.0	2.4	2.8	0.0
UOB30	0.8	0.8	0.0	0.6	5.4	58.2	0.0	0.0	0.0	0.0	2.0	21.4	0.2	0.4	2.4	0.0
UOB31	0.4	0.2	0.0	0.4	3.6	76.8	0.0	0.0	0.0	0.0	2.2	11.6	0.0	0.0	0.0	0.0
UOB32	2.0	0.6	0.0	7.0	12.8	52.4	0.0	0.6	0.0	0.2	1.2	14.0	0.0	0.2	2.0	0.0
UOB33	1.8	0.2	0.0	0.8	8.2	59.2	0.0	0.0	0.0	0.0	5.0	16.4	0.0	0.0	0.4	0.0
UOB34	2.0	2.0	0.0	1.8	14.6	51.4	0.0	0.0	0.0	0.0	1.4	12.8	0.0	0.2	0.8	0.0
UOB35	2.6	0.8	0.0	5.0	18.2	46.8	0.0	0.0	0.0	0.0	2.0	13.6	0.4	0.8	1.2	0.0
UOB36	2.8	1.0	0.0	3.6	15.4	47.6	0.0	0.4	0.0	0.2	2.6	16.4	0.0	0.0	0.8	0.0
UOB37	2.2	0.6	0.0	8.8	59.2	10.2	0.0	0.6	0.0	0.2	1.8	8.0	0.4	0.2	0.6	0.0
BS1	4.0	0.2	0.0	25.0	35.0	7.0	0.0	0.0	0.4	0.0	1.2	14.8	0.4	0.8	0.6	0.0
BS2	4.8	0.2	0.2	16.0	33.8	0.0	0.0	1.2	0.0	0.6	6.2	17.8	0.6	1.2	4.0	0.0
BS3	5.2	0.4	0.0	11.4	41.0	3.0	0.0	0.0	0.0	0.0	2.6	24.2	0.4	0.4	4.2	0.0
BS4	1.0	0.0	0.4	2.4	8.4	0.0	0.0	0.4	1.6	0.0	16.8	28.8	0.4	3.0	14.4	0.2

SAMNO	UNDIF%	BOT%	FORAM%	PLANK%	SPORO%	AOM%	FUNG%	MEM%	CUTIC%	USPSU%	USCO%	USUN%	SDPT%	SDBN%	SDSP%	SDSR%
BS5	0.4	0.0	0.0	1.2	4.4	0.2	0.0	0.8	0.6	0.2	12.8	36.0	0.4	1.6	11.2	0.0
BS6	2.0	0.0	0.2	8.0	13.4	2.4	0.0	1.0	0.2	0.4	9.6	37.8	0.2	1.0	7.8	0.6
BS7	2.4	0.0	0.2	3.0	5.2	0.0	0.0	0.6	0.6	0.4	15.4	39.2	0.2	2.0	9.4	0.0
BS8	0.4	0.0	0.0	0.6	2.8	0.0	0.0	0.0	0.0	0.2	20.6	43.8	0.2	0.4	5.4	0.0
BS9	1.2	0.0	0.0	1.0	3.8	0.0	0.0	0.8	0.2	0.6	11.0	45.6	0.0	0.2	4.4	0.0
BS10	1.8	0.2	0.0	2.8	3.8	0.4	0.0	0.4	0.4	0.0	24.0	38.6	0.0	0.0	2.4	0.0
BS11	2.0	0.0	0.0	2.0	10.4	0.0	0.0	0.4	0.0	0.0	15.2	37.2	0.4	1.4	2.6	0.0
BS12	2.8	0.2	0.4	2.8	15.2	3.2	0.0	0.4	0.0	0.6	6.0	38.8	0.0	1.0	2.6	0.0
BS13	2.2	0.2	0.0	3.4	11.6	0.0	0.0	0.4	0.2	0.4	8.6	42.0	0.0	0.6	1.0	0.0
BS14	6.4	0.0	0.0	11.4	22.0	17.0	0.0	1.2	0.0	1.6	5.8	25.0	0.0	0.2	1.6	0.0
BS15	4.0	0.0	0.0	3.6	25.0	41.2	0.0	0.0	0.0	0.6	5.6	13.6	0.0	0.0	0.8	0.0

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
BBE1	6.8	0.0	0.0	0.4	0.0	0.4	1.0	3.0
BBE2	4.0	0.0	0.0	0.2	0.0	0.2	1.8	13.0
BBE3	7.6	0.0	0.0	0.0	0.0	0.0	1.8	2.0
BBE4	5.2	0.0	0.0	0.0	0.0	0.0	0.8	3.8
BBE5	0.6	0.0	0.0	0.0	0.0	0.0	6.8	10.0
BBE6	3.2	0.0	0.0	0.0	0.0	0.0	2.0	3.2
BBE7	4.2	0.0	0.0	0.2	0.0	0.2	2.8	2.2
BBE8	1.4	0.0	0.0	0.0	0.0	0.0	2.8	4.6
BBE9	3.8	0.0	0.0	0.0	0.0	0.0	2.4	4.6
BBE10	2.8	0.0	0.0	0.0	0.0	0.0	1.8	3.0
BBE11	4.8	0.0	0.0	0.2	0.0	0.2	2.4	2.0
BBE12	3.8	0.0	0.0	0.2	0.0	0.2	3.0	9.0
BBE13	5.6	0.0	0.0	0.0	0.0	0.0	0.8	3.6
BBE14	1.2	0.0	0.0	0.0	0.0	0.0	2.4	5.0
BBE15	1.6	0.0	0.0	0.0	0.0	0.0	3.2	4.2
BBE16	5.0	0.0	0.0	0.0	0.0	0.0	0.6	1.4
BBE17	1.6	0.0	0.0	0.0	0.0	0.0	1.0	4.0
BBE18	4.8	0.0	0.0	0.0	0.0	0.0	1.8	7.4
BBE19	7.2	0.0	0.0	0.0	0.0	0.0	1.6	3.4
BBE20	5.6	0.0	0.0	0.0	0.0	0.0	3.6	4.2
BBE21	4.2	0.0	0.0	0.0	0.0	0.0	1.2	2.6
BBE22	2.4	0.0	0.0	0.0	0.0	0.0	1.8	1.6
BBE23	5.6	0.0	0.0	0.0	0.0	0.0	0.4	2.0
BBE24	4.8	0.0	0.0	0.0	0.0	0.0	1.6	1.2
BBE25	3.6	0.0	0.0	0.0	0.0	0.0	1.8	4.2
BBE26	4.4	0.0	0.0	0.0	0.0	0.0	2.0	4.0
BBE27	0.8	0.0	0.0	0.0	0.0	0.0	2.0	1.8
BBE28	3.0	0.0	0.0	0.0	0.0	0.0	1.2	3.0
BBE29	2.8	0.0	0.0	0.0	0.0	0.0	1.6	3.0
BBE30	4.6	0.0	0.0	0.0	0.0	0.0	1.0	2.8
BBE31	5.0	0.0	0.0	0.0	0.0	0.0	2.0	2.2
BBE32	3.6	0.0	0.0	0.0	0.0	0.0	2.0	2.4
BBE33	3.0	0.0	0.0	0.0	0.0	0.0	1.0	1.2
BBE34	4.8	0.0	0.0	0.0	0.0	0.0	1.6	1.6
BBE35	2.4	0.0	0.0	0.0	0.0	0.0	1.6	1.4
BBE36	2.6	0.0	0.0	0.0	0.0	0.0	1.4	2.8
BBE37	4.8	0.0	0.0	0.0	0.0	0.0	0.8	1.2
BBE38	3.2	0.0	0.0	0.0	0.0	0.0	2.2	2.2
BBE39	3.0	0.0	0.0	0.0	0.0	0.0	2.4	1.8

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
BBE40	7.8	0.0	0.6	0.0	0.0	0.6	5.2	12.8
BBE41	18.0	0.0	0.8	0.0	0.0	0.8	3.6	6.6
BBE42	9.4	0.0	0.0	0.0	0.0	0.0	5.4	6.0
BBE43	5.4	0.0	0.0	0.0	0.0	0.0	3.4	3.0
BBE44	5.6	0.0	0.0	0.0	0.0	0.0	3.4	4.4
BBE45	4.0	0.0	0.0	0.2	0.0	0.2	4.6	7.0
BBE46	5.2	0.0	0.0	0.0	0.0	0.0	3.0	4.0
BBE47	6.2	0.0	0.0	0.0	0.0	0.0	2.6	3.4
BBE48	6.8	0.0	0.0	0.0	0.0	0.0	3.6	6.6
BBE49	6.8	0.0	0.0	0.6	0.0	0.6	2.2	10.8
BBO1	7.2	0.0	0.0	0.4	0.0	0.4	2.4	4.2
BBO2	13.8	0.0	0.0	0.0	0.0	0.0	1.8	2.2
BBU1	11.4	0.0	0.0	0.0	0.0	0.0	1.6	4.0
BBU2	12.6	0.0	0.0	0.2	0.0	0.2	3.2	6.8
BBU3	13.2	0.0	0.0	0.4	0.0	0.4	3.6	6.6
BBU4	12.0	0.0	0.0	0.0	0.0	0.0	1.8	3.6
BBU5	9.4	0.0	0.2	0.0	0.0	0.2	3.6	7.2
BBU6	12.4	0.0	0.2	0.4	0.0	0.6	4.6	9.0
BBU7	10.2	0.0	0.0	0.0	0.0	0.0	3.0	7.6
BBU8	9.4	0.0	0.2	0.0	0.0	0.2	5.0	6.0
BBU9	8.4	0.0	0.0	0.4	0.0	0.4	3.6	8.2
BBU10	10.6	0.0	0.0	0.0	0.0	0.0	3.6	6.0
BBU11	8.8	0.0	0.0	0.2	0.0	0.2	1.0	1.0
BBU12	6.0	0.0	0.0	0.0	0.0	0.0	1.6	4.0
BBU13	5.0	0.0	0.0	0.0	0.0	0.0	2.0	5.8
BBU14	6.4	0.0	0.0	0.0	0.0	0.0	2.2	7.8
BBU15	9.0	0.0	0.0	0.0	0.0	0.0	2.0	4.8
BBU16	8.6	0.0	0.0	0.0	0.0	0.0	3.4	4.8
BBU17	11.8	0.0	0.4	0.0	0.0	0.4	2.8	5.8
BBU18	8.6	0.0	0.2	0.0	0.0	0.2	3.0	9.2
BBU19	9.6	0.0	0.0	0.0	0.0	0.0	3.8	7.2
BBU20	11.8	0.0	0.2	0.0	0.0	0.2	3.0	8.4
BBU21	12.8	0.0	0.0	0.2	0.0	0.2	1.6	6.2
BBU22	9.6	0.0	0.2	0.0	0.0	0.2	1.4	3.0
BBU23	14.4	0.0	0.0	0.2	0.0	0.2	2.4	6.2
BBU24	5.6	0.0	0.0	0.0	0.0	0.0	1.6	6.6
BBU25	8.8	0.0	0.2	0.0	0.0	0.2	2.6	7.6
BBU26	12.0	0.0	0.0	0.0	0.0	0.0	3.2	8.6
BBU27	9.0	0.0	0.4	0.0	0.0	0.4	3.2	4.8

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
BBU28	7.4	0.0	0.2	0.0	0.0	0.2	2.2	7.4
BBU29	6.0	0.0	0.0	0.0	0.0	0.0	2.8	8.0
BBU30	7.2	0.0	0.2	0.0	0.0	0.2	1.6	7.8
BBH1	1.8	0.0	0.0	0.2	0.0	0.2	1.4	4.2
BBH2	1.8	0.0	0.0	0.0	0.0	0.0	1.6	6.6
BBH3	2.4	0.0	0.0	0.0	0.0	0.0	2.2	5.8
BBH4	2.0	0.0	0.0	0.0	0.0	0.0	1.0	5.4
BBH5	0.8	0.0	0.0	0.0	0.0	0.0	1.8	11.4
BBH6	0.4	0.0	0.0	0.0	0.0	0.0	1.4	7.0
BBH7	1.0	0.0	0.0	0.0	0.0	0.0	2.0	6.8
BBH8	0.8	0.0	0.0	0.0	0.0	0.0	1.4	6.2
BBH9	0.8	0.0	0.0	0.0	0.0	0.0	1.6	6.8
BBH10	1.2	0.0	0.0	0.0	0.0	0.0	1.6	6.6
BBH11	1.4	0.0	0.0	0.0	0.0	0.0	1.0	6.8
BBH12	1.4	0.0	0.2	0.0	0.0	0.2	1.8	6.4
BBR1	0.6	0.0	0.0	0.0	0.0	0.0	1.4	5.4
BBR2	1.0	0.0	0.0	0.0	0.0	0.0	2.2	8.6
BBR3	0.6	0.0	0.0	0.2	0.0	0.2	1.6	6.8
BBR4	1.2	0.0	0.0	0.0	0.0	0.0	0.8	6.0
BBR13	0.6	0.0	0.0	0.0	0.0	0.0	1.6	9.8
BBR14	0.8	0.0	0.0	0.0	0.0	0.0	3.2	9.0
BBR15	0.0	0.0	0.0	0.0	0.0	0.0	1.6	2.6
BBR16	1.0	0.0	0.0	0.0	0.0	0.0	1.2	3.0
BBR17	0.6	0.0	0.0	0.0	0.0	0.0	1.8	6.0
BBR18	0.4	0.0	0.0	0.0	0.0	0.0	0.6	4.2
BBR19	1.0	0.0	0.0	0.0	0.0	0.0	1.2	5.4
BBR5	2.0	0.0	0.0	0.0	0.0	0.0	3.2	6.6
BBR6	0.2	0.0	0.0	0.0	0.0	0.0	5.6	7.6
BBR7	1.4	0.0	0.0	0.0	0.0	0.0	2.0	6.2
BBR8	1.4	0.0	0.2	0.0	0.0	0.2	3.6	9.0
BBR9	1.0	0.0	0.0	0.0	0.0	0.0	2.4	6.4
BBR10	1.2	0.0	0.0	0.0	0.0	0.0	1.6	3.0
BBR11	2.2	0.0	0.0	0.0	0.0	0.0	1.0	4.4
BNL17	0.0	0.0	0.0	0.0	0.0	0.0	2.4	4.6
BNL16	0.4	0.0	0.0	0.0	0.0	0.0	1.4	8.0
BNL1	0.8	0.0	0.0	0.0	0.0	0.0	4.8	3.6
BNL2	0.8	0.0	0.0	0.0	0.0	0.0	3.8	5.2
BNL3	0.8	0.0	0.0	0.0	0.0	0.0	3.4	3.0
BNL4	0.6	0.0	0.0	0.0	0.0	0.0	3.4	3.4

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
BNL5	0.6	0.0	0.0	0.0	0.0	0.0	3.6	4.4
BNL6	0.2	0.0	0.0	0.0	0.0	0.0	3.0	4.0
BNL7	0.6	0.0	0.0	0.0	0.0	0.0	2.0	3.8
BNL8	0.4	0.0	0.0	0.0	0.0	0.0	3.2	4.2
BNL9	0.4	0.0	0.0	0.0	0.0	0.0	2.8	3.4
BNL10	0.4	0.0	0.0	0.0	0.0	0.0	2.0	5.2
BNL11	1.2	0.0	0.0	0.0	0.0	0.0	5.4	6.6
BNL12	1.2	0.0	0.0	0.0	0.0	0.0	5.0	7.0
BNL13	1.2	0.0	0.2	0.0	0.0	0.2	4.8	13.6
BNL15	0.0	0.0	0.0	0.0	0.0	0.0	5.0	8.2
RGC1	0.2	0.0	0.0	0.0	0.0	0.0	1.8	2.2
RGC2	0.4	0.0	0.0	0.2	0.0	0.2	0.6	2.0
RGC3	0.0	0.0	0.0	0.0	0.0	0.0	2.2	2.4
RGC4	1.0	0.0	0.0	0.0	0.0	0.0	2.6	2.4
RCS1	4.8	0.0	0.0	0.0	0.0	0.0	2.0	4.4
RCS2	3.4	0.0	0.0	0.0	0.0	0.0	1.6	3.4
RCS3	4.4	0.0	0.0	0.0	0.0	0.0	2.4	1.6
RCS4	1.0	0.0	0.0	0.0	0.0	0.0	1.6	4.2
RCS5	2.2	0.0	0.0	0.0	0.0	0.0	2.6	3.6
RCS6	1.8	0.0	0.0	0.0	0.0	0.0	2.0	4.4
RCS7	1.4	0.0	0.0	0.0	0.0	0.0	3.0	3.6
RCS8	6.2	0.0	0.0	0.0	0.0	0.0	2.0	3.2
RCS9	4.0	0.0	0.0	0.0	0.0	0.0	1.6	2.6
RCS10	4.2	0.0	0.2	0.0	0.0	0.2	3.0	5.0
RCS11	6.0	0.0	0.0	0.0	0.0	0.0	2.2	4.6
RCS12	6.0	0.0	0.0	0.0	0.0	0.0	2.2	4.2
RCS13	3.6	0.0	0.0	0.0	0.0	0.0	1.6	3.8
RCS14	5.2	0.0	0.0	0.0	0.0	0.0	3.4	4.4
RCS15	5.8	0.0	0.0	0.0	0.0	0.0	4.6	10.0
KE26	4.4	0.0	0.2	0.0	0.0	0.2	2.2	3.4
KE27	1.6	0.0	0.0	0.0	0.0	0.0	4.2	4.6
KE28	4.0	0.2	0.6	0.2	0.0	1.0	2.6	3.6
KE29	4.8	0.2	0.4	0.0	0.0	0.6	3.2	4.0
KE30	1.8	0.0	0.0	0.0	0.0	0.0	3.6	6.0
KE31	1.8	0.0	0.4	0.0	0.0	0.4	2.4	4.6
KE32	5.8	0.0	0.2	0.0	0.0	0.2	3.8	7.8
KE33	14.8	0.0	0.4	0.0	0.0	0.4	1.2	2.8
KE34	7.0	0.0	0.4	0.0	0.0	0.4	1.2	2.2
KE35	8.0	0.0	0.6	0.4	0.0	1.0	1.4	2.2

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
KE36	4.4	0.0	0.2	0.2	0.0	0.4	0.8	3.8
KE37	4.2	0.0	0.4	0.0	0.0	0.4	3.4	2.0
KE38	7.8	0.0	0.2	0.0	0.0	0.2	3.0	6.2
KE39	9.6	0.0	0.0	0.0	0.0	0.0	3.8	6.0
KE40	9.0	0.0	0.2	0.0	0.0	0.2	6.2	7.2
KE41	4.8	0.2	0.6	0.6	0.0	1.4	3.4	3.6
KE42	5.0	0.2	0.2	0.2	0.0	0.6	3.2	3.8
KE43	3.8	0.4	0.4	0.2	0.0	1.0	3.0	3.4
KE44	3.2	0.2	0.2	0.2	0.0	0.6	1.0	2.0
KE45	4.4	0.6	0.4	0.2	0.0	1.2	2.2	4.4
KE46	6.2	0.2	0.4	0.0	0.0	0.6	1.4	3.6
KE47	4.6	0.4	0.2	0.2	0.0	0.8	0.8	2.2
KE48	3.0	0.0	0.2	0.2	0.0	0.4	1.0	2.0
KE49	3.6	0.2	0.2	0.0	0.0	0.4	2.8	2.4
KE50	1.2	0.0	0.0	0.0	0.0	0.0	1.0	3.0
KE51	0.8	0.0	0.2	0.0	0.0	0.2	0.8	3.6
KE52	2.4	0.0	0.4	0.2	0.0	0.6	1.2	2.8
KE53	5.6	0.6	0.2	0.4	0.0	1.2	1.6	4.4
KE54	3.2	0.0	0.0	0.2	0.0	0.2	1.4	3.0
KE55	5.2	0.2	0.4	0.2	0.0	0.8	3.4	3.2
KE56	2.0	0.0	0.0	0.0	0.0	0.0	17.6	12.8
KE57	13.0	0.2	0.6	1.4	0.0	2.2	2.6	3.6
KE58	10.8	0.0	1.0	0.4	0.0	1.4	4.8	7.8
KE1	3.8	0.8	0.4	0.4	0.0	1.6	0.4	3.4
KE2	6.8	0.4	0.0	0.4	0.0	0.8	2.2	7.4
KE3	6.4	0.4	0.2	0.0	0.0	0.6	2.2	1.6
KE4	3.8	0.4	0.0	0.0	0.0	0.4	1.2	2.4
KE5	0.6	0.0	0.0	0.2	0.0	0.2	0.2	0.6
KE6	5.2	0.0	0.2	0.0	0.0	0.2	2.8	4.0
KE7	4.8	0.2	0.2	0.0	0.0	0.4	2.0	2.0
KE8	3.0	0.0	0.4	0.0	0.0	0.4	3.2	14.4
KE9	6.6	0.2	0.6	0.6	0.0	1.4	1.8	2.8
KE10	7.8	0.6	0.0	0.0	0.0	0.6	2.4	4.8
KE11	5.0	0.2	0.2	0.4	0.0	0.8	1.0	2.8
KE12	2.0	0.2	0.0	0.0	0.0	0.2	2.4	6.0
KE13	9.6	0.4	0.8	0.4	0.0	1.6	4.4	7.8
KE14	3.2	0.2	0.0	0.0	0.0	0.2	3.6	5.6
KE15	4.8	0.0	0.4	0.0	0.0	0.4	2.8	5.6
KE16	3.6	0.0	0.2	0.0	0.0	0.2	1.6	3.8

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
KE17	3.0	0.0	0.0	0.0	0.0	0.0	2.2	4.6
KE18	11.0	0.2	1.0	0.0	0.0	1.2	1.4	4.4
KE19	8.2	0.0	1.4	0.0	0.0	1.4	1.8	5.0
KE20	8.8	0.0	0.0	0.2	0.0	0.2	1.8	4.8
KE21	3.0	0.0	0.0	0.2	0.0	0.2	2.0	3.8
KE22	1.8	0.2	0.0	0.0	0.0	0.2	1.2	1.4
KE23	1.8	0.2	0.0	0.0	0.0	0.2	1.8	0.8
KE24	5.8	0.2	0.0	0.4	0.0	0.6	2.6	1.6
KE25	5.8	0.2	0.0	0.2	0.0	0.4	1.2	1.8
RNB1	8.4	0.0	0.4	0.0	0.0	0.4	1.4	4.0
RNB2	2.4	0.2	0.0	0.2	0.0	0.4	2.6	3.4
RNB3	1.6	0.0	0.0	0.0	0.0	0.0	1.6	3.6
RNB4	1.6	0.0	0.2	0.2	0.0	0.4	2.4	3.8
RNB5	2.4	0.0	0.0	0.0	0.0	0.0	3.0	1.0
RNB6	1.0	0.0	0.0	0.0	0.0	0.0	2.2	5.4
RNB7	1.4	0.0	0.2	0.0	0.0	0.2	2.4	2.6
RNB8	0.4	0.0	0.0	0.0	0.0	0.0	2.8	2.6
RNB9	0.4	0.0	0.0	0.0	0.0	0.0	2.0	2.2
RNB10	0.6	0.0	0.0	0.0	0.0	0.0	2.6	4.6
RNB11	2.2	0.0	0.2	0.0	0.0	0.2	0.8	4.6
RNB12	4.6	0.2	0.2	0.4	0.0	0.8	1.0	3.0
RNB13	9.6	0.0	0.0	0.4	0.0	0.4	3.2	4.6
RNB14	13.6	0.0	0.0	0.6	0.0	0.6	3.0	2.2
RNB15	1.8	0.0	0.0	0.0	0.0	0.0	1.6	2.6
RNB16	4.6	0.0	0.0	0.0	0.0	0.0	3.4	3.4
RNB17	1.4	0.0	0.0	0.0	0.0	0.0	1.6	1.8
RNB18	3.4	0.0	0.0	0.0	0.0	0.0	0.8	1.4
RNB19	10.2	0.6	0.2	0.2	0.0	1.0	3.4	4.4
RNB20	7.2	0.4	0.4	0.4	0.0	1.2	2.4	4.2
VS2	15.8	0.8	1.4	2.6	0.4	5.2	4.4	7.2
VS3	10.4	0.2	0.8	0.8	0.2	2.0	2.8	11.0
VS4	9.0	0.2	0.4	0.0	0.0	0.6	2.8	9.0
VS5	0.6	0.0	0.0	0.0	0.0	0.0	0.2	47.6
VS7	0.8	0.0	0.0	0.0	0.0	0.0	0.2	3.2
VS8	1.6	0.0	0.0	0.0	0.0	0.0	1.0	21.2
VS9	1.4	0.0	0.0	0.0	0.0	0.0	1.4	22.8
CGD1	0.4	0.0	0.0	0.0	0.0	0.0	1.8	0.2
CGD2	0.2	0.0	0.0	0.0	0.0	0.0	3.0	3.6
CGD3	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
CGD4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.0
CGD5	0.8	0.0	0.0	0.0	0.0	0.0	1.8	1.8
CGD6	0.2	0.0	0.0	0.0	0.0	0.0	1.2	2.6
CGD7	0.4	0.0	0.0	0.0	0.0	0.0	0.2	1.2
CGD8	0.2	0.0	0.0	0.0	0.0	0.0	0.8	1.4
CGD9	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.4
CGD10	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.8
CGD11	0.2	0.0	0.0	0.0	0.0	0.0	0.8	0.4
CGD12	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.4
CGD13	0.0	0.0	0.0	0.0	0.0	0.0	1.2	6.0
CGD14	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.6
CGD15	0.2	0.0	0.0	0.0	0.0	0.0	1.2	1.0
CGD16	0.2	0.0	0.0	0.0	0.0	0.0	0.4	2.4
CGD17	0.0	0.0	0.0	0.0	0.0	0.0	1.2	4.6
CGD18	0.4	0.0	0.0	0.0	0.0	0.0	1.2	4.6
CGD19	0.4	0.0	0.0	0.0	0.0	0.0	1.2	4.6
CGD20	0.6	0.0	0.0	0.0	0.0	0.0	0.8	2.4
CGD21	0.0	0.0	0.0	0.0	0.0	0.0	0.4	5.8
CGD23	0.2	0.0	0.0	0.0	0.0	0.0	0.6	2.8
CGD24	0.6	0.0	0.0	0.0	0.0	0.0	1.2	4.2
CGD25	5.6	0.0	0.0	0.4	0.2	0.6	2.2	4.8
CGD26	6.6	0.0	0.0	0.0	0.0	0.0	2.6	4.0
CGD27	5.0	0.0	0.0	0.0	0.0	0.0	0.8	5.2
CGD28	5.6	0.0	0.0	0.0	0.0	0.0	1.4	4.8
CGD29	4.0	0.0	0.0	0.0	0.0	0.0	3.2	6.8
CGD30	2.6	0.0	0.0	0.0	0.0	0.0	2.6	8.6
CGD31	2.4	0.0	0.0	0.0	0.0	0.0	3.2	7.4
CGD32	4.4	0.0	0.0	0.0	0.0	0.0	2.6	7.2
CGD33	2.6	0.0	0.0	0.0	0.0	0.0	3.4	8.2
CGD34	3.4	0.0	0.0	0.0	0.0	0.0	0.6	5.0
CGD35	3.4	0.0	0.0	0.0	0.0	0.0	0.8	4.0
CGD36	0.8	0.0	0.0	0.0	0.0	0.0	1.0	4.0
CGD37	2.4	0.0	0.0	0.0	0.0	0.0	1.4	2.8
CGD38	0.4	0.0	0.0	0.0	0.0	0.0	1.2	3.0
CGD39	2.6	0.4	0.0	0.0	0.0	0.4	2.6	6.8
CGD40	4.8	0.4	0.0	0.0	0.0	0.4	6.2	8.6
CGD41	2.6	0.0	0.0	0.0	0.0	0.0	1.2	4.2
CGD42	1.0	0.0	0.0	0.0	0.0	0.0	1.2	4.0
CGD43	0.4	0.0	0.0	0.0	0.0	0.0	0.2	1.4

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
CGD44	4.0	0.0	0.0	0.0	0.0	0.0	2.4	4.6
CGD45	2.8	0.4	0.0	0.0	0.0	0.4	0.8	2.2
CGD46	1.8	0.0	0.0	0.0	0.0	0.0	0.4	1.8
CGD47	2.0	0.0	0.0	0.0	0.0	0.0	0.6	3.0
CGD48	2.0	0.0	0.0	0.0	0.0	0.0	0.6	1.8
CGD49	2.2	0.0	0.0	0.0	0.0	0.0	0.8	3.4
CGD50	7.8	0.4	1.0	1.8	0.4	3.6	7.2	15.8
CGD51	4.2	0.0	0.0	0.0	0.0	0.0	3.0	10.6
CGD52	0.4	0.0	0.0	0.0	0.0	0.0	1.8	5.8
CGD53	5.2	0.8	0.2	0.4	0.2	1.6	3.4	5.6
CGD54	4.0	0.0	0.2	0.0	0.0	0.2	3.8	7.8
CGD55	0.8	0.0	0.2	0.2	0.0	0.4	0.2	3.0
CGD56	5.0	0.0	0.0	0.2	0.0	0.2	1.0	3.6
CGD57	1.0	0.0	0.2	0.0	0.0	0.2	0.8	1.2
CGD58	3.8	0.0	0.0	0.2	0.0	0.2	0.8	3.0
CGD59	3.4	0.0	0.0	0.0	0.0	0.0	1.6	2.8
CGD60	4.6	0.0	0.2	0.0	0.0	0.2	0.6	4.4
CGD61	7.0	0.0	0.4	0.2	0.0	0.6	0.8	3.4
CGD62	2.2	0.0	0.0	0.0	0.0	0.0	0.4	1.4
CGD63	2.0	0.0	0.0	0.0	0.0	0.0	0.8	4.2
CGD64	2.6	0.0	0.0	0.0	0.0	0.0	1.2	2.6
CGD65	4.2	0.0	0.0	0.2	0.0	0.2	0.4	2.8
CGD66	4.2	0.2	0.0	0.0	0.0	0.2	1.4	4.8
CGD67	3.0	0.0	0.0	0.0	0.0	0.0	1.8	5.0
CGD68	5.6	0.0	0.0	0.0	0.2	0.2	0.4	3.0
LOD1*	1.0	0.0	0.0	0.0	0.0	0.0	0.2	1.0
LOS4	4.0	0.0	1.0	0.0	0.0	1.0	8.0	15.4
LOD2	8.8	0.4	0.4	0.2	0.0	1.0	3.6	9.2
LOD3	3.8	0.2	0.6	0.4	0.0	1.2	3.8	16.6
LOD4	3.8	0.0	0.8	0.0	0.0	0.8	4.8	15.4
LOD5	1.2	0.0	0.2	0.0	0.0	0.2	2.2	7.8
LOS5	2.6	0.0	0.0	0.0	0.0	0.0	0.4	1.4
LOD5A	3.0	0.0	0.2	0.2	0.0	0.4	6.0	28.6
LOD6	3.2	0.2	0.0	0.2	0.0	0.4	9.6	25.4
LOD7	2.0	0.0	0.0	0.0	0.0	0.0	1.6	3.2
LOD8	3.6	0.0	0.2	0.0	0.0	0.2	2.4	3.0
LOD9	3.6	0.0	0.2	0.2	0.0	0.4	2.8	2.4
LOD10	2.4	0.0	0.0	0.2	0.0	0.2	1.0	3.0
LOK6	2.6	0.0	0.4	0.0	0.0	0.4	2.4	3.6

Appendix II: Simple percentages of the kerogen count categories

Key to abbreviations used in column headers (parameters all percentages based on 500 counts per sample):

SAMNO = sample number
UNDIF% = undifferentiated palynomorphs
BOT% = *Botryococcus*
FORAM% = Foraminiferal linings
PLANK% = marine plankton
SPORO% = sporomorphs
AOM% = AOM
FUNG% = fungal hyphae
MEM% = membranes
CUTIC% = cuticle
USPSU% = pseudoamorphous non-biostructured brown wood
USCO% = corroded non-biostructured brown wood
USUN% = undegraded non-biostructured brown wood
SDPT% = degraded pitted biostructured brown wood
SDBN% = degraded banded biostructured brown wood
SDSP% = degraded striped biostructured brown wood
SDSR% = degraded striate biostructured brown wood
STDEG% = total degraded biostructured brown wood
SUPT% = undegraded pitted biostructured brown wood
SUBN% = undegraded banded biostructured brown wood
SUSP% = undegraded striped biostructured brown wood
SUST% = undegraded striate biostructured brown wood
STUND% = total undegraded biostructured brown wood
BLKLAT% = lath shaped black wood
BLKEQUI% = equant shaped black wood

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
LOK7	2.0	0.0	0.0	0.0	0.0	0.0	0.8	5.6
LOK8	5.2	0.2	0.0	0.0	0.0	0.2	2.2	4.8
LOD11	1.8	0.0	0.0	0.0	0.0	0.0	1.0	1.8
LOD12	1.6	0.0	0.0	0.2	0.0	0.2	0.8	2.4
LOK11	1.8	0.0	0.2	0.0	0.0	0.2	1.0	2.2
LOD13	11.4	0.0	0.6	0.0	0.0	0.6	3.8	10.2
LOD14	6.0	0.0	0.0	0.2	0.0	0.2	4.0	14.6
LOD15	6.4	0.0	0.6	0.0	0.0	0.6	3.4	15.6
LOD16	7.6	0.0	0.2	0.0	0.0	0.2	4.6	26.0
LOK15	3.0	0.0	0.0	0.0	0.0	0.0	2.2	31.2
LOK16	0.4	0.0	1.4	0.0	0.0	1.4	2.0	12.6
LOK17	2.6	0.0	0.4	0.0	0.0	0.4	6.4	48.6
LOK20	9.4	0.0	0.8	0.0	0.0	0.8	5.2	40.0
LOK21	9.0	0.0	0.4	0.0	0.0	0.4	4.0	50.8
LOK22	4.0	0.0	0.8	0.0	0.0	0.8	5.6	47.6
LOK23	5.8	0.0	0.8	0.0	0.0	0.8	2.0	57.2
LOK24	12.8	0.2	0.0	0.0	0.0	0.2	1.0	7.0
LOK25	8.8	0.2	0.0	0.0	0.0	0.2	4.0	9.8
LOK26	10.0	0.0	0.4	0.0	0.0	0.4	2.4	10.6
LOK27	5.8	0.0	0.2	0.0	0.0	0.2	2.2	7.2
LOK28	15.2	0.0	0.2	0.0	0.0	0.2	3.8	13.6
LOK29	8.8	0.0	0.4	0.0	0.0	0.4	4.2	38.0
LOK30	4.6	0.0	0.0	0.0	0.0	0.0	1.2	40.2
LOK31	3.6	0.0	0.0	0.0	0.0	0.0	1.4	14.4
LOK32	2.4	0.0	0.2	0.0	0.0	0.2	0.4	5.2
LOK33	14.8	0.2	1.8	0.0	0.0	2.0	1.2	3.8
LOK34	9.8	0.0	0.0	0.0	0.0	0.0	1.2	7.4
LOK35	10.4	0.4	0.0	0.0	0.0	0.4	1.8	4.2
LOK36	9.2	0.2	1.4	0.2	0.0	1.8	2.4	4.0
LOK37	4.8	0.0	0.2	0.0	0.0	0.2	2.8	7.0
LOK38	8.0	0.0	0.6	0.0	0.0	0.6	3.0	12.0
LOK39	6.6	0.0	0.6	0.6	0.0	1.2	2.2	18.6
LBT1	0.2	0.0	0.2	0.0	0.0	0.2	0.8	1.6
LBT2	1.0	0.0	0.2	0.2	0.0	0.4	0.6	1.4
LBT3	6.6	0.0	0.0	0.0	0.0	0.0	0.8	5.0
LBT4	0.8	0.0	0.2	0.0	0.0	0.2	1.2	0.8
LBT5	6.2	0.0	0.2	0.0	0.0	0.2	1.6	4.4
LBT6	7.2	0.0	0.0	0.2	0.0	0.2	1.6	6.4
LBT7	4.4	0.0	0.0	0.0	0.0	0.0	1.0	2.0

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
LBT8	3.6	0.0	0.0	0.0	0.0	0.0	1.6	4.8
LBT9	7.0	0.0	1.0	0.0	0.0	1.0	1.6	2.8
LBT10	8.8	0.2	0.0	0.4	0.0	0.6	1.6	3.6
LBT11	6.2	0.0	0.0	0.0	0.0	0.0	4.4	6.2
LBT12	1.8	0.0	0.0	0.0	0.0	0.0	3.0	2.6
LBT13	4.8	0.4	0.4	0.4	0.0	1.2	6.4	7.4
LBT14	2.8	0.6	0.2	0.2	0.0	1.0	4.0	2.8
LBT15	3.0	0.0	0.2	0.2	0.0	0.4	2.2	2.2
LBT16	3.0	0.0	0.0	0.0	0.0	0.0	1.8	3.4
LBT17	5.6	0.0	0.0	0.0	0.0	0.0	1.6	4.8
LBM1	5.0	0.0	0.2	0.0	0.0	0.2	1.0	3.6
LBM2	2.8	0.0	0.2	0.0	0.0	0.2	1.4	4.4
LBM3	9.8	0.8	0.8	0.4	0.0	2.0	9.0	10.2
LBM4	4.0	0.2	0.2	0.0	0.0	0.4	2.6	5.6
LBM5	3.4	0.2	0.0	0.0	0.0	0.2	1.2	3.2
LBM6	4.6	0.0	0.0	0.0	0.0	0.0	1.0	5.2
LBM7	2.4	0.0	0.0	0.0	0.0	0.0	0.8	4.6
KBD1	2.6	0.0	0.0	0.0	0.0	0.0	0.4	2.8
KBK1	1.6	0.4	0.0	0.0	0.0	0.4	0.8	3.4
KBK2	1.4	0.0	0.4	0.0	0.0	0.8	1.4	2.4
KBK3	1.4	0.0	0.2	0.0	0.0	0.2	2.2	3.0
KBK4	1.4	0.0	0.0	0.0	0.0	0.0	3.8	6.8
KBK5	0.0	0.0	0.2	0.0	0.0	0.2	2.6	3.4
KBK7	14.0	0.0	0.0	0.2	0.0	0.2	0.4	17.2
KBK8	1.6	0.0	0.4	0.0	0.0	0.4	3.0	2.6
KBK9	1.0	0.0	0.2	0.0	0.0	0.2	2.6	4.2
KBK10	0.8	0.0	0.0	0.0	0.0	0.0	2.2	6.8
KBK11	0.4	0.0	0.0	0.0	0.0	0.0	2.2	3.4
SB1	0.2	0.0	0.0	0.0	0.0	0.0	1.4	75.4
SB4	0.2	0.0	0.0	0.0	0.0	0.0	2.4	76.8
SB7	0.4	0.0	0.0	0.0	0.0	0.0	1.0	70.2
SB10	0.0	0.0	0.0	0.0	0.0	0.0	1.4	85.6
SB14	0.0	0.0	0.0	0.0	0.0	0.0	2.4	69.2
SBS2	0.6	0.0	0.0	0.0	0.0	0.0	4.4	68.0
SBS4	0.0	0.0	0.0	0.0	0.0	0.0	3.0	53.6
SBS5	1.0	0.0	0.0	0.0	0.0	0.0	4.6	19.8
SBU1	0.6	0.4	0.6	0.4	0.0	1.4	1.6	4.6
UOB1	2.2	0.0	0.0	0.0	0.0	0.0	0.6	19.4
UOB2	2.0	0.0	0.0	0.0	0.0	0.0	1.8	9.8

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
UOB3	0.8	0.0	0.2	0.0	0.0	0.2	1.4	3.0
UOB4	0.6	0.0	0.2	0.2	0.0	0.4	4.6	13.6
UOB5	4.6	0.0	0.2	0.2	0.0	0.4	0.6	2.6
UOB6	3.6	0.2	0.2	0.0	0.0	0.4	0.2	7.6
UOB7	6.4	0.0	0.6	0.4	0.0	1.0	0.6	9.8
UOB8	6.6	0.0	0.6	0.2	0.0	0.8	1.2	4.4
UOB9	7.4	0.0	0.4	0.4	0.0	0.8	1.4	3.2
UOB10	9.8	0.6	1.0	0.4	0.0	2.0	1.2	5.6
UOB11	4.6	0.0	0.4	0.2	0.0	0.6	3.0	8.8
UOB12	3.8	0.0	0.6	0.2	0.0	0.8	2.6	5.4
UOB13	7.6	0.0	1.0	0.2	0.0	1.2	3.6	5.0
UOB14	7.2	0.2	1.8	1.4	0.0	3.4	1.8	4.8
UOB15	6.0	0.8	2.4	1.2	0.0	4.4	2.4	4.0
UOB16	5.4	0.0	1.2	1.0	0.0	2.2	3.6	6.6
UOB17	8.6	0.2	2.2	0.8	0.0	3.2	2.0	6.4
UOB18	4.6	0.0	2.2	0.6	0.0	2.8	1.4	8.4
UOB19	8.8	0.0	2.4	0.4	0.0	2.8	1.6	5.2
UOB20	4.2	0.0	1.8	0.2	0.0	2.0	2.6	6.4
UOB21	5.0	0.2	2.2	0.4	0.0	2.8	2.4	8.6
UOB22	6.0	0.0	1.8	0.8	0.0	2.6	2.0	2.8
UOB23	3.0	0.0	0.6	0.2	0.0	0.8	1.2	7.0
UOB24	1.2	0.0	0.4	0.6	0.0	1.0	2.4	6.4
UOB25	3.0	0.2	0.8	0.4	0.0	1.4	1.0	4.4
UOB26	13.0	0.0	0.6	0.4	0.0	1.0	2.2	5.8
UOB27	9.0	0.2	1.8	1.4	0.0	3.4	1.0	5.8
UOB28	8.2	0.0	0.8	0.2	0.0	1.0	1.2	4.0
UOB29	5.2	0.0	0.6	0.2	0.0	0.8	1.4	16.4
UOB30	3.0	0.0	0.4	0.2	0.0	0.6	3.0	4.2
UOB31	0.0	0.0	0.0	0.2	0.0	0.2	1.0	3.6
UOB32	2.2	0.0	0.4	0.0	0.0	0.4	3.0	3.6
UOB33	0.4	0.0	0.6	0.2	0.0	0.8	2.2	5.0
UOB34	1.0	0.0	1.2	0.0	0.0	1.2	4.8	7.0
UOB35	2.4	0.0	0.8	0.0	0.0	0.8	3.4	4.4
UOB36	0.8	0.0	1.0	0.0	0.0	1.0	2.8	5.6
UOB37	1.2	0.0	0.6	0.2	0.0	0.8	2.4	4.0
BS1	1.8	0.4	1.4	0.8	0.0	2.6	4.0	4.0
BS2	5.8	0.0	3.6	0.6	0.2	4.4	3.4	5.6
BS3	5.0	0.0	1.4	0.0	0.0	1.4	1.0	4.8
BS4	18.0	0.2	4.8	2.0	0.0	7.0	3.8	11.4

SAMNO	STDEG%	SUPT%	SUBN%	SUSP%	SUST%	STUND%	BLKLAT%	BLKEQI%
BS5	13.2	0.0	3.8	1.4	0.0	5.2	8.0	17.0
BS6	9.6	0.0	2.8	1.4	0.0	4.2	1.4	9.8
BS7	11.6	0.0	1.2	1.4	0.0	2.6	3.0	15.8
BS8	6.0	0.0	1.6	0.6	0.0	2.2	2.2	21.2
BS9	4.6	0.0	0.6	0.0	0.0	0.6	4.0	26.6
BS10	2.4	0.2	1.0	0.0	0.0	1.2	2.2	21.8
BS11	4.4	0.0	1.4	0.6	0.0	2.0	6.0	20.4
BS12	3.6	0.2	1.4	0.0	0.0	1.6	5.2	19.2
BS13	1.6	0.0	1.4	0.6	0.0	2.0	4.0	23.4
BS14	1.8	0.2	0.8	0.2	0.0	1.2	1.6	5.0
BS15	0.8	0.0	0.2	0.0	0.0	0.2	2.0	3.4

APPENDIX III

Appendix III: Simple percentages of the palynomorph count categories

Key to abbreviations used in column headers (parameters all percentages based on 300 counts per sample):

SAMNO	= sample number
%TNWS	= thin-walled spores
%TKWS	= thick-walled spores
%UPOL	= unidentified pollen
%CALL	= *Callialasporites*
%CEREB	= *Cerebropollenites*
%BISAC	= bisaccates
%UDIN	= unidentified dinocysts
%SMD	= very poorly preserved dinocysts
%NAN	= *Nannoceratopsis*
%CAD	= *Caddasphaera*
%BAT	= *Batiacasphaera*
%PRV	= *Parvocysta*
%DIS	= *Dissiliodinium*
%CTE	= *Ctenidodinium*
%DUR	= *Durotrigia*
%MEI	= *Meiurogonyaulax*
%G.T.	= other gonyaulacacean dinocysts
%PAR	= *Pareodinia*
%SEN	= *Sentusidinium*
%JMAN	= *Jansonia manifesta*
%RHY	= *Rhychodiniopsis*
%ADNAT	= *Adnatosphaeridium*
%DIN	= total dinocysts
%AC	= acritarchs
%TAS	= *Tasmanites*-type prasinophytes
%LEI	= leiospheres
%BOT	= *Botryococcus*
%UNDIF	= undifferentiated

Blank rows represent samples not counted for palynology, blank columns mean that the category was not counted in that formation (particularly common in the dinocyst categories that are often formation specific).

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
BBE1	1.3	0.0	72.7	0.0	2.7	13.3	2.7		0.7	0.0	0.0					
BBE2																
BBE3																
BBE4	2.3	0.0	83.3	0.0	0.3	5.0	3.0		0.0	0.0	0.3					
BBE5																
BBE6	1.3	0.0	80.3	0.0	2.0	7.7	1.3		0.3	0.0	0.0					
BBE7																
BBE8																
BBE9	1.3	0.0	79.7	0.0	0.3	8.7	4.0		0.3	0.0	0.7					
BBE10																
BBE11	2.0	0.0	77.0	0.0	1.0	11.3	3.3		0.0	0.0	0.0					
BBE12																
BBE13																
BBE14	1.3	0.0	79.0	0.0	1.7	8.7	2.7		0.0	0.0	0.3					
BBE15																
BBE16																
BBE17	0.0	0.0	80.0	0.7	1.3	3.7	2.3		2.0	0.0	0.3					
BBE18	2.0	0.0	86.7	0.0	1.0	3.0	0.7		0.7	0.0	0.0					
BBE19	3.3	0.0	85.3	0.0	0.7	3.3	0.7		0.0	0.0	0.0					
BBE20	1.3	0.0	83.3	0.0	1.0	6.0	1.3		1.0	0.0	0.7					
BBE21	2.7	0.0	76.3	0.3	3.0	5.7	2.7		2.0	0.0	1.0					
BBE22	4.7	0.0	79.0	0.0	1.0	7.0	0.7		1.7	0.0	0.7					
BBE23	3.7	0.0	81.3	0.7	1.7	5.0	1.3		1.7	0.0	0.3					
BBE24	6.0	0.0	80.3	1.0	1.3	3.7	0.7		1.3	0.0	0.3					
BBE25	6.0	0.0	73.3	0.3	2.7	7.7	1.7		1.0	0.0	1.0					
BBE26	5.7	0.3	77.0	0.0	2.7	7.0	1.0		0.0	0.3	1.0					
BBE27	4.3	0.3	75.7	0.3	2.3	8.3	1.3		1.7	0.0	0.0					
BBE28	5.3	0.3	78.0	0.3	3.0	4.7	1.7		1.3	0.3	0.3					
BBE29	5.7	0.0	80.0	0.7	1.3	4.3	1.0		0.7	0.7	0.7					
BBE30	3.3	0.0	83.7	0.0	1.7	3.3	1.0		1.7	0.0	0.7					
BBE31	4.7	1.0	79.0	0.7	2.0	5.3	1.3		0.7	0.0	0.0					
BBE32	2.3	0.0	80.7	0.7	0.7	7.0	0.7		1.3	0.3	0.3					
BBE33	3.0	0.0	80.7	1.3	2.7	6.7	0.7		0.7	0.0	0.3					
BBE34	3.3	0.0	80.7	0.7	2.7	6.7	0.0		0.7	0.0	0.7					
BBE35	2.0	0.0	83.7	0.0	2.3	6.7	0.3		1.0	0.0	0.0					
BBE36	1.7	0.3	84.7	0.7	1.7	5.7	0.7		0.3	0.0	0.3					
BBE37	3.7	0.0	75.3	1.7	2.0	5.7	1.0		4.3	0.0	1.3					
BBE38	4.3	0.0	76.0	1.0	2.7	6.0	1.3		4.3	0.0	0.7					
BBE39	3.7	2.0	70.3	2.0	3.7	8.3	2.3		2.3	0.3	0.7					

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
BBE40	5.0	0.3	68.0	1.7	3.7	12.3	2.0		0.7	0.0	1.3					
BBE41	11.3	1.0	59.0	4.0	2.0	10.0	2.3		3.3	0.0	0.0					
BBE42	6.7	1.0	66.3	3.3	4.0	9.0	2.3		2.7	0.0	0.3					
BBE43	6.7	2.0	61.0	3.7	5.0	12.7	1.0		1.7	0.0	1.0					
BBE44	5.0	0.7	73.3	2.0	2.0	8.3	3.0		0.3	0.0	0.3					
BBE45	5.7	0.0	69.0	1.3	3.0	11.7	3.0		1.0	0.0	0.7					
BBE46	6.7	0.0	75.3	1.7	1.3	10.0	1.0		0.3	0.0	0.0					
BBE47	5.7	0.0	78.0	1.7	1.7	8.3	0.7		0.0	0.0	0.3					
BBE48	6.0	0.3	69.0	1.3	3.3	13.3	0.3		0.7	0.0	1.0					
BBE49																
BBO1	3.3	0.0	73.3	0.7	2.7	9.3	2.7		1.3	0.0	0.7					
BBO2	2.3	0.0	66.7	1.3	3.3	14.3	2.7		2.3	0.7	C.3					
BBU1	4.0	0.3	72.7	1.0	3.0	10.7	0.7		1.0	0.0	0.7					
BBU2	4.7	0.3	66.0	1.7	3.0	13.0	1.3		2.0	0.3	0.3					
BBU3	5.0	0.3	70.7	0.7	1.3	12.3	2.0		0.3	0.0	0.0					
BBU4	7.7	0.7	65.0	3.0	1.7	10.7	3.0		1.7	0.0	0.7					
BBU5	4.7	0.0	70.0	2.0	2.0	12.0	2.3		1.3	0.3	0.0					
BBU6	4.7	0.0	70.0	0.0	0.3	13.0	2.0		1.3	0.0	0.3					
BBU7	7.7	1.3	67.0	1.7	1.0	9.7	2.7		2.3	0.0	0.7					
BBU8	6.0	0.7	69.0	0.3	1.3	15.3	1.3		1.3	0.0	1.0					
BBU9	8.3	0.0	64.3	0.7	0.7	15.0	2.7		1.0	0.0	1.3					
BBU10	6.0	0.0	73.7	0.7	0.3	11.7	2.7		1.3	0.0	0.0					
BBU11	4.3	0.0	71.7	0.3	0.7	10.3	2.7		1.3	0.0	0.0					
BBU12	5.0	0.0	71.7	0.7	2.0	13.0	1.0		0.3	0.0	1.0					
BBU13	7.0	0.0	72.7	0.3	0.3	8.0	2.0		2.0	0.0	1.3					
BBU14	3.7	0.0	76.7	0.3	1.3	7.3	2.3		1.0	0.0	0.0					
BBU15	4.7	0.0	80.3	0.3	0.0	7.7	1.7		0.7	0.0	0.3					
BBU16	3.7	0.0	80.0	1.0	0.3	8.3	2.0		0.3	0.3	0.7					
BBU17	3.7	0.0	71.3	1.0	1.3	14.7	1.0		1.0	0.0	1.0					
BBU18	5.7	0.0	72.7	1.0	1.7	12.7	1.0		0.0	0.0	0.7					
BBU19	7.3	0.0	73.3	1.0	0.3	8.3	1.7		2.3	0.0	0.3					
BBU20	8.0	0.3	72.3	1.7	1.3	9.3	0.7		0.3	0.7	0.7					
BBU21	10.7	0.7	66.3	2.7	2.3	6.7	2.0		1.7	0.7	1.3					
BBU22	8.0	0.3	68.7	1.3	0.7	12.7	1.3		2.7	0.0	0.0					
BBU23	8.3	0.0	74.7	1.0	1.3	6.3	1.7		1.7	0.0	0.7					
BBU24	5.0	0.3	79.0	1.0	2.0	7.0	0.3		1.0	0.0	0.0					
BBU25	6.0	0.0	79.7	0.0	1.7	6.0	0.3		0.3	1.0	0.0					
BBU26	4.3	0.0	82.3	0.0	1.3	7.0	0.7		0.3	0.0	0.0					
BBU27	3.3	0.0	80.0	1.0	0.3	6.3	1.3		1.0	0.3	C.0					

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
BBU28	4.7	0.0	76.7	0.0	0.0	11.7	1.3		0.0	0.0	0.7					
BBU29	3.7	0.0	76.7	1.3	2.0	7.3	0.3		0.3	0.0	0.3					
BBU30	4.0	0.3	73.3	0.3	2.0	9.7	1.0		0.7	0.0	0.7					
BBH1	3.3	0.0	76.0	0.7	1.0	7.3	1.0		1.3	0.7	1.0					
BBH2	9.0	0.0	72.3	1.7	0.7	6.7	0.7		1.3	0.7	0.7					
BBH3	7.0	0.0	73.0	0.7	2.7	9.3	0.7		0.3	0.3	1.0					
BBH4	3.7	0.0	83.0	0.3	0.7	7.0	0.3		0.7	0.0	0.0					
BBH5	2.0	0.0	83.0	0.7	1.0	8.3	0.7		0.3	0.0	0.0					
BBH6	5.3	0.0	79.0	0.7	0.7	6.3	0.3		1.0	0.7	0.3					
BBH7	6.7	0.0	72.0	1.3	2.0	12.3	0.3		0.3	0.0	0.7					
BBH8	3.7	0.0	76.7	2.0	2.0	9.0	0.7		0.7	0.0	0.3					
BBH9	2.3	0.0	83.0	0.0	1.7	6.7	0.0		0.7	0.0	0.3					
BBH10	3.0	0.3	71.0	1.0	1.7	18.0	0.3		0.3	0.0	0.3					
BBH11	6.0	0.0	68.7	1.7	2.7	13.3	0.3		0.3	0.3	1.0					
BBH12																
BBR1																
BBR2	3.7	0.0	76.7	0.7	2.7	4.3	2.3		0.3	0.7	1.7					
BBR3																
BBR4																
BBR13	2.7	0.0	79.3	0.0	2.0	5.3	1.0		0.0	0.0	0.7					
BBR14																
BBR15																
BBR16																
BBR17																
BBR18	3.0	0.0	79.3	0.0	3.0	5.7	1.3		0.0	0.3	0.0					
BBR19																
BBR5	2.3	0.0	76.7	0.0	7.3	2.7	1.7		0.0	0.3	0.0					
BBR6																
BBR7																
BBR8	2.0	0.0	75.7		7.0	4.0	0.3		0.0	0.0	0.7					
BBR9																
BBR10																
BBR11	2.7	0.0	77.0	0.0	3.0	5.0	4.0		0.0	0.3	1.3					
BNL17																
BNL16	1.0	0.3	78.3	0.3	1.0	7.3	3.3		2.3	0.3		2.3				
BNL1																
BNL2	0.3	0.0	85.0	0.7	0.0	4.3	3.3		2.0	0.3		0.7				
BNL3																
BNL4																

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
BNL5	0.0	0.0	87.3	0.0	1.7	5.3	1.3		1.7	0.7		0.0				
BNL6																
BNL7																
BNL8																
BNL9	1.7	0.0	80.7	0.0	0.7	7.7	3.3		2.0	0.0		1.0				
BNL10	1.3	0.0	83.3	0.0	0.0	6.0	3.7		0.7	0.0		1.3				
BNL11																
BNL12																
BNL13	0.3	0.0	83.0	0.0	0.3	6.0	2.3		1.3	0.0		2.3				
BNL15																
RGC1	2.3	0.0	65.7	0.3	1.0	14.7	7.0		0.0	0.0	2.0		0.0			
RGC2																
RGC3																
RGC4	1.3	0.0	69.3	0.0	0.0	14.0	6.7		0.3	0.0	0.7		0.0			
RCS1	4.0	0.3	33.3	0.3	1.7	34.3	2.3		0.0	0.0	1.3		3.3			
RCS2	4.0	0.3	27.7	0.3	1.0	42.0	1.3		0.7	0.0	1.7		0.3			
RCS3	6.3	0.7	25.3	1.0	1.7	41.0	1.3		0.0	0.7	0.7		1.3			
RCS4																
RCS5	8.7	0.3	20.0	0.7	3.0	31.0	1.7		0.0	0.3	1.3		0.7			
RCS6	3.7	0.7	23.3	0.7	1.3	43.3	1.3		0.0	0.0	0.7		0.7			
RCS7	6.7	1.0	26.0	1.0	2.0	40.3	0.3		0.0	0.3	0.0		1.0			
RCS8	5.0	1.0	20.3	1.0	1.7	49.3	0.7		0.0	0.3	0.0		0.0			
RCS9	8.7	0.3	28.0	0.3	2.3	40.3	0.7		0.0	0.0	0.3		1.0			
RCS10	5.3	0.3	26.0	1.0	1.0	39.3	1.0		0.0	0.0	1.3		1.3			
RCS11	12.3	0.0	29.3	1.3	3.7	29.0	0.7		0.0	0.0	0.7		0.0			
RCS12	8.3	0.0	31.0	1.0	1.7	37.3	0.7		0.0	0.0	0.0		0.0			
RCS13	8.3	2.0	33.3	1.0	2.3	34.7	0.7		0.0	0.0	1.0		1.3			
RCS14	8.7	1.0	25.3	0.7	2.0	43.0	1.0		0.0	0.0	0.0		1.7			
RCS15	7.0	1.0	24.0	0.0	3.3	43.0	0.7		0.0	0.0	0.3		1.7			
KE26	10.7	0.3	31.0	0.3	1.7	29.3	0.7			0.0	0.3		0.0		0.0	
KE27	2.3	1.3	28.3	0.0	0.3	21.7	0.0			0.0	0.0		0.0		0.0	
KE28	11.3	2.0	28.0	0.0	4.7	28.7	0.3			0.0	0.0		0.0		0.0	
KE29	7.0	2.0	30.7	3.3	0.0	35.0	0.0			0.0	0.0		0.0		0.0	
KE30	6.7	0.0	36.0	0.3	1.3	13.3	0.0			0.0	0.0		0.0		0.0	
KE31	1.3	0.0	30.3	0.0	0.0	14.0	0.0			0.0	0.0		0.0		0.0	
KE32	2.0	2.0	48.3	1.3	1.0	13.0	0.0			0.0	0.0		0.0		0.0	
KE33	5.7	2.7	41.7	0.3	0.7	23.7	0.3			0.0	0.0		0.0		0.0	
KE34	3.0	1.3	38.3	0.0	0.3	21.0	0.3			0.0	0.0		0.0		0.0	
KE35	2.0	2.3	44.3	0.3	1.0	20.0	0.0			0.0	0.0		0.0		0.0	

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
KE36	2.7	0.7	38.3	0.3	1.3	29.0	0.3			0.0	0.0		0.0		0.0	
KE37	4.7	1.7	44.7	0.3	0.7	25.0	0.0			0.0	0.0		0.0		0.0	
KE38	4.7	2.3	45.7	2.0	1.7	24.7	0.3			0.0	0.0		0.0		0.0	
KE39	3.0	1.7	45.0	1.3	2.0	31.0	0.0			0.0	0.0		0.0		0.0	
KE40	7.0	0.3	44.0	2.3	3.0	30.3	0.0			0.0	0.0		0.0		0.0	
KE41	6.7	1.3	37.0	1.3	1.3	32.3	0.0			0.0	0.0		0.0		0.0	
KE42	5.7	0.0	39.0	0.0	0.3	35.7	1.0			0.0	0.0		0.0		0.0	
KE43	2.7	1.7	41.3	0.3	1.7	34.3	0.3			0.0	0.0		0.0		0.0	
KE44	3.3	3.3	32.0	0.3	0.7	23.3	0.0			0.0	0.0		0.0		0.0	
KE45	7.7	0.3	40.0	0.3	1.7	33.7	0.0			0.0	0.0		0.0		0.0	
KE46	6.0	1.3	33.3	1.0	0.0	20.7	0.0			0.0	0.0		0.0		0.0	
KE47	12.7	1.7	28.0	0.7	0.3	27.3	0.7			0.3	0.0		0.0		0.0	
KE48	11.0	2.7	29.7	0.3	2.0	30.0	0.0			0.0	0.0		0.0		0.0	
KE49	6.3	1.3	36.7	0.0	2.7	37.7	0.7			0.0	0.0		0.0		0.0	
KE50	3.7	0.3	33.3	0.3	0.3	17.7	0.0			0.0	0.0		0.0		0.0	
KE51	4.7	1.0	31.3	0.3	1.3	24.3	0.0			0.0	0.0		0.0		0.0	
KE52	10.7	0.3	32.7	0.0	2.3	28.0	0.0			0.0	0.0		0.0		0.0	
KE53	11.7	0.7	28.7	4.7	0.0	37.7	0.0			0.0	0.0		0.0		0.0	
KE54	8.3	2.0	25.3	0.7	0.7	35.0	1.0			0.0	0.0		0.0		0.0	
KE55	10.0	1.3	46.3	0.7	2.0	23.3	0.0			0.0	0.0		0.0		0.0	
KE56																
KE57	13.3	2.0	39.7	1.0	1.7	31.0	0.0			0.0	0.0		0.0		0.0	
KE58	7.7	2.0	41.3	0.3	1.0	38.7	0.0			0.0	0.0		0.0		0.0	
KE1	8.0	2.0	29.3	1.0	0.7	51.0	0.3			0.0	0.0		0.0		0.0	
KE2	6.0	1.7	38.7	1.7	2.7	39.0	0.0			0.3	0.0		0.0		0.0	
KE3	5.3	0.3	44.0	0.7	1.7	40.7	1.0			0.3	0.0		0.0		0.3	
KE4	5.3	0.0	31.7	0.7	0.3	14.3	16.0			2.0	0.7		0.0		12.7	
KE5	0.7	0.0	24.0	0.0	0.3	4.7	4.0			54.0	0.3		0.0		3.7	
KE6	8.3	1.0	29.0	1.7	4.0	37.0	1.7			4.0	0.0		0.3		2.7	
KE7	10.0	1.7	33.7	0.7	2.0	31.7	1.0			1.7	0.3		0.0		0.3	
KE8	9.3	1.3	21.7	1.3	1.0	31.7	6.3			2.0	1.0		2.7		5.7	
KE9	4.3	0.3	33.7	0.7	0.7	27.7	4.7			3.7	0.3		2.3		2.7	
KE10	4.0	0.3	31.3	1.3	0.7	24.0	5.7			1.7	1.0		1.3		0.7	
KE11	6.3	1.3	15.0	0.3	2.3	32.3	2.3			0.3	0.3		2.0		0.3	
KE12	6.3	0.0	44.7	0.7	0.7	15.3	9.0			0.3	14.0		0.0		0.0	
KE13	4.0	0.7	29.3	0.7	0.3	24.7	1.0			0.0	3.7		0.0		0.0	
KE14	4.7	0.0	23.3	0.3	1.0	10.3	0.0			0.0	0.3		0.0		0.0	
KE15	2.7	1.0	23.3	0.0	0.7	14.3	0.7			0.0	0.0		0.0		0.0	
KE16	2.7	1.0	33.7	1.3	0.7	40.3	0.0			0.0	0.0		0.0		0.0	

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
KE17	3.7	0.7	44.0	1.0	0.3	28.7	1.3			0.0	0.7		0.0		0.0	
KE18	18.3	2.7	29.7	0.3	2.3	34.3	0.0			0.0	0.0		0.0		0.0	
KE19	22.7	5.0	30.7	1.0	3.0	26.0	0.0			0.0	0.0		0.0		0.0	
KE20	40.3	5.0	22.7	0.3	1.0	21.0	0.0			0.0	0.0		0.0		0.0	
KE21	2.0	0.0	29.7	0.7	0.7	17.3	0.3			0.0	0.0		0.3		0.0	
KE22	9.0	0.3	30.7	0.7	1.0	11.3	0.3			0.0	0.0		0.0		0.0	
KE23	5.7	0.7	32.0	2.0	1.7	27.7	0.0			0.0	0.0		0.7		0.0	
KE24	5.7	1.0	40.3	2.3	1.3	38.0	0.0			0.0	0.0		0.0		0.0	
KE25	11.0	0.7	28.3	1.0	1.3	44.3	0.0			0.0	0.0		0.0		0.0	
RNB1	2.7	9.3	18.0	1.0	0.3	18.3	0.7			0.0	0.0		0.0		0.0	
RNB2	1.3	0.0	12.0	0.0	0.0	10.3	0.0			0.0	0.0		0.7		0.0	
RNB3	1.3	0.7	15.7	0.0	0.7	26.3	0.3			0.0	0.7		0.0		0.0	
RNB4	1.0	0.0	21.3	0.3	0.7	16.0	1.7			0.0	0.0		0.0		0.3	
RNB5	0.7	0.7	14.7	0.7	0.3	23.3	0.3			0.0	0.0		0.3		1.7	
RNB6	0.0	0.0	34.0	0.3	0.0	21.7	2.3			0.0	0.7		1.0		1.3	
RNB7	1.7	0.0	9.7	0.3	0.0	52.7	0.7			0.0	0.0		0.7		0.3	
RNB8	0.7	0.0	24.7	0.3	0.3	20.7	1.7			0.0	0.0		0.3		2.0	
RNB9	1.3	0.0	4.7	0.0	0.0	13.0	0.0			0.0	0.0		0.0		0.0	
RNB10	1.7	0.3	30.3	0.3	0.3	21.7	1.0			0.0	0.0		0.7		1.3	
RNB11	1.7	0.3	51.0	0.0	0.0	18.3	1.0			0.0	0.0		0.0		0.3	
RNB12	1.3	0.3	20.3	1.3	0.0	45.0	0.0			0.0	0.0		0.0		0.0	
RNB13	3.7	1.7	32.7	1.0	1.3	31.0	1.0			0.0	0.0		0.0		0.0	
RNB14	4.7	2.7	40.7	1.3	1.7	26.0	1.0			0.0	0.0		0.0		0.3	
RNB15	3.3	1.0	48.7	0.3	0.0	14.7	0.3			0.0	0.0		0.7		0.0	
RNB16	7.0	0.3	35.0	0.7	0.7	28.3	0.0			0.0	0.0		1.0		0.0	
RNB17																
RNB18	7.0	0.3	34.3	1.7	0.3	24.7	0.0			0.0	0.0		0.0		0.3	
RNB19	7.0	1.3	40.0	1.7	1.3	36.3	0.0			0.0	0.0		0.0		0.3	
RNB20	5.0	2.7	39.0	0.7	1.3	28.3	0.0			0.0	0.0		0.0		0.0	
VS2	17.0	4.3	42.3	1.0	0.7	10.0										
VS3	9.7	4.3	49.0	1.7	0.0	15.7										
VS4	12.0	4.7	49.7	2.0	0.7	11.3										
VS5																
VS7																
VS8	10.7	0.3	29.3	1.0	0.0	42.3										
VS9																
CGD1																
CGD2																
CGD3																

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
CGD4																
CGD5																
CGD6																
CGD7																
CGD8																
CGD9																
CGD10																
CGD11	0.3	0.3	48.0	0.7		35.0	4.3				3.0			0.0	0.0	0.0
CGD12																
CGD13																
CGD14																
CGD15																
CGD16																
CGD17																
CGD18																
CGD19																
CGD20	3.3	1.3	49.3	2.0		17.7	4.0				1.0			0.0	0.0	17.7
CGD21																
CGD23	1.0	0.7	57.3	3.7		9.7	13.3				3.0			0.0	0.0	4.3
CGD24	1.0	0.3	20.7	0.0		10.7	7.0				15.7			20.0	1.3	13.7
CGD25	0.3	2.0	26.0	2.7		13.3	9.3				10.3			13.7	0.3	13.0
CGD26	0.7	1.0	30.0	1.7		13.3	5.7				9.0			4.3	0.0	5.7
CGD27	1.0	2.3	27.3	4.3		8.7	7.3				9.0			4.7	0.0	6.7
CGD28	0.0	0.0	17.0	1.0		4.7	10.0				12.3			5.0	5.7	6.0
CGD29	2.0	3.3	41.3	4.3		6.0	5.3				5.3			1.3	1.3	1.0
CGD30	5.3	4.7	42.7	3.0		9.7	9.0				3.7			0.7	1.3	1.0
CGD31	3.3	3.7	39.3	2.7		5.3	11.7				6.3			0.7	1.0	0.0
CGD32	1.0	3.0	49.0	3.3		11.7	4.7				4.3			1.3	0.3	0.7
CGD33	2.7	2.3	52.0	5.0		12.7	5.3				4.7			0.3	1.0	1.0
CGD34	0.7	0.7	36.3	3.3		12.0	8.7				7.7			7.3	0.3	2.0
CGD35	0.3	0.7	26.3	3.3		6.3	13.7				5.7			19.0	0.7	0.0
CGD36	0.3	0.3	33.0	0.3		6.0	11.7				9.0			20.7	0.7	1.3
CGD37	1.0	0.7	36.7	1.0		9.3	5.3				5.0			24.0	0.0	1.0
CGD38	2.7	4.0	64.3	2.7		5.7	3.0				4.3			5.3	0.0	0.3
CGD39	3.3	2.0	55.0	2.3		8.3	5.7				3.3			12.3	0.0	0.3
CGD40	1.3	0.3	60.0	2.0		11.7	3.7				3.3			9.3	0.3	0.0
CGD41	1.3	2.3	42.3	1.3		4.7	4.7				7.3			19.3	0.0	0.3
CGD42	0.3	1.3	35.7	1.0		5.3	5.7				8.7			19.7	0.0	0.0
CGD43	1.3	0.0	35.0	0.7		9.7	11.7				13.3			5.0	0.0	1.7

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
CGD44	1.0	0.3	45.3	1.3		9.7	6.7				7.7			4.0	0.0	0.0
CGD45	1.3	0.0	48.7	0.3		6.0	6.7				10.3			5.3	0.0	0.0
CGD46	1.0	0.7	44.0	0.3		5.3	4.3				8.7			12.7	0.0	0.3
CGD47	2.7	0.0	45.7	2.3		9.0	6.0				6.0			9.7	0.0	0.7
CGD48	1.3	0.3	35.7	3.3		8.7	4.7				4.7			23.7	0.0	0.0
CGD49	2.0	0.0	58.7	1.3		3.7	9.0				2.0			10.0	0.0	0.0
CGD50	28.0	4.7	49.0	8.7		6.0	1.0				0.0			0.0	0.0	0.0
CGD51	2.0	0.0	72.7	0.0		17.7	2.0				0.3			0.0	0.0	0.0
CGD52	5.0	1.0	66.7	2.7		7.3	5.3				0.7			0.7	0.0	0.3
CGD53	2.3	1.0	19.3	7.3		10.7	7.0				4.0			2.3	22.7	1.0
CGD54	3.0	0.3	17.0	3.7		7.0	8.3				3.3			4.0	21.0	0.3
CGD55	2.0	0.7	19.7	1.3		5.3	12.3				9.0			8.7	14.7	0.3
CGD56	0.3	0.3	17.0	5.3		5.3	20.0				10.3			7.3	8.3	6.3
CGD57	0.3	0.7	16.3	3.7		3.0	22.3				6.3			9.0	11.0	5.0
CGD58	2.0	1.7	14.7	4.7		7.0	18.3				6.7			7.0	8.3	9.0
CGD59	2.0	0.0	41.0	6.3		7.7	5.3				8.7			1.7	2.3	9.3
CGD60	1.7	0.7	41.3	3.7		10.3	4.7				8.3			2.3	0.7	10.7
CGD61	2.3	0.0	36.7	8.0		11.7	8.7				9.3			0.3	1.0	13.3
CGD62	2.3	0.0	27.3	5.3		13.7	8.3				6.0			1.7	5.3	13.3
CGD63	2.3	0.3	20.0	3.7		10.7	11.0				12.0			0.3	5.0	18.7
CGD64	3.0	0.0	22.0	5.3		12.3	7.7				11.3			0.3	4.0	16.7
CGD65	2.7	0.0	25.0	6.7		9.7	8.0				11.0			0.0	2.7	18.3
CGD66	4.0	1.0	56.3	9.7		18.0	2.3				0.0			0.0	0.7	6.7
CGD67	3.7	0.3	32.7	6.3		19.3	4.3				8.3			0.0	3.3	10.3
CGD68	4.0	1.0	37.0	5.3		18.7	7.3				4.7			0.3	7.0	5.3
LOD1*																
LOS4	6.0	3.7	55.7	5.3		23.7	0.0				0.0			0.0	0.0	0.0
LOD2	6.3	2.3	58.3	3.3		19.7	0.0				0.0			0.0	0.0	0.0
LOD3	5.0	3.7	57.0	4.3		22.0	0.0				0.0			0.0	0.0	0.0
LOD4	3.3	0.7	65.0	1.7		23.0	0.0				0.0			0.0	0.0	0.0
LOD5	1.3	0.3	56.0	1.0		37.3	0.0				0.0			0.0	0.0	0.0
LOS5	4.0	0.7	61.7	1.7		26.7	2.7				0.0			0.0	0.0	0.0
LOD5A	6.3	2.7	71.0	0.7		12.7	0.3				0.0			0.0	0.0	0.0
LOD6	7.0	3.0	72.3	0.7		12.3	0.0				0.0			0.0	0.0	0.0
LOD7	2.0	0.0	46.3	1.3		14.0	24.3				0.7			0.0	2.7	0.0
LOD8	0.3	0.0	20.3	1.3		9.3	51.7				2.7			0.0	5.3	0.0
LOD9	1.7	0.0	18.7	2.7		10.0	13.3				9.7			4.3	22.0	0.0
LOD10	0.0	0.3	26.0	1.0		6.3	34.7				8.0			0.0	9.7	4.7
LOK6	0.3	0.3	4.0	0.3		0.0	32.0				12.3			0.0	44.3	0.0

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
LOK7	1.3	1.0	14.7	1.0		10.7	23.3				7.3			5.0	19.7	7.3
LOK8	4.3	0.3	17.3	0.3		1.3	20.7				9.3			6.7	30.0	0.3
LOD11	1.7	0.0	15.7	1.0		5.7	6.7				1.7			35.3	22.0	0.3
LOD12	2.0	0.0	6.7	1.0		4.7	5.0				2.7			59.0	13.7	0.0
LOK11	2.3	0.3	10.7	0.0		3.3	13.3				3.7			32.0	22.7	0.0
LOD13	9.0	3.0	66.7	6.7		7.0	0.0				0.0			0.0	0.0	0.0
LOD14	8.7	3.3	61.3	7.7		10.7	0.3				0.0			0.0	0.0	0.0
LOD15	16.3	2.3	66.3	2.0		6.3	0.0				0.0			0.0	0.0	0.0
LOD16	14.0	3.3	66.7	2.7		2.7	0.0				0.0			0.0	0.0	0.0
LOK15																
LOK16	6.0	0.3	43.0	2.0		18.7	7.3				1.0			0.0	1.3	0.7
LOK17	11.7	0.0	70.7	2.0		10.0	0.3				0.0			0.0	0.0	0.0
LOK20	26.0	3.7	46.3	3.3		12.7	1.3				0.0			0.0	0.0	0.0
LOK21																
LOK22																
LOK23	4.7	2.0	80.0	0.7		4.0	1.3				0.0			0.0	0.0	0.0
LOK24	16.7	1.0	39.3	2.0		21.3	0.0				0.0			0.0	0.0	0.0
LOK25	8.7	4.7	45.3	3.3		24.7	0.0				0.0			0.0	0.0	0.0
LOK26	13.3	2.7	39.3	6.7		22.0	0.0				0.0			0.0	0.0	0.0
LOK27	13.7	1.0	48.0	4.0		19.7	0.0				0.0			0.0	0.0	0.0
LOK28	17.7	3.7	62.3	1.7		4.3	0.7				0.0			0.0	0.0	0.0
LOK29	22.0	9.3	61.0	0.0		1.7	0.0				0.0			0.0	0.0	0.0
LOK30	15.3	3.3	72.7	0.7		0.0	0.7				0.0			0.0	0.0	0.0
LOK31																
LOK32	24.0	2.3	67.3	1.3		2.7	0.0				0.0			0.0	0.0	0.0
LOK33	16.0	1.7	43.7	1.7		23.0	1.7				0.0			0.0	0.0	0.0
LOK34	16.3	2.0	46.3	3.3		16.7	0.7				0.0			0.0	0.0	0.0
LOK35	16.3	2.3	38.0	7.0		29.7	0.0				0.0			0.0	0.0	0.0
LOK36	19.0	1.3	42.3	3.3		29.7	0.3				0.0			0.0	0.0	0.0
LOK37	16.3	2.3	34.3	7.0		33.7	0.0				0.0			0.0	0.0	0.0
LOK38	22.0	3.7	44.7	7.7		15.7	0.3				0.0			0.0	0.0	0.0
LOK39	27.7	1.3	46.0	7.0		15.0	0.0				0.0			0.0	0.0	0.0
LBT1	1.3	0.0	31.0	2.3		5.0	48.0				1.0			1.3	0.3	0.0
LBT2	0.7	0.0	16.3	0.3		5.7	64.0				1.0			0.3	0.0	0.0
LBT3	3.7	0.7	37.0	2.0		27.0	9.0				1.7			0.0	0.0	4.3
LBT4	0.7	0.0	26.7	2.7		24.0	11.7				2.3			0.0	3.3	6.0
LBT5	3.0	0.3	27.3	3.7		22.0	9.0				3.0			0.0	0.3	2.0
LBT6	0.7	0.0	30.7	4.0		24.7	5.0				1.7			0.0	0.0	0.0
LBT7	2.3	0.7	15.3	4.7		52.0	4.0				0.3			0.7	1.3	0.3

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
LBT8	5.0	1.0	27.0	1.0		40.3	5.7				1.0			0.3	0.0	0.0
LBT9	3.0	1.7	29.7	7.0		27.3	5.3				0.0			0.0	0.0	0.0
LBT10	2.7	1.3	27.3	3.7		23.0	3.3				0.3			0.0	0.0	0.0
LBT11	1.7	1.3	22.7	7.0		19.3	3.0				0.3			0.3	0.3	0.0
LBT12	9.7	0.3	57.0	4.0		24.3	0.7				0.0			0.0	0.0	0.0
LBT13	7.3	0.7	59.7	7.3		19.0	2.0				0.0			0.0	0.0	0.0
LBT14	5.7	0.0	58.3	9.7		24.0	0.3				0.0			0.0	0.0	0.0
LBT15	5.0	0.3	29.3	4.3		39.3	3.3				0.0			4.0	1.3	0.7
LBT16	2.3	0.3	17.3	3.7		11.0	3.3				0.0			0.3	0.7	0.0
LBT17	5.7	1.3	44.7	4.3		18.0	7.7				0.0			4.3	0.0	0.3
LBM1	5.3	0.0	22.7	4.3		18.3	9.0				0.0			23.0	6.0	0.0
LBM2	4.0	0.0	29.0	4.7		14.3	5.0				1.0			28.0	3.0	0.3
LBM3	5.0	0.0	64.3	3.7		20.7	1.3				0.3			0.0	0.0	0.0
LBM4	7.0	0.0	53.7	5.0		30.0	2.0				0.0			0.0	0.0	0.0
LBM5	1.3	0.0	24.7	0.7		7.7	13.3				2.3			28.3	2.0	0.0
LBM6	5.0	0.0	48.0	8.0		28.3	4.3				0.3			1.0	0.0	0.0
LBM7	0.0	0.0	8.0	0.0		5.3	26.7				2.7			20.0	0.7	0.0
KBD1	3.0	0.0	49.0	0.7	0.3	18.3	3.0				1.3				6.0	
KBK1	5.7	0.3	45.0	3.3	1.7	33.0	1.7				0.0				0.0	
KBK2																
KBK3	7.3	0.0	59.3	0.0	0.0	23.3	0.0				0.0				0.0	
KBK4																
KBK5																
KBK7	18.0	0.3	52.7	3.0	0.0	19.0	0.0				0.0				0.0	
KBK8																
KBK9	8.3	0.7	54.3	1.0	1.7	10.3	0.0				0.0				0.0	
KBK10																
KBK11																
SB1																
SB4																
SB7																
SB10																
SB14																
SBS2																
SBS4																
SBS5	9.7	3.3	34.3	0.7	0.7	16.3	0.7	13.3			1.3				7.0	1.3
SBU1	7.7	0.0	32.7	1.7	0.7	12.7	1.0	16.7			0.3				9.3	1.7
UOB1	20.3	0.7	35.0	0.7	1.0	13.7	1.3	9.3			0.0				2.7	0.3
UOB2	18.0	0.3	31.3	0.7	1.0	12.3	2.0	7.0			0.0				12.0	0.0

Appendix III: Simple percentages of the palynomorph count categories

Key to abbreviations used in column headers (parameters all percentages based on 300 counts per sample):

SAMNO	= sample number
%TNWS	= thin-walled spores
%TKWS	= thick-walled spores
%UPOL	= unidentified pollen
%CALL	= *Callialasporites*
%CEREB	= *Cerebropollenites*
%BISAC	= bisaccates
%UDIN	= unidentified dinocysts
%SMD	= very poorly preserved dinocysts
%NAN	= *Nannoceratopsis*
%CAD	= *Caddasphaera*
%BAT	= *Batiacasphaera*
%PRV	= *Parvocysta*
%DIS	= *Dissiliodinium*
%CTE	= *Ctenidodinium*
%DUR	= *Durotrigia*
%MEI	= *Meiurogonyaulax*
%G.T.	= other gonyaulacacean dinocysts
%PAR	= *Pareodinia*
%SEN	= *Sentusidinium*
%JMAN	= *Jansonia manifesta*
%RHY	= *Rhychodiniopsis*
%ADNAT	= *Adnatosphaeridium*
%DIN	= total dinocysts
%AC	= acritarchs
%TAS	= *Tasmanites*-type prasinophytes
%LEI	= leiospheres
%BOT	= *Botryococcus*
%UNDIF	= undifferentiated

Blank rows represent samples not counted for palynology, blank columns mean that the category was not counted in that formation (particularly common in the dinocyst categories that are often formation specific).

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
UOB3	13.7	0.7	26.7	0.3	6.0	18.0	1.7	3.3			0.0				5.0	0.3
UOB4	29.0	1.0	22.0	1.0	4.7	27.0	2.0	5.0			0.0				2.3	0.3
UOB5	10.3	0.0	16.0	5.0	1.0	26.3	3.7	20.0			0.7				4.7	3.7
UOB6	10.3	1.0	20.7	4.7	0.3	17.3	4.7	18.7			0.3				6.7	0.7
UOB7	12.0	0.3	29.7	2.0	0.0	17.7	4.7	15.0			0.3				6.3	0.0
UOB8	10.3	0.0	29.0	4.0	0.3	18.0	8.7	10.3			1.3				3.7	1.7
UOB9	13.3	0.3	22.0	10.3	0.7	26.0	6.0	6.7			0.7				1.3	0.3
UOB10	13.0	0.7	20.0	12.7	0.3	22.0	4.7	6.7			0.7				4.3	0.3
UOB11	18.7	0.7	35.7	7.7	0.0	25.7	1.7	5.0			0.0				1.0	0.0
UOB12	23.0	0.7	30.3	4.3	0.3	26.3	0.3	6.0			0.0				1.7	0.0
UOB13	24.0	0.7	26.7	6.7	0.3	18.0	0.7	7.0			0.0				5.7	0.0
UOB14	7.3	0.7	30.3	0.3	6.0	20.0	2.7	10.7			0.0				1.7	0.0
UOB15	17.7	1.0	45.3	0.7	2.7	12.0	7.3	3.7			0.0				1.7	0.0
UOB16	28.3	1.0	42.3	2.3	3.3	10.3	1.7	2.7			0.3				1.7	0.3
UOB17	22.0	0.0	41.3	2.3	3.3	18.3	2.3	3.3			0.3				1.3	0.0
UOB18	24.3	0.0	50.3	1.7	3.0	10.0	1.7	2.3			0.3				1.3	0.0
UOB19	22.0	0.0	52.7	2.0	2.0	9.0	2.0	2.3			0.3				2.0	1.0
UOB20	14.7	1.7	53.3	1.3	3.0	19.3	1.0	1.7			0.3				0.7	0.3
UOB21	25.3	0.0	47.7	1.7	4.0	13.7	1.0	2.3			0.3				0.7	0.0
UOB22	22.3	1.0	35.0	1.3	3.3	13.0	3.3	3.7			0.3				3.3	0.0
UOB23	9.3	0.0	40.7	0.7	5.3	14.3	4.0	3.0			0.0				3.7	0.3
UOB24																
UOB25	11.0	0.3	38.7	2.3	4.3	11.3	6.0	4.0			0.0				5.3	0.0
UOB26	14.0	0.3	52.3	1.0	0.7	13.0	1.7	6.3			0.0				1.7	0.0
UOB27	13.3	0.7	40.7	0.0	4.0	19.7	2.0	7.3			0.0				3.7	0.0
UOB28	15.7	0.0	37.7	0.7	2.3	20.3	3.0	9.3			0.3				3.3	0.0
UOB29	21.3	0.0	46.0	1.3	1.0	9.3	3.3	4.7			0.0				1.0	0.3
UOB30	9.3	1.0	36.7	1.0	1.3	21.0	1.7	2.3			0.3				1.0	0.0
UOB31																
UOB32	10.7	0.0	32.0	0.7	3.7	18.0	0.7	5.3			0.3				4.0	0.0
UOB33	14.3	0.0	41.3	2.3	0.7	18.7	2.7	2.0			0.3				0.7	0.0
UOB34	19.0	0.3	33.0	0.3	10.0	22.7	1.0	2.0			0.0				0.3	0.0
UOB35	19.7	0.3	29.7	0.0	12.3	19.0	2.0	5.3			0.3				0.7	0.0
UOB36	18.0	0.3	32.0	0.7	5.0	21.7	1.7	8.7			0.0				3.7	0.0
UOB37	14.7	0.0	29.0	1.7	11.7	23.3	2.3	9.3			0.0				1.3	0.0
BS1	12.0	0.7	39.0	1.7	5.0	18.7	2.3	9.0			0.0				1.3	0.0
BS2	16.7	1.3	32.7	1.3	4.0	19.0	0.3	9.3			0.3				3.3	0.0
BS3	10.7	1.0	42.0	0.7	4.7	23.3	0.0	3.0			0.7				0.0	0.0
BS4	16.0	0.3	34.3	1.3	6.3	16.3	2.0	4.0			0.0				3.3	0.0

SAMNO	%TNWS	%TKWS	%UPOL	%CALL	%CEREB	%BISAC	%UDIN	%SMD	%NAN	%CAD	%BAT	%PRV	%DIS	%CTE	%DUR	%MEI
BS5	13.7	0.0	40.0	0.3	6.7	18.0	2.0	2.0			0.0				1.3	0.0
BS6	11.3	0.0	31.3	1.0	3.0	14.0	2.0	10.3			0.0				7.0	0.3
BS7																
BS8																
BS9																
BS10	16.7	0.0	34.0	0.0	6.0	13.3	0.7	6.0			0.7				3.3	0.0
BS11	13.3	0.0	33.7	1.7	5.3	15.3	1.0	8.3			0.3				0.3	1.0
BS12	20.0	0.0	40.3	1.7	8.0	17.0	0.7	4.7			0.0				2.3	0.0
BS13	26.7	0.0	33.3	0.7	3.0	18.7	1.0	3.0			0.3				1.7	0.3
BS14	10.0	0.3	40.7	1.3	3.7	16.0	3.0	4.7			0.0				2.7	0.0
BS15	7.7	0.0	49.0	1.3	1.7	25.3	0.7	1.3			0.0				1.3	0.0

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
BBE1							3.3	0.3	0.0	0.0	0.0	6.3
BBE2												
BBE3												
BBE4							3.3	1.7	0.0	0.0	0.3	3.7
BBE5												
BBE6							1.7	2.3	0.0	0.0	0.0	4.7
BBE7												
BBE8												
BBE9							5.0	2.7	0.0	0.0	0.0	2.3
BBE10												
BBE11							3.3	1.0	0.0	0.0	0.7	3.7
BBE12												
BBE13												
BBE14							3.0	1.0	0.0	0.0	0.7	4.7
BBE15												
BBE16												
BBE17							4.7	0.7	0.0	0.0	0.0	5.7
BBE18							1.3	0.3	0.0	0.0	0.0	5.7
BBE19							0.7	1.3	0.0	0.0	0.0	5.3
BBE20							3.0	1.3	0.0	0.0	0.0	4.0
BBE21							5.7	1.3	0.0	0.0	C.3	4.7
BBE22							3.0	0.3	0.0	0.0	0.0	5.0
BBE23							3.3	0.3	0.0	0.0	0.0	4.0
BBE24							2.3	1.0	0.0	0.0	0.0	4.3
BBE25							3.7	0.7	0.0	0.0	0.3	5.3
BBE26							2.3	0.3	0.0	0.0	0.0	4.7
BBE27							3.0	0.3	0.0	0.0	0.0	5.3
BBE28							3.7	0.0	0.0	0.0	0.0	4.7
BBE29							3.0	0.3	0.0	0.0	0.0	4.7
BBE30							3.3	0.3	0.0	0.0	0.0	4.3
BBE31							2.0	0.7	0.0	0.0	0.0	4.7
BBE32							2.7	0.3	0.0	0.0	0.3	5.3
BBE33							1.7	0.0	0.0	0.0	0.0	4.0
BBE34							1.3	0.7	0.0	0.0	0.0	4.0
BBE35							1.3	0.3	0.0	0.0	0.0	3.7
BBE36							1.3	0.0	0.0	0.0	0.0	4.0
BBE37							6.7	0.3	0.0	0.0	0.0	4.7
BBE38							6.3	0.0	0.0	0.0	0.0	3.7
BBE39							5.7	0.0	0.0	0.0	0.0	4.3

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
BBE40							4.0	1.0	0.0	0.0	0.0	4.7
BBE41							5.7	0.0	0.0	0.0	0.7	6.3
BBE42							5.3	0.7	0.0	0.0	0.0	3.7
BBE43							3.7	0.7	0.0	0.0	0.3	4.3
BBE44							3.7	0.7	0.0	0.0	0.3	4.0
BBE45							4.7	0.7	0.0	0.0	0.0	4.0
BBE46							1.3	0.0	0.0	0.0	0.3	3.3
BBE47							1.0	0.0	0.0	0.0	0.0	3.7
BBE48							2.0	0.3	0.0	0.0	0.3	4.0
BBE49												
BBO1							4.7	0.3	0.0	0.0	0.0	5.7
BBO2							6.0	0.0	0.0	0.0	0.0	6.0
BBU1							2.3	0.7	0.0	0.0	0.0	5.3
BBU2							4.0	1.0	0.3	0.0	0.0	6.0
BBU3							2.3	0.3	0.0	0.0	0.3	6.7
BBU4							5.3	0.0	0.0	0.0	0.0	6.0
BBU5							4.0	0.3	0.3	0.0	0.0	4.7
BBU6							3.7	0.0	0.0	0.0	1.3	7.0
BBU7							5.7	0.3	0.0	0.0	0.7	5.0
BBU8							3.7	0.0	0.0	0.0	0.3	3.3
BBU9							5.0	0.3	0.0	0.0	0.0	5.7
BBU10							4.0	0.0	0.0	0.0	0.0	3.7
BBU11							4.0	0.7	0.0	0.0	0.7	7.3
BBU12							2.3	0.0	0.0	0.0	0.0	5.3
BBU13							5.3	0.0	0.0	0.0	0.0	6.3
BBU14							3.3	0.7	0.0	0.0	0.3	6.3
BBU15							2.7	0.3	0.0	0.0	0.0	4.0
BBU16							3.3	0.0	0.0	0.0	0.0	3.3
BBU17							3.0	0.3	0.0	0.0	0.0	4.7
BBU18							1.7	0.3	0.0	0.0	0.0	4.3
BBU19							4.3	0.3	0.0	0.0	0.0	5.0
BBU20							2.3	0.3	0.0	0.0	0.3	4.0
BBU21							5.7	0.7	0.0	0.0	0.0	4.3
BBU22							4.0	0.3	0.0	0.0	0.0	4.0
BBU23							4.0	0.0	0.0	0.0	0.0	4.3
BBU24							1.3	0.0	0.0	0.0	0.0	4.3
BBU25							1.7	0.0	0.0	0.0	0.0	5.0
BBU26							1.0	0.0	0.0	0.0	0.3	3.7
BBU27							2.7	0.0	0.0	0.0	0.0	6.3

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
BBU28							2.0	0.0	0.0	0.0	0.0	5.0
BBU29							1.0	0.7	0.0	0.0	0 0	7.3
BBU30							2.3	0.0	0.0	0.0	0.0	8.0
BBH1							4.0	0.0	0.3	0.0	0.3	7.0
BBH2							3.3	0.3	0.0	0.0	0.0	6.0
BBH3							2.3	0.0	0.0	0.0	0.0	5.0
BBH4							1.0	0.3	0.0	0.0	0.3	3.7
BBH5							1.0	0.0	0.0	0.0	0.0	4.0
BBH6							2.3	0.0	0.0	0.0	0.3	5.3
BBH7							1.3	0.3	0.0	0.0	0.0	4.0
BBH8							1.7	0.0	0.0	0.0	0.0	5.0
BBH9							1.0	0.3	0.3	0.0	0.0	4.7
BBH10							1.0	0.0	0.0	0.0	0.0	4.0
BBH11							2.0	0.0	0.0	0.0	0.0	5.7
BBH12												
BBR1												
BBR2							5.0	0.0	0.0	0.0	0.0	7.0
BBR3												
BBR4												
BBR13							1.7	0.0	0.0	0.0	0.0	9.0
BBR14												
BBR15												
BBR16												
BBR17												
BBR18							1.7	0.0	0.0	0.0	0.0	7.3
BBR19												
BBR5							2.0	0.3	0.0	0.0	0.0	8.7
BBR6												
BBR7												
BBR8							1.0	0.7	0.0	0.0	0.0	9.7
BBR9												
BBR10												
BBR11							5.7	1.7	0.0	0.0	0.0	5.0
BNL17												
BNL16							8.3	1.0	0.0	0.0	0.0	2.0
BNL1												
BNL2							6.3	1.0	0.0	0.0	0.0	2.3
BNL3												
BNL4												

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
BNL5							3.7	0.7	0.0	0.0	0.0	1.3
BNL6												
BNL7												
BNL8												
BNL9							6.3	1.0	0.0	0.0	0.0	1.7
BNL10							5.7	1.0	0.0	0.0	0.0	2.7
BNL11												
BNL12												
BNL13							6.0	1.0	0.0	0.0	0.0	3.3
BNL15												
RGC1		0.0					9.0	0.0	0.0	0.0	0.0	7.0
RGC2												
RGC3												
RGC4		0.0					7.7	0.0	0.0	0.0	0.0	7.7
RCS1		1.0					8.0	0.7	0.0	0.0	13.7	3.7
RCS2		1.3					5.3	0.0	0.0	0.0	16.7	2.7
RCS3		0.7					4.7	1.3	0.0	0.0	16.0	2.0
RCS4												
RCS5		0.7					4.7	0.7	0.3	0.0	27.7	3.0
RCS6		0.3					3.0	0.3	0.0	0.0	21.0	2.7
RCS7		0.0					1.7	0.0	0.0	0.0	19.3	2.0
RCS8		0.0					1.0	0.0	0.0	0.0	20.0	0.7
RCS9		0.0					2.0	0.7	0.3	0.0	16.0	1.0
RCS10		0.7					4.3	0.7	0.0	0.0	19.3	2.7
RCS11		0.0					1.3	0.0	0.0	0.0	22.3	0.7
RCS12		0.0					0.7	0.0	0.0	0.0	19.0	1.0
RCS13		0.0					3.0	0.7	0.0	0.0	13.0	1.7
RCS14		0.0					2.7	0.0	0.0	0.0	14.0	2.7
RCS15		0.0					2.7	0.0	0.0	0.0	16.0	3.0
KE26		0.0	0.0				1.0	1.3	0.0	0.0	23.3	1.0
KE27		0.0	0.0				0.0	0.3	0.0	0.0	43.7	2.0
KE28		0.0	0.0				0.3	0.7	0.0	0.0	23.3	1.0
KE29		0.0	0.0				0.0	0.0	0.0	0.0	20.7	1.3
KE30		0.0	0.0				0.0	0.3	0.0	0.0	39.0	3.0
KE31		0.0	0.0				0.0	0.3	0.0	0.0	51.7	2.3
KE32		0.0	0.0				0.0	0.0	0.0	0.0	22.0	10.3
KE33		0.0	0.0				0.3	0.7	0.0	0.0	22.0	2.3
KE34		0.0	0.0				0.3	2.7	0.0	0.0	31.7	1.3
KE35		0.0	0.0				0.0	0.3	0.0	0.0	29.3	0.3

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
KE36		0.3	0.0				0.7	0.0	0.3	0.0	26.0	0.7
KE37		0.0	0.0				0.0	0.7	0.0	0.0	19.3	3.0
KE38		0.0	0.0				0.3	0.3	0.0	0.0	16.0	2.3
KE39		0.0	0.0				0.0	0.0	0.0	0.0	12.7	3.3
KE40		0.0	0.0				0.0	0.0	0.0	0.0	11.0	2.0
KE41		0.0	0.0				0.0	1.0	0.0	0.0	16.7	2.3
KE42		0.0	0.0				1.0	0.7	0.0	0.0	14.7	3.0
KE43		0.0	0.0				0.3	1.0	0.0	0.0	14.0	2.7
KE44		0.0	0.0				0.0	14.7	0.0	0.0	19.0	3.3
KE45		0.0	0.0				0.0	3.3	0.0	0.0	11.0	2.0
KE46		0.0	0.0				0.0	5.3	0.0	0.0	30.3	2.0
KE47		0.0	0.0				1.0	5.7	0.0	0.0	20.7	2.0
KE48		0.0	0.0				0.0	5.3	0.0	0.0	17.3	1.7
KE49		0.0	0.0				0.7	1.7	0.0	0.0	6.7	6.3
KE50		0.0	0.0				0.0	16.0	0.0	0.0	25.3	3.0
KE51		0.0	0.0				0.0	5.3	0.0	0.0	30.3	1.3
KE52		0.0	0.0				0.0	4.7	0.0	0.0	19.3	2.0
KE53		0.0	0.0				0.0	0.7	0.0	0.0	13.7	2.3
KE54		0.0	0.0				1.0	4.7	0.0	0.0	20.3	2.0
KE55		0.0	0.0				0.0	3.3	0.0	0.0	10 7	2.3
KE56												
KE57		0.0	0.0				0.0	0.0	0.0	0.0	11.0	0.3
KE58		0.0	0.0				0.0	0.7	0.0	0.0	7.7	0.7
KE1		0.0	0.0				0.3	0.3	0.0	0.0	6.0	1.3
KE2		0.0	0.0				0.3	0.0	0.0	0.0	8.7	1.3
KE3		0.3	0.0				2.0	0.0	0.0	0.0	4.0	1.3
KE4		0.7	0.0				32.0	0.0	0.0	0.0	4.3	11.3
KE5		0.0	0.0				62.0	0.0	0.0	0.0	4.3	4.0
KE6		0.7	0.0				9.3	0.0	0.0	0.0	7.3	2.3
KE7		0.0	0.0				3.3	1.0	0.0	0.0	14.3	1.7
KE8		0.3	0.0				18.0	0.0	0.0	0.0	12.3	3.3
KE9		0.3	0.0				14.0	0.0	0.0	0.0	17.3	1.3
KE10		0.0	0.3				10.7	0.0	0.0	0.0	26.3	1.3
KE11		0.0	0.0				5.3	0.0	0.0	0.0	34.3	2.7
KE12		0.0	0.0				23.3	0.0	0.0	0.0	5.0	4.0
KE13		0.0	0.7				5.3	4.0	0.0	0.0	30.0	1.0
KE14		0.0	0.0				0.3	8.7	0.0	0.0	48.0	3.3
KE15		0.0	0.0				0.7	11.3	0.0	0.0	43.7	2.3
KE16		0.0	0.0				0.0	2.0	0.0	0.0	17.3	1.0

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
KE17		1.0	0.0				3.0	2.7	0.0	0.0	13.7	2.3
KE18		0.0	0.0				0.0	0.0	0.0	0.0	11.7	0.7
KE19		0.0	0.0				0.0	0.0	0.0	0.0	11.7	0.0
KE20		0.0	0.0				0.0	0.0	0.0	0.0	9.7	0.0
KE21		0.0	0.0				0.7	14.7	0.0	0.0	30.0	4.3
KE22		0.0	0.0				0.3	23.0	0.0	0.0	19.7	4.0
KE23		0.3	0.0				1.0	19.7	0.0	0.0	7.3	2.3
KE24		0.0	0.0				0.0	3.3	0.0	0.0	7.0	1.0
KE25		0.0	0.0				0.0	0.0	0.0	0.0	6.0	0.7
RNB1		0.0	0.0				0.7	0.0	0.0	0.0	48.7	1.0
RNB2		0.0	0.0				0.7	1.3	0.0	0.0	72.0	2.3
RNB3		0.0	0.0				1.0	1.0	0.0	0.0	51.3	2.0
RNB4		0.0	0.3				2.3	0.3	0.0	0.0	56.7	1.3
RNB5		0.3	0.0				2.7	1.3	0.0	0.0	53.7	2.0
RNB6		0.0	0.0				5.3	0.3	0.0	0.0	31.7	6.7
RNB7		0.0	0.0				1.7	0.0	0.0	0.0	30.3	3.7
RNB8		0.0	0.0				4.0	0.0	0.0	0.0	47.0	2.3
RNB9		0.0	0.0				0.0	0.3	0.0	0.0	79.3	1.3
RNB10		0.0	0.0				3.0	1.3	0.0	0.0	39.3	1.7
RNB11		0.0	0.0				1.3	8.0	0.0	0.0	17.7	1.7
RNB12		0.3	0.0				0.3	1.0	0.0	0.0	29.0	1.3
RNB13		0.0	0.0				1.0	0.0	0.0	0.0	27.0	0.7
RNB14		0.0	0.0				1.3	0.0	0.0	0.0	20.0	1.7
RNB15		0.0	0.0				1.0	5.0	0.0	0.0	24.7	1.3
RNB16		0.0	0.0				1.0	2.7	0.0	0.0	23.0	1.3
RNB17												
RNB18		0.0	0.0				0.3	0.0	0.0	0.0	31.3	0.0
RNB19		0.0	0.0				0.3	0.0	0.0	0.0	10.7	1.3
RNB20		0.0	0.0				0.0	0.0	0.0	0.0	22.7	0.3
VS2							0.0	0.0	0.0	0.0	22.3	2.3
VS3							0.0	0.0	0.0	0.0	18.0	1.7
VS4							0.0	0.0	0.0	0.0	18.7	1.0
VS5												
VS7												
VS8							0.0	0.0	0.0	0.0	16.0	0.3
VS9												
CGD1												
CGD2												
CGD3												

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
CGD4												
CGD5												
CGD6												
CGD7												
CGD8												
CGD9												
CGD10												
CGD11		0.0	0.0				7.3	0.0	0.0	0.0	0.0	8.3
CGD12												
CGD13												
CGD14												
CGD15												
CGD16												
CGD17												
CGD18												
CGD19												
CGD20		0.0	0.0				22.7	0.0	0.0	0.0	0.3	3.3
CGD21												
CGD23		0.0	0.0				20.7	0.3	0.0	0.0	0.7	6.0
CGD24		2.0	5.0				64.7	0.0	0.0	0.0	0.0	2.7
CGD25		3.3	4.0				54.0	0.0	0.0	0.0	0.0	1.7
CGD26		11.3	15.0				51.0	0.0	0.0	0.0	0.0	2.3
CGD27		15.7	10.0				53.3	0.3	0.0	0.0	1.0	1.7
CGD28		15.3	19.3				73.7	0.0	0.0	0.0	1.0	2.7
CGD29		8.0	14.7				37.0	0.0	0.0	0.0	0.0	6.0
CGD30		7.0	7.3				30.0	0.0	0.0	0.0	1.0	3.7
CGD31		18.0	2.7				40.3	0.0	0.0	0.0	0.0	5.3
CGD32		14.3	2.3				28.0	0.0	0.0	0.0	0.3	3.7
CGD33		4.0	8.0				24.3	0.0	0.0	0.0	0.3	0.7
CGD34		4.7	12.0				42.7	0.3	0.0	0.0	0.0	4.0
CGD35		7.0	12.7				58.7	0.0	0.0	0.0	0.0	4.3
CGD36		4.3	7.7				55.3	0.0	0.0	0.0	0.0	4.7
CGD37		2.3	10.0				47.7	0.0	0.0	0.0	0.3	3.3
CGD38		1.7	1.3				16.0	0.0	0.0	0.7	1.0	3.0
CGD39		1.0	2.7				25.3	0.0	0.0	0.7	0.3	2.7
CGD40		1.3	4.7				22.7	0.0	0.0	0.0	0.7	1.3
CGD41		1.0	13.3				46.0	0.0	0.0	0.0	0.0	2.0
CGD42		3.0	16.0				53.0	0.0	0.0	0.0	0.0	3.3
CGD43		1.3	14.7				47.7	1.3	0.0	0.0	0.0	4.3

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
CGD44		5.7	14.7				38.7	0.0	0.0	0.0	0.0	3.7
CGD45		3.0	15.0				40.3	0.0	0.0	0.0	0.0	3.3
CGD46		0.3	18.3				44.7	0.0	0.0	0.0	0.0	4.3
CGD47		1.3	12.0				35.7	0.3	0.0	0.0	0.0	4.3
CGD48		2.0	8.7				43.7	2.7	0.0	0.3	0.0	4.0
CGD49		0.3	5.3				26.7	0.7	0.0	0.0	0.0	7.0
CGD50		0.0	0.0				1.0	0.0	0.0	0.0	0.7	2.0
CGD51		0.0	1.7				4.0	0.0	0.0	0.0	0.0	3.7
CGD52		2.3	1.3				10.7	0.0	0.0	0.0	1.0	5.7
CGD53		13.7	6.0				56.7	0.0	0.0	0.0	0.3	2.3
CGD54		18.3	9.7				65.0	0.0	0.0	0.0	0.0	4.0
CGD55		11.3	11.0				67.3	0.0	0.0	0.0	0.3	3.3
CGD56		7.0	7.0				66.3	0.0	0.0	0.0	0.0	5.3
CGD57		7.0	10.0				70.7	0.0	0.0	0.0	0.3	5.0
CGD58		6.3	7.7				63.3	0.0	0.0	0.3	0.3	6.0
CGD59		3.0	7.7				38.0	0.0	0.0	0.0	1.0	4.7
CGD60		2.3	8.0				37.0	0.0	0.0	0.0	0.7	4.7
CGD61		0.7	4.3				37.7	0.0	0.3	0.0	0.0	3.3
CGD62		2.0	8.3				45.0	0.3	0.0	0.7	0.7	4.7
CGD63		2.0	9.7				58.7	0.0	0.0	0.0	0.0	4.3
CGD64		1.0	13.0				54.0	0.0	0.0	0.0	0.0	3.3
CGD65		1.0	10.3				51.3	0.0	0.0	0.0	0.0	4.7
CGD66		0.0	0.0				9.7	0.0	0.0	0.0	0.3	1.0
CGD67		3.7	5.7				35.7	0.0	0.0	0.0	0.0	5.3
CGD68		4.3	2.0				31.0	0.0	0.0	0.0	0.0	3.0
LOD1*												
LOS4		0.0	0.0				0.0	0.0	0.0	0.0	4.3	1.3
LOD2		0.0	0.0				0.0	0.0	0.0	0.0	7.3	2.7
LOD3		0.0	0.0				0.0	0.0	0.0	0.0	5.7	2.3
LOD4		0.0	0.0				0.0	0.0	0.0	0.0	3.3	3.0
LOD5		0.0	0.0				0.0	0.0	0.0	0.0	1.7	2.3
LOS5		0.0	0.0				2.7	0.0	0.0	0.0	0.3	2.3
LOD5A		0.0	0.0				0.3	0.0	0.0	0.0	2.7	3.7
LOD6		0.0	0.0				0.0	0.0	0.0	0.0	3.0	2.0
LOD7		4.3	0.0				32.0	0.0	0.0	0.0	0.0	4.3
LOD8		4.3	1.3				65.3	0.0	0.0	0.0	0.0	3.3
LOD9		8.3	4.0				61.7	0.0	0.0	0.0	0.3	5.0
LOD10		3.3	1.7				62.0	0.0	0.0	0.0	0.0	4.3
LOK6		2.0	3.0				93.7	0.0	0.0	0.0	0.0	1.3

Appendix III: Simple percentages of the palynomorph count categories

Key to abbreviations used in column headers (parameters all percentages based on 300 counts per sample):

SAMNO = sample number
%TNWS = thin-walled spores
%TKWS = thick-walled spores
%UPOL = unidentified pollen
%CALL = *Callialasporites*
%CEREB = *Cerebropollenites*
%BISAC = bisaccates
%UDIN = unidentified dinocysts
%SMD = very poorly preserved dinocysts
%NAN = *Nannoceratopsis*
%CAD = *Caddasphaera*
%BAT = *Batiacasphaera*
%PRV = *Parvocysta*
%DIS = *Dissiliodinium*
%CTE = *Ctenidodinium*
%DUR = *Durotrigia*
%MEI = *Meiurogonyaulax*
%G.T. = other gonyaulacacean dinocysts
%PAR = *Pareodinia*
%SEN = *Sentusidinium*
%JMAN = *Jansonia manifesta*
%RHY = *Rhychodiniopsis*
%ADNAT = *Adnatosphaeridium*
%DIN = total dinocysts
%AC = acritarchs
%TAS = *Tasmanites*-type prasinophytes
%LEI = leiospheres
%BOT = *Botryococcus*
%UNDIF = undifferentiated

Blank rows represent samples not counted for palynology, blank columns mean that the category was not counted in that formation (particularly common in the dinocyst categories that are often formation specific).

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
LOK7		0.3	0.7				63.7	0.0	0.0	0.0	0.7	7.0
LOK8		2.3	1.7				71.0	0.0	0.0	0.0	0.0	5.3
LOD11		7.7	0.0				73.7	0.0	0.0	0.0	0.0	2.3
LOD12		3.0	0.0				83.3	0.0	0.0	0.0	0.0	2.3
LOK11		8.0	1.3				81.0	0.0	0.0	0.0	0.0	2.3
LOD13		0.0	0.0				0.0	0.0	0.0	0.0	6.3	1.3
LOD14		0.0	0.0				0.3	0.0	0.0	0.0	6.7	1.3
LOD15		0.7	0.0				0.7	0.0	0.0	0.0	5.7	0.3
LOD16		0.0	0.0				0.0	0.0	0.0	0.0	5.3	5.3
LOK15												
LOK16		6.0	0.0				16.3	1.0	0.0	0.3	1.0	8.0
LOK17		0.0	0.0				0.3	0.0	0.0	0.0	2.7	2.7
LOK20		1.3	0.0				2.7	0.0	0.0	0.0	2.0	3.3
LOK21												
LOK22												
LOK23		0.0	0.0				1.3	0.0	0.0	0.0	2.7	4.7
LOK24		0.0	0.0				0.0	0.0	0.0	0.0	18.0	1.7
LOK25		0.0	0.0				0.0	0.0	0.0	0.0	12.3	1.0
LOK26		0.0	0.0				0.0	0.0	0.0	0.0	14.0	2.0
LOK27		0.0	0.0				0.0	0.0	0.0	0.0	13.0	0.7
LOK28		0.3	0.0				1.0	0.0	0.0	0.0	8.0	1.3
LOK29		0.0	0.0				0.0	0.3	0.0	0.0	5.3	0.3
LOK30		0.0	0.0				0.7	0.0	0.0	0.0	0.7	6.7
LOK31												
LOK32		0.0	0.0				0.0	0.0	0.3	0.0	1.3	0.7
LOK33		0.3	0.0				2.0	0.0	0.0	0.0	9.7	2.3
LOK34		0.3	0.0				1.0	0.0	0.0	0.0	11.7	2.7
LOK35		0.0	0.0				0.0	0.0	0.0	0.0	6.3	0.3
LOK36		0.0	0.0				0.3	0.0	0.0	0.0	2.3	1.7
LOK37		0.0	0.0				0.0	0.0	0.0	0.0	4.3	2.0
LOK38		0.0	0.0				0.3	0.0	0.0	0.0	4.7	1.3
LOK39		0.0	0.0				0.0	0.0	0.0	0.0	2.0	1.0
LBT1		1.0	0.7				52.3	0.0	0.0	0.0	1.3	6.7
LBT2		3.0	0.3				68.7	0.0	0.0	0.0	1.3	7.0
LBT3		9.7	0.7				25.3	0.0	0.0	0.0	0.7	3.7
LBT4		14.3	1.3				39.0	0.0	0.0	0.0	2.0	5.0
LBT5		14.0	8.3				36.7	0.0	0.0	0.0	3.0	4.0
LBT6		27.3	0.7				34.7	0.0	0.0	0.0	1.3	4.0
LBT7		11.7	3.3				21.7	0.0	0.0	0.0	0.3	3.0

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
LBT8		8.0	6.3				21.3	0.0	0.0	0.0	0.7	3.7
LBT9		21.7	0.3				27.3	0.3	0.0	0.0	0.0	3.7
LBT10		33.7	0.0				37.3	0.0	0.0	0.0	0.3	4.3
LBT11		38.7	0.3				43.0	0.0	0.0	0.0	0.3	4.7
LBT12		0.7	0.0				1.3	0.0	0.0	0.0	0.7	2.7
LBT13		0.0	0.0				2.0	0.0	0.0	0.0	2.3	1.7
LBT14		0.0	0.0				0.3	0.0	0.0	0.0	0.7	1.3
LBT15		8.3	1.0				18.7	0.0	0.0	0.0	C.3	2.7
LBT16		59.0	0.0				63.3	0.0	0.0	0.0	0.0	2.0
LBT17		5.0	2.7				20.0	0.0	0.0	0.0	1.3	4.7
LBM1		4.0	4.0				46.0	0.0	0.0	0.0	0.0	3.3
LBM2		4.0	2.7				44.0	0.0	0.0	0.0	0.7	3.3
LBM3		0.0	0.0				1.7	0.0	0.0	0.0	2.7	2.0
LBM4		1.3	0.0				3.3	0.0	0.0	0.0	0.3	0.7
LBM5		11.0	5.3				62.3	0.3	0.0	0.0	0.3	2.7
LBMЄ		1.0	1.3				8.0	0.0	0.0	0.0	0.3	2.3
LBM7		8.0	26.7				84.7	0.7	0.0	0.0	0.0	1.3
KBD1		7.3					17.7	0.0	0.0	0.0	0.3	10.7
KBK1		3.0					4.7	0.0	0.0	0.0	3.0	3.3
KBK2												
KBK3		0.0					0.0	0.0	0.0	0.0	8.3	1.7
KBK4												
KBK5												
KBK7		0.0					0.0	0.0	0.3	0.0	5.3	1.3
KBK8												
KBK9		0.0					0.0	0.0	0.0	0.0	22.0	1.7
KBK10												
KBK11												
SB1												
SB4												
SB7												
SB10												
SB14												
SBS2												
SBS4												
SBS5	1.3	0.0					25.0	0.0	0.0	0.0	0.7	9.3
SBU1	11.3	1.0					41.3	0.0	0.0	0.0	0.0	3.3
UOB1	1.7	0.3					15.7	0.0	0.0	0.0	4.7	8.3
UOB2	3.7	0.7					25.3	0.0	0.0	0.0	0.3	10.7

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
UOB3	1.0	2.0					13.3	0.0	0.0	0.0	14.0	7.3
UOB4	0.0	1.3					11.0	0.0	0.0	0.0	0.3	4.0
UOB5	1.7	0.3					34.7	0.7	0.0	0.0	0.0	6.0
UOB6	7.0	0.7					38.7	0.0	0.0	0.0	0.0	7.0
UOB7	4.7	0.7					31.7	0.0	0.0	0.0	1.3	5.3
UOB8	5.0	0.7					31.3	0.7	0.0	0.0	2.0	4.3
UOB9	7.3	0.0					22.3	0.3	0.0	0.0	2.3	2.3
UOB10	8.3	0.7					25.7	1.0	0.0	0.0	1.7	3.0
UOB11	0.0	0.0					7.7	0.0	0.0	0.0	0.0	4.0
UOB12	0.0	3.3					11.3	0.3	0.0	0.0	0.0	3.3
UOB13	0.0	7.0					20.3	0.0	0.0	0.0	0.0	3.3
UOB14	0.3	15.0					30.3	0.3	0.0	0.0	0.3	4.3
UOB15	1.3	4.0					18.0	0.0	0.0	0.0	0.3	2.3
UOB16	0.7	2.3					9.7	0.0	0.0	0.0	0.3	2.3
UOB17	0.7	3.3					11.3	0.0	0.0	0.0	1.0	0.3
UOB18	1.0	1.0					7.7	0.3	0.0	0.0	1.0	1.7
UOB19	0.3	2.0					10.0	0.0	0.0	0.0	0.3	2.0
UOB20	0.0	0.0					4.0	0.0	0.0	0.0	1.3	1.3
UOB21	0.3	0.0					4.7	0.0	0.0	0.0	0.7	2.3
UOB22	4.0	6.0					20.7	0.0	0.0	0.0	0 3	3.0
UOB23	0.3	8.7					20.0	0.3	0.0	0.0	2.7	6.7
UOB24												
UOB25	1.3	4.0					20.7	0.3	0.0	0.0	5.3	5.7
UOB26	0.7	4.0					14.3	0.0	0.0	0.0	0.7	3.7
UOB27	1.3	1.7					16.0	0.0	0.0	0.0	0.0	5.7
UOB28	1.7	1.0					18.7	0.0	0.0	0.0	0.3	4.3
UOB29	1.3	0.3					11.0	0.0	0.0	0.0	2.3	7.7
UOB30	2.3	12.3					20.0	0.3	0.0	0.0	6.0	3.3
UOB31												
UOB32	5.0	15.3					30.7	0.0	0.0	0.0	1.3	3.0
UOB33	1.3	4.3					11.3	0.0	0.0	0.0	1.3	10.0
UOB34	1.3	1.0					5.7	0.0	0.0	0.0	7.0	2.0
UOB35	1.3	4.0					13.7	0.3	0.0	0.0	2.3	2.7
UOB36	2.7	2.0					18.7	0.0	0.0	0.0	2.0	1.7
UOB37	3.3	0.0					16.3	0.0	0.0	0.0	0.7	2.7
BS1	0.7	5.0					18.3	0.0	0.0	0.0	0.7	4.0
BS2	0.0	7.3					20.7	0.0	0.0	0.0	0.0	4.3
BS3	0.0	8.7					12.3	0.0	0.0	0.0	1.0	4.3
BS4	4.3	3.3					17.0	0.0	0.0	0.0	1.0	7.3

SAMNO	%G.T.	%PAR	%SEN	%JMAN	%RHY	%ADNAT	%DIN	%AC	%TAS	%LEI	%BOT	%UNDIF
BS5	2.3	5.3					13.0	0.0	0.0	0.0	0.7	7.7
BS6	8.7	5.3					33.7	0.0	0.0	0.0	0.3	5.3
BS7												
BS8												
BS9												
BS10	7.3	6.0					24.0	0.0	0.0	0.0	0.0	6.0
BS11	3.3	9.0					23.3	0.3	0.0	0.0	1.0	6.0
BS12	1.7	1.7					11.0	0.0	0.0	0.0	0.0	2.0
BS13	4.7	1.7					12.7	0.0	0.0	0.0	0.7	4.3
BS14	6.3	6.3					23.0	0.0	0.0	0.0	0.3	4.7
BS15	3.3	2.3					9.0	0.0	0.0	0.0	0.7	5.3

APPENDIX IV

Appendix IV: Parameters derived from the kerogen counts (also includes the results of the geochemical analyses).

Key to abbreviations used in column headers (parameters expressed as a percentage unless otherwise stated):

Samno	= sample number
TOC	= total organic carbon
phytoc	= 'phytoc' parameter (not percentage)
HI	= hydrogen index (mgHC/gTOC)
S2	= S_2 value (mgHC/g rock)
Tmax	= Tmax value (°C)
fluor	= fluorescence value (from the scale in Table 2.4)
AOM	= AOM of kerogen
tphy	= phytoclasts of kerogen
tpaly	= palynomorphs of kerogen
stri/bstb	= striate of biostructured brown wood
stp/bstb	= striped of biostructured brown wood
ban/bstb	= banded of biostructured brown wood
pit/bstb	= pitted of biostructured brown wood
und/bstb	= undegraded of biostructured brown wood
deg/bstb	= degraded of biostructured brown wood
lt/blk	= lath of black wood
eq/blk	= equant of black wood
blk/phy	= black wood of phytoclasts
br/phy	= brown wood of phytoclasts
co/nbbr	= corroded of non-biostructured brown wood
ud/nbbr	= undegraded of non-biostructured brown wood
psu/nbbr	= pseudoamorphous of non-biostructured brown wood
cu/phy	= cuticle of phytoclasts
me/phy	= membranes of phytoclasts
bstr/br	= biostructured of brown wood
nbstr/br	= non-biostructured of brown wood
sp/pal	= sporomorphs of palynomorphs
mp/pal	= marine plankton of palynomorphs
und/pal	= undifferentiated of palynomorphs
lbr/blk	= log ratio brown:black wood
lbstr/nbst	= log ratio biostructured:non-biostructured brown wood
#leq/lat	= log ratio black equant:lath wood calculated out of a count total of a minimum of 50 particles
lstst/bp	= log ratio striate and striped:banded and pitted biostructured brown wood
#NUM	= parameter not calculated due to missing value in one category
#DIV0	= parameter not calculated due to the value in one category being zero

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
BBE1	2.7	2.5	242.0	6.5	425.0	2.0	4.0	93.4	2.6	55.6	16.7	27.8	0.0	5.6	94.4	25.0	75.0
BBE2							5.6	91.6	2.8	66.7	33.3	0.0	0.0	4.8	95.2	12.2	87.8
BBE3	2.5	2.2				2.0	10.2	87.2	2.6	97.4	2.6	0.0	0.0	0.0	100.0	47.4	52.6
BBE4	2.0	1.6				3.0	17.0	81.4	3.4	96.2	3.8	0.0	0.0	0.0	100.0	17.4	82.6
BBE5						3.0	3.6	95.4	1.0	0.0	66.7	33.3	0.0	0.0	100.0	40.5	59.5
BBE6						4.0	16.0	80.0	4.0	87.5	12.5	0.0	0.0	0.0	100.0	38.5	61.5
BBE7	2.5	2.0	311.0	7.8	424.0	4.0	19.0	78.8	2.0	81.8	13.6	4.5	0.0	4.5	95.5	56.0	44.0
BBE8							9.4	86.8	3.8	85.7	14.3	0.0	0.0	0.0	100.0	37.8	62.2
BBE9	2.3	2.0				3.0	11.4	86.2	2.4	100.0	0.0	0.0	0.0	0.0	100.0	34.3	65.7
BBE10	2.7	2.2				3.0	14.2	81.8	4.4	100.0	0.0	0.0	0.0	0.0	100.0	37.5	62.5
BBE11						3.0	12.2	87.2	2.0	88.0	12.0	0.0	0.0	4.0	96.0	54.5	45.5
BBE12	2.6	2.4				3.0	6.8	92.4	0.6	95.0	5.0	0.0	0.0	5.0	95.0	25.0	75.0
BBE13							18.0	77.6	4.4	92.9	3.6	3.6	0.0	0.0	100.0	18.2	81.8
BBE14	2.5	2.1				3.0	11.4	84.8	3.8	100.0	0.0	0.0	0.0	0.0	100.0	32.4	67.6
BBE15						2.0	12.2	84.0	3.8	100.0	0.0	0.0	0.0	0.0	100.0	43.2	56.8
BBE16	2.8	2.5	460.0	12.9	424.0		10.4	89.2	0.4	100.0	0.0	0.0	0.0	0.0	100.0	30.0	70.0
BBE17	1.8	1.7				3.0	3.4	93.0	3.6	87.5	0.0	12.5	0.0	0.0	100.0	20.0	80.0
BBE18						4.0	6.0	92.8	1.2	91.7	8.3	0.0	0.0	0.0	100.0	19.6	80.4
BBE19	1.2	1.1					8.0	89.8	2.2	97.2	2.8	0.0	0.0	0.0	100.0	32.0	68.0
BBE20						4.0	8.0	89.4	2.6	92.9	7.1	0.0	0.0	0.0	100.0	46.2	53.8
BBE21	1.5	1.3				4.0	13.4	84.2	2.4	95.2	4.8	0.0	0.0	0.0	100.0	31.6	68.4
BBE22							19.2	77.8	3.0	100.0	0.0	0.0	0.0	0.0	100.0	52.9	47.1
BBE23						4.0	8.8	88.8	2.4	100.0	0.0	0.0	0.0	0.0	100.0	16.7	83.3
BBE24	2.0	1.5				4.0	19.4	76.8	3.8	95.8	4.2	0.0	0.0	0.0	100.0	57.1	42.9
BBE25						4.0	9.4	88.0	2.6	94.4	5.6	0.0	0.0	0.0	100.0	30.0	70.0
BBE26	3.5	3.0	217.0	7.6	421.0	4.0	11.4	86.0	2.6	90.9	9.1	0.0	0.0	0.0	100.0	33.3	66.7
BBE27						4.0	14.0	85.0	1.0	100.0	0.0	0.0	0.0	0.0	100.0	52.6	47.4
BBE28						4.0	13.4	84.4	2.2	100.0	0.0	0.0	0.0	0.0	100.0	28.6	71.4
BBE29	2.5	2.1				3.0	14.4	83.4	2.2	92.9	0.0	7.1	0.0	0.0	100.0	34.8	65.2
BBE30						4.0	12.4	85.6	1.4	95.7	0.0	4.3	0.0	0.0	100.0	26.3	73.7
BBE31	2.0	1.8					9.0	89.2	1.8	80.0	0.0	16.0	4.0	0.0	100.0	47.6	52.4
BBE32						4.0	16.2	83.2	0.6	100.0	0.0	0.0	0.0	0.0	100.0	45.5	54.5
BBE33	1.6	1.3				4.0	14.4	81.6	4.0	100.0	0.0	0.0	0.0	0.0	100.0	45.5	54.5
BBE34							10.0	88.6	1.4	95.8	4.2	0.0	0.0	0.0	100.0	50.0	50.0
BBE35	2.3	1.9	359.0	8.3	422.0	4.0	16.8	81.4	1.6	91.7	0.0	8.3	0.0	0.0	100.0	53.3	46.7
BBE36	1.7	1.2					25.4	72.6	3.4	100.0	0.0	0.0	0.0	0.0	100.0	33.3	66.7
BBE37	1.8	1.5				4.0	16.8	82.2	1.0	100.0	0.0	0.0	0.0	0.0	100.0	40.0	60.0
BBE38						4.0	23.2	74.8	2.0	87.5	12.5	0.0	0.0	0.0	100.0	50.0	50.0
BBE39	1.7	1.2					29.2	68.6	2.2	100.0	0.0	0.0	0.0	0.0	100.0	57.1	42.9

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
BBE40	2.4	2.1	88.0	2.1	428.0	3.0	8.4	86.2	5.2	83.3	2.4	14.3	0.0	7.1	92.9	28.9	71.1
BBE41	1.4	1.1					12.6	82.0	5.4	85.1	3.2	9.6	2.1	4.3	95.7	35.3	64.7
BBE42	2.1	1.5	78.0	1.6	428.0	3.0	27.4	70.6	2.0	91.5	2.1	6.4	0.0	0.0	100.0	47.4	52.6
BBE43	1.5	1.0	71.0	1.1	427.0	3.0	33.6	63.8	2.6	81.5	11.1	7.4	0.0	0.0	100.0	53.1	46.9
BBE44	1.6	1.0				3.0	33.2	64.0	2.8	82.1	10.7	7.1	0.0	0.0	100.0	43.6	56.4
BBE45	1.8	1.3					23.4	73.6	3.0	52.4	33.3	4.8	9.5	4.8	95.2	39.7	60.3
BBE46	2.6	1.9	64.0	1.7	428.0	3.0	26.6	71.8	1.6	57.7	38.5	3.8	0.0	0.0	100.0	42.9	57.1
BBE47	2.1	1.3	71.0	1.4	427.0	3.0	37.2	60.2	2.6	61.3	32.3	3.2	3.2	0.0	100.0	43.3	56.7
BBE48	1.8	1.2				3.0	31.8	66.8	1.4	70.6	23.5	0.0	5.9	0.0	100.0	35.3	64.7
BBE49						2.0	10.8	83.0	6.2	37.8	56.8	0.0	5.4	8.1	91.9	16.9	83.1
BBO1	0.8	0.6					8.0	75.8	16.2	52.6	44.7	0.0	2.6	5.3	94.7	36.4	63.6
BBO2							9.4	80.2	10.4	60.9	31.9	0.0	7.2	0.0	100.0	45.0	55.0
BBU1	1.4	1.2	36.0	0.5	429.0		4.4	83.2	12.2	54.4	36.8	0.0	8.8	0.0	100.0	28.6	71.4
BBU2							7.6	80.4	12.0	56.3	34.4	7.8	1.6	1.6	98.4	32.0	68.0
BBU3	0.7	0.5				3.0	7.8	76.8	14.4	52.9	42.6	2.9	1.5	2.9	97.1	35.3	64.7
BBU4						2.0	9.8	75.4	12.6	55.0	31.7	5.0	8.3	0.0	100.0	33.3	66.7
BBU5	0.9	0.8					7.0	84.6	8.4	43.8	39.6	8.3	8.3	2.1	97.9	33.3	66.7
BBU6	0.9	0.7					12.0	79.4	8.6	70.8	24.6	4.6	0.0	4.6	95.4	33.8	66.2
BBU7						3.0	24.6	68.2	6.8	84.3	11.8	0.0	3.9	0.0	100.0	28.3	71.7
BBU8	1.2	0.8					25.2	69.0	5.4	54.2	18.8	20.8	6.3	2.1	97.9	45.5	54.5
BBU9	1.0	0.7					20.4	72.0	7.6	50.0	40.9	2.3	6.8	4.5	95.5	30.5	69.5
BBU10	0.9	0.6				2.0	28.4	65.0	6.4	54.7	41.5	1.9	1.9	0.0	100.0	37.5	62.5
BBU11						2.0	27.2	63.4	8.6	71.1	24.4	4.4	0.0	2.2	97.8	50.0	50.0
BBU12	0.9	0.7				3.0	18.0	73.2	6.6	66.7	26.7	6.7	0.0	0.0	100.0	28.6	71.4
BBU13	1.0	0.5					46.0	50.4	3.2	60.0	36.0	4.0	0.0	0.0	100.0	25.6	74.4
BBU14						2.0	21.4	65.4	13.2	62.5	31.3	0.0	6.3	0.0	100.0	22.0	78.0
BBU15	1.4	1.0					15.8	72.6	11.6	57.8	35.6	2.2	4.4	0.0	100.0	29.4	70.6
BBU16						3.0	31.2	58.6	10.0	69.8	25.6	4.7	0.0	0.0	100.0	41.5	58.5
BBU17	0.9	0.7					9.2	76.4	14.4	54.1	32.8	11.5	1.6	3.3	96.7	32.6	67.4
BBU18	1.4	0.9				3.0	24.6	64.6	10.8	52.3	29.5	13.6	4.5	2.3	97.7	24.6	75.4
BBU19						2.0	14.6	75.0	12.0	41.7	56.3	2.1	0.0	0.0	100.0	34.5	65.5
BBU20	1.4	1.0				3.0	13.8	72.8	13.4	63.3	33.3	3.3	0.0	1.7	98.3	26.3	73.7
BBU21							16.2	70.4	13.4	67.7	32.3	0.0	0.0	1.5	98.5	20.5	79.5
BBU22	1.0	0.5				3.0	34.2	55.0	10.8	81.6	12.2	4.1	2.0	2.0	98.0	31.8	68.2
BBU23							25.2	61.8	12.8	56.2	41.1	2.7	0.0	1.4	98.6	27.9	72.1
BBU24	2.1	1.2	40.0	0.9	439.0		34.2	59.0	6.6	53.6	28.6	17.9	0.0	0.0	100.0	19.5	80.5
BBU25	1.0	0.6				3.0	28.8	63.6	7.6	64.4	26.7	6.7	2.2	2.2	97.8	25.5	74.5
BBU26	0.9	0.6				4.0	23.8	66.0	10.2	68.3	26.7	3.3	1.7	0.0	100.0	27.1	72.9
BBU27	1.7	1.1				3.0	27.4	65.4	7.2	85.1	6.4	8.5	0.0	4.3	95.7	40.0	60.0

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
BBU28	0.8	0.6				2.0	13.6	73.2	14.6	73.7	21.1	5.3	0.0	2.6	97.4	22.9	77.1
BBU29	1.4	1.0					15.8	73.2	11.0	66.7	26.7	6.7	0.0	0.0	100.0	25.9	74.1
BBU30	0.6	0.4				3.0	20.0	71.2	8.8	59.5	24.3	13.5	2.7	2.7	97.3	17.0	83.0
BBH1	1.1	0.7				2.0	27.8	66.2	5.8	50.0	30.0	20.0	0.0	10.0	90.0	25.0	75.0
BBH2	1.3	0.9				4.0	26.4	68.8	4.8	55.6	33.3	0.0	11.1	0.0	100.0	19.5	80.5
BBH3							27.0	69.4	3.6	50.0	33.3	16.7	0.0	0.0	100.0	27.5	72.5
BBH4	1.0	0.7				4.0	26.0	69.6	4.4	60.0	20.0	0.0	20.0	0.0	100.0	15.6	84.4
BBH5						3.0	9.6	83.4	7.0	0.0	100.0	0.0	0.0	0.0	100.0	13.6	86.4
BBH6	1.0	0.8					12.6	80.4	7.0	100.0	0.0	0.0	0.0	0.0	100.0	16.7	83.3
BBH7						4.0	15.8	80.6	3.6	60.0	40.0	0.0	0.0	0.0	100.0	22.7	77.3
BBH8	0.7	0.5					19.6	75.4	4.8	75.0	0.0	0.0	25.0	0.0	100.0	18.4	81.6
BBH9	0.9	0.8					8.2	84.0	7.8	0.0	75.0	25.0	0.0	0.0	100.0	19.0	81.0
BBH10	1.1	0.8					19.4	69.4	11.2	50.0	50.0	0.0	0.0	0.0	100.0	19.5	80.5
BBH11	0.4	0.3				3.0	20.2	72.0	7.6	14.3	42.9	14.3	28.6	0.0	100.0	12.8	87.2
BBH12						3.0	14.4	79.2	6.2	37.5	37.5	12.5	12.5	12.5	87.5	22.0	78.0
BBR1							20.6	76.6	2.8	0.0	66.7	33.3	0.0	0.0	100.0	20.6	79.4
BBR2	0.7	0.5	89.0	0.5	427.0	4.0	21.8	72.6	5.6	40.0	40.0	20.0	0.0	0.0	100.0	20.4	79.6
BBR3							17.0	78.6	4.8	75.0	25.0	0.0	0.0	25.0	75.0	19.0	81.0
BBR4	0.4	0.3				3.0	12.4	81.2	6.4	83.3	16.7	0.0	0.0	0.0	100.0	11.8	88.2
BBR13							13.4	80.4	6.2	0.0	33.3	0.0	66.7	0.0	100.0	14.0	86.0
BBR14	0.5	0.4				3.0	19.2	72.8	8.0	25.0	50.0	25.0	0.0	0.0	100.0	26.2	73.8
BBR15							22.6	73.8	3.6	0.0	0.0	0.0	0.0	0.0	0.0	38.1	61.9
BBR16							21.6	72.4	5.4	20.0	0.0	60.0	20.0	0.0	100.0	28.6	71.4
BBR17							25.6	68.8	5.2	0.0	33.3	33.3	33.3	0.0	100.0	23.1	76.9
BBR18							21.0	73.6	5.2	0.0	50.0	0.0	50.0	0.0	100.0	12.5	87.5
BBR19	0.5	0.4				3.0	16.8	76.8	6.4	40.0	0.0	20.0	40.0	0.0	100.0	18.2	81.8
BBR5							17.2	76.2	6.6	70.0	10.0	20.0	0.0	0.0	100.0	32.7	67.3
BBR6	0.4	0.3				3.0	15.8	80.2	4.0	0.0	0.0	100.0	0.0	0.0	100.0	42.4	57.6
BBR7							25.6	68.6	5.8	42.9	42.9	0.0	14.3	0.0	100.0	24.4	75.6
BBR8							20.4	73.0	6.6	50.0	0.0	50.0	0.0	12.5	87.5	28.6	71.4
BBR9	0.8	0.5	75.0	0.6	427.0	4.0	32.2	64.0	3.8	60.0	0.0	40.0	0.0	0.0	100.0	27.3	72.7
BBR10							21.8	67.2	11.0	33.3	33.3	33.3	0.0	0.0	100.0	34.8	65.2
BBR11							13.8	63.2	22.8	9.1	63.6	27.3	0.0	0.0	100.0	18.5	81.5
BNL17							52.8	45.8	1.4	0.0	0.0	0.0	0.0	0.0	0.0	34.3	65.7
BNL16	2.0	1.2	197.0	3.9	429.0		34.0	60.4	5.6	0.0	0.0	100.0	0.0	0.0	100.0	14.9	85.1
BNL1							28.4	68.4	2.8	0.0	0.0	100.0	0.0	0.0	100.0	57.1	42.9
BNL2							20.0	73.4	6.6	0.0	100.0	0.0	0.0	0.0	100.0	42.2	57.8
BNL3	2.0	1.3	227.0	4.5	427.0		34.4	63.8	1.8	0.0	50.0	50.0	0.0	0.0	100.0	53.1	46.9
BNL4							26.6	67.4	6.0	0.0	66.7	33.3	0.0	0.0	100.0	50.0	50.0

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
BNL5							29.6	66.4	4.0	0.0	66.7	33.3	0.0	0.0	100.0	45.0	55.0
BNL6	1.8	1.5					16.6	82.2	1.2	0.0	100.0	0.0	0.0	0.0	100.0	42.9	57.1
BNL7	1.5	0.9					36.8	62.6	0.6	0.0	0.0	100.0	0.0	0.0	100.0	34.5	65.5
BNL8							34.4	63.2	2.4	0.0	100.0	0.0	0.0	0.0	100.0	43.2	56.8
BNL9	0.6	0.4					27.8	61.0	11.0	0.0	100.0	0.0	0.0	0.0	100.0	45.2	54.8
BNL10							35.0	62.2	2.8	50.0	50.0	0.0	0.0	0.0	100.0	27.8	72.2
BNL11	0.9	0.5					38.0	56.6	5.4	0.0	50.0	16.7	33.3	0.0	100.0	45.0	55.0
BNL12							33.2	62.8	4.0	0.0	50.0	33.3	16.7	0.0	100.0	41.7	58.3
BNL13	0.9	0.6	77.0	0.7	428.0		23.6	68.6	7.8	0.0	42.9	57.1	0.0	14.3	85.7	26.1	73.9
BNL15							32.4	63.4	4.2	0.0	0.0	0.0	0.0	0.0	0.0	37.9	62.1
RGC1	4.0	2.0				5.0	48.4	49.6	2.0	0.0	0.0	0.0	100.0	0.0	100.0	45.0	55.0
RGC2						5.0	57.4	40.6	2.0	0.0	33.3	33.3	33.3	33.3	66.7	23.1	76.9
RGC3						4.0	62.6	36.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	47.8	52.2
RGC4	5.2	2.8	288.0	15.0	417.0	5.0	42.0	53.8	4.0	0.0	80.0	20.0	0.0	0.0	100.0	52.0	48.0
RCS1	1.5	0.6				4.0	42.8	42.2	14.4	12.5	45.8	25.0	16.7	0.0	100.0	31.3	68.8
RCS2	1.2	0.4	126.0	1.5	435.0	4.0	50.8	35.4	13.4	5.9	41.2	41.2	11.8	0.0	100.0	32.0	68.0
RCS3	0.9	0.3				5.0	51.4	35.0	13.4	4.5	59.1	36.4	0.0	0.0	100.0	60.0	40.0
RCS4	1.0	0.6				1.0	36.0	61.8	2.0	0.0	40.0	40.0	20.0	0.0	100.0	27.6	72.4
RCS5						4.0	50.0	38.8	9.8	0.0	45.5	45.5	9.1	0.0	100.0	41.9	58.1
RCS6	1.6	0.5				4.0	57.4	30.6	9.6	0.0	22.2	66.7	11.1	0.0	100.0	31.3	68.8
RCS7						4.0	63.0	26.0	9.6	0.0	14.3	57.1	28.6	0.0	100.0	45.5	54.5
RCS8	1.7	0.6				4.0	48.6	38.2	11.4	19.4	41.9	35.5	3.2	0.0	100.0	38.5	61.5
RCS9						5.0	57.4	32.2	8.8	20.0	20.0	55.0	5.0	0.0	100.0	38.1	61.9
RCS10	1.8	0.7				4.0	47.2	39.8	11.0	0.0	36.4	59.1	4.5	4.5	95.5	37.5	62.5
RCS11						5.0	54.0	36.4	7.2	6.7	43.3	46.7	3.3	0.0	100.0	32.4	67.6
RCS12	2.0	0.8	212.0	4.3	430.0	4.0	51.8	38.4	8.6	10.0	30.0	50.0	10.0	0.0	100.0	34.4	65.6
RCS13						5.0	51.6	33.6	12.8	0.0	38.9	61.1	0.0	0.0	100.0	29.6	70.4
RCS14						4.0	40.6	42.8	13.8	3.8	26.9	69.2	0.0	0.0	100.0	43.6	56.4
RCS15	0.8	0.5				4.0	26.4	59.8	12.0	6.9	34.5	55.2	3.4	0.0	100.0	31.5	68.5
KE26	2.0	0.7	216.0	4.3	441.0	4.0	46.4	33.4	16.2	17.4	30.4	47.8	4.3	4.3	95.7	39.3	60.7
KE27						4.0	58.4	24.6	10.0	12.5	50.0	37.5	0.0	0.0	100.0	47.7	52.3
KE28	1.9	0.5				3.0	46.2	28.8	21.0	4.0	48.0	36.0	12.0	20.0	80.0	41.9	58.1
KE29						4.0	47.2	34.8	13.4	7.4	14.8	51.9	25.9	11.1	88.9	44.4	55.6
KE30						4.0	53.8	32.0	7.4	22.2	44.4	33.3	0.0	0.0	100.0	37.5	62.5
KE31	2.1	0.7	298.0	6.3	443.0	4.0	43.4	34.4	12.0	18.2	36.4	36.4	9.1	18.2	81.8	34.3	65.7
KE32						4.0	0.6	67.2	23.2	6.7	30.0	56.7	6.7	3.3	96.7	32.8	67.2
KE33						2.0	3.2	73.0	18.4	13.2	47.4	31.6	7.9	2.6	97.4	30.0	70.0
KE34						3.0	33.4	46.0	14.0	16.2	16.2	56.8	10.8	5.4	94.6	35.3	64.7
KE35	1.6	0.7				4.0	22.4	43.6	26.6	6.7	42.2	37.8	13.3	11.1	88.9	38.9	61.1

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
KE36						3.0	42.4	32.0	16.0	4.2	37.5	37.5	20.8	8.3	91.7	17.4	82.6
KE37	1.3	0.5				3.0	44.2	36.0	12.8	8.7	8.7	65.2	17.4	8.7	91.3	63.0	37.0
KE38						4.0	23.8	52.2	19.6	7.5	35.0	45.0	12.5	2.5	97.5	32.6	67.4
KE39	1.7	1.0				3.0	2.4	60.4	34.0	8.3	37.5	29.2	25.0	0.0	100.0	38.8	61.2
KE40	1.3	0.7	93.0	1.2	434.0	3.0	1.2	54.2	41.8	17.4	41.3	32.6	8.7	2.2	97.8	46.3	53.7
KE41						3.0	11.0	35.2	49.8	9.7	38.7	32.3	19.4	22.6	77.4	48.6	51.4
KE42	1.2	0.4				3.0	22.8	32.6	39.4	0.0	42.9	39.3	17.9	10.7	89.3	45.7	54.3
KE43						4.0	9.8	28.6	55.2	0.0	37.5	37.5	25.0	20.8	79.2	46.9	53.1
KE44	2.8	0.9	168.0	4.7	442.0	4.0	45.4	31.8	15.4	0.0	52.6	36.8	10.5	15.8	84.2	33.3	66.7
KE45						3.0	25.2	32.0	38.0	7.1	32.1	39.3	21.4	21.4	78.6	33.3	66.7
KE46	1.5	0.5				4.0	39.2	36.8	15.2	5.9	38.2	35.3	20.6	8.8	91.2	28.0	72.0
KE47						3.0	31.0	35.2	23.4	14.8	44.4	22.2	18.5	14.8	85.2	26.7	73.3
KE48	1.5	0.4				4.0	40.2	29.0	24.2	5.9	29.4	47.1	17.6	11.8	88.2	33.3	66.7
KE49						4.0	52.2	23.8	20.4	0.0	50.0	30.0	20.0	10.0	90.0	53.8	46.2
KE50	2.6	0.6				5.0	63.2	21.8	8.4	0.0	66.7	33.3	0.0	0.0	100.0	25.0	75.0
KE51						4.0	59.2	19.6	12.4	0.0	20.0	80.0	0.0	20.0	80.0	18.2	81.8
KE52	2.1	0.4				4.0	57.4	21.2	14.0	6.7	53.3	40.0	0.0	20.0	80.0	30.0	70.0
KE53						4.0	29.2	29.0	33.6	5.9	50.0	17.6	26.5	17.6	82.4	26.7	73.3
KE54	0.6	0.1				4.0	45.8	25.8	23.4	5.9	58.8	11.8	23.5	5.9	94.1	31.8	68.2
KE55						3.0	25.0	47.2	22.6	6.7	63.3	13.3	16.7	13.3	86.7	51.5	48.5
KE56	0.4	0.3				4.0	15.4	73.8	6.2	20.0	60.0	20.0	0.0	0.0	100.0	57.9	42.1
KE57						2.0	3.2	61.4	33.0	5.3	55.3	28.9	10.5	14.5	85.5	41.9	58.1
KE58	1.3	0.7	126.0	1.6	442.0	2.0	6.2	50.4	38.4	13.1	47.5	32.8	6.6	11.5	88.5	38.1	61.9
KE1	0.5	0.1				3.0	16.2	21.6	58.2	3.7	25.9	25.9	44.4	29.6	70.4	10.5	89.5
KE2						3.0	11.2	44.4	41.0	15.8	52.6	21.1	10.5	10.5	89.5	22.9	77.1
KE3						4.0	16.8	30.6	50.2	11.4	34.3	34.3	20.0	8.6	91.4	57.9	42.1
KE4	0.4	0.1				4.0	20.4	23.4	54.2	57.1	28.6	4.8	9.5	9.5	90.5	33.3	66.7
KE5						5.0	14.4	12.0	72.0	0.0	50.0	25.0	25.0	25.0	75.0	25.0	75.0
KE6						3.0	13.6	37.2	47.0	14.8	40.7	40.7	3.7	3.7	96.3	41.2	58.8
KE7	1.4	0.4	193.0	2.7	441.0	4.0	51.6	29.0	16.6	3.8	50.0	38.5	7.7	7.7	92.3	50.0	50.0
KE8						3.0	14.8	50.6	32.6	0.0	17.6	70.6	11.8	11.8	88.2	18.2	81.8
KE9						3.0	37.8	40.8	15.6	0.0	45.0	42.5	12.5	17.5	82.5	39.1	60.9
KE10	1.8	0.8				3.0	22.6	43.6	22.0	7.1	40.5	33.3	19.0	7.1	92.9	33.3	66.7
KE11						3.0	40.4	34.2	17.6	13.8	51.7	17.2	17.2	13.8	86.2	26.3	73.7
KE12						3.0	22.2	35.8	40.2	9.1	0.0	81.8	36.4	9.1	90.9	28.6	71.4
KE13	2.3	1.2				4.0	25.4	52.6	17.8	5.4	39.3	42.9	12.5	14.3	85.7	36.1	63.9
KE14	3.0	0.8	373.0	11.2	443.0	4.0	59.6	25.4	8.8	5.9	29.4	58.8	5.9	5.9	94.1	39.1	60.9
KE15						5.0	46.8	33.4	9.0	23.1	30.8	34.6	11.5	7.7	92.3	33.3	66.7
KE16	2.0	0.7				4.0	37.0	35.8	19.6	10.5	26.3	57.9	5.3	5.3	94.7	29.6	70.4

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
KE18						3.0	3.6	62.8	31.2	4.9	41.0	39.3	14.8	9.8	90.2	24.1	75.9
KE19	0.8	0.4	100.0	0.8	443.0	4.0	0.4	48.4	47.6	8.3	43.8	37.5	10.4	14.6	85.4	26.5	73.5
KE20						4.0	5.8	28.8	61.2	11.1	35.6	40.0	13.3	2.2	97.8	27.3	72.7
KE21	2.5	0.6				4.0	71.0	22.4	4.2	0.0	56.3	43.8	0.0	6.3	93.8	34.5	65.5
KE22	2.2	0.3	388.0	8.6	421.0	4.0	77.8	13.4	5.8	10.0	20.0	50.0	20.0	10.0	90.0	46.2	53.8
KE23	1.6	0.2				4.0	72.2	14.0	11.2	0.0	50.0	30.0	20.0	10.0	90.0	69.2	30.8
KE24						3.0	38.2	27.2	31.6	0.0	56.3	34.4	9.4	9.4	90.6	61.9	38.1
KE25	0.9	0.4				3.0	6.0	47.0	42.2	16.1	41.9	32.3	9.7	6.5	93.5	40.0	60.0
RNB1						3.0	16.4	38.2	29.0	25.0	43.2	22.7	9.1	4.5	95.5	25.9	74.1
RNB2	2.9	0.6	224.0	6.5	437.0	4.0	45.8	20.4	7.0	7.1	42.9	35.7	14.3	14.3	85.7	43.3	56.7
RNB3						4.0	38.8	24.0	16.4	25.0	50.0	25.0	0.0	0.0	100.0	30.8	69.2
RNB4						4.0	51.6	21.6	13.0	0.0	40.0	50.0	10.0	20.0	80.0	38.7	61.3
RNB5	2.5	0.6				5.0	46.2	25.0	15.8	16.7	33.3	50.0	0.0	0.0	100.0	75.0	25.0
RNB6						4.0	49.6	39.6	6.4	0.0	0.0	80.0	20.0	0.0	100.0	28.9	71.1
RNB7						5.0	57.6	24.0	12.2	0.0	37.5	37.5	25.0	12.5	87.5	48.0	52.0
RNB8						5.0	78.4	13.6	3.0	0.0	50.0	50.0	0.0	0.0	100.0	51.9	48.1
RNB9	3.3	0.4	461.0	15.2	433.0	5.0	71.4	11.6	1.4	50.0	0.0	0.0	50.0	0.0	100.0	47.6	52.4
RNB10						5.0	67.8	22.2	3.2	0.0	100.0	0.0	0.0	0.0	100.0	36.1	63.9
RNB11						5.0	61.6	23.8	8.4	8.3	58.3	16.7	16.7	8.3	91.7	14.8	85.2
RNB12	2.9	0.9				5.0	39.6	30.4	18.8	0.0	55.6	29.6	14.8	14.8	85.2	25.0	75.0
RNB13						4.0	2.6	51.0	33.2	12.0	42.0	10.0	36.0	4.0	96.0	41.0	59.0
RNB14	1.7	0.9				4.0	1.4	53.2	36.6	15.5	46.5	25.4	12.7	4.2	95.8	57.7	42.3
RNB15						4.0	65.0	22.6	8.2	11.1	44.4	33.3	11.1	0.0	100.0	38.1	61.9
RNB16	3.2	0.9				5.0	53.2	29.2	11.4	13.0	52.2	26.1	8.7	0.0	100.0	50.0	50.0
RNB17	4.4	0.7	463.0	20.4	433.0	4.0	80.0	15.4	4.6	14.3	42.9	28.6	14.3	0.0	100.0	47.1	52.9
RNB18						4.0	57.4	22.4	16.4	5.9	41.2	23.5	29.4	0.0	100.0	36.4	63.6
RNB19	1.7	0.9				4.0	22.4	50.6	23.6	12.5	33.9	35.7	17.9	8.9	91.1	43.6	56.4
RNB20	2.1	1.0	172.0	3.6	436.0	4.0	16.8	46.0	26.6	14.3	54.8	9.5	21.4	14.3	85.7	36.4	63.6
VS2	1.5	1.1	53.0	0.8	432.0	3.0	5.4	74.8	14.2	5.7	38.1	30.5	25.7	24.8	75.2	37.9	62.1
VS3	1.1	0.8				4.0	6.8	74.6	13.8	3.2	43.5	43.5	9.7	16.1	83.9	20.3	79.7
VS4						4.0	7.6	63.4	20.2	4.2	37.5	39.6	18.8	6.3	93.8	23.7	76.3
VS5						2.0	1.8	94.8	2.2	0.0	0.0	66.7	33.3	0.0	100.0	0.4	99.6
VS7	0.2	0.1				3.0	63.6	22.4	9.6	0.0	25.0	25.0	50.0	0.0	100.0	5.9	94.1
VS8	0.2	0.1				2.0	8.4	60.4	26.0	0.0	25.0	37.5	37.5	0.0	100.0	4.5	95.5
VS9						2.0	9.8	69.2	16.0	14.3	42.9	28.6	14.3	0.0	100.0	5.8	94.2
CGD1	1.1	0.3					76.2	23.2	0.6	50.0	50.0	0.0	0.0	0.0	100.0	90.0	10.0
CGD2	0.7	0.2					75.2	24.4	0.4	0.0	100.0	0.0	0.0	0.0	100.0	45.5	54.5
CGD3							78.4	21.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
CGD4	0.1	0.1					62.2	37.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	9.1	90.9

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
CGD5		.					61.0	38.2	0.8	0.0	100.0	0.0	0.0	0.0	100.0	50.0	50.0
CGD6		.					63.2	36.6	0.2	0.0	100.0	0.0	0.0	0.0	100.0	31.6	68.4
CGD7		.					42.6	56.2	1.2	0.0	100.0	0.0	0.0	0.0	100.0	14.3	85.7
CGD8	0.8	0.4					43.6	55.8	0.6	0.0	0.0	0.0	100.0	0.0	100.0	36.4	63.6
CGD9		.					52.6	46.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	41.7	58.3
CGD10		.					52.4	46.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	40.0	60.0
CGD11		.					49.6	48.8	1.6	100.0	0.0	0.0	0.0	0.0	100.0	66.7	33.3
CGD12		.					46.6	52.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0	36.4	63.6
CGD13		.					41.4	58.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	16.7	83.3
CGD14		.					51.4	48.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	88.9
CGD15		.					43.4	48.4	0.2	0.0	0.0	0.0	100.0	0.0	100.0	54.5	45.5
CGD16	0.5	0.2					55.0	45.0	0.0	0.0	0.0	0.0	100.0	0.0	100.0	14.3	85.7
CGD17		.					46.0	50.8	3.2	0.0	0.0	0.0	0.0	0.0	0.0	20.7	79.3
CGD18		.					44.0	51.2	4.8	0.0	100.0	0.0	0.0	0.0	100.0	20.7	79.3
CGD19		.					51.6	44.6	3.8	50.0	50.0	0.0	0.0	0.0	100.0	20.7	79.3
CGD20		.					42.8	51.8	5.0	100.0	0.0	0.0	0.0	0.0	100.0	25.0	75.0
CGD21	0.3	0.2					40.0	54.8	5.2	0.0	0.0	0.0	0.0	0.0	0.0	6.5	93.5
CGD23	0.2	0.1				5.0	66.8	30.4	2.6	100.0	0.0	0.0	0.0	0.0	100.0	17.6	82.4
CGD24	0.8	0.5				4.0	31.4	60.6	4.0	33.3	66.7	0.0	0.0	0.0	100.0	22.2	77.8
CGD25		.				3.0	8.6	46.6	43.6	38.7	61.3	0.0	0.0	9.7	90.3	31.4	68.6
CGD26	0.9	0.5				2.0	4.4	59.2	36.2	60.6	30.3	6.1	3.0	0.0	100.0	39.4	60.6
CGD27	0.6	0.4				2.0	11.4	67.8	20.8	56.0	40.0	0.0	4.0	0.0	100.0	13.3	86.7
CGD28		.				2.0	1.2	77.8	20.6	35.7	64.3	0.0	0.0	0.0	100.0	22.6	77.4
CGD29	0.2	0.2				3.0	3.0	82.4	14.4	30.0	65.0	5.0	0.0	0.0	100.0	32.0	68.0
CGD30		.				2.0	0.4	91.0	8.6	7.7	76.9	7.7	7.7	0.0	100.0	23.2	76.8
CGD31	0.3	0.3				2.0	0.2	88.8	10.4	0.0	41.7	50.0	8.3	0.0	100.0	30.2	69.8
CGD32		.				3.0	6.4	80.4	12.8	0.0	72.7	22.7	4.5	0.0	100.0	26.5	73.5
CGD33	0.8	0.5	119.0	1.0	432.0	4.0	34.0	59.0	7.0	0.0	46.2	23.1	30.8	0.0	100.0	29.3	70.7
CGD34	0.3	0.2				4.0	13.6	74.8	10.8	11.8	82.4	0.0	5.9	0.0	100.0	10.7	89.3
CGD35		.				4.0	14.8	74.2	11.0	47.1	29.4	11.8	11.8	0.0	100.0	16.7	83.3
CGD36	0.3	0.2				4.0	10.2	79.0	10.8	0.0	100.0	0.0	0.0	0.0	100.0	20.0	80.0
CGD37	0.5	0.3				4.0	22.4	64.8	12.2	41.7	41.7	16.7	0.0	0.0	100.0	33.3	66.7
CGD38	0.8	0.3				5.0	57.0	39.2	3.8	0.0	50.0	50.0	0.0	0.0	100.0	28.6	71.4
CGD39	0.6	0.3				4.0	38.8	49.8	11.4	20.0	46.7	13.3	20.0	13.3	86.7	27.7	72.3
CGD40	0.5	0.3				4.0	25.4	57.4	17.2	15.4	30.8	26.9	26.9	7.7	92.3	41.9	58.1
CGD41	0.4	0.2				5.0	25.4	57.6	17.0	53.8	46.2	0.0	0.0	0.0	100.0	22.2	77.8
CGD42	.					4.0	19.0	59.4	21.6	80.0	20.0	0.0	0.0	0.0	100.0	23.1	76.9
CGD43	0.3	0.2				4.0	10.0	61.0	28.4	50.0	50.0	0.0	0.0	0.0	100.0	12.5	87.5
CGD44						4.0	17.6	63.2	19.0	60.0	30.0	0.0	10.0	0.0	100.0	34.3	65.7

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
CGD45	3.2	1.6	261.0	8.4	425.0	4.0	28.8	48.8	22.0	56.3	31.3	0.0	12.5	12.5	87.5	26.7	73.3
CGD46						4.0	14.0	68.0	17.8	33.3	66.7	0.0	0.0	0.0	100.0	18.2	81.8
CGD47	0.3	0.2				4.0	9.8	82.4	7.6	30.0	60.0	10.0	0.0	0.0	100.0	16.7	83.3
CGD48						5.0	39.0	53.6	7.0	20.0	70.0	10.0	0.0	0.0	100.0	25.0	75.0
CGD49	0.6	0.4				5.0	25.6	67.0	7.4	9.1	72.7	18.2	0.0	0.0	100.0	19.0	81.0
CGD50	1.1	0.9				2.0	1.6	78.0	20.4	5.3	47.4	31.6	15.8	31.6	68.4	31.3	68.7
CGD51	1.8	0.9	297.0	5.3	434.0	2.0	1.8	51.6	46.4	14.3	28.6	47.6	9.5	0.0	100.0	22.1	77.9
CGD52	1.9	0.6	347.0	6.6	428.0	3.0	54.2	30.8	10.6	50.0	50.0	0.0	0.0	0.0	100.0	23.7	76.3
CGD53						2.0	15.8	43.6	40.2	17.6	47.1	23.5	11.8	23.5	76.5	37.8	62.2
CGD54	0.5	0.3				2.0	12.0	54.0	32.8	0.0	76.2	19.0	4.8	4.8	95.2	32.8	67.2
CGD55	2.1	0.3	95.0	2.0	428.0	3.0	55.4	16.8	27.2	0.0	50.0	16.7	33.3	33.3	66.7	6.3	93.8
CGD56	0.8	0.3				3.0	21.8	36.0	41.6	30.8	61.5	0.0	7.7	3.8	96.2	21.7	78.3
CGD57	0.4	0.1				3.0	42.4	17.0	40.0	0.0	16.7	66.7	16.7	16.7	83.3	40.0	60.0
CGD58						3.0	52.0	34.8	12.8	15.0	65.0	20.0	0.0	5.0	95.0	21.1	78.9
CGD59	1.4	0.4				4.0	57.8	31.2	10.4	0.0	58.8	35.3	5.9	0.0	100.0	36.4	63.6
CGD60						4.0	42.6	37.6	15.6	16.7	66.7	16.7	0.0	4.2	95.8	12.0	88.0
CGD61	0.6	0.2				4.0	36.4	41.6	21.2	7.9	47.4	44.7	0.0	7.9	92.1	19.0	81.0
CGD62	0.8	0.2				4.0	58.8	28.0	13.0	0.0	72.7	27.3	0.0	0.0	100.0	22.2	77.8
CGD63						5.0	53.0	31.4	15.2	10.0	50.0	30.0	10.0	0.0	100.0	16.0	84.0
CGD64						3.0	36.8	45.8	17.0	30.8	53.8	15.4	0.0	0.0	100.0	31.6	68.4
CGD65	0.6	0.2				3.0	42.0	40.0	17.6	9.1	81.8	4.5	4.5	4.5	95.5	12.5	87.5
CGD66	1.6	0.6	73.0	1.2	425.0	4.0	54.0	37.2	8.6	4.5	68.2	9.1	18.2	4.5	95.5	22.6	77.4
CGD67						3.0	25.8	49.2	24.8	0.0	93.3	6.7	0.0	0.0	100.0	26.5	73.5
CGD68	0.5	0.2				3.0	28.6	34.2	36.8	3.4	69.0	27.6	0.0	3.4	96.6	11.8	88.2
LOD1*	0.7	0.2	138.0	1.0	421.0	5.0	64.4	30.2	5.2	40.0	0.0	60.0	0.0	0.0	100.0	16.7	83.3
LOS4						3.0	2.4	65.4	32.2	12.0	16.0	60.0	12.0	20.0	80.0	34.2	65.8
LOD2	0.8	0.6				2.0	2.2	77.2	19.6	6.1	46.9	28.6	18.4	10.2	89.8	28.1	71.9
LOD3						2.0	6.2	61.0	31.8	0.0	40.0	40.0	20.0	24.0	76.0	18.6	81.4
LOD4						5.0	6.6	55.8	36.2	0.0	4.3	82.6	13.0	17.4	82.6	23.8	76.2
LOD5	0.4	0.2				2.0	2.6	58.8	35.8	0.0	14.3	71.4	14.3	14.3	85.7	22.0	78.0
LOS5	0.3	0.1				5.0	55.6	32.4	11.8	30.8	23.1	38.5	7.7	0.0	100.0	22.2	77.8
LOD5A	0.9	0.8				2.0	3.2	85.2	10.6	0.0	35.3	47.1	17.6	11.8	88.2	17.3	82.7
LOD6	1.5	1.3				4.0	2.0	84.2	12.8	0.0	27.8	55.6	16.7	11.1	88.9	27.4	72.6
LOD7	0.5	0.2				4.0	27.8	38.6	33.6	20.0	60.0	10.0	10.0	0.0	100.0	33.3	66.7
LOD8						4.0	34.2	18.0	47.6	26.3	26.3	26.3	21.1	5.3	94.7	44.4	55.6
LOD9						4.0	36.4	15.2	48.2	15.0	55.0	25.0	5.0	10.0	90.0	53.8	46.2
LOD10	0.7	0.1				4.0	48.0	17.2	34.6	23.1	38.5	38.5	0.0	7.7	92.3	25.0	75.0
LOK6						3.0	10.2	21.2	67.6	6.7	46.7	46.7	0.0	13.3	86.7	40.0	60.0
LOK7						3.0	4.8	25.8	69.0	50.0	0.0	30.0	20.0	0.0	100.0	12.5	87.5

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
LOK8						2.0	10.0	30.8	59.0	18.5	44.4	29.6	7.4	3.7	96.3	31.4	68.6
LOD11	0.5	0.1	73.0	0.4	426.0	4.0	67.8	16.0	15.8	22.2	44.4	33.3	0.0	0.0	100.0	35.7	64.3
LOD12		.				3.0	43.6	21.0	35.2	22.2	44.4	22.2	11.1	11.1	88.9	25.0	75.0
LOK11		.				4.0	18.8	14.0	66.8	30.0	50.0	20.0	0.0	10.0	90.0	31.3	68.8
LOD13	0.6	0.5				4.0	6.0	83.8	10.2	16.7	38.3	28.3	16.7	5.0	95.0	27.1	72.9
LOD14						2.0	3.0	89.8	6.4	19.4	41.9	25.8	12.9	3.2	96.8	21.5	78.5
LOD15						2.0	2.2	82.2	14.0	2.9	17.1	71.4	8.6	8.6	91.4	17.9	82.1
LOD16	0.6	0.5				2.0	4.2	86.4	8.4	2.6	30.8	35.9	30.8	2.6	97.4	15.0	85.0
LOK15						1.0	2.2	88.2	8.6	0.0	0.0	100.0	0.0	0.0	100.0	6.6	93.4
LOK16	0.2	0.1				2.0	42.2	39.8	16.4	0.0	0.0	77.8	22.2	77.8	22.2	13.7	86.3
LOK17	0.3	0.3				2.0	4.2	88.4	7.2	0.0	0.0	73.3	26.7	13.3	86.7	11.6	88.4
LOK20						2.0	1.4	86.8	11.4	2.0	11.8	70.6	15.7	7.8	92.2	11.5	88.5
LOK21						2.0	1.4	87.8	10.2	0.0	10.6	80.9	8.5	4.3	95.7	7.3	92.7
LOK22	0.3	0.3				2.0	0.2	94.8	4.6	4.2	4.2	91.7	0.0	16.7	83.3	10.5	89.5
LOK23						2.0	3.0	91.2	5.8	0.0	0.0	100.0	0.0	12.1	87.9	3.4	96.6
LOK24	0.7	0.5				3.0	1.2	76.0	20.8	0.0	38.5	49.2	12.3	1.5	98.5	12.5	87.5
LOK25						3.0	5.2	70.4	23.8	0.0	42.2	46.7	11.1	2.2	97.8	29.0	71.0
LOK26	0.8	0.6	39.0	0.3	430.0	3.0	1.0	79.0	16.6	0.0	38.5	57.7	3.8	3.8	96.2	18.5	81.5
LOK27						3.0	2.4	82.6	12.4	0.0	23.3	73.3	3.3	3.3	96.7	23.4	76.6
LOK28	0.4	0.4				3.0	0.2	89.4	10.0	6.5	33.8	53.2	6.5	1.3	98.7	21.8	78.2
LOK29						2.0	0.6	92.2	7.0	2.2	10.9	80.4	6.5	4.3	95.7	10.0	90.0
LOK30	0.4	0.4				2.0	2.0	92.4	5.4	0.0	8.7	82.6	8.7	0.0	100.0	2.9	97.1
LOK31						5.0	42.0	54.8	3.2	0.0	16.7	83.3	0.0	0.0	100.0	8.9	91.1
LOK32	0.6	0.2				5.0	56.6	40.8	2.4	0.0	23.1	69.2	7.7	7.7	92.3	7.1	92.9
LOK33						4.0	2.6	79.2	17.6	1.2	29.8	58.3	10.7	11.9	88.1	24.0	76.0
LOK34	0.4	0.3				3.0	2.2	77.4	20.2	0.0	36.7	55.1	4.1	0.0	100.0	14.0	86.0
LOK35						3.0	1.2	71.4	26.6	1.9	35.2	46.3	16.7	3.7	96.3	30.0	70.0
LOK36						3.0	3.2	59.2	37.2	1.8	43.6	43.6	10.9	16.4	83.6	37.5	62.5
LOK37	1.3	0.7				3.0	3.2	52.4	43.6	0.0	12.0	72.0	24.0	4.0	96.0	28.6	71.4
LOK38						2.0	0.6	88.6	10.8	0.0	20.9	67.4	11.6	7.0	93.0	20.0	80.0
LOK39	1.0	0.9				2.0	0.4	86.8	12.6	2.6	17.9	74.4	5.1	15.4	84.6	10.6	89.4
LBT1	1.3	0.5	350.0	4.6	431.0	5.0	50.8	39.0	10.2	50.0	0.0	50.0	0.0	50.0	50.0	33.3	66.7
LBT2						4.0	47.8	20.8	31.0	0.0	71.4	14.3	14.3	28.6	71.4	30.0	70.0
LBT3						4.0	36.6	44.0	18.8	18.2	51.5	24.2	6.1	0.0	100.0	13.8	86.2
LBT4	0.7	0.2				4.0	50.4	23.6	25.8	20.0	20.0	60.0	0.0	20.0	80.0	60.0	40.0
LBT5						3.0	27.2	45.4	27.4	12.5	59.4	25.0	3.1	3.1	96.9	26.7	73.3
LBT6	0.6	0.3				3.0	17.2	52.6	28.2	0.0	67.6	27.0	5.4	2.7	97.3	20.0	80.0
LBT7						3.0	36.2	34.4	28.6	9.1	68.2	18.2	4.5	0.0	100.0	33.3	66.7
LBT8	0.6	0.2				4.0	48.6	26.4	24.0	11.1	66.7	22.2	0.0	0.0	100.0	25.0	75.0

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
LBT9						4.0	53.8	29.8	16.0	0.0	40.0	40.0	20.0	12.5	87.5	36.4	63.6
LBT10						3.0	41.4	36.0	22.4	0.0	68.1	23.4	8.5	6.4	93.6	30.8	69.2
LBT11						4.0	36.4	38.6	24.8	3.2	77.4	12.9	6.5	0.0	100.0	41.5	58.5
LBT12	0.5	0.1	130.0	0.7	430.0	1.0	80.4	15.8	5.4	0.0	77.8	11.1	11.1	0.0	100.0	53.6	46.4
LBT13						3.0	54.6	38.8	6.6	0.0	36.7	36.7	26.7	20.0	80.0	46.4	53.6
LBT14	0.4	0.1				3.0	71.0	21.8	7.2	0.0	36.8	21.1	42.1	26.3	73.7	58.8	41.2
LBT15						3.0	59.4	18.0	21.8	0.0	52.9	29.4	17.6	11.8	88.2	50.0	50.0
LBT16						4.0	63.6	22.4	13.6	13.3	40.0	26.7	20.0	0.0	100.0	34.6	65.4
LBT17	0.8	0.3				3.0	49.6	32.8	16.4	7.1	50.0	28.6	14.3	0.0	100.0	25.0	75.0
LBM1	1.0	0.4	63.0	0.6	425.0	2.0	15.8	42.4	41.8	0.0	65.4	26.9	7.7	3.8	96.2	21.7	78.3
LBM2						3.0	32.2	30.2	37.0	20.0	53.3	20.0	6.7	6.7	93.3	24.1	75.9
LBM3						4.0	16.6	68.2	15.2	8.5	27.1	40.7	23.7	16.9	83.1	46.9	53.1
LBM4	1.4	0.4	81.0	1.1	422.0	4.0	54.0	29.8	16.0	0.0	22.7	22.7	54.5	9.1	90.9	31.7	68.3
LBM5						4.0	20.0	40.6	39.0	5.6	38.9	44.4	11.1	5.6	94.4	27.3	72.7
LBM6	0.3	0.1				4.0	46.8	30.6	21.2	8.7	30.4	60.9	0.0	0.0	100.0	16.1	83.9
LBM7						5.0	23.6	39.4	34.0	8.3	50.0	41.7	0.0	0.0	100.0	14.8	85.2
KBD1	0.5	0.2				2.0	7.2	31.6	60.4	0.0	84.6	7.7	7.7	0.0	100.0	12.5	87.5
KBK1	0.5	0.1				4.0	60.0	18.2	20.6	10.0	50.0	10.0	30.0	20.0	80.0	19.0	81.0
KBK2	2.5	0.4	723.0	18.1	449.0	5.0	75.8	17.0	3.6	9.1	18.2	54.5	0.0	36.4	63.6	36.8	63.2
KBK3						5.0	75.2	17.0	4.0	12.5	37.5	37.5	12.5	12.5	87.5	42.3	57.7
KBK4	2.0	0.5	682.0	13.6	437.0	5.0	68.2	26.2	2.8	0.0	71.4	28.6	0.0	0.0	100.0	35.8	64.2
KBK5						5.0	79.0	13.4	2.6	0.0	0.0	100.0	0.0	100.0	0.0	43.3	56.7
KBK7	0.9	0.7				2.0	1.8	81.2	15.0	8.5	50.7	40.8	0.0	1.4	98.6	2.3	97.7
KBK8						4.0	78.0	16.0	4.0	20.0	30.0	30.0	20.0	20.0	80.0	53.6	46.4
KBK9	1.4	0.2				4.0	79.4	16.4	2.2	16.7	33.3	33.3	16.7	16.7	83.3	38.2	61.8
KBK10						5.0	81.0	15.0	0.2	50.0	0.0	50.0	0.0	0.0	100.0	24.4	75.6
KBK11	2.6	0.2	810.0	21.1	450.0	5.0	86.6	7.6	2.4	50.0	0.0	0.0	50.0	0.0	100.0	39.3	60.7
SB1		.				2.0	0.0	97.4	1.8	0.0	0.0	0.0	100.0	0.0	100.0	1.8	98.2
SB4		.				2.0	1.6	94.6	3.0	0.0	100.0	0.0	0.0	0.0	100.0	3.0	97.0
SB7		.				2.0	4.4	92.0	2.4	50.0	50.0	0.0	0.0	0.0	100.0	1.4	98.6
SB10		.				2.0	0.6	93.4	3.6	0.0	0.0	0.0	0.0	0.0	0.0	1.6	98.4
SB14		.				2.0	0.0	93.4	4.2	0.0	0.0	0.0	0.0	0.0	0.0	3.4	96.6
SBS2		.				2.0	0.0	99.6	0.4	0.0	100.0	0.0	0.0	0.0	100.0	6.1	93.9
SBS4	0.1	0.1				2.0	1.2	99.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	94.7
SBS5	5.6	3.2				2.0	16.2	57.8	28.4	20.0	60.0	20.0	0.0	0.0	100.0	18.9	81.1
SBU1	0.9	0.3				3.0	15.8	32.6	51.6	0.0	40.0	40.0	20.0	70.0	30.0	25.8	74.2
UOB1	0.6	0.5				4.0	4.2	75.0	18.8	18.2	54.5	27.3	0.0	0.0	100.0	3.0	97.0
UOB2						3.0	3.4	71.8	23.6	10.0	50.0	40.0	0.0	0.0	100.0	15.5	84.5
UOB3	4.0	1.2	458.0	18.3	431.0	4.0	59.4	31.0	6.8	40.0	40.0	20.0	0.0	20.0	80.0	31.8	68.2

Appendix IV: Parameters derived from the kerogen counts (also includes the results of the geochemical analyses).

Key to abbreviations used in column headers (parameters expressed as a percentage unless otherwise stated):

Samno	= sample number
TOC	= total organic carbon
phytoc	= 'phytoc' parameter (not percentage)
HI	= hydrogen index (mgHC/gTOC)
S2	= S_2 value (mgHC/g rock)
Tmax	= Tmax value (°C)
fluor	= fluorescence value (from the scale in Table 2.4)
AOM	= AOM of kerogen
tphy	= phytoclasts of kerogen
tpaly	= palynomorphs of kerogen
stri/bstb	= striate of biostructured brown wood
stp/bstb	= striped of biostructured brown wood
ban/bstb	= banded of biostructured brown wood
pit/bstb	= pitted of biostructured brown wood
und/bstb	= undegraded of biostructured brown wood
deg/bstb	= degraded of biostructured brown wood
lt/blk	= lath of black wood
eq/blk	= equant of black wood
blk/phy	= black wood of phytoclasts
br/phy	= brown wood of phytoclasts
co/nbbr	= corroded of non-biostructured brown wood
ud/nbbr	= undegraded of non-biostructured brown wood
psu/nbbr	= pseudoamorphous of non-biostructured brown wood
cu/phy	= cuticle of phytoclasts
me/phy	= membranes of phytoclasts
bstr/br	= biostructured of brown wood
nbstr/br	= non-biostructured of brown wood
sp/pal	= sporomorphs of palynomorphs
mp/pal	= marine plankton of palynomorphs
und/pal	= undifferentiated of palynomorphs
lbr/blk	= log ratio brown:black wood
lbstr/nbst	= log ratio biostructured:non-biostructured brown wood
#leq/lat	= log ratio black equant:lath wood calculated out of a count total of a minimum of 50 particles
lstst/bp	= log ratio striate and striped:banded and pitted biostructured brown wood
#NUM	= parameter not calculated due to missing value in one category
#DIV0	= parameter not calculated due to the value in one category being zero

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
UOB4						4.0	38.0	44.2	17.8	0.0	40.0	40.0	20.0	40.0	60.0	25.3	74.7
UOB5						4.0	6.2	20.8	73.0	0.0	44.0	24.0	32.0	8.0	92.0	18.8	81.3
UOB6						4.0	4.2	33.6	62.0	5.0	55.0	30.0	10.0	10.0	90.0	2.6	97.4
UOB7	0.8	0.3				2.0	5.4	39.4	54.8	0.0	62.2	35.1	2.7	13.5	86.5	5.8	94.2
UOB8						3.0	20.4	32.6	46.6	2.7	62.2	29.7	5.4	10.8	89.2	21.4	78.6
UOB9	1.9	0.7				3.0	11.2	38.6	49.8	4.9	65.9	29.3	0.0	9.8	90.2	30.4	69.6
UOB10						4.0	9.0	51.2	39.2	0.0	39.0	35.6	8.5	16.9	83.1	17.6	82.4
UOB11	2.0	0.9				4.0	5.8	46.0	48.2	0.0	38.5	50.0	11.5	11.5	88.5	25.4	74.6
UOB12						2.0	12.0	41.2	46.8	4.3	43.5	47.8	4.3	17.4	82.6	32.5	67.5
UOB13	2.7	1.2				3.0	16.0	42.8	41.2	0.0	50.0	45.5	4.5	13.6	86.4	41.9	58.1
UOB14						4.0	6.8	37.2	55.8	0.0	69.8	24.5	5.7	32.1	67.9	27.3	72.7
UOB15	2.1	0.9				2.0	10.6	44.0	45.2	0.0	51.9	40.4	7.7	42.3	57.7	37.5	62.5
UOB16						4.0	21.2	46.6	32.2	0.0	63.2	34.2	2.6	28.9	71.1	35.3	64.7
UOB17	2.3	1.0				3.0	8.2	46.4	45.4	0.0	62.7	35.6	1.7	27.1	72.9	23.8	76.2
UOB18						3.0	8.2	53.2	38.4	0.0	35.1	43.2	13.5	37.8	62.2	14.3	85.7
UOB19	4.3	2.6				3.0	9.8	59.8	30.4	0.0	50.0	48.3	1.7	24.1	75.9	23.5	76.5
UOB20						2.0	26.4	38.8	34.4	0.0	48.4	45.2	6.5	32.3	67.7	28.9	71.1
UOB21	1.4	0.7				2.0	9.6	51.6	40.8	0.0	41.0	48.7	10.3	35.9	64.1	21.8	78.2
UOB22						2.0	21.8	38.2	39.8	0.0	69.8	27.9	2.3	30.2	69.8	41.7	58.3
UOB23	2.9	0.8				4.0	51.8	26.6	21.2	0.0	63.2	36.8	0.0	21.1	78.9	14.6	85.4
UOB24						4.0	68.0	23.0	8.6	0.0	63.6	36.4	0.0	45.5	54.5	27.3	72.7
UOB25	7.8	1.6				4.0	67.8	20.2	11.2	0.0	50.0	40.9	9.1	31.8	68.2	18.5	81.5
UOB26	1.1	0.8				4.0	3.0	74.8	21.8	0.0	51.4	48.6	0.0	7.1	92.9	27.5	72.5
UOB27						2.0	0.8	57.8	40.8	0.0	66.1	30.6	3.2	27.4	72.6	14.7	85.3
UOB28	1.2	0.8				2.0	2.4	64.0	33.2	0.0	76.1	21.7	2.2	10.9	89.1	23.1	76.9
UOB29						2.0	4.8	80.2	15.0	0.0	50.0	50.0	0.0	13.3	86.7	7.9	92.1
UOB30	6.3	2.0	355.0	22.4	431.0	4.0	58.2	34.2	6.8	0.0	72.2	22.2	5.6	16.7	83.3	41.7	58.3
UOB31						5.0	76.8	18.6	4.4	0.0	100.0	0.0	0.0	100.0	0.0	21.7	78.3
UOB32	4.1	1.0	132.0	5.4	429.0	4.0	52.4	25.2	21.8	0.0	76.9	23.1	0.0	15.4	84.6	45.5	54.5
UOB33						3.0	59.2	29.8	10.8	0.0	50.0	50.0	0.0	66.7	33.3	30.6	69.4
UOB34	5.5	1.6	284.0	15.7	428.0	4.0	51.4	28.2	18.4	0.0	36.4	63.6	0.0	54.5	45.5	40.7	59.3
UOB35						3.0	46.8	26.6	25.8	0.0	37.5	50.0	12.5	25.0	75.0	43.6	56.4
UOB36	5.0	1.5	270.0	13.5	428.0	3.0	47.6	29.8	21.8	0.0	44.4	55.6	0.0	55.6	44.4	33.3	66.7
UOB37						3.0	10.2	19.0	70.2	0.0	40.0	40.0	20.0	40.0	60.0	37.5	62.5
BS1	3.7	1.1	94.0	3.5	427.0	2.0	7.0	28.8	64.0	0.0	31.8	50.0	18.2	59.1	40.9	50.0	50.0
BS2						2.0	0.0	45.0	54.6	2.0	45.1	47.1	5.9	43.1	56.9	37.8	62.2
BS3	2.0	0.8				2.0	3.0	39.0	57.6	0.0	65.6	28.1	6.3	21.9	78.1	17.2	82.8
BS4						2.0	0.0	87.8	11.8	0.8	65.6	31.2	2.4	28.0	72.0	25.0	75.0
BS5	2.4	2.3				2.0	0.2	93.8	6.0	0.0	68.5	29.3	2.2	28.3	71.7	32.0	68.0

Samno	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk	eq/blk
BS6	1.9	1.4				2.0	2.4	74.0	23.4	4.3	66.7	27.5	1.4	30.4	69.6	12.5	87.5
BS7						3.0	0.0	89.2	10.6	0.0	76.1	22.5	1.4	18.3	81.7	16.0	84.0
BS8	3.0	2.9				2.0	0.0	96.2	3.8	0.0	73.2	24.4	2.4	26.8	73.2	9.4	90.6
BS9						2.0	0.0	94.0	6.0	0.0	84.6	15.4	0.0	11.5	88.5	13.1	86.9
BS10	0.9	0.8				3.0	0.4	91.0	8.4	0.0	66.7	27.8	5.6	33.3	66.7	9.2	90.8
BS11						2.0	0.0	85.6	14.4	0.0	50.0	43.8	6.3	31.3	68.8	22.7	77.3
BS12	0.7	0.5				2.0	3.2	75.4	20.8	0.0	50.0	46.2	3.8	30.8	69.2	21.3	78.7
BS13						2.0	0.0	82.6	17.2	0.0	44.4	55.6	0.0	55.6	44.4	14.6	85.4
BS14	1.3	0.6				2.0	17.0	43.2	39.8	0.0	60.0	33.3	6.7	40.0	60.0	24.2	75.8
BS15	1.3	0.3	40.0	0.5	421.0	2.0	41.2	26.2	32.6	0.0	80.0	20.0	0.0	20.0	80.0	37.0	63.0

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
BBE1	4.3	95.7	93.1	1.3	5.6	0.0	0.0	8.1	91.9	46.2	7.7	46.2	1.3	-1.1	0.2	0.4
BBE2	16.2	83.4	96.9	2.1	1.0	0.0	0.4	5.5	94.5	42.9	14.3	42.9	0.7	-1.2	0.9	#DIV/0!
BBE3	4.4	94.5	93.9	2.9	3.2	0.0	1.1	9.2	90.8	76.9	7.7	15.4	1.3	-1.0	-0.1	#DIV/0!
BBE4	5.7	93.1	86.0	3.2	10.8	0.0	1.2	6.9	93.1	58.8	17.6	23.5	1.2	-1.1	0.7	#DIV/0!
BBE5	17.6	82.4	100.0	0.0	0.0	0.0	0.0	0.8	99.2	100.0	0.0	0.0	0.7	-2.1	0.2	0.3
BBE6	6.5	92.5	81.1	4.9	14.1	0.0	1.0	4.3	95.7	60.0	20.0	20.0	1.2	-1.3	0.6	#DIV/0!
BBE7	6.3	92.9	91.5	4.6	3.8	0.3	0.5	6.0	94.0	80.0	20.0	0.0	1.2	-1.2	0.0	1.3
BBE8	8.5	91.5	96.0	2.5	1.5	0.0	0.0	1.8	98.2	84.2	15.8	0.0	1.0	-1.7	0.2	#DIV/0!
BBE9	8.1	90.7	91.0	2.0	6.9	0.2	0.9	4.9	95.1	66.7	16.7	16.7	1.0	-1.3	0.3	#DIV/0!
BBE10	5.9	93.4	89.5	1.8	8.6	0.0	0.7	3.7	96.3	81.8	9.1	9.1	1.2	-1.4	0.2	#DIV/0!
BBE11	5.0	93.1	96.6	2.7	0.7	0.2	1.6	6.2	93.8	100.0	0.0	0.0	1.3	-1.2	0.2	#DIV/0!
BBE12	13.0	87.0	99.3	0.7	0.0	0.0	0.0	5.0	95.0	100.0	0.0	0.0	0.8	-1.3	0.5	#DIV/0!
BBE13	5.7	91.8	89.9	2.8	7.3	0.0	2.6	7.9	92.1	77.3	13.6	9.1	1.2	-1.1	0.4	1.4
BBE14	8.7	91.3	95.6	2.8	1.6	0.0	0.0	1.6	98.4	78.9	21.1	0.0	1.0	-1.8	0.4	#DIV/0!
BBE15	8.8	91.2	96.1	2.9	1.0	0.0	0.0	2.1	97.9	89.5	10.5	0.0	1.0	-1.7	0.1	#DIV/0!
BBE16	2.2	96.9	91.4	0.9	7.6	0.0	0.9	5.8	94.2	50.0	50.0	0.0	1.6	-1.2	0.2	#DIV/0!
BBE17	5.4	94.4	94.8	2.1	3.2	0.0	0.2	1.8	98.2	66.7	16.7	16.7	1.2	-1.7	0.4	0.8
BBE18	9.9	89.9	98.6	1.2	0.2	0.0	0.2	5.8	94.2	50.0	0.0	50.0	1.0	-1.2	0.6	#DIV/0!
BBE19	5.6	94.2	98.6	1.4	0.0	0.0	0.2	8.5	91.5	36.4	9.1	54.5	1.2	-1.0	0.2	#DIV/0!
BBE20	8.7	91.3	100.0	0.0	0.0	0.0	0.0	6.9	93.1	61.5	7.7	30.8	1.0	-1.1	0.0	#DIV/0!
BBE21	4.5	94.5	92.7	1.8	5.5	0.0	1.0	5.3	94.7	58.3	8.3	33.3	1.3	-1.3	0.2	#DIV/0!
BBE22	4.4	95.1	85.9	0.5	13.5	0.3	0.3	3.2	96.8	66.7	13.3	20.0	1.3	-1.5	0.4	#DIV/0!
BBE23	2.7	95.0	91.5	0.5	8.1	0.0	2.3	6.6	93.4	75.0	8.3	16.7	1.5	-1.1	0.1	#DIV/0!
BBE24	3.6	95.1	94.0	2.7	3.3	0.0	1.3	6.6	93.4	68.4	21.1	10.5	1.4	-1.2	0.0	#DIV/0!
BBE25	6.8	92.0	91.1	3.5	5.4	0.0	1.1	4.4	95.6	76.9	7.7	15.4	1.1	-1.3	0.3	#DIV/0!
BBE26	7.0	91.9	91.9	2.8	5.3	0.0	1.2	5.6	94.4	69.2	15.4	15.4	1.1	-1.2	0.1	#DIV/0!
BBE27	4.5	93.9	94.7	0.8	4.5	0.0	1.6	1.0	99.0	60.0	40.0	0.0	1.3	-2.0	-0.1	#DIV/0!
BBE28	5.0	94.1	89.2	2.0	8.8	0.0	0.9	3.8	96.2	72.7	9.1	18.2	1.3	-1.4	0.2	#DIV/0!
BBE29	5.5	93.8	89.0	2.6	8.4	0.0	0.7	3.6	96.4	90.9	9.1	0.0	1.2	-1.4	0.3	1.1
BBE30	4.4	93.5	92.0	1.0	7.0	0.0	2.1	5.8	94.3	57.1	14.3	28.6	1.3	-1.2	0.2	1.3
BBE31	4.7	94.4	89.5	1.4	9.0	0.0	0.9	5.9	94.1	77.8	11.1	11.1	1.3	-1.2	0.2	0.6
BBE32	5.3	93.0	86.8	2.1	11.1	0.0	1.7	4.7	95.3	100.0	0.0	0.0	1.2	-1.3	0.3	#DIV/0!
BBE33	2.7	95.3	87.4	4.1	8.5	0.0	2.0	3.9	96.1	65.0	20.0	15.0	1.5	-1.4	0.0	#DIV/0!
BBE34	3.6	94.8	89.0	1.4	9.5	0.0	1.6	5.7	94.3	85.7	14.3	0.0	1.4	-1.2	0.2	1.0
BBE35	3.7	95.3	89.7	2.1	8.2	0.0	1.0	3.1	96.9	75.0	12.5	12.5	1.4	-1.5	0.1	#DIV/0!
BBE36	5.8	92.3	89.3	3.6	7.2	0.0	1.9	3.9	96.1	64.7	23.5	11.8	1.2	-1.4	0.1	#DIV/0!
BBE37	2.4	96.1	89.1	1.8	9.1	0.0	1.5	6.1	93.9	100.0	0.0	0.0	1.6	-1.2	0.4	#DIV/0!
BBE38	5.9	92.8	84.4	4.0	11.5	0.0	1.3	4.6	95.4	70.0	10.0	20.0	1.2	-1.3	0.2	#DIV/0!
BBE39	6.1	91.3	86.9	3.5	9.6	0.0	2.6	4.8	95.2	72.7	18.2	9.1	1.2	-1.3	-0.1	0.8

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
BBE40	20.9	78.2	51.0	15.7	33.2	0.0	0.9	12.5	87.5	38.5	19.2	42.3	0.6	-0.8	0.4	0.9
BBE41	12.4	86.6	60.8	9.0	30.1	0.0	1.0	26.5	73.5	44.4	11.1	44.4	0.8	-0.4	0.3	1.2
BBE42	16.1	82.4	54.0	6.5	39.5	0.0	1.4	16.2	83.8	20.0	20.0	60.0	0.7	-0.7	0.0	1.1
BBE43	10.0	88.7	58.3	5.3	36.4	0.0	1.3	9.5	90.5	38.5	23.1	38.5	0.9	-1.0	0.0	1.1
BBE44	12.2	85.6	57.7	6.6	35.8	0.0	2.2	10.2	89.8	35.7	14.3	50.0	0.8	-0.9	0.2	0.8
BBE45	15.8	83.2	63.7	5.6	30.7	0.0	1.1	6.9	93.1	40.0	26.7	33.3	0.7	-1.1	0.2	1.4
BBE46	9.7	90.0	67.2	5.3	27.6	0.0	0.3	8.0	92.0	37.5	25.0	37.5	1.0	-1.1	0.0	1.2
BBE47	10.0	89.4	75.1	7.4	17.5	0.0	0.7	11.5	88.5	46.2	15.4	38.5	1.0	-0.9	0.0	1.2
BBE48	15.3	83.8	78.9	3.2	17.9	0.0	0.9	12.1	87.9	42.9	14.3	42.9	0.7	-0.9	0.3	1.2
BBE49	15.7	83.1	92.5	3.2	4.3	0.2	1.0	10.7	89.3	64.5	9.7	25.8	0.7	-0.9	0.7	1.6
BBO1	8.7	90.8	96.2	2.0	1.7	0.0	0.5	11.0	89.0	75.3	12.3	12.3	1.0	-0.9	0.2	1.1
BBO2	5.0	93.0	93.0	4.3	2.7	0.0	2.0	18.5	81.5	84.6	3.8	11.5	1.3	-0.6	0.2	1.0
BBU1	6.7	92.8	95.1	2.1	2.8	0.0	0.5	14.8	85.2	75.4	9.8	14.8	1.1	-0.8	0.5	1.0
BBU2	12.4	87.3	90.3	5.1	4.6	0.0	0.2	18.2	81.8	83.3	5.0	11.7	0.8	-0.7	0.3	1.3
BBU3	13.3	85.9	89.7	6.7	3.6	0.0	0.8	20.6	79.4	65.3	12.5	22.2	0.8	-0.6	0.3	0.8
BBU4	7.2	92.3	88.5	7.8	3.7	0.0	0.5	17.2	82.8	84.1	7.9	7.9	1.1	-0.7	0.1	0.7
BBU5	12.8	87.2	94.3	3.0	2.7	0.0	0.0	13.0	87.0	73.8	7.1	19.0	0.8	-0.8	0.3	1.3
BBU6	17.1	82.9	90.6	6.4	3.0	0.0	0.0	19.8	80.2	90.7	4.7	4.7	0.7	-0.6	0.3	1.4
BBU7	15.5	83.0	79.2	10.6	10.2	0.0	1.5	18.0	82.0	88.2	0.0	11.8	0.7	-0.7	0.4	0.4
BBU8	15.9	84.1	85.5	5.5	9.0	0.0	0.0	16.6	83.4	66.7	22.2	11.1	0.7	-0.7	0.1	1.0
BBU9	16.4	82.5	85.9	11.4	2.7	0.0	1.1	14.8	85.2	78.9	21.1	0.0	0.7	-0.8	0.4	1.4
BBU10	14.8	85.2	85.6	9.0	5.4	0.0	0.0	19.1	80.9	81.3	15.6	3.1	0.8	-0.6	0.2	1.3
BBU11	3.2	95.9	84.9	7.6	7.6	0.0	0.9	14.8	85.2	65.1	7.0	27.9	1.5	-0.8	#DIV/0!	1.1
BBU12	7.7	91.8	89.0	4.2	6.8	0.0	0.5	8.9	91.1	75.8	9.1	15.2	1.1	-1.0	0.4	1.4
BBU13	15.5	84.5	80.8	7.5	11.7	0.0	0.0	11.7	88.3	87.5	6.3	6.3	0.7	-0.9	0.4	1.2
BBU14	15.3	84.4	87.0	8.3	4.7	0.0	0.3	11.6	88.4	81.8	12.1	6.1	0.7	-0.9	0.5	1.1
BBU15	9.4	90.1	75.8	13.1	11.0	0.0	0.6	13.8	86.2	75.9	15.5	8.6	1.0	-0.8	0.4	1.3
BBU16	14.0	85.0	74.3	14.5	11.2	0.0	1.0	17.3	82.7	74.0	16.0	10.0	0.8	-0.7	0.1	0.7
BBU17	11.3	88.2	88.7	8.3	3.0	0.0	0.5	18.1	81.9	80.6	15.3	4.2	0.9	-0.7	0.3	1.7
BBU18	18.9	80.5	82.3	11.9	5.8	0.0	0.6	16.9	83.1	81.5	11.1	7.4	0.6	-0.7	0.5	1.5
BBU19	14.7	85.3	89.7	8.1	2.2	0.0	0.0	15.0	85.0	80.0	13.3	6.7	0.8	-0.8	0.3	#DIV/0!
BBU20	15.7	83.8	75.1	16.7	8.2	0.0	0.5	19.7	80.3	82.1	6.0	11.9	0.7	-0.6	0.4	1.2
BBU21	11.1	88.4	74.9	17.0	8.0	0.0	0.6	20.9	79.1	89.6	3.0	7.5	0.9	-0.6	0.5	1.6
BBU22	8.0	90.2	78.2	14.1	7.7	0.0	1.8	19.8	80.2	72.2	13.0	14.8	1.1	-0.6	0.4	0.7
BBU23	13.9	85.8	76.2	16.2	7.5	0.0	0.3	27.5	72.5	81.3	10.9	7.8	0.8	-0.4	0.5	1.0
BBU24	13.9	85.8	83.0	7.1	9.9	0.0	0.3	11.1	88.9	78.8	9.1	12.1	0.8	-0.9	0.7	1.3
BBU25	16.0	83.0	82.2	8.3	9.5	0.0	0.9	17.0	83.0	78.9	2.6	18.4	0.7	-0.7	0.5	1.0
BBU26	17.9	82.1	87.8	8.1	4.1	0.0	0.0	22.1	77.9	88.2	11.8	0.0	0.7	-0.5	0.4	1.3
BBU27	12.2	87.8	86.4	8.7	4.9	0.0	0.0	16.4	83.6	88.9	8.3	2.8	0.9	-0.7	0.2	1.1

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
BBU28	13.1	86.9	92.8	6.6	0.6	0.0	0.0	11.9	88.1	78.1	9.6	12.3	0.8	-0.9	0.5	0.7
BBU29	14.8	85.2	90.7	6.1	3.2	0.0	0.0	9.6	90.4	80.0	10.9	9.1	0.8	-1.0	0.5	0.6
BBU30	13.2	86.8	90.9	4.5	4.5	0.0	0.0	12.0	88.0	90.9	2.3	6.8	0.8	-0.9	0.7	0.9
BBH1	8.5	90.3	85.6	5.0	9.4	0.0	1.2	3.3	96.7	82.8	6.9	10.3	1.0	-1.5	0.6	0.7
BBH2	11.9	86.9	87.3	4.7	8.0	0.0	1.2	3.0	97.0	70.8	12.5	16.7	0.9	-1.5	0.5	0.6
BBH3	11.5	86.7	89.4	2.7	8.0	0.0	1.7	4.0	96.0	66.7	5.6	27.8	0.9	-1.4	0.4	#DIV/0!
BBH4	9.2	90.5	92.4	2.2	5.4	0.0	0.3	3.2	96.8	81.8	9.1	9.1	1.0	-1.5	0.5	#DIV/0!
BBH5	15.8	83.9	97.4	1.1	1.4	0.0	0.2	1.1	98.9	85.7	11.4	2.9	0.7	-1.9	0.8	#DIV/0!
BBH6	10.4	89.1	95.0	2.0	3.1	0.0	0.5	0.6	99.4	74.3	14.3	11.4	0.9	-2.3	0.6	0.5
BBH7	10.9	89.1	93.9	0.8	5.3	0.0	0.0	1.4	98.6	83.3	11.1	5.6	0.9	-1.9	0.6	0.5
BBH8	10.1	89.7	98.5	0.3	1.2	0.0	0.3	1.2	98.8	75.0	8.3	16.7	0.9	-1.9	0.6	#DIV/0!
BBH9	10.0	90.0	94.4	2.6	2.9	0.0	0.0	1.1	98.9	82.1	12.8	5.1	1.0	-2.0	0.7	0.1
BBH10	11.8	87.9	93.1	1.3	5.6	0.0	0.3	2.0	98.0	78.6	5.4	16.1	0.9	-1.7	0.5	0.5
BBH11	10.8	89.2	96.9	1.2	1.9	0.0	0.0	2.2	97.8	94.7	2.6	2.6	0.9	-1.7	0.5	0.3
BBH12	10.4	89.1	97.7	1.7	0.6	0.3	0.3	2.3	97.7	80.6	12.9	6.5	0.9	-1.6	0.5	0.6
BBR1	8.9	89.8	96.2	1.2	2.6	1.0	0.3	0.9	99.1	57.1	28.6	14.3	1.0	-2.1	0.7	#DIV/0!
BBR2	14.9	84.8	96.8	0.6	2.6	0.0	0.3	1.6	98.4	57.1	17.9	25.0	0.8	-1.8	0.6	#DIV/0!
BBR3	10.7	88.8	98.6	1.1	0.3	0.0	0.5	1.1	98.9	62.5	8.3	29.2	0.9	-1.9	0.5	-0.3
BBR4	8.4	91.6	97.3	1.6	1.1	0.0	0.0	1.6	98.4	56.3	18.8	25.0	1.0	-1.8	0.7	0.5
BBR13	14.2	85.8	96.2	0.9	2.9	0.0	0.0	0.9	99.1	71.0	19.4	9.7	0.8	-2.1	0.8	#DIV/0!
BBR14	16.8	83.0	95.4	2.0	2.6	0.0	0.3	1.3	98.7	85.0	15.0	0.0	0.7	-1.9	0.4	-0.6
BBR15	5.7	94.3	95.1	0.9	4.0	0.0	0.0	0.0	100.0	88.9	11.1	0.0	1.2	#NUM!	0.2	0.0
BBR16	5.8	93.6	96.2	0.6	3.2	0.0	0.6	1.5	98.5	70.4	11.1	18.5	1.2	-1.8	0.7	-0.2
BBR17	11.3	88.7	96.1	1.3	2.6	0.0	0.0	1.0	99.0	92.3	7.7	0.0	0.9	-2.0	0.6	0.6
BBR18	6.5	93.5	96.5	0.3	3.2	0.0	0.0	0.6	99.4	76.9	3.8	19.2	1.2	-2.2	0.9	#NUM!
BBR19	8.6	91.1	95.7	0.9	3.4	0.0	0.3	1.4	98.6	84.4	3.1	12.5	1.0	-1.8	0.5	0.8
BBR5	12.9	86.9	96.1	1.2	2.7	0.0	0.3	3.0	97.0	87.9	6.1	6.1	0.8	-1.5	0.3	0.0
BBR6	16.5	83.0	94.9	2.1	3.0	0.0	0.5	0.3	99.7	45.0	15.0	40.0	0.7	-2.5	0.1	0.2
BBR7	12.0	87.2	96.7	0.7	2.7	0.0	0.9	2.3	97.7	58.6	6.9	34.5	0.9	-1.6	0.3	0.3
BBR8	17.3	82.5	91.7	4.3	4.0	0.0	0.3	2.7	97.3	57.6	15.2	27.3	0.7	-1.6	0.4	0.4
BBR9	13.8	85.0	94.1	1.5	4.4	0.0	1.3	1.8	98.2	68.4	5.3	26.3	0.8	-1.7	0.5	#DIV/0!
BBR10	6.8	92.3	93.2	0.6	6.1	0.0	0.9	1.9	98.1	56.4	16.4	27.3	1.1	-1.7	#DIV/0!	#NUM!
BBR11	8.5	91.5	96.9	1.7	1.4	0.0	0.0	3.8	96.2	83.3	8.8	7.9	1.0	-1.4	#DIV/0!	#NUM!
BNL17	15.3	84.7	99.0	0.0	1.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0	0.7	#NUM!	#DIV/0!	#DIV/0!
BNL16	15.6	84.4	86.7	0.8	12.5	0.0	0.0	0.8	99.2	78.6	17.9	3.6	0.7	-2.1	0.8	0.0
BNL1	12.3	87.7	82.0	2.7	15.3	0.0	0.0	1.3	98.7	71.4	14.3	14.3	0.9	-1.9	-0.1	0.3
BNL2	12.3	87.5	87.9	0.6	11.5	0.0	0.3	1.2	98.8	87.9	12.1	0.0	0.9	-1.9	0.1	0.3
BNL3	10.0	90.0	94.8	0.3	4.9	0.0	0.0	1.4	98.6	88.9	0.0	11.1	1.0	-1.8	#DIV/0!	#DIV/0!
BNL4	10.1	89.9	93.4	0.3	6.3	0.0	0.0	1.0	99.0	93.3	6.7	0.0	0.9	-2.0	#DIV/0!	#NUM!

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
BNL5	12.0	88.0	89.4	1.4	9.2	0.0	0.0	1.0	99.0	95.0	5.0	0.0	0.9	-2.0	0.1	#DIV/0!
BNL6	8.5	91.5	94.1	0.3	5.6	0.0	0.0	0.3	99.7	83.3	16.7	0.0	1.0	-2.6	0.2	#DIV/0!
BNL7	9.3	90.7	98.9	1.1	0.0	0.0	0.0	1.1	98.9	66.7	33.3	0.0	1.0	-2.0	0.3	#DIV/0!
BNL8	11.7	88.3	89.6	0.0	10.4	0.0	0.0	0.7	99.3	100.0	0.0	0.0	0.9	-2.1	0.2	0.0
BNL9	10.2	89.8	92.3	1.5	6.2	0.0	0.0	0.7	99.3	92.7	7.3	0.0	0.9	-2.1	0.2	0.0
BNL10	11.6	88.4	85.1	1.1	13.8	0.0	0.0	0.7	99.3	85.7	14.3	0.0	0.9	-2.1	0.4	-0.1
BNL11	21.2	78.8	90.6	1.3	8.1	0.0	0.0	2.7	97.3	92.6	3.7	3.7	0.6	-1.6	0.1	#DIV/0!
BNL12	19.1	80.9	89.0	2.4	8.7	0.0	0.0	2.4	97.6	85.0	15.0	0.0	0.6	-1.6	0.1	#NUM!
BNL13	26.8	73.2	97.2	1.2	1.6	0.0	0.0	2.8	97.2	71.8	17.9	10.3	0.4	-1.5	0.5	-0.3
BNL15	20.8	79.2	97.6	0.0	2.4	0.0	0.0	0.0	100.0	90.5	9.5	0.0	0.6	#NUM!	0.2	#DIV/0!
RGC1	8.1	30.2	70.7	21.3	8.0	40.3	21.4	1.3	98.7	80.0	0.0	20.0	0.6	-1.9	0.0	0.6
RGC2	6.4	36.9	84.0	14.7	1.3	42.9	13.8	4.0	96.0	90.0	10.0	0.0	0.8	-1.4	0.2	0.1
RGC3	12.8	35.0	77.8	11.1	11.1	39.4	12.8	0.0	100.0	100.0	0.0	0.0	0.4	#NUM!	0.1	-0.1
RGC4	9.3	37.2	71.0	19.0	10.0	36.1	17.5	5.0	95.0	55.0	10.0	35.0	0.6	-1.3	0.0	0.2
RCS1	15.2	82.0	85.5	5.8	8.7	0.5	2.4	13.9	86.1	86.1	12.5	1.4	0.7	-0.8	0.2	-0.2
RCS2	14.1	84.7	85.3	9.3	5.3	0.0	1.1	11.3	88.7	88.1	7.5	4.5	0.8	-0.9	0.1	-0.5
RCS3	11.4	88.0	82.5	13.6	3.9	0.0	0.6	14.3	85.7	91.0	1.5	7.5	0.9	-0.8	0.0	-0.8
RCS4	9.4	90.6	80.0	3.2	16.8	0.0	0.0	1.8	98.2	100.0	0.0	0.0	1.0	-1.7	0.2	0.2
RCS5	16.0	82.0	77.4	17.6	5.0	0.0	2.1	6.9	93.1	87.8	6.1	6.1	0.7	-1.1	0.1	-0.2
RCS6	20.9	78.4	76.7	18.3	5.0	0.0	0.7	7.5	92.5	85.4	6.3	8.3	0.6	-1.1	0.3	-0.2
RCS7	25.4	73.1	78.9	17.9	3.2	0.8	0.8	7.4	92.6	83.3	6.3	10.4	0.5	-1.1	0.1	0.0
RCS8	13.6	84.3	76.4	16.1	7.5	0.0	2.1	19.3	80.7	89.5	3.5	7.0	0.8	-0.6	0.3	-0.2
RCS9	13.0	85.1	78.8	13.9	7.3	1.2	0.6	14.6	85.4	81.8	4.5	13.6	0.8	-0.8	0.1	-0.2
RCS10	20.1	75.4	73.3	15.3	11.3	1.5	3.0	14.7	85.3	81.8	9.1	9.1	0.6	-0.8	0.2	-0.4
RCS11	18.7	80.2	71.2	21.2	7.5	0.0	1.1	20.5	79.5	80.6	5.6	13.9	0.6	-0.6	0.2	-0.2
RCS12	16.7	78.6	66.2	25.8	7.9	2.6	2.1	19.9	80.1	86.0	2.3	11.6	0.7	-0.6	0.2	0.0
RCS13	16.1	79.8	71.6	22.4	6.0	0.6	3.6	13.4	86.6	93.8	1.6	4.7	0.7	-0.8	0.3	0.2
RCS14	18.2	73.4	59.2	27.4	13.4	2.8	5.6	16.6	83.4	94.2	1.4	4.3	0.6	-0.7	0.2	0.0
RCS15	24.4	72.9	77.5	6.0	16.5	0.3	2.3	13.3	86.7	95.0	1.7	3.3	0.5	-0.8	0.3	-0.5
KE26	16.8	53.9	58.9	37.8	3.3	21.0	8.4	25.6	74.4	96.3	1.2	2.5	0.5	-0.5	0.0	0.3
KE27	35.8	52.0	59.4	40.6	0.0	5.7	6.5	12.5	87.5	92.0	0.0	8.0	0.2	-0.8	0.1	0.1
KE28	21.5	66.7	64.6	33.3	2.1	9.7	2.1	26.0	74.0	95.2	1.0	3.8	0.5	-0.5	0.1	-0.2
KE29	20.7	63.8	65.8	32.4	1.8	12.6	2.9	24.3	75.7	94.0	3.0	3.0	0.5	-0.5	0.1	0.2
KE30	30.0	52.5	61.9	35.7	2.4	11.9	5.6	10.7	89.3	83.8	0.0	16.2	0.2	-0.9	0.2	-0.3
KE31	20.3	54.1	60.2	35.5	4.3	12.2	13.4	11.8	88.2	91.7	0.0	8.3	0.4	-0.9	0.1	0.0
KE32	17.3	56.5	77.4	22.1	0.5	8.9	17.3	15.8	84.2	93.1	0.0	6.9	0.5	-0.7	0.3	-0.1
KE33	5.5	55.1	56.7	38.3	5.0	21.6	17.8	37.8	62.2	96.7	0.0	3.3	1.0	-0.2	0.5	-0.7
KE34	7.4	67.0	50.0	46.8	3.2	15.2	10.4	24.0	76.0	98.6	0.0	1.4	1.0	-0.5	0.4	-0.1
KE35	8.3	56.4	54.5	42.3	3.3	18.8	16.5	36.6	63.4	97.7	0.0	2.3	0.8	-0.2	0.2	-0.1

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
KE36	14.4	51.9	53.0	43.4	3.6	13.8	20.0	28.9	71.1	93.8	2.5	3.8	0.6	-0.4	0.1	0.2
KE37	15.0	53.9	50.5	44.3	5.2	11.7	19.4	23.7	76.3	95.3	0.0	4.7	0.6	-0.5	-0.2	0.0
KE38	17.6	62.5	69.9	25.8	4.3	14.6	5.4	24.5	75.5	95.9	1.0	3.1	0.5	-0.5	0.3	-0.1
KE39	16.2	66.9	78.2	21.3	0.5	10.6	6.3	23.8	76.2	95.3	0.6	4.1	0.6	-0.5	0.2	-0.2
KE40	24.7	57.6	66.0	32.7	1.3	12.5	5.2	29.5	70.5	98.1	0.0	1.9	0.4	-0.4	0.1	0.0
KE41	19.9	64.8	50.0	49.1	0.9	6.8	8.5	27.2	72.8	98.4	0.0	1.6	0.5	-0.4	0.0	-0.2
KE42	21.5	65.6	54.2	38.3	7.5	6.7	6.1	26.2	73.8	91.9	2.5	5.6	0.5	-0.5	0.1	-0.1
KE43	22.4	67.1	42.7	47.9	9.4	7.0	3.5	25.0	75.0	97.5	0.0	2.5	0.5	-0.5	0.1	0.2
KE44	9.4	44.7	52.1	46.5	1.4	17.0	28.9	26.8	73.2	89.6	9.1	1.3	0.7	-0.4	0.2	-0.3
KE45	20.6	52.5	51.2	42.9	6.0	21.9	5.0	33.3	66.7	95.8	1.6	2.6	0.4	-0.3	0.3	0.3
KE46	13.6	65.8	61.2	30.6	8.3	9.2	11.4	28.1	71.9	90.8	3.9	5.3	0.7	-0.4	0.3	-0.6
KE47	8.5	59.1	44.2	48.1	7.7	17.0	15.3	26.0	74.0	94.9	1.7	3.4	0.8	-0.5	0.3	0.2
KE48	10.3	65.5	43.2	56.8	0.0	14.5	9.7	17.9	82.1	94.2	2.5	3.3	0.8	-0.7	0.3	0.1
KE49	21.8	66.4	40.5	59.5	0.0	4.2	7.6	25.3	74.7	89.2	4.9	5.9	0.5	-0.5	-0.1	0.3
KE50	18.3	71.6	26.9	67.9	5.1	2.8	7.3	7.7	92.3	83.3	9.5	7.1	0.6	-1.1	0.2	0.4
KE51	22.4	65.3	28.1	71.9	0.0	2.0	10.2	7.8	92.2	87.1	8.1	4.8	0.5	-1.1	0.5	0.6
KE52	18.9	73.6	48.7	50.0	1.3	4.7	2.8	19.2	80.8	81.4	12.9	5.7	0.6	-0.6	0.0	0.2
KE53	20.7	66.9	46.4	52.6	1.0	7.6	4.8	35.1	64.9	92.3	1.2	6.5	0.5	-0.3	0.1	0.2
KE54	17.1	72.9	46.8	52.1	1.1	5.4	4.7	18.1	81.9	89.7	3.4	6.8	0.6	-0.7	0.3	-0.4
KE55	14.0	61.9	50.7	45.9	3.4	11.0	13.1	20.5	79.5	94.7	1.8	3.5	0.6	-0.6	0.1	0.3
KE56	41.2	14.9	54.5	45.5	0.0	0.8	43.1	18.2	81.8	83.9	0.0	16.1	-0.4	-0.7	-0.1	-0.1
KE57	10.1	73.6	54.9	42.5	2.7	11.4	4.9	33.6	66.4	96.4	0.6	3.0	0.9	-0.3	0.0	0.8
KE58	25.0	60.7	58.2	38.6	3.3	7.9	6.3	39.9	60.1	88.5	2.6	8.9	0.4	-0.2	0.2	0.0
KE1	17.6	64.8	68.6	28.6	2.9	1.9	15.7	38.6	61.4	96.9	0.0	3.1	0.6	-0.2	0.3	0.1
KE2	21.6	64.0	62.7	33.8	3.5	4.5	9.9	26.8	73.2	95.6	0.0	4.4	0.5	-0.4	0.5	0.1
KE3	12.4	73.9	60.2	31.0	8.8	1.3	12.4	31.0	69.0	92.4	4.0	3.6	0.8	-0.3	0.1	-0.7
KE4	15.4	64.1	74.7	22.7	2.7	0.0	20.5	28.0	72.0	36.9	53.5	9.6	0.6	-0.4	0.5	-0.1
KE5	6.7	63.3	52.6	47.4	0.0	0.0	30.0	10.5	89.5	17.5	77.8	4.7	1.0	-0.9		0.0
KE6	18.3	75.3	87.1	10.7	2.1	0.0	6.5	19.3	80.7	78.7	14.9	6.4	0.6	-0.6	0.2	0.3
KE7	13.8	63.4	68.5	29.3	2.2	0.0	22.8	28.3	71.7	80.7	12.0	7.2	0.7	-0.4	0.2	-1.1
KE8	34.8	59.7	78.1	21.2	0.7	0.4	5.1	11.3	88.7	78.5	14.1	7.4	0.2	-0.9	0.7	-0.1
KE9	11.3	75.0	66.7	33.3	0.0	4.9	8.8	26.1	73.9	76.9	15.4	7.7	0.8	-0.5	0.2	-0.3
KE10	16.5	65.6	81.8	16.8	1.4	3.2	14.7	29.4	70.6	87.3	7.3	5.5	0.6	-0.4	0.3	0.1
KE11	11.1	63.2	67.6	30.6	1.9	3.5	22.2	26.9	73.1	81.8	6.8	11.4	0.8	-0.4	0.5	-0.2
KE12	23.5	49.7	64.0	33.7	2.2	0.0	26.8	12.4	87.6	68.2	20.4	11.4	0.3	-0.9	0.5	0.1
KE13	23.2	63.5	65.3	31.1	3.6	0.8	12.5	33.5	66.5	86.5	4.5	9.0	0.4	-0.3	0.2	-0.1
KE14	36.2	52.8	40.3	55.2	4.5	2.4	8.7	25.4	74.6	90.9	0.0	9.1	0.2	-0.5	0.1	0.0
KE15	25.1	58.1	58.8	38.1	3.1	1.2	15.6	26.8	73.2	86.7	4.4	8.9	0.4	-0.4	0.2	-0.1
KE16	15.1	69.8	68.0	28.8	3.2	2.2	12.8	15.2	84.8	96.9	0.0	3.1	0.7	-0.7	0.4	0.1

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
KE18	9.2	57.6	79.0	17.7	3.3	9.6	23.6	33.7	66.3	98.1	0.0	1.9	0.8	-0.3	0.6	0.0
KE19	14.0	57.0	75.4	22.5	2.2	16.5	12.4	34.8	65.2	95.8	0.0	4.2	0.6	-0.3	0.4	0.1
KE20	22.9	59.7	82.6	17.4	0.0	7.6	9.7	52.3	47.7	96.1	1.0	2.9	0.4	0.0	0.3	0.3
KE21	25.9	58.9	42.4	56.1	1.5	2.7	12.5	24.2	75.8	61.9	28.6	9.5	0.4	-0.5	0.1	0.0
KE22	19.4	61.2	53.7	46.3	0.0	0.0	19.4	24.4	75.6	75.9	17.2	6.9	0.5	-0.5	0.0	0.5
KE23	18.6	58.6	53.7	43.9	2.4	7.1	15.7	24.4	75.6	85.7	10.7	3.6	0.5	-0.5	0.0	-0.2
KE24	15.4	58.1	72.2	27.8	0.0	11.8	14.7	40.5	59.5	98.1	0.6	1.3	0.6	-0.2	0.0	0.0
KE25	6.4	52.3	61.0	35.0	4.1	26.4	14.9	25.2	74.8	98.1	0.0	1.9	0.9	-0.5	0.3	#NUM!
RNB1	14.1	50.8	68.0	20.6	11.3	12.6	22.5	45.4	54.6	96.6	0.0	3.4	0.6	-0.1	0.2	-0.2
RNB2	29.4	52.0	49.1	39.6	11.3	1.0	17.6	26.4	73.6	94.3	2.9	2.9	0.2	-0.4	0.0	0.0
RNB3	21.7	66.7	57.5	33.8	8.8	0.8	10.8	10.0	90.0	91.5	1.2	7.3	0.5	-1.0	0.1	0.0
RNB4	28.7	64.8	38.6	52.9	8.6	1.9	4.6	14.3	85.7	96.9	0.0	3.1	0.4	-0.8	0.1	#DIV/0!
RNB5	16.0	56.8	25.4	70.4	4.2	8.0	19.2	16.9	83.1	100.0	0.0	0.0	0.6	-0.7	0.0	0.3
RNB6	19.2	41.4	42.7	40.2	17.1	0.5	38.9	6.1	93.9	75.0	12.5	12.5	0.3	-1.2	0.3	0.1
RNB7	20.8	58.3	41.4	54.3	4.3	2.5	18.3	11.4	88.6	90.2	0.0	9.8	0.4	-0.9	-0.1	0.1
RNB8	39.7	38.2	26.9	61.5	11.5	0.0	22.1	7.7	92.3	73.3	0.0	26.7	0.0	-1.1	0.0	0.2
RNB9	36.2	55.2	12.5	87.5	0.0	0.0	8.6	6.3	93.8	85.7	0.0	14.3	0.2	-1.2	0.1	0.1
RNB10	32.4	35.1	33.3	56.4	10.3	0.0	32.4	7.7	92.3	81.3	0.0	18.8	0.0	-1.1	0.1	0.3
RNB11	22.7	64.7	28.6	63.6	7.8	0.0	12.6	15.6	84.4	69.0	16.7	14.3	0.5	-0.7	0.2	0.1
RNB12	13.2	50.7	50.6	35.1	14.3	5.3	30.9	35.1	64.9	80.9	7.4	11.7	0.6	-0.3	0.1	-0.1
RNB13	15.3	56.5	71.5	27.8	0.7	3.1	25.1	34.7	65.3	89.8	3.6	6.6	0.6	-0.3	0.1	-0.1
RNB14	9.8	66.9	60.7	37.1	2.2	3.8	19.5	39.9	60.1	94.5	1.1	4.4	0.8	-0.2	-0.1	0.3
RNB15	18.6	54.0	44.3	54.1	1.6	0.9	26.5	14.8	85.2	80.5	4.9	14.6	0.5	-0.8	0.2	-0.1
RNB16	23.3	63.0	51.1	43.5	5.4	3.4	10.3	25.0	75.0	93.0	3.5	3.5	0.4	-0.5	0.1	-0.1
RNB17	22.1	70.1	46.3	13.0	40.7	7.8	0.0	13.0	87.0	100.0	0.0	0.0	0.5	-0.8	0.1	-0.1
RNB18	9.8	43.8	40.8	55.1	4.1	8.0	38.4	34.7	65.3	92.7	0.0	7.3	0.6	-0.3	0.2	#NUM!
RNB19	15.4	52.2	65.2	29.5	5.3	5.5	26.9	42.4	57.6	98.3	0.8	0.8	0.5	-0.1	0.1	-0.5
RNB20	14.3	63.9	47.6	44.9	7.5	4.3	17.4	28.6	71.4	96.2	1.5	2.3	0.6	-0.4	0.2	-0.5
VS2	15.5	75.7	57.2	42.0	0.7	1.6	7.2	37.1	62.9	98.6	0.0	1.4	0.7	-0.2	0.2	0.1
VS3	18.5	73.7	50.9	48.7	0.4	1.3	6.4	22.5	77.5	92.8	0.0	7.2	0.6	-0.5	0.6	#DIV/0!
VS4	18.6	71.3	48.7	49.6	1.8	1.3	8.8	21.2	78.8	92.1	0.0	7.9	0.6	-0.6	0.5	#DIV/0!
VS5	50.4	48.3	86.9	12.7	0.4	0.0	1.3	1.3	98.7	90.9	0.0	9.1	0.0	-1.9	2.4	#DIV/0!
VS7	15.2	78.6	38.6	53.4	8.0	0.0	6.3	4.5	95.5	95.8	0.0	4.2	0.7	-1.3	1.2	#DIV/0!
VS8	36.8	60.9	60.3	32.6	7.1	0.7	1.7	4.3	95.7	100.0	0.0	0.0	0.2	-1.3	1.3	#DIV/0!
VS9	35.0	62.7	35.9	59.4	4.6	2.0	0.3	3.2	96.8	100.0	0.0	0.0	0.3	-1.5	1.2	#DIV/0!
CGD1	8.6	91.4	50.9	2.8	46.2	0.0	0.0	1.9	98.1	0.0	33.3	66.7	1.0	-1.7		#NUM!
CGD2	27.0	72.1	38.6	4.5	56.8	0.8	0.0	1.1	98.9	0.0	0.0	100.0	0.4	-1.9	0.0	#DIV/0!
CGD3	3.8	96.2	56.9	0.0	43.1	0.0	0.0	0.0	100.0	50.0	0.0	50.0	1.4	#NUM!		#DIV/0!
CGD4	11.9	87.6	89.5	3.1	7.4	0.5	0.0	0.0	100.0	50.0	0.0	50.0	0.9	#NUM!	1.1	#DIV/0!

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
CGD5	9.4	90.6	71.1	0.6	28.3	0.0	0.0	2.3	97.7	25.0	25.0	50.0	1.0	-1.6	0.0	#DIV/0!
CGD6	10.4	89.6	75.0	0.0	25.0	0.0	0.0	0.6	99.4	0.0	0.0	100.0	0.9	-2.2	0.5	#DIV/0!
CGD7	2.5	97.5	75.2	0.0	24.8	0.0	0.0	0.7	99.3	0.0	33.3	66.7	1.6	-2.1		#DIV/0!
CGD8	3.9	96.1	82.1	1.1	16.8	0.0	0.0	0.4	99.6	33.3	33.3	33.3	1.4	-2.4	0.2	#NUM!
CGD9	5.2	94.8	90.9	0.0	9.1	0.0	0.0	0.0	100.0	0.0	66.7	33.3	1.3	#NUM!	0.2	#NUM!
CGD10	6.4	93.6	90.4	0.0	9.6	0.0	0.0	0.0	100.0	0.0	0.0	100.0	1.2	#NUM!	0.3	#DIV/0!
CGD11	2.5	97.5	92.9	0.0	7.1	0.0	0.0	0.4	99.6	12.5	37.5	50.0	1.6	-2.4		#DIV/0!
CGD12	4.2	95.8	92.1	0.0	7.9	0.0	0.0	0.0	100.0	50.0	0.0	50.0	1.4	#NUM!	0.1	#DIV/0!
CGD13	12.3	87.7	86.7	0.0	13.3	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.9	#NUM!	0.7	#DIV/0!
CGD14	3.7	96.3	88.9	0.0	11.1	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1.4	#NUM!		#DIV/0!
CGD15	4.5	95.5	83.5	0.0	16.5	0.0	0.0	0.4	99.6	0.0	0.0	100.0	1.3	-2.4	0.1	#DIV/0!
CGD16	6.2	93.8	82.9	0.0	17.1	0.0	0.0	0.5	99.5	0.0	0.0	0.0	1.2	-2.3	0.4	#DIV/0!
CGD17	11.4	88.6	86.2	0.0	13.8	0.0	0.0	0.0	100.0	18.8	37.5	43.8	0.9	#NUM!	0.7	#DIV/0!
CGD18	11.3	88.7	87.7	0.4	11.9	0.0	0.0	0.9	99.1	16.7	16.7	66.7	0.9	-2.1	0.5	1.0
CGD19	13.0	86.1	87.0	0.0	13.0	0.0	0.9	1.0	99.0	15.8	15.8	68.4	0.8	-2.0	0.6	1.4
CGD20	6.2	93.8	94.2	0.4	5.3	0.0	0.0	1.2	98.8	48.0	12.0	40.0	1.2	-1.9	0.6	#DIV/0!
CGD21	11.3	87.6	91.3	0.4	8.3	0.0	1.1	0.0	100.0	42.3	30.8	26.9	0.9	#NUM!	0.8	1.3
CGD23	11.2	88.8	77.0	0.7	22.2	0.0	0.0	0.7	99.3	30.8	15.4	53.8	0.9	-2.1	0.5	0.7
CGD24	8.9	89.1	89.3	0.0	10.7	0.0	2.0	1.1	98.9	40.0	25.0	35.0	1.0	-1.9	0.4	-0.1
CGD25	15.0	82.8	95.3	3.1	1.6	0.9	1.3	16.1	83.9	35.3	46.3	18.3	0.7	-0.7	0.4	0.4
CGD26	11.1	87.8	94.2	2.7	3.1	0.0	1.0	12.7	87.3	41.4	48.6	9.9	0.9	-0.8	0.2	-0.1
CGD27	8.8	89.7	92.8	1.3	5.9	0.0	1.5	8.2	91.8	40.4	46.2	13.5	1.0	-1.0	0.6	1.2
CGD28	8.0	91.8	98.3	1.7	0.0	0.0	0.3	7.8	92.2	24.3	60.2	15.5	1.1	-1.1	0.5	0.5
CGD29	12.1	86.9	97.5	1.1	1.4	0.0	1.0	5.6	94.4	47.2	38.9	13.9	0.9	-1.2	0.3	#DIV/0!
CGD30	12.3	87.5	99.5	0.3	0.3	0.0	0.2	3.3	96.7	58.1	25.6	16.3	0.9	-1.5	0.5	0.7
CGD31	11.9	88.1	99.0	0.8	0.3	0.0	0.0	3.1	96.9	78.8	9.6	11.5	0.9	-1.5	0.4	0.0
CGD32	12.2	86.6	98.0	1.4	0.6	0.0	1.2	6.3	93.7	62.5	29.7	7.8	0.9	-1.2	0.5	0.3
CGD33	19.7	80.0	87.3	0.8	11.9	0.0	0.3	5.5	94.5	71.4	11.4	17.1	0.6	-1.2	0.4	-0.1
CGD34	7.5	91.7	92.7	0.9	6.4	0.0	0.8	5.0	95.0	50.0	37.0	13.0	1.1	-1.3	0.5	#DIV/0!
CGD35	6.5	91.9	95.3	0.6	4.1	0.0	1.6	5.0	95.0	29.1	56.4	14.5	1.2	-1.3	0.7	#DIV/0!
CGD36	6.3	93.4	98.1	0.3	1.6	0.0	0.3	1.1	98.9	27.8	61.1	11.1	1.2	-2.0	0.4	1.0
CGD37	6.5	91.7	94.3	0.3	5.4	0.0	1.9	4.0	96.0	32.8	50.8	16.4	1.2	-1.4	0.5	0.8
CGD38	10.7	89.3	78.3	1.1	20.6	0.0	0.0	1.1	98.9	68.4	31.6	0.0	0.9	-1.9	0.2	#DIV/0!
CGD39	18.9	80.7	93.5	2.5	4.0	0.0	0.4	7.5	92.5	47.4	38.6	14.0	0.6	-1.1	0.4	1.0
CGD40	25.8	74.2	93.4	1.4	5.2	0.0	0.0	12.2	87.8	40.7	41.9	17.4	0.5	-0.9	0.1	1.0
CGD41	9.4	90.3	92.7	1.9	5.4	0.0	0.3	5.0	95.0	29.4	55.3	15.3	1.0	-1.3	0.5	0.7
CGD42	8.8	90.6	94.1	1.1	4.8	0.0	0.7	1.9	98.1	29.6	54.6	15.7	1.0	-1.7	0.5	0.0
CGD43	2.6	97.0	94.3	2.0	3.7	0.3	0.0	0.7	99.3	22.5	69.0	8.5	1.6	-2.2		-0.1
CGD44	11.1	88.3	93.5	0.4	6.1	0.0	0.6	7.2	92.8	21.1	63.2	15.8	0.9	-1.1	0.4	#DIV/0!

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
CGD45	6.1	93.4	96.1	1.3	2.6	0.0	0.4	7.0	93.0	16.4	63.6	20.0	1.2	-1.1	0.6	0.3
CGD46	3.2	94.4	98.8	0.3	0.9	0.0	2.4	2.8	97.2	10.1	67.4	22.5	1.5	-1.5		0.5
CGD47	4.4	94.7	97.7	0.5	1.8	0.0	1.0	2.6	97.4	23.7	60.5	15.8	1.3	-1.6	0.6	0.0
CGD48	4.5	92.9	96.0	0.0	4.0	0.4	2.2	4.0	96.0	20.0	60.0	20.0	1.3	-1.4		1.1
CGD49	6.3	90.7	97.4	0.3	2.3	0.3	2.7	3.6	96.4	24.3	45.9	29.7	1.2	-1.4	0.5	-0.7
CGD50	29.5	68.5	74.2	24.3	1.5	0.5	1.5	21.3	78.7	90.2	6.9	2.9	0.4	-0.6	0.3	0.6
CGD51	26.4	73.6	65.3	31.1	3.7	0.0	0.0	11.1	88.9	85.8	6.5	7.8	0.4	-0.9	0.5	0.2
CGD52	24.7	74.7	64.3	13.0	22.6	0.0	0.6	1.7	98.3	66.0	20.8	13.2	0.5	-1.8	0.5	0.7
CGD53	20.6	76.6	76.6	18.0	5.4	0.0	2.8	20.4	79.6	35.3	54.7	10.0	0.6	-0.6	0.2	0.1
CGD54	21.5	77.8	87.1	8.1	4.8	0.0	0.7	10.0	90.0	37.2	56.1	6.7	0.6	-1.0	0.3	0.4
CGD55	19.0	81.0	60.3	27.9	11.8	0.0	0.0	8.8	91.2	27.9	63.2	8.8	0.6	-1.0		0.2
CGD56	12.8	83.9	82.1	13.9	4.0	0.6	2.8	17.2	82.8	26.0	64.4	9.6	0.8	-0.7	0.6	0.7
CGD57	11.8	80.0	57.4	27.9	14.7	0.0	8.2	8.8	91.2	29.0	61.0	10.0	0.8	-1.0	0.5	1.0
CGD58	10.9	85.1	77.0	19.6	3.4	0.0	4.0	13.5	86.5	67.2	1.6	31.3	0.9	-0.8	0.7	0.4
CGD59	14.1	84.0	69.5	23.7	6.9	0.0	1.9	13.0	87.0	38.5	40.4	21.2	0.8	-0.8		1.1
CGD60	13.3	85.6	78.3	19.3	2.5	0.0	1.1	14.9	85.1	52.6	35.9	11.5	0.8	-0.8	0.5	0.4
CGD61	10.1	88.9	75.7	18.9	5.4	0.0	0.5	20.5	79.5	45.3	49.1	5.7	0.9	-0.6		-0.2
CGD62	6.4	90.0	76.2	21.4	2.4	0.0	3.6	8.7	91.3	38.5	46.2	15.4	1.1	-1.0		-0.4
CGD63	15.9	84.1	83.3	9.8	6.8	0.0	0.0	7.6	92.4	35.5	50.0	14.5	0.7	-1.1	0.5	0.1
CGD64	8.3	88.6	88.2	6.9	4.9	0.0	2.6	6.4	93.6	36.5	49.4	14.1	1.0	-1.2	0.4	-0.2
CGD65	8.0	85.5	87.1	8.2	4.7	0.0	6.5	12.9	87.1	28.4	60.2	11.4	1.0	-0.8	0.4	-1.3
CGD66	16.7	83.3	78.7	16.1	5.2	0.0	0.0	14.2	85.8	74.4	20.9	4.7	0.7	-0.8	0.5	-0.8
CGD67	13.8	83.3	94.1	4.4	1.5	0.4	2.4	7.3	92.7	69.4	22.6	8.1	0.8	-1.1	0.4	0.1
CGD68	9.9	90.1	89.0	11.0	0.0	0.0	0.0	18.8	81.2	76.1	13.6	10.3	1.0	-0.6	0.6	-0.4
LOD1*	4.0	76.2	73.9	6.1	20.0	8.6	11.3	4.3	95.7	23.1	7.7	69.2	1.3	-1.3		0.6
LOS4	35.8	64.2	80.0	18.6	1.4	0.0	0.0	11.9	88.1	96.9	1.9	1.2	0.3	-0.9	0.3	0.0
LOD2	16.6	82.4	91.5	8.2	0.3	0.5	0.5	15.4	84.6	99.0	0.0	1.0	0.7	-0.7	0.4	0.4
LOD3	33.4	65.9	79.6	17.9	2.5	0.3	0.3	12.4	87.6	97.5	0.0	2.5	0.3	-0.8	0.6	0.2
LOD4	36.2	63.8	79.8	16.3	3.9	0.0	0.0	12.9	87.1	97.8	1.1	1.1	0.2	-0.8	0.5	0.1
LOD5	17.0	83.0	79.5	18.4	2.0	0.0	0.0	2.9	97.1	95.0	0.6	4.5	0.7	-1.5	0.5	0.0
LOS5	5.6	92.6	78.7	14.7	6.7	0.0	1.9	8.7	91.3	81.4	6.8	11.9	1.2	-1.0		0.2
LOD5A	40.6	59.4	89.3	9.5	1.2	0.0	0.0	6.7	93.3	100.0	0.0	0.0	0.2	-1.1	0.7	0.3
LOD6	41.6	58.4	87.0	11.0	2.0	0.0	0.0	7.3	92.7	95.3	0.0	4.7	0.1	-1.1	0.4	0.3
LOD7	12.4	83.4	88.2	9.3	2.5	0.0	4.1	6.2	93.8	54.2	45.2	0.6	0.8	-1.2	0.4	0.6
LOD8	30.0	70.0	74.6	22.2	3.2	0.0	0.0	30.2	69.8	2.1	88.7	9.2	0.4	-0.4	0.0	0.1
LOD9	34.2	64.5	61.2	32.7	6.1	0.0	1.3	40.8	59.2	10.4	79.7	10.0	0.3	-0.2	0.0	0.2
LOD10	23.3	75.6	87.7	7.7	4.6	0.0	1.2	20.0	80.0	11.6	79.8	8.7	0.5	-0.6	0.5	-0.6
LOK6	28.3	66.0	68.6	24.3	7.1	0.0	5.7	21.4	78.6	6.2	87.3	6.5	0.4	-0.6	0.2	-0.3
LOK7	24.8	44.2	75.4	22.8	1.8	0.0	31.0	17.5	82.5	11.0	85.2	3.8	0.3	-0.7	0.8	#NUM!

Appendix IV: Parameters derived from the kerogen counts (also includes the results of the geochemical analyses).

Key to abbreviations used in column headers (parameters expressed as a percentage unless otherwise stated):

Samno	= sample number
TOC	= total organic carbon
phytoc	= 'phytoc' parameter (not percentage)
HI	= hydrogen index (mgHC/gTOC)
S2	= S_2 value (mgHC/g rock)
Tmax	= Tmax value (°C)
fluor	= fluorescence value (from the scale in Table 2.4)
AOM	= AOM of kerogen
tphy	= phytoclasts of kerogen
tpaly	= palynomorphs of kerogen
stri/bstb	= striate of biostructured brown wood
stp/bstb	= striped of biostructured brown wood
ban/bstb	= banded of biostructured brown wood
pit/bstb	= pitted of biostructured brown wood
und/bstb	= undegraded of biostructured brown wood
deg/bstb	= degraded of biostructured brown wood
lt/blk	= lath of black wood
eq/blk	= equant of black wood
blk/phy	= black wood of phytoclasts
br/phy	= brown wood of phytoclasts
co/nbbr	= corroded of non-biostructured brown wood
ud/nbbr	= undegraded of non-biostructured brown wood
psu/nbbr	= pseudoamorphous of non-biostructured brown wood
cu/phy	= cuticle of phytoclasts
me/phy	= membranes of phytoclasts
bstr/br	= biostructured of brown wood
nbstr/br	= non-biostructured of brown wood
sp/pal	= sporomorphs of palynomorphs
mp/pal	= marine plankton of palynomorphs
und/pal	= undifferentiated of palynomorphs
lbr/blk	= log ratio brown:black wood
lbstr/nbst	= log ratio biostructured:non-biostructured brown wood
#leq/lat	= log ratio black equant:lath wood calculated out of a count total of a minimum of 50 particles
lstst/bp	= log ratio striate and striped:banded and pitted biostructured brown wood
#NUM	= parameter not calculated due to missing value in one category
#DIV0	= parameter not calculated due to the value in one category being zero

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
LOK8	22.7	63.0	71.1	20.6	8.2	1.9	12.3	27.8	72.2	19.7	70.2	10.2	0.4	-0.4	0.1	#NUM!
LOD11	17.5	82.5	80.3	19.7	0.0	0.0	0.0	13.6	86.4	22.8	63.3	13.9	0.7	-0.8	0.2	#NUM!
LOD12	15.2	84.8	84.3	15.7	0.0	0.0	0.0	10.1	89.9	21.6	68.2	10.2	0.7	-0.9	0.5	-0.8
LOK11	22.9	72.9	66.7	27.5	5.9	0.0	4.3	19.6	80.4	12.3	81.1	6.6	0.5	-0.6	0.2	-0.9
LOD13	16.7	83.3	90.5	8.9	0.6	0.0	0.0	17.2	82.8	92.2	0.0	7.8	0.7	-0.7	0.4	-1.0
LOD14	20.7	79.3	92.4	6.5	1.1	0.0	0.0	8.7	91.3	96.9	0.0	3.1	0.6	-1.0	0.6	#NUM!
LOD15	23.1	76.4	90.1	8.9	1.0	0.0	0.5	11.1	88.9	94.3	4.3	1.4	0.5	-0.9	0.7	-0.2
LOD16	35.4	64.6	85.3	13.6	1.1	0.0	0.0	14.0	86.0	97.6	2.4	0.0	0.3	-0.8	0.8	-0.1
LOK15	37.9	61.0	88.1	9.3	2.6	0.0	1.1	5.6	94.4	72.1	9.3	18.6	0.2	-1.2	1.2	-0.2
LOK16	36.7	57.3	58.8	31.6	9.6	2.5	3.5	7.9	92.1	78.0	7.3	14.6	0.2	-1.1	0.8	-0.5
LOK17	62.2	37.8	68.3	29.3	2.4	0.0	0.0	9.0	91.0	100.0	0.0	0.0	-0.2	-1.0	0.9	-0.2
LOK20	52.1	47.2	82.4	15.6	2.0	0.0	0.7	24.9	75.1	91.2	3.5	5.3	0.0	-0.5	0.9	-0.8
LOK21	62.4	36.7	83.2	14.3	2.5	0.0	0.9	29.2	70.8	94.1	2.0	3.9	-0.2	-0.4	1.1	-1.0
LOK22	56.1	42.8	78.8	17.7	3.4	0.2	0.8	11.8	88.2	95.7	0.0	4.3	-0.1	-0.9	0.9	-0.7
LOK23	64.9	34.6	80.4	17.1	2.5	0.0	0.4	20.9	79.1	93.1	3.4	3.4	-0.3	-0.6	1.5	-0.5
LOK24	10.5	69.2	84.0	12.5	3.4	9.2	11.1	24.7	75.3	100.0	0.0	0.0	0.8	-0.5	0.9	-0.3
LOK25	19.6	64.5	78.9	21.1	0.0	8.5	7.4	19.8	80.2	99.2	0.0	0.8	0.5	-0.6	0.4	-0.2
LOK26	16.5	74.4	88.8	9.5	1.7	5.3	3.8	17.7	82.3	96.4	3.6	0.0	0.7	-0.7	0.6	-0.1
LOK27	11.4	77.5	90.6	7.2	2.2	9.7	1.5	9.4	90.6	98.4	0.0	1.6	0.8	-1.0	0.5	-0.9
LOK28	19.5	75.2	84.8	13.7	1.5	2.7	2.7	22.9	77.1	84.0	2.0	14.0	0.6	-0.5	0.6	-0.6
LOK29	45.8	52.9	84.0	13.5	2.5	0.7	0.7	18.9	81.1	97.1	0.0	2.9	0.1	-0.6	1.0	-0.6
LOK30	44.8	53.0	76.3	20.0	3.7	0.0	2.2	9.4	90.6	77.8	7.4	14.8	0.1	-1.0	1.5	0.0
LOK31	28.8	66.4	88.5	9.9	1.6	0.0	4.7	9.9	90.1	87.5	0.0	12.5	0.4	-1.0	1.0	0.4
LOK32	13.7	64.2	88.5	10.7	0.8	0.5	21.6	9.9	90.1	91.7	0.0	8.3	0.7	-1.0	0.5	0.4
LOK33	6.3	91.4	86.5	11.9	1.7	0.8	1.5	23.2	76.8	97.7	0.0	2.3	1.2	-0.5	0.3	-0.2
LOK34	11.1	83.2	87.6	11.5	0.9	2.1	3.6	15.2	84.8	97.0	0.0	3.0	0.9	-0.7	0.7	0.4
LOK35	8.4	60.5	83.3	14.4	2.3	21.3	9.8	25.0	75.0	95.5	0.8	3.8	0.9	-0.5	0.3	0.3
LOK36	10.8	65.2	83.4	16.1	0.5	14.5	9.5	28.5	71.5	90.3	4.8	4.8	0.8	-0.4	0.0	0.5
LOK37	18.7	69.8	82.0	16.9	1.1	6.1	5.3	13.7	86.3	98.6	0.0	1.4	0.6	-0.8	0.4	0.5
LOK38	16.9	62.8	78.1	20.1	1.8	14.0	6.3	15.5	84.5	94.4	3.7	1.9	0.6	-0.7	0.6	-0.2
LOK39	24.0	55.1	70.3	29.7	0.0	13.4	7.6	16.3	83.7	95.2	3.2	1.6	0.4	-0.7	0.9	0.3
LBT1	6.2	90.3	86.4	9.1	4.5	0.0	3.6	1.1	98.9	31.4	58.8	9.8	1.2	-1.9		0.6
LBT2	9.6	70.2	87.7	11.0	1.4	1.0	19.2	9.6	90.4	32.9	56.1	11.0	0.9	-1.0		0.5
LBT3	13.2	84.1	93.0	4.9	2.2	0.0	2.7	17.8	82.2	55.3	33.0	11.7	0.8	-0.7	0.6	-0.2
LBT4	8.5	84.7	72.0	26.0	2.0	0.0	6.8	5.0	95.0	28.7	56.6	14.7	1.0	-1.3		-0.2
LBT5	13.2	85.5	95.9	4.1	0.0	0.0	1.3	16.5	83.5	48.9	39.4	11.7	0.8	-0.7	0.5	0.1
LBT6	15.2	84.0	86.0	12.7	1.4	0.8	0.0	16.7	83.3	53.9	40.4	5.7	0.7	-0.7	0.5	0.1
LBT7	8.7	87.2	84.7	14.0	1.3	0.0	4.1	14.7	85.3	48.3	41.3	10.5	1.0	-0.8		0.1
LBT8	24.2	65.2	82.6	14.0	3.5	0.0	10.6	20.9	79.1	51.7	34.2	14.2	0.4	-0.6	0.5	0.3

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
LBT9	14.8	81.2	81.8	17.4	0.8	1.3	2.7	33.1	66.9	63.8	31.3	5.0	0.7	-0.3	0.2	0.4
LBT10	14.4	82.2	83.8	13.5	2.7	0.0	3.3	31.8	68.2	60.7	32.1	7.1	0.8	-0.3	0.3	-0.3
LBT11	27.5	71.5	87.0	10.1	2.9	0.0	1.0	22.5	77.5	43.5	47.6	8.9	0.4	-0.5	0.1	-0.5
LBT12	35.4	54.4	93.0	7.0	0.0	0.0	10.1	20.9	79.1	85.2	11.1	3.7	0.2	-0.6	-0.2	-0.1
LBT13	35.6	63.9	63.7	31.5	4.8	0.0	0.5	24.2	75.8	69.7	18.2	12.1	0.3	-0.5	0.1	-0.2
LBT14	31.2	63.3	40.6	56.5	2.9	0.0	5.5	27.5	72.5	88.9	2.8	8.3	0.3	-0.4	-0.2	0.1
LBT15	24.4	71.1	68.8	31.3	0.0	0.0	4.4	26.6	73.4	78.9	11.9	9.2	0.5	-0.4	0.0	0.7
LBT16	23.2	74.1	72.3	26.5	1.2	0.0	2.7	18.1	81.9	23.5	66.2	10.3	0.5	-0.7	0.2	0.2
LBT17	19.5	74.4	78.7	21.3	0.0	0.0	6.1	23.0	77.0	46.3	39.0	14.6	0.6	-0.5	0.4	-0.3
LBM1	10.8	84.4	87.7	10.1	2.2	0.0	4.7	14.5	85.5	67.0	23.0	10.0	0.9	-0.8	0.4	0.0
LBM2	19.2	78.1	77.1	20.3	2.5	0.0	2.6	12.7	87.3	50.3	37.8	11.9	0.6	-0.8	0.5	0.4
LBM3	28.2	70.4	76.7	18.8	4.6	0.3	1.2	24.6	75.4	88.2	5.3	6.6	0.4	-0.5	0.1	0.2
LBM4	27.5	69.1	74.8	23.3	1.9	0.0	3.4	21.4	78.6	93.8	3.8	2.5	0.4	-0.6	0.2	0.0
LBM5	10.8	84.2	91.2	6.4	2.3	0.0	4.9	10.5	89.5	58.5	33.8	7.7	0.9	-0.9	0.5	0.0
LBM6	20.3	78.4	86.7	11.7	1.7	0.0	1.3	19.2	80.8	85.8	7.5	6.6	0.6	-0.6	0.5	0.0
LBM7	13.7	77.2	93.4	6.6	0.0	0.5	8.6	7.9	92.1	29.4	56.5	14.1	0.8	-1.1	0.5	0.0
KBD1	10.1	85.4	57.0	39.3	3.7	0.6	3.8	9.6	90.4	78.8	13.6	7.6	0.9	-1.0		#NUM!
KBK1	23.1	48.4	40.9	43.2	15.9	0.0	28.6	22.7	77.3	79.6	6.8	13.6	0.3	-0.5	0.2	#DIV/0!
KBK2	22.4	72.9	32.3	61.3	6.5	1.2	3.5	17.7	82.3	88.9	0.0	11.1	0.5	-0.7	-0.1	#DIV/0!
KBK3	30.6	58.8	28.0	72.0	0.0	3.5	7.1	16.0	84.0	100.0	0.0	0.0	0.3	-0.7	0.1	#DIV/0!
KBK4	40.5	54.2	26.8	67.6	5.6	2.3	3.1	9.9	90.1	100.0	0.0	0.0	0.1	-1.0	0.3	#DIV/0!
KBK5	44.8	50.7	11.8	85.3	2.9	1.5	3.0	2.9	97.1	92.3	0.0	7.7	0.1	-1.5	0.0	#DIV/0!
KBK7	21.7	66.7	74.5	22.1	3.3	10.1	1.5	26.2	73.8	98.7	0.0	1.3	0.5	-0.4	1.6	#DIV/0!
KBK8	35.0	60.0	20.8	77.1	2.1	1.3	3.8	20.8	79.2	100.0	0.0	0.0	0.2	-0.6	-0.1	0.6
KBK9	41.5	57.3	19.1	76.6	4.3	0.0	1.2	12.8	87.2	90.9	0.0	9.1	0.1	-0.8	0.1	-0.2
KBK10	60.0	37.3	28.6	71.4	0.0	0.0	2.7	14.3	85.7	100.0	0.0	0.0	-0.2	-0.8	0.5	0.4
KBK11	73.7	23.7	44.4	55.6	0.0	2.6	0.0	22.2	77.8	91.7	0.0	8.3	-0.5	-0.5	0.1	0.2
SB1	78.9	20.3	34.3	60.6	5.1	0.0	0.8	1.0	99.0	88.9	0.0	11.1	-0.6	-2.0	1.7	0.6
SB4	83.7	11.8	67.9	32.1	0.0	0.2	4.2	1.8	98.2	93.3	0.0	6.7	-0.8	-1.7	1.5	-0.2
SB7	77.4	22.2	50.0	47.1	2.9	0.0	0.4	2.0	98.0	91.7	0.0	8.3	-0.5	-1.7	1.8	-0.1
SB10	93.1	6.4	50.0	50.0	0.0	0.0	0.4	0.0	100.0	72.2	0.0	27.8	-1.2	#NUM!	1.8	0.2
SB14	76.7	13.7	54.7	34.4	10.9	0.2	9.4	0.0	100.0	90.5	0.0	9.5	-0.7	#NUM!	1.5	0.2
SBS2	72.7	26.9	61.2	38.1	0.7	0.0	0.4	2.2	97.8	100.0	0.0	0.0	-0.4	-1.6	1.2	0.3
SBS4	56.7	43.3	73.6	18.5	7.9	0.0	0.0	0.0	100.0	80.0	0.0	20.0	-0.1	#NUM!	1.3	0.4
SBS5	42.2	57.1	44.8	32.1	23.0	0.0	0.7	3.0	97.0	76.8	10.6	12.7	0.1	-1.5	0.6	-0.1
SBU1	19.0	80.4	13.0	85.5	1.5	0.0	0.6	7.6	92.4	48.4	45.3	6.2	0.6	-1.1	0.5	-0.2
UOB1	26.7	71.5	67.5	30.2	2.2	0.0	1.9	4.1	95.9	63.8	19.1	17.0	0.4	-1.4	1.5	0.0
UOB2	16.2	81.9	75.2	22.1	2.7	0.0	1.9	3.4	96.6	49.2	25.4	25.4	0.7	-1.5	0.7	0.0
UOB3	14.2	78.7	41.8	49.2	9.0	0.6	6.5	4.1	95.9	61.8	11.8	26.5	0.7	-1.4	0.2	0.4

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
UOB4	41.2	58.4	48.1	45.0	7.0	0.0	0.5	3.9	96.1	55.1	13.5	31.5	0.2	-1.4	0.5	0.0
UOB5	15.4	78.8	47.6	52.4	0.0	1.9	3.8	30.5	69.5	42.7	46.3	11.0	0.7	-0.4	0.2	0.2
UOB6	23.2	70.2	51.7	44.1	4.2	2.4	4.2	16.9	83.1	48.1	37.7	14.2	0.5	-0.7	1.0	0.2
UOB7	26.4	68.0	66.4	28.4	5.2	3.0	2.5	27.6	72.4	55.1	30.7	14.2	0.4	-0.4	1.2	-0.2
UOB8	17.2	76.7	60.0	35.2	4.8	2.5	3.7	29.6	70.4	53.2	36.5	10.3	0.6	-0.4	0.3	0.0
UOB9	11.9	83.9	59.3	35.2	5.6	2.6	1.6	25.3	74.7	65.1	27.7	7.2	0.8	-0.5	0.5	-0.2
UOB10	13.3	82.4	46.4	50.7	2.8	1.6	2.7	28.0	72.0	68.9	25.0	6.1	0.8	-0.4	0.7	0.4
UOB11	25.7	73.0	47.6	44.6	7.7	0.9	0.4	15.5	84.5	85.9	11.2	2.9	0.5	-0.7	0.5	0.2
UOB12	19.4	79.1	39.3	53.4	7.4	1.0	0.5	14.1	85.9	87.6	6.4	6.0	0.6	-0.8	0.4	0.2
UOB13	20.1	78.5	41.1	56.5	2.4	0.0	1.4	26.2	73.8	76.2	15.5	8.3	0.6	-0.4	0.1	0.0
UOB14	17.7	79.0	42.2	57.1	0.7	1.1	2.2	36.1	63.9	59.5	29.7	10.8	0.6	-0.2	0.2	0.0
UOB15	14.5	85.5	34.0	63.8	2.1	0.0	0.0	27.7	72.3	76.5	11.5	11.9	0.8	-0.4	0.1	0.3
UOB16	21.9	78.1	28.0	69.2	2.7	0.0	0.0	20.9	79.1	88.8	5.0	6.2	0.6	-0.6	0.3	0.5
UOB17	18.1	81.0	37.2	61.2	1.6	0.0	0.9	31.4	68.6	69.2	19.8	11.0	0.7	-0.3	0.5	0.0
UOB18	18.4	80.8	35.8	60.5	3.7	0.4	0.4	17.2	82.8	82.8	8.9	8.3	0.6	-0.7	0.8	0.4
UOB19	11.4	88.6	48.3	50.2	1.5	0.0	0.0	21.9	78.1	86.8	9.9	3.3	0.9	-0.6	0.3	#DIV/0!
UOB20	23.2	76.8	22.8	77.2	0.0	0.0	0.0	20.8	79.2	86.6	7.0	6.4	0.5	-0.6	0.4	0.5
UOB21	21.3	73.6	32.1	67.4	0.5	5.0	0.0	20.5	79.5	84.8	10.3	4.9	0.5	-0.6	0.6	0.0
UOB22	12.6	86.4	33.3	63.6	3.0	0.0	1.0	26.1	73.9	69.3	19.1	11.6	0.8	-0.5	0.1	-0.2
UOB23	30.8	68.4	19.8	79.1	1.1	0.0	0.8	20.9	79.1	72.6	12.3	15.1	0.3	-0.6	0.5	-0.2
UOB24	38.3	59.1	19.1	79.4	1.5	0.0	2.6	16.2	83.8	74.4	7.0	18.6	0.2	-0.7	0.4	-0.1
UOB25	26.7	73.3	21.6	78.4	0.0	0.0	0.0	29.7	70.3	78.6	12.5	8.9	0.4	-0.4	0.2	-0.2
UOB26	10.7	87.7	62.8	36.3	0.9	0.5	1.1	21.3	78.7	85.3	5.5	9.2	0.9	-0.6	0.5	-0.3
UOB27	11.8	86.9	44.6	55.0	0.4	0.0	1.4	24.7	75.3	84.8	8.3	6.9	0.9	-0.5	0.5	-0.1
UOB28	8.1	90.9	44.7	54.6	0.7	0.3	0.6	15.8	84.2	78.3	11.4	10.2	1.0	-0.7	0.5	0.3
UOB29	22.2	76.6	58.6	41.0	0.3	1.0	0.2	9.8	90.2	85.3	9.3	5.3	0.5	-1.0	1.1	0.3
UOB30	21.1	78.9	18.5	81.5	0.0	0.0	0.0	13.3	86.7	79.4	8.8	11.8	0.6	-0.8	0.2	0.3
UOB31	24.7	75.3	15.7	84.3	0.0	0.0	0.0	1.4	98.6	81.8	9.1	9.1	0.5	-1.8	0.3	0.4
UOB32	26.2	71.4	18.9	80.0	1.1	0.0	2.4	14.4	85.6	58.7	32.1	9.2	0.4	-0.8	0.1	0.5
UOB33	24.2	75.8	23.9	76.1	0.0	0.0	0.0	5.3	94.7	75.9	7.4	16.7	0.5	-1.3	0.2	0.4
UOB34	41.8	58.2	14.6	85.4	0.0	0.0	0.0	13.4	86.6	79.3	9.8	10.9	0.1	-0.8	0.2	0.7
UOB35	29.3	70.7	23.4	76.6	0.0	0.0	0.0	17.0	83.0	70.5	19.4	10.1	0.4	-0.7	0.1	0.3
UOB36	28.2	70.5	16.2	82.9	1.0	0.0	1.3	8.6	91.4	70.6	16.5	12.8	0.4	-1.0	0.2	0.0
UOB37	33.7	63.2	25.0	73.3	1.7	0.0	3.2	16.7	83.3	84.3	12.5	3.1	0.3	-0.7	0.1	0.0
BS1	27.8	70.8	14.7	85.3	0.0	1.4	0.0	21.6	78.4	54.7	39.1	6.3	0.4	-0.6	0.0	-0.1
BS2	20.0	77.3	34.5	63.8	1.7	0.0	2.7	29.3	70.7	61.9	29.3	8.8	0.6	-0.4	0.2	0.2
BS3	14.9	85.1	22.9	77.1	0.0	0.0	0.0	19.3	80.7	71.2	19.8	9.0	0.8	-0.6	0.4	0.6
BS4	17.3	80.4	49.3	50.7	0.0	1.8	0.5	35.4	64.6	71.2	20.3	8.5	0.7	-0.3	0.5	0.3
BS5	26.7	71.9	38.6	61.1	0.3	0.6	0.9	27.3	72.7	73.3	20.0	6.7	0.4	-0.4	0.3	0.3

Samno	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbst	#leq/lat	lstst/bp
BS6	15.1	83.2	31.2	68.2	0.6	0.3	1.4	22.4	77.6	57.3	34.2	8.5	0.7	-0.5	0.8	0.4
BS7	21.1	77.6	39.0	60.4	0.6	0.7	0.7	20.5	79.5	49.1	28.3	22.6	0.6	-0.6	0.7	0.5
BS8	24.3	75.7	36.5	63.2	0.3	0.0	0.0	11.3	88.7	73.7	15.8	10.5	0.5	-0.9	1.0	0.4
BS9	32.6	66.4	25.0	74.0	1.0	0.2	0.9	8.3	91.7	63.3	16.7	20.0	0.3	-1.0	0.8	0.7
BS10	26.4	72.7	39.9	60.1	0.0	0.4	0.4	5.4	94.6	45.2	33.3	21.4	0.4	-1.2	1.0	0.3
BS11	30.8	68.7	33.3	66.7	0.0	0.0	0.5	10.9	89.1	72.2	13.9	13.9	0.3	-0.9	0.5	0.0
BS12	32.4	67.1	19.0	79.8	1.2	0.0	0.5	10.3	89.7	73.1	13.5	13.5	0.3	-0.9	0.6	0.0
BS13	33.2	66.1	18.7	80.6	0.7	0.2	0.5	6.6	93.4	67.4	19.8	12.8	0.3	-1.2	0.8	-0.1
BS14	15.3	81.9	21.5	74.0	4.5	0.0	2.8	8.5	91.5	55.3	28.6	16.1	0.7	-1.0	0.4	0.2
BS15	20.6	79.4	30.8	66.3	2.9	0.0	0.0	4.8	95.2	76.7	11.0	12.3	0.6	-1.3	0.3	0.6

APPENDIX V

Appendix V: Parameters derived from the palynomorph counts

Key to abbreviations used in column headers (percentage parameters unless otherwise stated):

SAMNO	= sample number
bot	= *Botryococcus* of palynomorphs
undif	= undifferentiated of palynomorphs
mp	= marine plankton of palynomorphs
sporo	= sporomorphs of palynomorphs
tnw/sp	= thin-walled of spores
tkw/sp	= thick-walled of spores
sp/spor	= spores of sporomorphs
up/tp	= unidentified of pollen
cal/tp	= *Callialasporites* of pollen
cer/tp	= *Cerebropollenites* of pollen
bis/tp	= bisaccates of pollen
tp/spor	= pollen of sporomorphs
ud/td	= unidentified of dinocysts
smd/td	= very poorly preserved of dinocysts
nan/td	= *Nannoceratopsis* of dinocysts
cad/td	= *Caddasphaera* of dinocysts
bat/td	= *Batiacasphaera* of dinocysts
prv/td	= *Parvocysta* of dinocysts
dis/td	= *Dissiliodinium* of dinocysts
cte/td	= *Ctenidodinium* of dinocysts
dur/td	= *Durotrigia* of dinocysts
mei/td	= *Meiurogonyaulax* of dinocysts
gt/td	= other gonyaulacacean type of dinocysts
par/td	= *Pareodinia* of dinocysts
sen/td	= *Sentusidinium* of dinocysts
jman/td	= *Jansonia manifesta* of dinocysts
rhy/td	= *Rhychodiniopsis* of dinocysts
adnat/td	= *Adnatosphaeridium* of dinocysts
dindiv	= dinocyst diversity (number of genera present, only calculated for main lagoonal formations)
dindom	= dinocyst dominance (only calculated for main lagoonal formations)
din/mp	= dinocysts of marine plankton
ac/mp	= acritarchs of marine plankton
tas/mp	= *Tasmanites* type prasinophyte marine plankton
lei/mp	= leiospheres of marine plankton
lspor/mp	= log ratio sporomorphs:marine plankton
lacr/din	= log ratio acritarchs:dinocysts
lup/bis	= log ratio unidentified pollen:bisaccates
lspore/bis	= log ratio spores:bisaccates
#NUM	= parameter not calculated due to missing value in one category
#DIV0	= parameter not calculated due to value in one category being zero

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
BBE1	0.0	6.3	3.7	90.0	100.0	0.0	1.5	82.0	0.0	3.0	15.0	98.5	80.0		20.0	0.0
BBE2																
BBE3																
BBE4	0.3	3.7	5.0	91.0	100.0	0.0	2.6	94.0	0.0	0.4	5.6	97.4	90.0		0.0	0.0
BBE5																
BBE6	0.0	4.7	4.0	91.3	100.0	0.0	1.5	89.3	0.0	2.2	8.5	98.5	80.0		20.0	0.0
BBE7																
BBE8																
BBE9	0.0	2.3	7.7	90.0	100.0	0.0	1.5	89.8	0.0	0.4	9.8	98.5	80.0		6.7	0.0
BBE10																
BBE11	0.7	3.7	4.3	91.3	100.0	0.0	2.2	86.2	0.0	1.1	12.7	97.8	100.0		0.0	0.0
BBE12																
BBE13																
BBE14	0.7	4.7	4.0	90.7	100.0	0.0	1.5	88.4	0.0	1.9	9.7	98.5	88.9		0.0	0.0
BBE15																
BBE16																
BBE17	0.0	5.7	5.3	85.7	0.0	0.0	0.0	93.4	0.8	1.6	4.3	100.0	50.0		42.9	0.0
BBE18	0.0	5.7	1.7	92.7	100.0	0.0	2.2	95.6	0.0	1.1	3.3	97.8	50.0		50.0	0.0
BBE19	0.0	5.3	2.0	92.7	100.0	0.0	3.6	95.5	0.0	0.7	3.7	96.4	100.0		0.0	0.0
BBE20	0.0	4.0	4.3	91.7	100.0	0.0	1.5	92.3	0.0	1.1	6.6	98.5	44.4		33.3	0.0
BBE21	0.3	4.7	7.0	88.0	100.0	0.0	3.0	89.5	0.4	3.5	6.6	97.0	47.1		35.3	0.0
BBE22	0.0	5.0	3.3	91.7	100.0	0.0	5.1	90.8	0.0	1.1	8.0	94.9	22.2		55.6	0.0
BBE23	0.0	4.0	3.7	92.3	100.0	0.0	4.0	91.7	0.8	1.9	5.6	96.0	40.0		50.0	0.0
BBE24	0.0	4.3	3.3	92.3	100.0	0.0	6.5	93.1	1.2	1.5	4.2	93.5	28.6		57.1	0.0
BBE25	0.3	5.3	4.3	90.0	100.0	0.0	6.7	87.3	0.4	3.2	9.1	93.3	45.5		27.3	0.0
BBE26	0.0	4.7	2.7	92.7	94.4	5.6	6.5	88.8	0.0	3.1	8.1	93.5	42.9		0.0	14.3
BBE27	0.0	5.3	3.3	91.3	92.9	7.1	5.1	87.3	0.4	2.7	9.6	94.9	44.4		55.6	0.0
BBE28	0.0	4.7	3.7	91.7	94.1	5.9	6.2	90.7	0.4	3.5	5.4	93.8	45.5		36.4	9.1
BBE29	0.0	4.7	3.3	92.0	100.0	0.0	6.2	92.7	0.8	1.5	5.0	93.8	33.3		22.2	22.2
BBE30	0.0	4.3	3.7	92.0	100.0	0.0	3.6	94.4	0.0	1.9	3.8	96.4	30.0		50.0	0.0
BBE31	0.0	4.7	2.7	92.7	82.4	17.6	6.1	90.8	0.8	2.3	6.1	93.9	66.7		33.3	0.0
BBE32	0.3	5.3	3.0	91.3	100.0	0.0	2.6	90.6	0.7	0.7	7.9	97.4	25.0		50.0	12.5
BBE33	0.0	4.0	1.7	94.3	100.0	0.0	3.2	88.3	1.5	2.9	7.3	96.8	40.0		40.0	0.0
BBE34	0.0	4.0	2.0	94.0	100.0	0.0	3.5	89.0	0.7	2.9	7.4	96.5	0.0		50.0	0.0
BBE35	0.0	3.7	1.7	94.7	100.0	0.0	2.1	90.3	0.0	2.5	7.2	97.9	25.0		75.0	0.0
BBE36	0.0	4.0	1.3	94.7	83.3	16.7	2.1	91.4	0.7	1.8	6.1	97.9	50.0		25.0	0.0
BBE37	0.0	4.7	7.0	88.3	100.0	0.0	4.2	89.0	2.0	2.4	6.7	95.8	15.0		65.0	0.0
BBE38	0.0	3.7	6.3	90.0	100.0	0.0	4.8	88.7	1.2	3.1	7.0	95.2	21.1		68.4	0.0
BBE39	0.0	4.3	5.7	90.0	64.7	35.3	6.3	83.4	2.4	4.3	9.9	93.7	41.2		41.2	5.9

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
BBE40	0.0	4.7	5.0	91.0	93.8	6.3	5.9	79.4	1.9	4.3	14.4	94.1	50.0		16.7	0.0
BBE41	0.7	6.3	5.7	87.3	91.9	8.1	14.1	78.7	5.3	2.7	13.3	85.9	41.2		58.8	0.0
BBE42	0.0	3.7	6.0	90.3	87.0	13.0	8.5	80.2	4.0	4.8	10.9	91.5	43.8		50.0	0.0
BBE43	0.3	4.3	4.3	91.0	76.9	23.1	9.5	74.1	4.5	6.1	15.4	90.5	27.3		45.5	0.0
BBE44	0.3	4.0	4.3	91.3	88.2	11.8	6.2	85.6	2.3	2.3	9.7	93.8	81.8		9.1	0.0
BBE45	0.0	4.0	5.3	90.7	100.0	0.0	6.3	81.2	1.6	3.5	13.7	93.8	64.3		21.4	0.0
BBE46	0.3	3.3	1.3	95.0	100.0	0.0	7.0	85.3	1.9	1.5	11.3	93.0	75.0		25.0	0.0
BBE47	0.0	3.7	1.0	95.3	100.0	0.0	5.9	87.0	1.9	1.9	9.3	94.1	66.7		0.0	0.0
BBE48	0.3	4.0	2.3	93.3	94.7	5.3	6.8	79.3	1.5	3.8	15.3	93.2	16.7		33.3	0.0
BBE49																
BBO1	0.0	5.7	5.0	89.3	100.0	0.0	3.7	85.3	0.8	3.1	10.9	96.3	57.1		28.6	0.0
BBO2	0.0	6.0	6.0	88.0	100.0	0.0	2.7	77.8	1.6	3.9	16.7	97.3	44.4		38.9	11.1
BBU1	0.0	5.3	3.0	91.7	92.3	7.7	4.7	83.2	1.1	3.4	12.2	95.3	28.6		42.9	0.0
BBU2	0.0	6.0	5.3	88.7	93.3	6.7	5.6	78.9	2.0	3.6	15.5	94.4	33.3		50.0	8.3
BBU3	0.3	6.7	2.7	90.3	93.8	6.3	5.9	83.1	0.8	1.6	14.5	94.1	85.7		14.3	0.0
BBU4	0.0	6.0	5.3	88.7	92.0	8.0	9.4	80.9	3.7	2.1	13.3	90.6	56.3		31.3	0.0
BBU5	0.0	4.7	4.7	90.7	100.0	0.0	5.1	81.4	2.3	2.3	14.0	94.9	58.3		33.3	8.3
BBU6	1.3	7.0	3.7	88.0	100.0	0.0	5.3	84.0	0.0	0.4	15.6	94.7	54.5		36.4	0.0
BBU7	0.7	5.0	6.0	88.3	85.2	14.8	10.2	84.5	2.1	1.3	12.2	89.8	47.1		41.2	0.0
BBU8	0.3	3.3	3.7	92.7	90.0	10.0	7.2	80.2	0.4	1.6	17.8	92.8	36.4		36.4	0.0
BBU9	0.0	5.7	5.3	89.0	100.0	0.0	9.4	79.8	0.8	0.8	18.6	90.6	53.3		20.0	0.0
BBU10	0.0	3.7	4.0	92.3	100.0	0.0	6.5	85.3	0.8	0.4	13.5	93.5	66.7		33.3	0.0
BBU11	0.7	7.3	4.7	87.3	100.0	0.0	5.0	86.3	0.4	0.8	12.4	95.0	66.7		33.3	0.0
BBU12	0.0	5.3	2.3	92.3	100.0	0.0	5.4	82.1	0.8	2.3	14.9	94.6	42.9		14.3	0.0
BBU13	0.0	6.3	5.3	88.3	100.0	0.0	7.9	89.3	0.4	0.4	9.8	92.1	37.5		37.5	0.0
BBU14	0.3	6.3	4.0	89.3	100.0	0.0	4.1	89.5	0.4	1.6	8.6	95.9	70.0		30.0	0.0
BBU15	0.0	4.0	3.0	93.0	100.0	0.0	5.0	90.9	0.4	0.0	8.7	95.0	62.5		25.0	0.0
BBU16	0.0	3.3	3.3	93.3	100.0	0.0	3.9	89.2	1.1	0.4	9.3	96.1	60.0		10.0	10.0
BBU17	0.0	4.7	3.3	92.0	100.0	0.0	4.0	80.8	1.1	1.5	16.6	96.0	33.3		33.3	0.0
BBU18	0.0	4.3	2.0	93.7	100.0	0.0	6.0	82.6	1.1	1.9	14.4	94.0	60.0		0.0	0.0
BBU19	0.0	5.0	4.7	90.3	100.0	0.0	8.1	88.4	1.2	0.4	10.0	91.9	38.5		53.8	0.0
BBU20	0.3	4.0	2.7	93.0	96.0	4.0	9.0	85.4	2.0	1.6	11.0	91.0	28.6		14.3	28.6
BBU21	0.0	4.3	6.3	89.3	94.1	5.9	12.7	85.0	3.4	3.0	8.5	87.3	35.3		29.4	11.8
BBU22	0.0	4.0	4.3	91.7	96.0	4.0	9.1	82.4	1.6	0.8	15.2	90.9	33.3		66.7	0.0
BBU23	0.0	4.3	4.0	91.7	100.0	0.0	9.1	89.6	1.2	1.6	7.6	90.9	41.7		41.7	0.0
BBU24	0.0	4.3	1.3	94.3	93.8	6.3	5.7	88.8	1.1	2.2	7.9	94.3	25.0		75.0	0.0
BBU25	0.0	5.0	1.7	93.3	100.0	0.0	6.4	91.2	0.0	1.9	6.9	93.6	20.0		20.0	60.0
BBU26	0.3	3.7	1.0	95.0	100.0	0.0	4.6	90.8	0.0	1.5	7.7	95.4	66.7		33.3	0.0
BBU27	0.0	6.3	2.7	91.0	100.0	0.0	3.7	91.3	1.1	0.4	7.2	96.3	50.0		37.5	12.5

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
BBU28	0.0	5.0	2.0	93.0	100.0	0.0	5.0	86.8	0.0	0.0	13.2	95.0	66.7		0.0	0.0
BBU29	0.0	7.3	1.7	91.0	100.0	0.0	4.0	87.8	1.5	2.3	8.4	96.0	33.3		33.3	0.0
BBU30	0.0	8.0	2.3	89.7	92.3	7.7	4.8	85.9	0.4	2.3	11.3	95.2	42.9		28.6	0.0
BBH1	0.3	7.0	4.3	88.3	100.0	0.0	3.8	89.4	0.8	1.2	8.6	96.2	25.0		33.3	16.7
BBH2	0.0	6.0	3.7	90.3	100.0	0.0	10.0	88.9	2.0	0.8	8.2	90.0	20.0		40.0	20.0
BBH3	0.0	5.0	2.3	92.7	100.0	0.0	7.6	85.2	0.8	3.1	10.9	92.4	28.6		14.3	14.3
BBH4	0.3	3.7	1.3	94.7	100.0	0.0	3.9	91.2	0.4	0.7	7.7	96.1	33.3		66.7	0.0
BBH5	0.0	4.0	1.0	95.0	100.0	0.0	2.1	89.2	0.7	1.1	9.0	97.9	66.7		33.3	0.0
BBH6	0.3	5.3	2.3	92.0	100.0	0.0	5.8	91.2	0.8	0.8	7.3	94.2	14.3		42.9	28.6
BBH7	0.0	4.0	1.7	94.3	100.0	0.0	7.1	82.1	1.5	2.3	14.1	92.9	25.0		25.0	0.0
BBH8	0.0	5.0	1.7	93.3	100.0	0.0	3.9	85.5	2.2	2.2	10.0	96.1	40.0		40.0	0.0
BBH9	0.0	4.7	1.7	93.7	100.0	0.0	2.5	90.9	0.0	1.8	7.3	97.5	0.0		66.7	0.0
BBH10	0.0	4.0	1.0	95.0	90.0	10.0	3.5	77.5	1.1	1.8	13.6	96.5	33.3		33.3	0.0
BBH11	0.0	5.7	2.0	92.3	100.0	0.0	6.5	79.5	1.9	3.1	15.4	93.5	16.7		16.7	16.7
BBH12																
BBR1																
BBR2	0.0	7.0	5.0	88.0	100.0	0.0	4.2	90.9	0.8	3.2	5.1	95.8	46.7		6.7	13.3
BBR3																
BBR4																
BBR13	0.0	9.0	1.7	89.3	100.0	0.0	3.0	91.5	0.0	2.3	6.2	97.0	60.0		0.0	0.0
BBR14																
BBR15																
BBR16																
BBR17																
BBR18	0.0	7.3	1.7	91.0	100.0	0.0	3.3	90.2	0.0	3.4	6.4	96.7	80.0		0.0	20.0
BBR19																
BBR5	0.0	8.7	2.3	89.0	100.0	0.0	2.6	88.5	0.0	8.5	3.1	97.4	83.3		0.0	16.7
BBR6																
BBR7																
BBR8	0.0	9.7	1.7	88.7	100.0	0.0	2.3	90.4	0.0	4.8	4.9	97.8	33.3		0.0	0.0
BBR9																
BBR10																
BBR11	0.0	5.0	7.3	87.7	100.0	0.0	3.0	90.6	0.0	3.5	5.9	97.0	70.6		0.0	5.9
BNL17																
BNL16	0.0	2.0	9.3	88.3	100.0	0.0	1.5	90.0	0.4	1.1	8.4	98.5	40.0		28.0	4.0
BNL1																
BNL2	0.0	2.3	7.3	90.3	100.0	0.0	0.4	94.4	0.7	0.0	4.8	99.6	52.6		31.6	5.3
BNL3																
BNL4																

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
BNL5	0.0	1.3	4.3	94.3	0.0	0.0	0.0	92.6	0.0	1.8	5.7	100.0	36.4		45.5	18.2
BNL6																
BNL7																
BNL8																
BNL9	0.0	1.7	7.3	90.7	100.0	0.0	1.8	90.6	0.0	0.7	8.6	98.2	52.6		31.6	0.0
BNL10	0.0	2.7	6.7	90.7	100.0	0.0	1.5	93.3	0.0	0.0	6.7	98.5	64.7		11.8	0.0
BNL11																
BNL12																
BNL13	0.0	3.3	7.0	89.7	100.0	0.0	0.4	92.9	0.0	0.4	6.7	99.6	38.9		22.2	0.0
BNL15																
RGC1	0.0	7.0	9.0	84.0	100.0	0.0	2.8	80.4	0.4	1.2	18.0	97.2	77.8		0.0	0.0
RGC2																
RGC3																
RGC4	0.0	7.7	7.7	84.7	100.0	0.0	1.6	83.2	0.0	0.0	16.8	98.4	87.0		4.3	0.0
RCS1	13.7	3.7	8.7	74.0	92.3	7.7	5.9	47.8	0.5	2.4	49.3	94.1	29.2		0.0	0.0
RCS2	16.7	2.7	5.3	75.3	92.3	7.7	5.8	39.0	0.5	1.4	59.2	94.2	25.0		12.5	0.0
RCS3	16.0	2.0	6.0	76.0	90.5	9.5	9.2	36.7	1.4	2.4	59.4	90.8	28.6		0.0	14.3
RCS4																
RCS5	27.7	3.0	5.7	63.7	96.3	3.7	14.1	36.6	1.2	5.5	56.7	85.9	35.7		0.0	7.1
RCS6	21.0	2.7	3.3	73.0	84.6	15.4	5.9	34.0	1.0	1.9	63.1	94.1	44.4		0.0	0.0
RCS7	19.3	2.0	1.7	77.0	87.0	13.0	10.0	37.5	1.4	2.9	58.2	90.0	20.0		0.0	20.0
RCS8	20.0	0.7	1.0	78.3	83.3	16.7	7.7	28.1	1.4	2.3	68.2	92.3	66.7		0.0	33.3
RCS9	16.0	1.0	3.0	80.0	96.3	3.7	11.3	39.4	0.5	3.3	56.8	88.8	33.3		0.0	0.0
RCS10	19.3	2.7	5.0	73.0	94.1	5.9	7.8	38.6	1.5	1.5	58.4	92.2	23.1		0.0	0.0
RCS11	22.3	0.7	1.3	75.7	100.0	0.0	16.3	46.3	2.1	5.8	45.8	83.7	50.0		0.0	0.0
RCS12	19.0	1.0	0.7	79.3	100.0	0.0	10.5	43.7	1.4	2.3	52.6	89.5	100.0		0.0	0.0
RCS13	13.0	1.7	3.7	81.7	80.6	19.4	12.7	46.7	1.4	3.3	48.6	87.3	22.2		0.0	0.0
RCS14	14.0	2.7	2.7	80.7	89.7	10.3	12.0	35.7	0.9	2.8	60.6	88.0	37.5		0.0	0.0
RCS15	16.0	3.0	2.7	78.3	87.5	12.5	10.2	34.1	0.0	4.7	61.1	89.8	25.0		0.0	0.0
KE26	23.3	1.0	2.3	73.3	97.0	3.0	15.0	49.7	0.5	2.7	47.1	85.0	66.7			0.0
KE27	43.7	2.0	0.3	54.0	63.6	36.4	6.8	56.3	0.0	0.7	43.0	93.2	0.0			
KE28	23.3	1.0	1.0	74.7	85.0	15.0	17.9	45.7	0.0	7.6	46.7	82.1	100.0			0.0
KE29	20.7	1.3	0.0	78.0	77.8	22.2	11.5	44.4	4.8	0.0	50.7	88.5	0.0			
KE30	39.0	3.0	0.3	57.7	100.0	0.0	11.6	70.6	0.7	2.6	26.1	88.4	0.0			
KE31	51.7	2.3	0.3	45.7	100.0	0.0	2.9	68.4	0.0	0.0	31.6	97.1	0.0			
KE32	22.0	10.3	0.0	67.7	50.0	50.0	5.9	75.9	2.1	1.6	20.4	94.1	0.0			
KE33	22.0	2.3	1.0	74.7	68.0	32.0	11.2	62.8	0.5	1.0	35.7	88.8	100.0			0.0
KE34	31.7	1.3	3.0	64.0	69.2	30.8	6.8	64.2	0.0	0.6	35.2	93.2	100.0			0.0
KE35	29.3	0.3	0.3	70.0	46.2	53.8	6.2	67.5	0.5	1.5	30.5	93.8	0.0			

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
KE36	26.0	0.7	1.0	72.3	80.0	20.0	4.6	55.6	0.5	1.9	42.0	95.4	50.0			0.0
KE37	19.3	3.0	0.7	77.0	73.7	26.3	8.2	63.2	0.5	0.9	35.4	91.8	0.0			
KE38	16.0	2.3	0.7	81.0	66.7	33.3	8.6	61.7	2.7	2.3	33.3	91.4	100.0			0.0
KE39	12.7	3.3	0.0	84.0	64.3	35.7	5.6	56.7	1.7	2.5	39.1	94.4	0.0			
KE40	11.0	2.0	0.0	87.0	95.5	4.5	8.4	55.2	2.9	3.8	38.1	91.6	0.0			
KE41	16.7	2.3	1.0	80.0	83.3	16.7	10.0	51.4	1.9	1.9	44.9	90.0	0.0			
KE42	14.7	3.0	1.7	80.7	100.0	0.0	7.0	52.0	0.0	0.4	47.6	93.0	100.0			0.0
KE43	14.0	2.7	1.3	82.0	61.5	38.5	5.3	53.2	0.4	2.1	44.2	94.7	100.0			0.0
KE44	19.0	3.3	14.7	63.0	50.0	50.0	10.6	56.8	0.6	1.2	41.4	89.4	0.0			
KE45	11.0	2.0	3.3	83.7	95.8	4.2	9.6	52.9	0.4	2.2	44.5	90.4	0.0			
KE46	30.3	2.0	5.3	62.3	81.8	18.2	11.8	60.6	1.8	0.0	37.6	88.2	0.0			
KE47	20.7	2.0	6.7	70.7	88.4	11.6	20.3	49.7	1.2	0.6	48.5	79.7	66.7			33.3
KE48	17.3	1.7	5.3	75.7	80.5	19.5	18.1	47.8	0.5	3.2	48.4	81.9	0.0			
KE49	6.7	6.3	2.3	84.7	82.6	17.4	9.1	47.6	0.0	3.5	48.9	90.9	100.0			0.0
KE50	25.3	3.0	16.0	55.7	91.7	8.3	7.2	64.5	0.6	0.6	34.2	92.8	0.0			
KE51	30.3	1.3	5.3	63.0	82.4	17.6	9.0	54.7	0.6	2.3	42.4	91.0	0.0			
KE52	19.3	2.0	4.7	74.0	97.0	3.0	14.9	51.9	0.0	3.7	44.4	85.1	0.0			
KE53	13.7	2.3	0.7	83.3	94.6	5.4	14.8	40.4	6.6	0.0	53.1	85.2	0.0			
KE54	20.3	2.0	5.7	72.0	80.6	19.4	14.4	41.1	1.1	1.1	56.8	85.6	100.0			0.0
KE55	10.7	2.3	3.3	83.7	88.2	11.8	13.5	64.1	0.9	2.8	32.3	86.5	0.0			
KE56																
KE57	11.0	0.3	0.0	88.7	87.0	13.0	17.3	54.1	1.4	2.3	42.3	82.7	0.0			
KE58	7.7	0.7	0.7	91.0	79.3	20.7	10.6	50.8	0.4	1.2	47.5	89.4	0.0			
KE1	6.0	1.3	0.7	92.0	80.0	20.0	10.9	35.8	1.2	0.8	62.2	89.1	100.0			0.0
KE2	8.7	1.3	0.3	89.7	78.3	21.7	8.6	47.2	2.0	3.3	47.6	91.4	0.0			100.0
KE3	4.0	1.3	2.0	92.7	94.1	5.9	6.1	50.6	0.8	1.9	46.7	93.9	50.0			16.7
KE4	4.3	11.3	32.0	52.3	100.0	0.0	10.2	67.4	1.4	0.7	30.5	89.8	50.0			6.3
KE5	4.3	4.0	62.0	29.7	100.0	0.0	2.2	82.8	0.0	1.1	16.1	97.8	6.5			87.1
KE6	7.3	2.3	9.3	81.0	89.3	10.7	11.5	40.5	2.3	5.6	51.6	88.5	17.9			42.9
KE7	14.3	1.7	4.3	79.7	85.7	14.3	14.6	49.5	1.0	2.9	46.6	85.4	30.0			50.0
KE8	12.3	3.3	18.0	66.3	87.5	12.5	16.1	38.9	2.4	1.8	56.9	83.9	35.2			11.1
KE9	17.3	1.3	14.0	67.3	92.9	7.1	6.9	53.7	1.1	1.1	44.1	93.1	33.3			26.2
KE10	26.3	1.3	10.7	61.7	92.3	7.7	7.0	54.7	2.3	1.2	41.9	93.0	53.1			15.6
KE11	34.3	2.7	5.3	57.7	82.6	17.4	13.3	30.0	0.7	4.7	64.7	86.7	43.8			6.3
KE12	5.0	4.0	23.3	67.7	100.0	0.0	9.4	72.8	1.1	1.1	25.0	90.6	38.6			1.4
KE13	30.0	1.0	9.3	59.7	85.7	14.3	7.8	53.3	1.2	0.6	44.8	92.2	18.8			0.0
KE14	48.0	3.3	9.0	39.7	100.0	0.0	11.8	66.7	1.0	2.9	29.5	88.2	0.0			0.0
KE15	43.7	2.3	12.0	42.0	72.7	27.3	8.7	60.9	0.0	1.7	37.4	91.3	100.0			0.0
KE16	17.3	1.0	2.0	79.7	72.7	27.3	4.6	44.3	1.8	0.9	53.1	95.4				

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
KE17	13.7	2.3	5.7	78.3	84.6	15.4	5.5	59.5	1.4	0.5	38.7	94.5	44.4			0.0
KE18	11.7	0.7	0.0	87.7	87.3	12.7	24.0	44.5	0.5	3.5	51.5	76.0	0.0			
KE19	11.7	0.0	0.0	88.3	81.9	18.1	31.3	50.5	1.6	4.9	42.9	68.7	0.0			
KE20	9.7	0.0	0.0	90.3	89.0	11.0	50.2	50.4	0.7	2.2	46.7	49.8	0.0			
KE21	30.0	4.3	15.3	50.3	100.0	0.0	4.0	61.4	1.4	1.4	35.9	96.0	50.0			0.0
KE22	19.7	4.0	23.3	53.0	96.4	3.6	17.6	70.2	1.5	2.3	26.0	82.4	100.0			0.0
KE23	7.3	2.3	20.7	69.7	89.5	10.5	9.1	50.5	3.2	2.6	43.7	90.9	0.0			0.0
KE24	7.0	1.0	3.3	88.7	85.0	15.0	7.5	49.2	2.8	1.6	46.3	92.5	0.0			
KE25	6.0	0.7	0.0	86.7	94.3	5.7	13.5	37.8	1.3	1.8	59.1	86.5	0.0			
RNB1	48.7	1.0	0.7	49.7	22.2	77.8	24.2	47.8	2.7	0.9	48.7	75.8	100.0			
RNB3	51.3	2.0	2.0	44.7	66.7	33.3	4.5	36.7	0.0	1.6	61.7	95.5	33.3			
RNB4	56.7	1.3	2.7	39.3	100.0	0.0	2.5	55.7	0.9	1.7	41.7	97.5	71.4			
RNB5	53.7	2.0	4.0	40.3	50.0	50.0	3.3	37.6	1.7	0.9	59.8	96.7	12.5			
RNB6	31.7	6.7	5.7	56.0	0.0	0.0	0.0	60.7	0.6	0.0	38.7	100.0	43.8			
RNB7	30.3	3.7	1.7	64.3	100.0	0.0	2.6	15.4	0.5	0.0	84.0	97.4	40.0			
RNB8	47.0	2.3	4.0	46.7	100.0	0.0	1.4	53.6	0.7	0.7	44.9	98.6	41.7			
RNB9	79.3	1.3	0.3	19.0	100.0	0.0	7.0	26.4	0.0	0.0	73.6	93.0	0.0			
RNB10	39.3	1.7	4.3	54.7	83.3	16.7	3.7	57.6	0.6	0.6	41.1	96.3	33.3			
RNB11	17.7	1.7	9.3	71.3	83.3	16.7	2.8	73.6	0.0	0.0	26.4	97.2	75.0			
RNB12	29.0	1.3	1.3	68.3	80.0	20.0	2.4	30.5	2.0	0.0	67.5	97.6	0.0			
RNB13	27.0	0.7	1.0	71.3	68.8	31.3	7.5	49.5	1.5	2.0	47.0	92.5	100.0			
RNB14	20.0	1.7	1.3	77.0	63.6	36.4	9.5	58.4	1.9	2.4	37.3	90.5	75.0			
RNB15	24.7	1.3	6.0	68.0	76.9	23.1	6.4	76.4	0.5	0.0	23.0	93.6	33.3			
RNB16	23.0	1.3	3.7	72.0	95.5	4.5	10.2	54.1	1.0	1.0	43.8	89.8	0.0			
RNB17																
RNB18	31.3	0.0	0.3	68.3	95.5	4.5	10.7	56.3	2.7	0.5	40.4	89.3	0.0			
RNB19	10.7	1.3	0.3	87.7	84.0	16.0	9.5	50.4	2.1	1.7	45.8	90.5	0.0			
RNB20	22.7	0.3	0.0	77.0	65.2	34.8	10.0	56.3	1.0	1.9	40.9	90.0	0.0			
VS2	22.3	2.3	0.0	75.3	79.7	20.3	28.3	78.4	1.9	1.2	18.5	71.7				
VS3	18.0	1.7	0.0	80.3	69.0	31.0	17.4	73.9	2.5	0.0	23.6	82.6				
VS4	18.7	1.0	0.0	80.3	72.0	28.0	20.7	78.0	3.1	1.0	17.8	79.3				
VS5																
VS7																
VS8	16.0	0.3	0.0	83.7	97.0	3.0	13.1	40.4	1.4	0.0	58.3	86.9				
VS9																
CGD1																
CGD2																
CGD3																
CGD4																

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
CGD5																
CGD6																
CGD7																
CGD8																
CGD9																
CGD10																
CGD11	0.0	8.3	7.3	84.3	50.0	50.0	0.8	57.4	0.8		41.8	99.2	27.3			
CGD12																
CGD13																
CGD14																
CGD15																
CGD16																
CGD17																
CGD18																
CGD19																
CGD20	0.3	3.3	22.7	73.7	71.4	28.6	6.3	71.5	2.9		25.6	93.7	13.2			
CGD21																
CGD23	0.7	6.0	21.0	72.3	60.0	40.0	2.3	81.1	5.2		13.7	97.7	64.5			
CGD24	0.0	2.7	64.7	32.7	75.0	25.0	4.1	66.0	0.0		34.0	95.9	9.8			
CGD25	0.0	1.7	54.0	44.3	14.3	85.7	5.3	61.9	6.3		31.7	94.7	16.0			
CGD26	0.0	2.3	51.0	46.7	40.0	60.0	3.6	66.7	3.7		29.6	96.4	9.8			
CGD27	1.0	1.7	53.7	43.7	30.0	70.0	7.6	67.8	10.7		21.5	92.4	11.3			
CGD28	1.0	2.7	73.7	22.7	0.0	0.0	0.0	75.0	4.4		20.6	100.0	13.1			
CGD29	0.0	6.0	37.0	57.0	37.5	62.5	9.4	80.0	8.4		11.6	90.6	14.4			
CGD30	1.0	3.7	30.0	65.3	53.3	46.7	15.3	77.1	5.4		17.5	84.7	25.6			
CGD31	0.0	5.3	40.3	54.3	47.6	52.4	12.9	83.1	5.6		11.3	87.1	22.3			
CGD32	0.3	3.7	28.0	68.0	25.0	75.0	5.9	76.6	5.2		18.2	94.1	13.1			
CGD33	0.3	0.7	24.3	74.7	53.3	46.7	6.7	74.6	7.2		18.2	93.3	11.0			
CGD34	0.0	4.0	43.0	53.0	50.0	50.0	2.5	70.3	6.5		23.2	97.5	13.3			
CGD35	0.0	4.3	58.7	37.0	33.3	66.7	2.7	73.1	9.3		17.6	97.3	13.6			
CGD36	0.0	4.7	55.3	40.0	50.0	50.0	1.7	83.9	0.8		15.3	98.3	12.0			
CGD37	0.3	3.3	47.7	48.7	60.0	40.0	3.4	78.0	2.1		19.9	96.6	7.7			
CGD38	1.0	3.0	16.7	79.3	40.0	60.0	8.4	88.5	3.7		7.8	91.6	14.6			
CGD39	0.3	2.7	26.0	71.0	62.5	37.5	7.5	83.8	3.6		12.7	92.5	14.5			
CGD40	0.7	1.3	22.7	75.3	80.0	20.0	2.2	81.4	2.7		15.8	97.8	11.8			
CGD41	0.0	2.0	46.0	52.0	36.4	63.6	7.1	87.6	2.8		9.7	92.9	8.0			
CGD42	0.0	3.3	53.0	43.7	20.0	80.0	3.8	84.9	2.4		12.7	96.2	9.4			
CGD43	0.0	4.3	49.0	46.7	100.0	0.0	2.9	77.2	1.5		21.3	97.1	20.3			
CGD44	0.0	3.7	38.7	57.7	75.0	25.0	2.3	80.5	2.4		17.2	97.7	15.5			

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
CGD45	0.0	3.3	40.3	56.3	100.0	0.0	2.4	88.5	0.6		10.9	97.6	16.5			
CGD46	0.0	4.3	44.7	51.3	60.0	40.0	3.2	88.6	0.7		10.7	96.8	9.0			
CGD47	0.0	4.3	36.0	59.7	100.0	0.0	4.5	80.1	4.1		15.8	95.5	13.1			
CGD48	0.0	4.0	46.7	49.3	80.0	20.0	3.4	74.8	7.0		18.2	96.6	10.7			
CGD49	0.0	7.0	27.3	65.7	100.0	0.0	3.0	92.1	2.1		5.8	97.0	32.5			
CGD50	0.7	2.0	1.0	96.3	85.7	14.3	33.9	77.0	13.6		9.4	66.1	100.0			
CGD51	0.0	3.7	4.0	92.3	100.0	0.0	2.2	80.4	0.0		19.6	97.8	50.0			
CGD52	1.0	5.7	10.7	82.7	83.3	16.7	7.3	87.0	3.5		9.6	92.7	50.0			
CGD53	0.3	2.3	56.7	40.7	70.0	30.0	8.2	51.8	19.6		28.6	91.8	11.2			
CGD54	0.0	4.0	65.0	31.0	90.0	10.0	10.8	61.4	13.3		25.3	89.2	5.1			
CGD55	0.3	3.3	67.3	29.0	75.0	25.0	9.2	74.7	5.1		20.3	90.8	8.4			
CGD56	0.0	5.3	66.3	28.3	50.0	50.0	2.4	61.4	19.3		19.3	97.6	21.1			
CGD57	0.3	5.0	70.7	24.0	33.3	66.7	4.2	71.0	15.9		13.0	95.8	9.0			
CGD58	0.3	6.0	63.7	30.0	54.5	45.5	12.2	55.7	17.7		26.6	87.8	13.7			
CGD59	1.0	4.7	38.0	57.0	100.0	0.0	3.5	74.5	11.5		13.9	96.5	5.3			
CGD60	0.7	4.7	37.0	57.7	71.4	28.6	4.0	74.7	6.6		18.7	96.0	2.7			
CGD61	0.0	3.3	38.0	58.7	100.0	0.0	4.0	65.1	14.2		20.7	96.0	15.9			
CGD62	0.7	4.7	46.0	48.7	100.0	0.0	4.8	59.0	11.5		29.5	95.2	10.4			
CGD63	0.0	4.3	58.7	37.0	87.5	12.5	7.2	58.3	10.7		31.1	92.8	10.2			
CGD64	0.0	3.3	54.0	42.7	100.0	0.0	7.0	55.5	13.4		31.1	93.0	12.3			
CGD65	0.0	4.7	51.3	44.0	100.0	0.0	6.1	60.5	16.1		23.4	93.9	9.7			
CGD66	0.3	1.0	9.7	89.0	80.0	20.0	5.6	67.1	11.5		21.4	94.4	13.8			
CGD67	0.0	5.3	35.7	62.3	91.7	8.3	6.4	56.0	10.9		33.1	93.6	5.6			
CGD68	0.0	3.0	31.0	66.0	80.0	20.0	7.6	60.7	8.7		30.6	92.4	11.8			
LOD1*																
LOS4	4.3	1.3	0.0	94.3	62.1	37.9	10.2	65.7	6.3		28.0	89.8	0.0			
LOD2	7.3	2.7	0.0	90.0	73.1	26.9	9.6	71.7	4.1		24.2	90.4	0.0			
LOD3	5.7	2.3	0.0	92.0	57.7	42.3	9.4	68.4	5.2		26.4	90.6	0.0			
LOD4	3.3	3.0	0.0	93.7	83.3	16.7	4.3	72.5	1.9		25.7	95.7	0.0			
LOD5	1.7	2.3	0.0	96.0	80.0	20.0	1.7	59.4	1.1		39.6	98.3	0.0			
LOS5	0.3	2.3	2.7	94.7	85.7	14.3	4.9	68.5	1.9		29.6	95.1	12.5			
LOD5A	2.7	3.7	0.3	93.3	70.4	29.6	9.6	84.2	0.8		15.0	90.4	0.0			
LOD6	3.0	2.0	0.0	95.3	70.0	30.0	10.5	84.8	0.8		14.5	89.5	0.0			
LOD7	0.0	4.3	32.0	63.7	100.0	0.0	3.1	75.1	2.2		22.7	96.9	0.0			
LOD8	0.0	3.3	65.3	31.3	100.0	0.0	1.1	65.6	4.3		30.1	98.9	3.1			
LOD9	0.3	5.0	61.7	33.0	100.0	0.0	5.1	59.6	8.5		31.9	94.9	9.2			
LOD10	0.0	4.3	62.0	33.7	0.0	100.0	1.0	78.0	3.0		19.0	99.0	6.5			
LOK6	0.0	1.3	93.7	5.0	50.0	50.0	13.3	92.3	7.7		0.0	86.7	9.6			
LOK7	0.7	7.0	63.7	28.7	57.1	42.9	8.1	55.7	3.8		40.5	91.9	20.9			

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
LOK8	0.0	5.3	71.0	23.7	92.9	7.1	19.7	91.2	1.8		7.0	80.3	14.1			
LOD11	0.0	2.3	73.7	24.0	100.0	0.0	6.9	70.1	4.5		25.4	93.1	1.8			
LOD12	0.0	2.3	83.3	14.3	100.0	0.0	14.0	54.1	8.1		37.8	86.0	0.8			
LOK11	0.0	2.3	81.0	16.7	87.5	12.5	16.0	76.2	0.0		23.8	84.0	9.1			
LOD13	6.3	1.3	0.0	92.3	75.0	25.0	13.0	83.0	8.3		8.7	87.0	0.0			
LOD14	6.7	1.3	0.3	91.7	72.2	27.8	13.1	77.0	9.6		13.4	86.9	0.0			
LOD15	5.7	0.3	0.7	93.3	87.5	12.5	20.0	88.8	2.7		8.5	80.0	0.0			
LOD16	5.3	5.3	0.0	89.3	80.8	19.2	19.4	92.6	3.7		3.7	80.6	0.0			
LOK15																
LOK16	1.0	8.0	17.7	70.0	94.7	5.3	9.0	67.5	3.1		29.3	91.0	44.9			
LOK17	2.7	2.7	0.3	94.3	100.0	0.0	12.4	85.5	2.4		12.1	87.6	100.0			
LOK20	2.0	3.3	2.7	92.0	87.6	12.4	32.2	74.3	5.3		20.3	67.8	50.0			
LOK21																
LOK22																
LOK23	2.7	4.7	1.3	91.3	70.0	30.0	7.3	94.5	0.8		4.7	92.7	100.0			
LOK24	18.0	1.7	0.0	80.3	94.3	5.7	22.0	62.8	3.2		34.0	78.0	0.0			
LOK25	12.3	1.0	0.0	86.7	65.0	35.0	15.4	61.8	4.5		33.6	84.6	0.0			
LOK26	14.0	2.0	0.0	84.0	83.3	16.7	19.0	57.8	9.8		32.4	81.0	0.0			
LOK27	13.0	0.7	0.0	86.3	93.2	6.8	17.0	67.0	5.6		27.4	83.0	0.0			
LOK28	8.0	1.3	1.0	89.7	82.8	17.2	23.8	91.2	2.4		6.3	76.2	66.7			
LOK29	5.3	0.3	0.3	94.0	70.2	29.8	33.3	97.3	0.0		2.7	66.7	0.0			
LOK30	0.7	6.7	0.7	92.0	82.1	17.9	20.3	99.1	0.9		0.0	79.7	100.0			
LOK31																
LOK32	1.3	0.7	0.3	97.7	91.1	8.9	27.0	94.4	1.9		3.7	73.0	0.0			
LOK33	9.7	2.3	2.0	86.0	90.6	9.4	20.5	63.9	2.4		33.7	79.5	83.3			
LOK34	11.7	2.7	1.0	84.7	89.1	10.9	21.7	69.8	5.0		25.1	78.3	66.7			
LOK35	6.3	0.3	0.0	93.3	87.5	12.5	20.0	50.9	9.4		39.7	80.0	0.0			
LOK36	2.3	1.7	0.3	95.7	93.4	6.6	21.3	56.2	4.4		39.4	78.7	100.0			
LOK37	4.3	2.0	0.0	93.7	87.5	12.5	19.9	45.8	9.3		44.9	80.1	0.0			
LOK38	4.7	1.3	0.3	93.7	85.7	14.3	27.4	65.7	11.3		23.0	72.6	100.0			
LOK39	2.0	1.0	0.0	97.0	95.4	4.6	29.9	67.6	10.3		22.1	70.1	0.0			
LBT1	1.3	6.7	52.3	39.7	100.0	0.0	3.4	80.9	6.1		13.0	96.6	45.2			
LBT2	1.3	7.0	68.7	23.0	100.0	0.0	2.9	73.1	1.5		25.4	97.1	24.8			
LBT3	0.7	3.7	25.3	70.3	84.6	15.4	6.2	56.1	3.0		40.9	93.8	10.5			
LBT4	2.0	5.0	39.0	54.0	100.0	0.0	1.2	50.0	5.0		45.0	98.8	19.7			
LBT5	3.0	4.0	36.7	56.3	90.0	10.0	5.9	51.6	6.9		41.5	94.1	11.8			
LBT6	1.3	4.0	34.7	60.0	100.0	0.0	1.1	51.7	6.7		41.6	98.9	5.8			
LBT7	0.3	3.0	21.7	75.0	77.8	22.2	4.0	21.3	6.5		72.2	96.0	3.1			
LBT8	0.7	3.7	21.3	74.3	83.3	16.7	8.1	39.5	1.5		59.0	91.9	6.3			

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
LBT9	0.0	3.7	27.7	68.7	64.3	35.7	6.8	46.4	10.9		42.7	93.2	3.7			
LBT10	0.3	4.3	37.3	58.0	66.7	33.3	6.9	50.6	6.8		42.6	93.1	2.7			
LBT11	0.3	4.7	43.0	52.0	55.6	44.4	5.8	46.3	14.3		39.5	94.2	5.4			
LBT12	0.7	2.7	1.3	95.3	96.7	3.3	10.5	66.8	4.7		28.5	89.5	50.0			
LBT13	2.3	1.7	2.0	94.0	91.7	8.3	8.5	69.4	8.5		22.1	91.5	83.3			
LBT14	0.7	1.3	0.3	97.7	100.0	0.0	5.8	63.4	10.5		26.1	94.2	100.0			
LBT15	0.3	2.7	18.7	78.3	93.8	6.3	6.8	40.2	5.9		53.9	93.2	17.9			
LBT16	0.0	2.0	63.3	34.7	87.5	12.5	7.7	54.2	11.5		34.4	92.3	5.3			
LBT17	1.3	4.7	20.0	74.0	81.0	19.0	9.5	66.7	6.5		26.9	90.5	38.3			
LBM1	0.0	3.3	46.0	50.7	100.0	0.0	10.5	50.0	9.6		40.4	89.5	17.4			
LBM2	0.7	3.3	44.0	52.0	100.0	0.0	7.7	60.4	9.7		29.9	92.3	8.3			
LBM3	2.7	2.0	1.7	93.7	100.0	0.0	5.3	72.6	4.1		23.3	94.7	80.0			
LBM4	0.3	0.7	3.3	95.7	100.0	0.0	7.3	60.5	5.6		33.8	92.7	60.0			
LBM5	0.3	2.7	62.7	34.3	100.0	0.0	3.9	74.7	2.0		23.2	96.1	20.9			
LBM6	0.3	2.3	8.0	89.3	100.0	0.0	5.6	56.9	9.5		33.6	94.4	50.0			
LBM7	0.0	1.3	85.3	13.3	0.0	0.0	0.0	60.0	0.0		40.0	100.0	31.5			
KBD1	0.3	10.7	17.7	71.3	100.0	0.0	4.2	71.7	1.0	0.5	26.8	95.8	17.0			
KBK1	3.0	3.3	4.7	89.0	94.4	5.6	6.7	54.2	4.0	2.0	39.8	93.3	35.7			
KBK2																
KBK3	8.3	1.7	0.0	90.0	100.0	0.0	8.1	71.8	0.0	0.0	28.2	91.9				
KBK4																
KBK5																
KBK7	5.3	1.3	0.3	93.0	98.2	1.8	19.7	70.5	4.0	0.0	25.4	80.3				
KBK8																
KBK9	22.0	1.7	0.0	76.3	92.6	7.4	11.8	80.7	1.5	2.5	15.3	88.2				
KBK10																
KBK11																
SB1																
SB4																
SB7																
SB10																
SB14																
SBS2																
SBS4																
SBS5	0.7	9.3	25.0	65.0	74.4	25.6	20.0	66.0	1.3	1.3	31.4	80.0	2.7	53.3		
SBU1	0.0	3.3	41.3	55.3	100.0	0.0	13.9	68.5	3.5	1.4	26.6	86.1	2.4	40.3		
UOB1	4.7	8.3	15.7	71.3	96.8	3.2	29.4	69.5	1.3	2.0	27.2	70.6	8.5	59.6		
UOB2	0.3	10.7	25.3	63.7	98.2	1.8	28.8	69.1	1.5	2.2	27.2	71.2	7.9	27.6		
UOB3	14.0	7.3	13.3	65.3	95.3	4.7	21.9	52.3	0.7	11.8	35.3	78.1	12.5	25.0		

Appendix V: Parameters derived from the palynomorph counts

Key to abbreviations used in column headers (percentage parameters unless otherwise stated):

SAMNO	= sample number
bot	= *Botryococcus* of palynomorphs
undif	= undifferentiated of palynomorphs
mp	= marine plankton of palynomorphs
sporo	= sporomorphs of palynomorphs
tnw/sp	= thin-walled of spores
tkw/sp	= thick-walled of spores
sp/spor	= spores of sporomorphs
up/tp	= unidentified of pollen
cal/tp	= *Callialasporites* of pollen
cer/tp	= *Cerebropollenites* of pollen
bis/tp	= bisaccates of pollen
tp/spor	= pollen of sporomorphs
ud/td	= unidentified of dinocysts
smd/td	= very poorly preserved of dinocysts
nan/td	= *Nannoceratopsis* of dinocysts
cad/td	= *Caddasphaera* of dinocysts
bat/td	= *Batiacasphaera* of dinocysts
prv/td	= *Parvocysta* of dinocysts
dis/td	= *Dissiliodinium* of dinocysts
cte/td	= *Ctenidodinium* of dinocysts
dur/td	= *Durotrigia* of dinocysts
mei/td	= *Meiurogonyaulax* of dinocysts
gt/td	= other gonyaulacacean type of dinocysts
par/td	= *Pareodinia* of dinocysts
sen/td	= *Sentusidinium* of dinocysts
jman/td	= *Jansonia manifesta* of dinocysts
rhy/td	= *Rhychodiniopsis* of dinocysts
adnat/td	= *Adnatosphaeridium* of dinocysts
dindiv	= dinocyst diversity (number of genera present, only calculated for main lagoonal formations)
dindom	= dinocyst dominance (only calculated for main lagoonal formations)
din/mp	= dinocysts of marine plankton
ac/mp	= acritarchs of marine plankton
tas/mp	= *Tasmanites* type prasinophyte marine plankton
lei/mp	= leiospheres of marine plankton
lspor/mp	= log ratio sporomorphs:marine plankton
lacr/din	= log ratio acritarchs:dinocysts
lup/bis	= log ratio unidentified pollen:bisaccates
lspore/bis	= log ratio spores:bisaccates
#NUM	= parameter not calculated due to missing value in one category
#DIV0	= parameter not calculated due to value in one category being zero

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
UOB4	0.3	4.0	11.0	84.7	96.7	3.3	35.4	40.2	1.8	8.5	49.4	64.6	18.2	45.5		
UOB5	0.0	6.0	35.3	58.7	100.0	0.0	17.6	33.1	10.3	2.1	54.5	82.4	10.6	57.7		
UOB6	0.0	7.0	38.7	54.3	91.2	8.8	20.9	48.1	10.9	0.8	40.3	79.1	12.1	48.3		
UOB7	1.3	5.3	31.7	61.7	97.3	2.7	20.0	60.1	4.1	0.0	35.8	80.0	14.7	47.4		
UOB8	2.0	4.3	32.0	61.7	100.0	0.0	16.8	56.5	7.8	0.6	35.1	83.2	27.7	33.0		
UOB9	2.3	2.3	22.7	72.7	97.6	2.4	18.8	37.3	17.5	1.1	44.1	81.2	19.4	29.9		
UOB10	1.7	3.0	26.7	68.7	95.1	4.9	19.9	36.4	23.0	0.6	40.0	80.1	15.6	26.0		
UOB11	0.0	4.0	7.7	88.3	96.6	3.4	21.9	51.7	11.1	0.0	37.2	78.1	21.7	65.2		
UOB12	0.0	3.3	11.7	85.0	97.2	2.8	27.8	49.5	7.1	0.5	42.9	72.2	2.9	52.9		
UOB13	0.0	3.3	20.3	76.3	97.3	2.7	32.3	51.6	12.9	0.6	34.8	67.7	3.3	34.4		
UOB14	0.3	4.3	30.7	64.7	91.7	8.3	12.4	53.5	0.6	10.6	35.3	87.6	8.8	35.2		
UOB15	0.3	2.3	18.0	79.3	94.6	5.4	23.5	74.7	1.1	4.4	19.8	76.5	22.2	20.4		
UOB16	0.3	2.3	9.7	87.7	96.6	3.4	33.5	72.6	4.0	5.7	17.7	66.5	17.2	27.6		
UOB17	1.0	0.3	11.3	87.3	100.0	0.0	25.2	63.3	3.6	5.1	28.1	74.8	20.6	29.4		
UOB18	1.0	1.7	8.0	89.3	100.0	0.0	27.2	77.4	2.6	4.6	15.4	72.8	21.7	30.4		
UOB19	0.3	2.0	10.0	87.7	100.0	0.0	25.1	80.2	3.0	3.0	13.7	74.9	20.0	23.3		
UOB20	1.3	1.3	4.0	93.3	89.8	10.2	17.5	69.3	1.7	3.9	25.1	82.5	25.0	41.7		
UOB21	0.7	2.3	4.7	92.3	100.0	0.0	27.4	71.1	2.5	6.0	20.4	72.6	21.4	50.0		
UOB22	0.3	3.0	20.7	76.0	95.7	4.3	30.7	66.5	2.5	6.3	24.7	69.3	16.1	17.7		
UOB23	2.7	6.7	20.3	70.3	100.0	0.0	13.3	66.7	1.1	8.7	23.5	86.7	20.0	15.0		
UOB24																
UOB25	5.3	5.7	21.0	68.0	97.1	2.9	16.7	68.2	4.1	7.6	20.0	83.3	29.0	19.4		
UOB26	0.7	3.7	14.3	81.3	97.7	2.3	17.6	78.1	1.5	1.0	19.4	82.4	11.6	44.2		
UOB27	0.0	5.7	16.0	78.3	95.2	4.8	17.9	63.2	0.0	6.2	30.6	82.1	12.5	45.8		
UOB28	0.3	4.3	18.7	76.7	100.0	0.0	20.4	61.7	1.1	3.8	33.3	79.6	14.3	50.0		
UOB29	2.3	7.7	11.0	79.0	100.0	0.0	27.0	79.8	2.3	1.7	16.2	73.0	30.3	42.4		
UOB30	6.0	3.3	20.3	70.3	90.3	9.7	14.7	61.1	1.7	2.2	35.0	85.3	8.3	11.7		
UOB31																
UOB32	1.3	3.0	30.7	65.0	100.0	0.0	16.4	58.9	1.2	6.7	33.1	83.6	2.2	17.4		
UOB33	1.3	10.0	11.3	77.3	100.0	0.0	18.5	65.6	3.7	1.1	29.6	81.5	23.5	17.6		
UOB34	7.0	2.0	5.7	85.3	98.3	1.7	22.7	50.0	0.5	15.2	34.3	77.3	17.6	35.3		
UOB35	2.3	2.7	14.0	81.0	98.3	1.7	24.7	48.6	0.0	20.2	31.1	75.3	14.6	39.0		
UOB36	2.0	1.7	18.7	77.7	98.2	1.8	23.6	53.9	1.1	8.4	36.5	76.4	8.9	46.4		
UOB37	0.7	2.7	16.3	80.3	100.0	0.0	18.3	44.2	2.5	17.8	35.5	81.7	14.3	57.1		
BS1	0.7	4.0	18.3	77.0	94.7	5.3	16.5	60.6	2.6	7.8	29.0	83.5	12.7	49.1		
BS2	0.0	4.3	20.7	75.0	92.6	7.4	24.0	57.3	2.3	7.0	33.3	76.0	1.6	45.2		
BS3	1.0	4.3	12.3	82.3	91.4	8.6	14.2	59.4	0.9	6.6	33.0	85.8	0.0	24.3		
BS4	1.0	7.3	17.0	74.7	98.0	2.0	21.9	58.9	2.3	10.9	28.0	78.1	11.8	23.5		
BS5	0.7	7.7	13.0	78.7	100.0	0.0	17.4	61.5	0.5	10.3	27.7	82.6	15.4	15.4		

SAMNO	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
BS6	0.3	5.3	33.7	60.7	100.0	0.0	18.7	63.5	2.0	6.1	28.4	81.3	5.9	30.7		
BS7																
BS8																
BS9																
BS10	0.0	6.0	24.0	70.0	100.0	0.0	23.8	63.8	0.0	11.3	25.0	76.2	2.8	25.0		
BS11	1.0	6.0	23.7	69.3	100.0	0.0	19.2	60.1	3.0	9.5	27.4	80.8	4.3	35.7		
BS12	0.0	2.0	11.0	87.0	100.0	0.0	23.0	60.2	2.5	11.9	25.4	77.0	6.1	42.4		
BS13	0.7	4.3	12.7	82.3	100.0	0.0	32.4	59.9	1.2	5.4	33.5	67.6	7.9	23.7		
BS14	0.3	4.7	23.0	72.0	96.8	3.2	14.4	65.9	2.2	5.9	25.9	85.6	13.0	20.3		
BS15	0.7	5.3	9.0	85.0	100.0	0.0	9.0	63.4	1.7	2.2	32.8	91.0	7.4	14.8		

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
BBE1	0.0														90.9	9.1
BBE2																
BBE3																
BBE4	10.0														66.7	33.3
BBE5																
BBE6	0.0														41.7	58.3
BBE7																
BBE8																
BBE9	13.3														65.2	34.8
BBE10																
BBE11	0.0														76.9	23.1
BBE12																
BBE13																
BBE14	11.1														75.0	25.0
BBE15																
BBE16																
BBE17	7.1														87.5	12.5
BBE18	0.0														80.0	20.0
BBE19	0.0														33.3	66.7
BBE20	22.2														69.2	30.8
BBE21	17.6														81.0	19.0
BBE22	22.2														90.0	10.0
BBE23	10.0														90.9	9.1
BBE24	14.3														70.0	30.0
BBE25	27.3														84.6	15.4
BBE26	42.9														87.5	12.5
BBE27	0.0														90.0	10.0
BBE28	9.1														100.0	0.0
BBE29	22.2														90.0	10.0
BBE30	20.0														90.9	9.1
BBE31	0.0														75.0	25.0
BBE32	12.5														88.9	11.1
BBE33	20.0														100.0	0.0
BBE34	50.0														66.7	33.3
BBE35	0.0														80.0	20.0
BBE36	25.0														100.0	0.0
BBE37	20.0														95.2	4.8
BBE38	10.5														100.0	0.0
BBE39	11.8														100.0	0.0

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
BBE40	33.3														80.0	20.0
BBE41	0.0														100.0	0.0
BBE42	6.3														88.9	11.1
BBE43	27.3														84.6	15.4
BBE44	9.1														84.6	15.4
BBE45	14.3														87.5	12.5
BBE46	0.0														100.0	0.0
BBE47	33.3														100.0	0.0
BBE48	50.0														85.7	14.3
BBE49																
BBO1	14.3														93.3	6.7
BBO2	5.6														100.0	0.0
BBU1	28.6														77.8	22.2
BBU2	8.3														75.0	18.8
BBU3	0.0														87.5	12.5
BBU4	12.5														100.0	0.0
BBU5	0.0														85.7	7.1
BBU6	9.1														100.0	0.0
BBU7	11.8														94.4	5.6
BBU8	27.3														100.0	0.0
BBU9	26.7														93.8	6.3
BBU10	0.0														100.0	0.0
BBU11	0.0														85.7	14.3
BBU12	42.9														100.0	0.0
BBU13	25.0														100.0	0.0
BBU14	0.0														83.3	16.7
BBU15	12.5														88.9	11.1
BBU16	20.0														100.0	0.0
BBU17	33.3														90.0	10.0
BBU18	40.0														83.3	16.7
BBU19	7.7														92.9	7.1
BBU20	28.6														87.5	12.5
BBU21	23.5														89.5	10.5
BBU22	0.0														92.3	7.7
BBU23	16.7														100.0	0.0
BBU24	0.0														100.0	0.0
BBU25	0.0														100.0	0.0
BBU26	0.0														100.0	0.0
BBU27	0.0														100.0	0.0

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
BBU28	33.3														100.0	0.0
BBU29	33.3														60.0	40.0
BBU30	28.6														100.0	0.0
BBH1	25.0														92.3	0.0
BBH2	20.0														90.9	9.1
BBH3	42.9														100.0	0.0
BBH4	0.0														75.0	25.0
BBH5	0.0														100.0	0.0
BBH6	14.3														100.0	0.0
BBH7	50.0														80.0	20.0
BBH8	20.0														100.0	0.0
BBH9	33.3														60.0	20.0
BBH10	33.3														100.0	0.0
BBH11	50.0														100.0	0.0
BBH12																
BBR1																
BBR2	33.3														100.0	0.0
BBR3																
BBR4																
BBR13	40.0														100.0	0.0
BBR14																
BBR15																
BBR16																
BBR17																
BBR18	0.0														100.0	0.0
BBR19																
BBR5	0.0														85.7	14.3
BBR6																
BBR7																
BBR8	66.7														60.0	40.0
BBR9																
BBR10																
BBR11	23.5														77.3	22.7
BNL17																
BNL16		28.0													89.3	10.7
BNL1																
BNL2		10.5													86.4	13.6
BNL3																
BNL4																

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
BNL5		0.0													84.6	15.4
BNL6																
BNL7																
BNL8																
BNL9		15.8													86.4	13.6
BNL10		23.5													85.0	15.0
BNL11																
BNL12																
BNL13		38.9													85.7	14.3
BNL15																
RGC1	22.2		0.0					0.0							100.0	0.0
RGC2																
RGC3																
RGC4	8.7		0.0					0.0							100.0	0.0
RCS1	16.7		41.7					12.5							92.3	7.7
RCS2	31.3		6.3					25.0							100.0	0.0
RCS3	14.3		28.6					14.3							77.8	22.2
RCS4																
RCS5	28.6		14.3					14.3							82.4	11.8
RCS6	22.2		22.2					11.1							90.0	10.0
RCS7	0.0		60.0					0.0							100.0	0.0
RCS8	0.0		0.0					0.0							100.0	0.0
RCS9	16.7		50.0					0.0							66.7	22.2
RCS10	30.8		30.8					15.4							86.7	13.3
RCS11	50.0		0.0					0.0							100.0	0.0
RCS12	0.0		0.0					0.0							100.0	0.0
RCS13	33.3		44.4					0.0							81.8	18.2
RCS14	0.0		62.5					0.0							100.0	0.0
RCS15	12.5		62.5					0.0							100.0	0.0
KE26	33.3		0.0		0.0			0.0	0.0						42.9	57.1
KE27															0.0	100.0
KE28	0.0		0.0		0.0			0.0	0.0						33.3	66.7
KE29															0.0	0.0
KE30															0.0	100.0
KE31															0.0	100.0
KE32															0.0	0.0
KE33	0.0		0.0		0.0			0.0	0.0						33.3	66.7
KE34	0.0		0.0		0.0			0.0	0.0						11.1	88.9
KE35															0.0	100.0

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
KE36	0.0		0.0		0.0			50.0	0.0						66.7	0.0
KE37															0.0	100.0
KE38	0.0		0.0		0.0			0.0	0.0						50.0	50.0
KE39															0.0	0.0
KE40															0.0	0.0
KE41															0.0	100.0
KE42	0.0		0.0		0.0			0.0	0.0						60.0	40.0
KE43	0.0		0.0		0.0			0.0	0.0						25.0	75.0
KE44															0.0	100.0
KE45															0.0	100.0
KE46															0.0	100.0
KE47	0.0		0.0		0.0			0.0	0.0						15.0	85.0
KE48															0.0	100.0
KE49	0.0		0.0		0.0			0.0	0.0						28.6	71.4
KE50															0.0	100.0
KE51															0.0	100.0
KE52															0.0	100.0
KE53															0.0	100.0
KE54	0.0		0.0		0.0			0.0	0.0						17.6	82.4
KE55															0.0	100.0
KE56																
KE57															0.0	0.0
KE58															0.0	100.0
KE1	0.0		0.0		0.0			0.0	0.0						50.0	50.0
KE2	0.0		0.0		0.0			0.0	0.0						100.0	0.0
KE3	0.0		0.0		16.7			16.7	0.0						100.0	0.0
KE4	2.1		0.0		39.6			2.1	0.0				4.0	92.0	100.0	0.0
KE5	0.5		0.0		5.9			0.0	0.0				3.0	99.0	100.0	0.0
KE6	0.0		3.6		28.6			7.1	0.0				4.0	87.0	100.0	0.0
KE7	10.0		0.0		10.0			0.0	0.0				3.0	100.0	76.9	23.1
KE8	5.6		14.8		31.5			1.9	0.0				5.0	71.0	100.0	0.0
KE9	2.4		16.7		19.0			2.4	0.0				5.0	68.0	100.0	0.0
KE10	9.4		12.5		6.3			0.0	3.1				5.0	60.0	100.0	0.0
KE11	6.3		37.5		6.3			0.0	0.0				5.0	70.0	100.0	0.0
KE12	60.0		0.0		0.0			0.0	0.0				3.0	98.0	100.0	0.0
KE13	68.8		0.0		0.0			0.0	12.5				2.0	100.0	57.1	42.9
KE14	100.0		0.0		0.0			0.0	0.0						3.7	96.3
KE15	0.0		0.0		0.0			0.0	0.0						5.6	94.4
KE16															0.0	100.0

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
KE17	22.2		0.0		0.0			33.3	0.0						52.9	47.1
KE18															0.0	0.0
KE19															0.0	0.0
KE20															0.0	0.0
KE21	0.0		50.0		0.0			0.0	0.0						4.3	95.7
KE22	0.0		0.0		0.0			0.0	0.0						1.4	98.6
KE23	0.0		66.7		0.0			33.3	0.0						4.8	95.2
KE24															0.0	100.0
KE25															0.0	0.0
RNB1	0.0		0.0		0.0			0.0	0.0						100.0	0.0
RNB3	66.7		0.0		0.0			0.0	0.0						50.0	50.0
RNB4	0.0		0.0		14.3			0.0	14.3						87.5	12.5
RNB5	0.0		12.5		62.5			12.5	0.0						66.7	33.3
RNB6	12.5		18.8		25.0			0.0	0.0						94.1	5.9
RNB7	0.0		40.0		20.0			0.0	0.0						100.0	0.0
RNB8	0.0		8.3		50.0			0.0	0.0						100.0	0.0
RNB9															0.0	100.0
RNB10	0.0		22.2		44.4			0.0	0.0						69.2	30.8
RNB11	0.0		0.0		25.0			0.0	0.0						14.3	85.7
RNB12	0.0		0.0		0.0			100.0	0.0						25.0	75.0
RNB13	0.0		0.0		0.0			0.0	0.0						100.0	0.0
RNB14	0.0		0.0		25.0			0.0	0.0						100.0	0.0
RNB15	0.0		66.7		0.0			0.0	0.0						16.7	83.3
RNB16	0.0		100.0		0.0			0.0	0.0						27.3	72.7
RNB17																
RNB18	0.0		0.0		100.0			0.0	0.0						100.0	0.0
RNB19	0.0		0.0		100.0			0.0	0.0						100.0	0.0
RNB20															0.0	0.0
VS2															0.0	0.0
VS3															0.0	0.0
VS4															0.0	0.0
VS5																
VS7																
VS8															0.0	0.0
VS9																
CGD1																
CGD2																
CGD3																
CGD4																

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
CGD5																
CGD6																
CGD7																
CGD8																
CGD9																
CGD10																
CGD11	40.9			0.0	0.0	0.0		0.0	0.0	9.1			3.0	87.5	100.0	0.0
CGD12																
CGD13																
CGD14																
CGD15																
CGD16																
CGD17																
CGD18																
CGD19																
CGD20	4.4			0.0	0.0	77.9		0.0	0.0	0.0			3.0	94.9	100.0	0.0
CGD21																
CGD23	14.5		0.0	0.0	0.0	21.0		0.0	0.0	0.0			2.0	100.0	98.4	1.6
CGD24	24.2		1.0	30.9	2.1	21.1		3.1	7.7	0.0			7.0	61.1	100.0	0.0
CGD25	19.1		0.0	25.3	0.6	24.1		6.2	7.4	1.2			7.0	58.8	100.0	0.0
CGD26	17.6		0.0	8.5	0.0	11.1		22.2	29.4	0.0			6.0	57.2	100.0	0.0
CGD27	16.9		0.0	8.8	0.0	12.5		29.4	18.8	0.0			7.0	54.2	99.4	0.6
CGD28	16.7		0.0	6.8	7.7	8.1		20.8	26.2	0.0			7.0	54.2	100.0	0.0
CGD29	14.4		0.0	3.6	3.6	2.7		21.6	39.6	0.0			6.0	71.6	100.0	0.0
CGD30	12.2		0.0	2.2	4.4	3.3		23.3	24.4	0.0			8.0	64.2	100.0	0.0
CGD31	15.7		0.0	1.7	2.5	0.0		44.6	6.6	0.0			7.0	77.7	100.0	0.0
CGD32	15.5		0.0	4.8	1.2	2.4		51.2	8.3	0.0			7.0	76.7	100.0	0.0
CGD33	19.2		5.5	1.4	4.1	4.1		16.4	32.9	0.0			8.0	58.5	100.0	0.0
CGD34	18.0		4.7	17.2	0.8	4.7		10.9	28.1	0.0			8.0	53.2	99.2	0.8
CGD35	9.7		2.8	32.4	1.1	0.0		11.9	21.6	0.0			10.0	62.5	100.0	0.0
CGD36	16.3		3.0	37.3	1.2	2.4		7.8	13.9	0.0			10.0	60.9	100.0	0.0
CGD37	10.5		0.7	50.3	0.0	2.1		4.9	21.0	0.0			8.0	77.3	100.0	0.0
CGD38	27.1		2.1	33.3	0.0	2.1		10.4	8.3	0.0			7.0	70.7	96.0	0.0
CGD39	13.2		5.3	48.7	0.0	1.3		3.9	10.5	0.0			7.0	72.3	97.4	0.0
CGD40	14.7		2.9	41.2	1.5	0.0		5.9	20.6	0.0			7.0	70.0	100.0	0.0
CGD41	15.9		0.7	42.0	0.0	0.7		2.2	29.0	0.0			8.0	77.2	100.0	0.0
CGD42	16.4		0.0	37.1	0.0	0.0		5.7	30.2	0.0			6.0	74.3	100.0	0.0
CGD43	28.0		0.0	10.5	0.0	3.5		2.8	30.8	0.0			8.0	73.7	97.3	2.7
CGD44	19.8		0.0	10.3	0.0	0.0		14.7	37.9	0.0			5.0	68.4	100.0	0.0

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
CGD45	25.6		0.0	13.2	0.0	0.0		7.4	37.2	0.0			4.0	75.2	100.0	0.0
CGD46	19.4		0.0	28.4	0.0	0.7		0.7	41.0	0.0			6.0	76.2	100.0	0.0
CGD47	16.8		0.0	27.1	0.0	1.9		3.7	33.6	0.0			6.0	69.9	99.1	0.9
CGD48	10.7		0.0	54.2	0.0	0.0		4.6	19.8	0.0			4.0	82.9	93.6	5.7
CGD49	7.5		0.0	37.5	0.0	0.0		1.3	20.0	0.0			5.0	85.2	97.6	2.4
CGD50	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0					100.0	0.0
CGD51	8.3		0.0	0.0	0.0	0.0		0.0	41.7	0.0			2.0	100.0	100.0	0.0
CGD52	6.3		0.0	6.3	0.0	3.1		21.9	12.5	0.0			5.0	68.8	100.0	0.0
CGD53	7.1		1.2	4.1	40.0	1.8		24.1	10.6	0.0			7.0	72.2	100.0	0.0
CGD54	5.1		0.0	6.2	32.3	0.5		28.2	14.9	7.7			7.0	63.8	100.0	0.0
CGD55	13.4		7.9	12.9	21.8	0.5		16.8	16.3	2.0			8.0	42.2	100.0	0.0
CGD56	15.6		5.5	11.1	12.6	9.5		10.6	10.6	0.0			8.0	35.7	100.0	0.0
CGD57	9.0		14.6	12.7	15.6	7.1		9.9	14.2	0.9			10.0	33.2	100.0	0.0
CGD58	10.5		8.9	11.1	13.2	14.2		10.0	12.1	0.5			11.0	31.7	99.5	0.0
CGD59	22.8		6.1	4.4	6.1	24.6		7.9	20.2	0.0			8.0	50.0	100.0	0.0
CGD60	22.5		6.3	6.3	1.8	28.8		6.3	21.6	1.8			9.0	52.8	100.0	0.0
CGD61	24.8		4.4	0.9	2.7	35.4		1.8	11.5	2.7			8.0	71.6	99.1	0.0
CGD62	13.3		3.7	3.7	11.9	29.6		4.4	18.5	1.5			10.0	68.4	97.8	0.7
CGD63	20.5		4.5	0.6	8.5	31.8		3.4	16.5	0.6			9.0	58.2	100.0	0.0
CGD64	21.0		2.5	0.6	7.4	30.9		1.9	24.1	0.0			8.0	62.7	100.0	0.0
CGD65	21.4		2.6	0.0	5.2	35.7		1.9	20.1	1.9			8.0	63.3	100.0	0.0
CGD66	0.0		6.9	0.0	6.9	69.0		0.0	0.0	0.0			4.0	88.0	100.0	0.0
CGD67	23.4		2.8	0.0	9.3	29.0		10.3	15.9	1.9			8.0	55.4	100.0	0.0
CGD68	15.1		8.6	1.1	22.6	17.2		14.0	6.5				8.0	45.1	100.0	0.0
LOD1*																
LOS4	0.0			0.0	0.0	0.0		0.0	0.0						0.0	0.0
LOD2	0.0			0.0	0.0	0.0		0.0	0.0						0.0	0.0
LOD3	0.0			0.0	0.0	0.0		0.0	0.0						0.0	0.0
LOD4	0.0			0.0	0.0	0.0		0.0	0.0						0.0	0.0
LOD5	0.0			0.0	0.0	0.0		0.0	0.0						0.0	0.0
LOS5	0.0		0.0	0.0	0.0	0.0		0.0	0.0	87.5			1.0	100.0	100.0	0.0
LOD5A	0.0		0.0	0.0	0.0	0.0		0.0	0.0	100.0			1.0	100.0	100.0	0.0
LOD6	0.0			0.0	0.0	0.0		0.0	0.0						0.0	0.0
LOD7	2.1		1.0	0.0	8.3	0.0		13.5	0.0	74.0			6.0	87.5	100.0	0.0
LOD8	4.1		1.5	0.0	8.2	0.0		6.6	2.0	74.0			7.0	84.7	100.0	0.0
LOD9	15.7		9.7	7.0	35.7	0.0		13.5	6.5	1.1			8.0	50.0	100.0	0.0
LOD10	12.9		10.8	0.0	15.6	7.5		5.4	2.7	37.6			8.0	56.9	100.0	0.0
LOK6	13.2		22.8	0.0	47.3	0.0		2.1	3.2	1.4			7.0	77.6	100.0	0.0
LOK7	11.5		15.7	7.9	30.9	11.5		0.5	1.0	0.0			7.0	58.9	100.0	0.0

Appendix V: Parameters derived from the palynomorph counts

Key to abbreviations used in column headers (percentage parameters unless otherwise stated):

SAMNO	= sample number
bot	= *Botryococcus* of palynomorphs
undif	= undifferentiated of palynomorphs
mp	= marine plankton of palynomorphs
sporo	= sporomorphs of palynomorphs
tnw/sp	= thin-walled of spores
tkw/sp	= thick-walled of spores
sp/spor	= spores of sporomorphs
up/tp	= unidentified of pollen
cal/tp	= *Callialasporites* of pollen
cer/tp	= *Cerebropollenites* of pollen
bis/tp	= bisaccates of pollen
tp/spor	= pollen of sporomorphs
ud/td	= unidentified of dinocysts
smd/td	= very poorly preserved of dinocysts
nan/td	= *Nannoceratopsis* of dinocysts
cad/td	= *Caddasphaera* of dinocysts
bat/td	= *Batiacasphaera* of dinocysts
prv/td	= *Parvocysta* of dinocysts
dis/td	= *Dissiliodinium* of dinocysts
cte/td	= *Ctenidodinium* of dinocysts
dur/td	= *Durotrigia* of dinocysts
mei/td	= *Meiurogonyaulax* of dinocysts
gt/td	= other gonyaulacacean type of dinocysts
par/td	= *Pareodinia* of dinocysts
sen/td	= *Sentusidinium* of dinocysts
jman/td	= *Jansonia manifesta* of dinocysts
rhy/td	= *Rhychodiniopsis* of dinocysts
adnat/td	= *Adnatosphaeridium* of dinocysts
dindiv	= dinocyst diversity (number of genera present, only calculated for main lagoonal formations)
dindom	= dinocyst dominance (only calculated for main lagoonal formations)
din/mp	= dinocysts of marine plankton
ac/mp	= acritarchs of marine plankton
tas/mp	= *Tasmanites* type prasinophyte marine plankton
lei/mp	= leiospheres of marine plankton
lspor/mp	= log ratio sporomorphs:marine plankton
lacr/din	= log ratio acritarchs:dinocysts
lup/bis	= log ratio unidentified pollen:bisaccates
lspore/bis	= log ratio spores:bisaccates
#NUM	= parameter not calculated due to missing value in one category
#DIV0	= parameter not calculated due to value in one category being zero

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
LOK8	13.1		13.6	9.4	42.3	0.5		3.3	2.3	0.5			10.0	65.0	100.0	0.0
LOD11	2.3		1.4	48.0	29.9	0.5		10.4	0.0	0.9			8.0	79.3	100.0	0.0
LOD12	3.2		0.4	70.8	16.4	0.0		3.6	0.0	2.0			7.0	87.9	100.0	0.0
LOK11	4.5		0.8	39.5	28.0	0.0		9.9	1.6	0.8			7.0	74.2	100.0	0.0
LOD13	0.0			0.0	0.0	0.0		0.0	0.0						0.0	0.0
LOD14	0.0		0.0	0.0	0.0	0.0		0.0	0.0	100.0			1.0	100.0	100.0	0.0
LOD15	0.0		0.0	0.0	0.0	0.0		100.0	0.0	0.0			1.0	100.0	100.0	0.0
LOD16	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	0.0
LOK15										0.0						
LOK16	6.1		0.0	0.0	8.2	4.1		36.7	0.0	0.0			4.0	81.5	92.5	5.7
LOK17	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0					100.0	0.0
LOK20	0.0		0.0	0.0	0.0	0.0		50.0	0.0	0.0			1.0	100.0	100.0	0.0
LOK21										0.0						
LOK22										0.0						
LOK23	0.0			0.0	0.0	0.0		0.0	0.0	0.0					100.0	0.0
LOK24	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	0.0
LOK25	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	0.0
LOK26	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	0.0
LOK27	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	0.0
LOK28	0.0			0.0	0.0	0.0		33.3	0.0	0.0			1.0	100.0	100.0	0.0
LOK29	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	100.0
LOK30	0.0			0.0	0.0	0.0		0.0	0.0	0.0					100.0	0.0
LOK31										0.0						
LOK32	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	0.0
LOK33	0.0			0.0	0.0	0.0		16.7	0.0	0.0					100.0	0.0
LOK34	0.0			0.0	0.0	0.0		33.3	0.0	0.0			1.0	100.0	100.0	0.0
LOK35	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	0.0
LOK36	0.0			0.0	0.0	0.0		0.0	0.0	0.0					100.0	0.0
LOK37	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	0.0
LOK38	0.0			0.0	0.0	0.0		0.0	0.0	0.0					100.0	0.0
LOK39	0.0			0.0	0.0	0.0		0.0	0.0	0.0					0.0	0.0
LBT1	1.9		6.4	2.5	0.6	0.0		1.9	1.3	43.9			9.0	85.0	100.0	0.0
LBT2	1.5		14.6	0.5	0.0	0.0		4.4	0.5	65.0			7.0	92.0	100.0	0.0
LBT3	6.6		0.0	0.0	0.0	17.1		38.2	2.6	25.0			5.0	71.0	100.0	0.0
LBT4	6.0		0.0	0.0	8.5	15.4		36.8	3.4	10.3			6.0	76.0	100.0	0.0
LBT5	8.2		0.0	0.0	0.9	5.5		38.2	22.7	10.9			8.0	69.0	100.0	0.0
LBT6	4.8		0.0	0.0	0.0	0.0		78.8	1.9	8.7			4.0	93.0	100.0	0.0
LBT7	1.5		0.0	3.1	6.2	1.5		53.8	15.4	15.4			7.0	71.0	100.0	0.0
LBT8	4.7		0.0	1.6	0.0	0.0		37.5	29.7	20.3			5.0	72.0	100.0	0.0

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
LBT9	0.0		0.0	0.0	0.0	0.0		79.3	1.2	15.9			3.0	99.0	98.8	1.2
LBT10	0.9		0.0	0.0	0.0	0.0		90.2	0.0	6.3			3.0	99.0	100.0	0.0
LBT11	0.8		0.0	0.8	0.8	0.0		89.9	0.8	1.6			6.0	97.0	100.0	0.0
LBT12	0.0		0.0	0.0	0.0	0.0		50.0	0.0	0.0			1.0	100.0	100.0	0.0
LBT13	0.0		0.0	0.0	0.0	0.0		0.0	0.0	16.7			1.0	100.0	100.0	0.0
LBT14	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0					100.0	0.0
LBT15	0.0		0.0	21.4	7.1	3.6		44.6	5.4	0.0			5.0	80.0	100.0	0.0
LBT16	0.0		0.0	0.5	1.1	0.0		93.2	0.0	0.0			3.0	99.0	100.0	0.0
LBT17	0.0		0.0	21.7	0.0	1.7		25.0	13.3	0.0			4.0	76.0	100.0	0.0
LBM1	0.0		14.5	50.0	13.0	0.0		8.7	8.7	0.0			6.0	76.0	100.0	0.0
LBM2	2.3		0.0	63.6	6.8	0.8		9.1	6.1	0.0			8.0	79.0	100.0	0.0
LBM3	20.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0			1.0	100.0	100.0	0.0
LBM4	0.0		0.0	0.0	0.0	0.0		40.0	0.0	0.0			1.0	100.0	100.0	0.0
LBM5	3.7		5.3	45.5	3.2	0.0		17.6	8.6	0.0			6.0	80.0	99.5	0.5
LBM6	4.2		41.7	12.5	0.0	0.0		12.5	16.7	0.0			5.0	58.0	100.0	0.0
LBM7	3.1		0.0	23.6	0.8	0.0		9.4	31.5	0.0			5.0	80.0	99.2	0.8
KBD1	7.5				34.0			41.5							100.0	0.0
KBK1	0.0				0.0			64.3							100.0	0.0
KBK2																
KBK3																
KBK4																
KBK5																
KBK7															0.0	0.0
KBK8																
KBK9																
KBK10																
KBK11																
SB1																
SB4																
SB7																
SB10																
SB14																
SBS2																
SBS4																
SBS5	5.3				28.0	5.3	5.3	0.0							100.0	0.0
SBU1	0.8				22.6	4.0	27.4	2.4							100.0	0.0
UOB1	0.0				17.0	2.1	10.6	2.1			0.0	0.0	4.0	87.0	100.0	0.0
UOB2	0.0				47.4	0.0	14.5	2.6			0.0	0.0	3.0	96.0	100.0	0.0
UOB3	0.0				37.5	2.5	7.5	15.0			0.0	0.0	4.0	84.0	100.0	0.0

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
UOB4	0.0				21.2	3.0	0.0	12.1			0.0	0.0	3.0	92.0	100.0	0.0
UOB5	1.9				13.5	10.6	4.8	1.0			0.0	0.0	5.0	76.0	98.1	1.9
UOB6	0.9				17.2	1.7	17.2	1.7			0.9	0.0	6.0	87.0	100.0	0.0
UOB7	1.1				20.0	0.0	13.7	2.1			0.0	0.0	5.0	89.0	100.0	0.0
UOB8	4.3				11.7	5.3	16.0	2.1			0.0	0.0	5.0	70.0	97.9	2.1
UOB9	3.0				6.0	1.5	32.8	0.0			0.0	7.5	5.0	79.0	98.5	1.5
UOB10	2.6				16.9	1.3	32.5	2.6			0.0	2.6	6.0	84.0	96.3	3.8
UOB11	0.0				13.0	0.0	0.0	0.0			0.0	0.0	1.0	100.0	100.0	0.0
UOB12	0.0				14.7	0.0	0.0	29.4			0.0	0.0	2.0	100.0	97.1	2.9
UOB13	0.0				27.9	0.0	0.0	34.4			0.0	0.0	2.0	100.0	100.0	0.0
UOB14	0.0				5.5	0.0	1.1	49.5			0.0	0.0	3.0	98.0	98.9	1.1
UOB15	0.0				9.3	0.0	7.4	22.2			14.8	3.7	5.0	65.0	100.0	0.0
UOB16	3.4				17.2	3.4	6.9	24.1			0.0	0.0	5.0	75.0	100.0	0.0
UOB17	2.9				11.8	0.0	5.9	29.4			0.0	0.0	4.0	82.0	100.0	0.0
UOB18	4.3				17.4	0.0	13.0	13.0			0.0	0.0	4.0	64.0	95.8	4.2
UOB19	3.3				20.0	10.0	3.3	20.0			0.0	0.0	5.0	71.0	100.0	0.0
UOB20	8.3				16.7	8.3	0.0	0.0			0.0	0.0	3.0	95.0	100.0	0.0
UOB21	7.1				14.3	0.0	7.1	0.0			0.0	0.0	3.0	95.0	100.0	0.0
UOB22	1.6				16.1	0.0	19.4	29.0			0.0	0.0	4.0	73.0	100.0	0.0
UOB23	0.0				18.3	1.7	1.7	43.3			0.0	0.0	4.0	95.0	98.4	1.6
UOB24																
UOB25	0.0				25.8	0.0	6.5	19.4			0.0	0.0	3.0	88.0	98.4	1.6
UOB26	0.0				11.6	0.0	4.7	27.9			0.0	0.0	3.0	89.0	100.0	0.0
UOB27	0.0				22.9	0.0	8.3	10.4			0.0	0.0	4.0	80.0	100.0	0.0
UOB28	1.8				17.9	0.0	8.9	5.4			0.0	0.0	4.0	75.0	100.0	0.0
UOB29	0.0				9.1	3.0	12.1	3.0			0.0	0.0	4.0	90.0	100.0	0.0
UOB30	1.7				5.0	0.0	11.7	61.7			0.0	0.0	4.0	92.0	98.4	1.6
UOB31																
UOB32	1.1				13.0	0.0	16.3	50.0			0.0	0.0	4.0	82.0	100.0	0.0
UOB33	2.9				5.9	0.0	11.8	38.2			0.0	0.0	4.0	85.0	100.0	0.0
UOB34	0.0				5.9	0.0	23.5	17.6			0.0	0.0	3.0	95.0	100.0	0.0
UOB35	2.4				4.9	0.0	9.8	29.3			0.0	0.0	4.0	84.0	97.6	2.4
UOB36	0.0				19.6	0.0	14.3	10.7			0.0	0.0	3.0	76.0	100.0	0.0
UOB37	0.0				8.2	0.0	20.4	0.0			0.0	0.0	2.0	100.0	100.0	0.0
BS1	0.0				7.3	0.0	3.6	27.3			0.0	0.0	3.0	90.0	100.0	0.0
BS2	1.6				16.1	0.0	0.0	35.5			0.0	0.0	3.0	97.0	100.0	0.0
BS3	5.4				0.0	0.0	0.0	70.3			0.0	0.0	2.0	100.0	100.0	0.0
BS4	0.0				19.6	0.0	25.5	19.6			0.0	0.0	3.0	70.0	100.0	0.0
BS5	0.0				10.3	0.0	17.9	41.0			0.0	0.0	3.0	85.0	100.0	0.0

SAMNO	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
BS6	0.0				20.8	1.0	25.7	15.8			0.0	0.0	4.0	73.0	100.0	0.0
BS7																
BS8																
BS9																
BS10	2.8				13.9	0.0	30.6	25.0			0.0	0.0	4.0	77.0	100.0	0.0
BS11	1.4				1.4	4.3	14.3	38.6			0.0	0.0	5.0	88.0	98.6	1.4
BS12	0.0				21.2	0.0	15.2	15.2			0.0	0.0	3.0	71.0	100.0	0.0
BS13	2.6				13.2	2.6	36.8	13.2			0.0	0.0	5.0	73.0	100.0	0.0
BS14	0.0				11.6	0.0	27.5	27.5			0.0	0.0	3.0	83.0	100.0	0.0
BS15	0.0				14.8	0.0	37.0	25.9			0.0	0.0	3.0	81.0	100.0	0.0

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
BBE1	0.0	0.0	1.4	-1.0	0.7	-1.0
BBE2			#DIV/0!		#DIV/0!	#DIV/0!
BBE3			#DIV/0!		#DIV/0!	#DIV/0!
BBE4	0.0	0.0	1.3	-0.3	1.2	-0.3
BBE5			#DIV/0!		#DIV/0!	#DIV/0!
BBE6	0.0	0.0	1.4	0.1	1.0	-0.8
BBE7			#DIV/0!		#DIV/0!	#DIV/0!
BBE8			#DIV/0!		#DIV/0!	#DIV/0!
BBE9	0.0	0.0	1.1	-0.3	1.0	-0.8
BBE10			#DIV/0!		#DIV/0!	#DIV/0!
BBE11	0.0	0.0	1.3	-0.5	0.8	-0.8
BBE12			#DIV/0!		#DIV/0!	#DIV/0!
BBE13			#DIV/0!		#DIV/0!	#DIV/0!
BBE14	0.0	0.0	1.4	-0.5	1.0	-0.8
BBE15			#DIV/0!		#DIV/0!	#DIV/0!
BBE16			#DIV/0!		#DIV/0!	#DIV/0!
BBE17	0.0	0.0	1.2	-0.8	1.3	#NUM!
BBE18	0.0	0.0	1.7	-0.6	1.5	-0.2
BBE19	0.0	0.0	1.7	0.3	1.4	0.0
BBE20	0.0	0.0	1.3	-0.4	1.1	-0.7
BBE21	0.0	0.0	1.1	-0.6	1.1	-0.3
BBE22	0.0	0.0	1.4	-1.0	1.1	-0.2
BBE23	0.0	0.0	1.4	-1.0	1.2	-0.1
BBE24	0.0	0.0	1.4	-0.4	1.3	0.2
BBE25	0.0	0.0	1.3	-0.7	1.0	-0.1
BBE26	0.0	0.0	1.5	-0.8	1.0	-0.1
BBE27	0.0	0.0	1.4	-1.0	1.0	-0.3
BBE28	0.0	0.0	1.4		1.2	0.1
BBE29	0.0	0.0	1.4	-1.0	1.3	0.1
BBE30	0.0	0.0	1.4	-1.0	1.4	0.0
BBE31	0.0	0.0	1.5	-0.5	1.2	0.0
BBE32	0.0	0.0	1.5	-0.9	1.1	-0.5
BBE33	0.0	0.0	1.8		1.1	-0.3
BBE34	0.0	0.0	1.7	-0.3	1.1	-0.3
BBE35	0.0	0.0	1.8	-0.6	1.1	-0.5
BBE36	0.0	0.0	1.9		1.2	-0.5
BBE37	0.0	0.0	1.1	-1.3	1.1	-0.2
BBE38	0.0	0.0	1.2		1.1	-0.1
BBE39	0.0	0.0	1.2		0.9	-0.2

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
BBE40	0.0	0.0	1.3	-0.6	0.7	-0.4
BBE41	0.0	0.0	1.2		0.8	0.1
BBE42	0.0	0.0	1.2	-0.9	0.9	-0.1
BBE43	0.0	0.0	1.3	-0.7	0.7	-0.2
BBE44	0.0	0.0	1.3	-0.7	0.9	-0.2
BBE45	0.0	0.0	1.2	-0.8	0.8	-0.3
BBE46	0.0	0.0	1.9		0.9	-0.2
BBE47	0.0	0.0	2.0		1.0	-0.2
BBE48	0.0	0.0	1.6	-0.8	0.7	-0.3
BBE49					#DIV/0!	#DIV/0!
BBO1	0.0	0.0	1.3	-0.7	0.9	-0.4
BBO2	0.0	0.0	1.2	#NUM!	0.7	-0.8
BBU1	0.0	0.0	1.5	-0.1	0.8	-0.4
BBU2	6.3	0.0	1.2	-0.1	0.7	-0.4
BBU3	0.0	0.0	1.5	-0.4	0.8	-0.4
BBU4	0.0	0.0	1.2	#NUM!	0.8	-0.1
BBU5	7.1	0.0	1.3	-0.6	0.8	-0.4
BBU6	0.0	0.0	1.4	#NUM!	0.7	-0.4
BBU7	0.0	0.0	1.2	-0.8	0.8	0.0
BBU8	0.0	0.0	1.4	#NUM!	0.7	-0.4
BBU9	0.0	0.0	1.2	-0.7	0.6	-0.3
BBU10	0.0	0.0	1.4	#NUM!	0.8	-0.3
BBU11	0.0	0.0	1.3	-0.3	0.8	-0.4
BBU12	0.0	0.0	1.6	#NUM!	0.7	-0.4
BBU13	0.0	0.0	1.2	#NUM!	1.0	-0.1
BBU14	0.0	0.0	1.3	-0.2	1.0	-0.3
BBU15	0.0	0.0	1.5	-0.4	1.0	-0.2
BBU16	0.0	0.0	1.4	#NUM!	1.0	-0.4
BBU17	0.0	0.0	1.4	-0.5	0.7	-0.6
BBU18	0.0	0.0	1.7	-0.2	0.8	-0.3
BBU19	0.0	0.0	1.3	-0.6	0.9	-0.1
BBU20	0.0	0.0	1.5	-0.4	0.9	0.0
BBU21	0.0	0.0	1.1	-0.5	1.0	0.2
BBU22	0.0	0.0	1.3	-0.6	0.7	-0.2
BBU23	0.0	0.0	1.4	#NUM!	1.1	0.1
BBU24	0.0	0.0	1.8	#NUM!	1.1	-0.1
BBU25	0.0	0.0	1.7	#NUM!	1.1	0.0
BBU26	0.0	0.0	2.0	#NUM!	1.1	-0.2
BBU27	0.0	0.0	1.5	#NUM!	1.1	-0.3

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
BBU28	0.0	0.0	1.7	#NUM!	0.8	-0.4
BBU29	0.0	0.0	1.7	0.3	1.0	-0.3
BBU30	0.0	0.0	1.6	#NUM!	0.9	-0.3
BBH1	7.7	0.0	1.3	#NUM!	1.0	-0.3
BBH2	0.0	0.0	1.4	-0.5	1.0	0.1
BBH3	0.0	0.0	1.6	#NUM!	0.9	-0.1
BBH4	0.0	0.0	1.9	0.0	1.1	-0.3
BBH5	0.0	0.0	2.0	#NUM!	1.0	-0.6
BBH6	0.0	0.0	1.6	#NUM!	1.1	-0.1
BBH7	0.0	0.0	1.8	-0.1	0.8	-0.3
BBH8	0.0	0.0	1.7	#NUM!	0.9	-0.4
BBH9	20.0	0.0	1.7	0.0	1.1	-0.5
BBH10	0.0	0.0	2.0	#NUM!	0.6	-0.7
BBH11	0.0	0.0	1.7	#NUM!	0.7	-0.3
BBH12			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR1			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR2	0.0	0.0	1.2	#NUM!	1.2	-0.1
BBR3			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR4			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR13	0.0	0.0	1.7	#NUM!	1.2	-0.3
BBR14			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR15			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR16			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR17			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR18	0.0	0.0	1.7	#NUM!	1.1	-0.3
BBR19			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR5	0.0	0.0	1.6	-0.3	1.5	-0.1
BBR6			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR7			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR8	0.0	0.0	0.1	0.3	1.3	-0.3
BBR9			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR10			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BBR11	0.0	0.0	1.1	-0.1	1.2	-0.3
BNL17			#DIV/0!		#DIV/0!	#DIV/0!
BNL16	0.0	0.0	1.0	-0.9	1.0	-0.7
BNL1			#DIV/0!		#DIV/0!	#DIV/0!
BNL2	0.0	0.0	1.1	-0.8	1.3	-1.1
BNL3			#DIV/0!		#DIV/0!	#DIV/0!
BNL4			#DIV/0!		#DIV/0!	#DIV/0!

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
BNL5	0.0	0.0	1.3	-0.7	1.2	#NUM!
BNL6			#DIV/0!		#DIV/0!	#DIV/0!
BNL7			#DIV/0!		#DIV/0!	#DIV/0!
BNL8			#DIV/0!		#DIV/0!	#DIV/0!
BNL9	0.0	0.0	1.1	-0.8	1.0	-0.7
BNL10	0.0	0.0	1.1	-0.8	1.1	-0.7
BNL11			#DIV/0!		#DIV/0!	#DIV/0!
BNL12			#DIV/0!		#DIV/0!	#DIV/0!
BNL13	0.0	0.0	1.1	-0.8	1.1	-1.3
BNL15					#DIV/0!	#DIV/0!
RGC1	0.0	0.0	1.0	#NUM!	0.7	-0.8
RGC2					#DIV/0!	#DIV/0!
RGC3					#DIV/0!	#DIV/0!
RGC4	0.0	0.0	1.0	#NUM!	0.7	-1.0
RCS1	0.0	0.0	0.9	-1.1	0.0	-0.9
RCS2	0.0	0.0	1.1	#NUM!	-0.2	-1.0
RCS3	0.0	0.0	1.1	-0.5	-0.2	-0.8
RCS4					#DIV/0!	#DIV/0!
RCS5	5.9	0.0	1.1	-0.8	-0.2	-0.5
RCS6	0.0	0.0	1.3	-1.0	-0.3	-1.0
RCS7	0.0	0.0	1.7	#NUM!	-0.2	-0.7
RCS8	0.0	0.0	1.9	#NUM!	-0.4	-0.9
RCS9	11.1	0.0	1.4	-0.5	-0.2	-0.7
RCS10	0.0	0.0	1.2	-0.8	-0.2	-0.8
RCS11	0.0	0.0	1.8	#NUM!	0.0	-0.4
RCS12	0.0	0.0	2.1	#NUM!	-0.1	-0.7
RCS13	0.0	0.0	1.3	-0.7	0.0	-0.5
RCS14	0.0	0.0	1.5	#NUM!	-0.2	-0.6
RCS15	0.0	0.0	1.5	#NUM!	-0.3	-0.7
KE26	0.0	0.0	1.5	0.1	0.0	-0.4
KE27	0.0	0.0	2.2		0.1	-0.8
KE28	0.0	0.0	1.9	0.3	0.0	-0.3
KE29	0.0	0.0			-0.1	-0.6
KE30	0.0	0.0	2.2		0.4	-0.3
KE31	0.0	0.0	2.1		0.3	-1.0
KE32	0.0	0.0			0.6	-0.5
KE33	0.0	0.0	1.9	0.3	0.2	-0.5
KE34	0.0	0.0	1.3	0.9	0.3	-0.7
KE35	0.0	0.0	2.3		0.3	-0.7

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
KE36	33.3	0.0	1.9		0.1	-0.9
KE37	0.0	0.0	2.1		0.3	-0.6
KE38	0.0	0.0	2.1	0.0	0.3	-0.5
KE39	0.0	0.0			0.2	-0.8
KE40	0.0	0.0			0.2	-0.6
KE41	0.0	0.0	1.9		0.1	-0.6
KE42	0.0	0.0	1.7	-0.2	0.0	-0.8
KE43	0.0	0.0	1.8	0.5	0.1	-0.9
KE44	0.0	0.0	0.6		0.1	-0.5
KE45	0.0	0.0	1.4		0.1	-0.6
KE46	0.0	0.0	1.1		0.2	-0.4
KE47	0.0	0.0	1.0	0.8	0.0	-0.3
KE48	0.0	0.0	1.2		0.0	-0.3
KE49	0.0	0.0	1.6	0.4	0.0	-0.7
KE50	0.0	0.0	0.5		0.3	-0.6
KE51	0.0	0.0	1.1		0.1	-0.6
KE52	0.0	0.0	1.2		0.1	-0.4
KE53	0.0	0.0	2.1		-0.1	-0.5
KE54	0.0	0.0	1.1	0.7	-0.1	-0.5
KE55	0.0	0.0	1.4		0.3	-0.3
KE56					#DIV/0!	#DIV/0!
KE57	0.0	0.0			0.1	-0.3
KE58	0.0	0.0	2.1		0.0	-0.6
KE1	0.0	0.0	2.1	0.0	-0.2	-0.7
KE2	0.0	0.0	2.4		0.0	-0.7
KE3	0.0	0.0	1.7		0.0	-0.9
KE4	0.0	0.0	0.2		0.3	-0.4
KE5	0.0	0.0	-0.3		0.7	-0.8
KE6	0.0	0.0	0.9		-0.1	-0.6
KE7	0.0	0.0	1.3	-0.5	0.0	-0.4
KE8	0.0	0.0	0.6		-0.2	-0.5
KE9	0.0	0.0	0.7		0.1	-0.8
KE10	0.0	0.0	0.8		0.1	-0.7
KE11	0.0	0.0	1.0		-0.3	-0.6
KE12	0.0	0.0	0.5		0.5	-0.4
KE13	0.0	0.0	0.8	-0.1	0.1	-0.7
KE14	0.0	0.0	0.6	1.4	0.4	-0.3
KE15	0.0	0.0	0.5	1.2	0.2	-0.6
KE16	0.0	0.0	1.6		-0.1	-1.0

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
KE17	0.0	0.0	1.1	-0.1	0.2	-0.8
KE18	0.0	0.0			-0.1	-0.2
KE19	0.0	0.0			0.1	0.0
KE20	0.0	0.0			0.0	0.3
KE21	0.0	0.0	0.5	1.3	0.2	-0.9
KE22	0.0	0.0	0.4	1.8	0.4	-0.1
KE23	0.0	0.0	0.5	1.3	0.1	-0.6
KE24	0.0	0.0	1.4		0.0	-0.8
KE25	0.0	0.0			-0.2	-0.6
RNB1	0.0	0.0	1.9		0.0	-0.2
RNB3	0.0	0.0	1.3	0.0	-0.2	-1.1
RNB4	0.0	0.0	1.2	-0.8	0.1	-1.2
RNB5	0.0	0.0	1.0	-0.3	-0.2	-1.2
RNB6	0.0	0.0	1.0	-1.2	0.2	#NUM!
RNB7	0.0	0.0	1.6		-0.7	-1.5
RNB8	0.0	0.0	1.1		0.1	-1.5
RNB9	0.0	0.0	1.8		-0.4	-1.0
RNB10	0.0	0.0	1.1	-0.4	0.1	-1.0
RNB11	0.0	0.0	0.9	0.8	0.4	-1.0
RNB12	0.0	0.0	1.7	0.5	-0.3	-1.4
RNB13	0.0	0.0	1.9		0.0	-0.8
RNB14	0.0	0.0	1.8		0.2	-0.5
RNB15	0.0	0.0	1.1	0.7	0.5	-0.5
RNB16	0.0	0.0	1.3	0.4	0.1	-0.6
RNB17					#DIV/0!	#DIV/0!
RNB18	0.0	0.0	2.3		0.1	-0.5
RNB19	0.0	0.0	2.4		0.0	-0.6
RNB20	0.0	0.0			0.1	-0.6
VS2	0.0	0.0			0.6	0.3
VS3	0.0	0.0			0.5	0.0
VS4	0.0	0.0			0.6	0.2
VS5					#DIV/0!	#DIV/0!
VS7					#DIV/0!	#DIV/0!
VS8	0.0	0.0			-0.2	-0.6
VS9					#DIV/0!	#DIV/0!
CGD1					#DIV/0!	#DIV/0!
CGD2					#DIV/0!	#DIV/0!
CGD3					#DIV/0!	#DIV/0!
CGD4					#DIV/0!	#DIV/0!

Appendix V: Parameters derived from the palynomorph counts

Key to abbreviations used in column headers (percentage parameters unless otherwise stated):

SAMNO	= sample number
bot	= *Botryococcus* of palynomorphs
undif	= undifferentiated of palynomorphs
mp	= marine plankton of palynomorphs
sporo	= sporomorphs of palynomorphs
tnw/sp	= thin-walled of spores
tkw/sp	= thick-walled of spores
sp/spor	= spores of sporomorphs
up/tp	= unidentified of pollen
cal/tp	= *Callialasporites* of pollen
cer/tp	= *Cerebropollenites* of pollen
bis/tp	= bisaccates of pollen
tp/spor	= pollen of sporomorphs
ud/td	= unidentified of dinocysts
smd/td	= very poorly preserved of dinocysts
nan/td	= *Nannoceratopsis* of dinocysts
cad/td	= *Caddasphaera* of dinocysts
bat/td	= *Batiacasphaera* of dinocysts
prv/td	= *Parvocysta* of dinocysts
dis/td	= *Dissiliodinium* of dinocysts
cte/td	= *Ctenidodinium* of dinocysts
dur/td	= *Durotrigia* of dinocysts
mei/td	= *Meiurogonyaulax* of dinocysts
gt/td	= other gonyaulacacean type of dinocysts
par/td	= *Pareodinia* of dinocysts
sen/td	= *Sentusidinium* of dinocysts
jman/td	= *Jansonia manifesta* of dinocysts
rhy/td	= *Rhychodiniopsis* of dinocysts
adnat/td	= *Adnatosphaeridium* of dinocysts
dindiv	= dinocyst diversity (number of genera present, only calculated for main lagoonal formations)
dindom	= dinocyst dominance (only calculated for main lagoonal formations)
din/mp	= dinocysts of marine plankton
ac/mp	= acritarchs of marine plankton
tas/mp	= *Tasmanites* type prasinophyte marine plankton
lei/mp	= leiospheres of marine plankton
lspor/mp	= log ratio sporomorphs:marine plankton
lacr/din	= log ratio acritarchs:dinocysts
lup/bis	= log ratio unidentified pollen:bisaccates
lspore/bis	= log ratio spores:bisaccates
#NUM	= parameter not calculated due to missing value in one category
#DIV0	= parameter not calculated due to value in one category being zero

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
CGD5					#DIV/0!	#DIV/0!
CGD6					#DIV/0!	#DIV/0!
CGD7					#DIV/0!	#DIV/0!
CGD8					#DIV/0!	#DIV/0!
CGD9					#DIV/0!	#DIV/0!
CGD10					#DIV/0!	#DIV/0!
CGD11	0.0	0.0	1.1	#NUM!	0.1	-1.7
CGD12			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CGD13			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CGD14			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CGD15			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CGD16			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CGD17			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CGD18			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CGD19			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CGD20	0.0	0.0	0.5	#NUM!	0.4	-0.6
CGD21			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CGD23	0.0	0.0	0.5	-1.8	0.8	-0.8
CGD24	0.0	0.0	-0.3	#NUM!	0.3	-0.9
CGD25	0.0	0.0	-0.1	#NUM!	0.3	-0.8
CGD26	0.0	0.0	0.0	#NUM!	0.4	-0.9
CGD27	0.0	0.0	-0.1	-2.2	0.5	-0.4
CGD28	0.0	0.0	-0.5	#NUM!	0.6	#NUM!
CGD29	0.0	0.0	0.2	#NUM!	0.8	-0.1
CGD30	0.0	0.0	0.3	#NUM!	0.6	0.0
CGD31	0.0	0.0	0.1	#NUM!	0.9	0.1
CGD32	0.0	0.0	0.4	#NUM!	0.6	-0.5
CGD33	0.0	0.0	0.5	#NUM!	0.6	-0.4
CGD34	0.0	0.0	0.1	-2.1	0.5	-1.0
CGD35	0.0	0.0	-0.2	#NUM!	0.6	-0.8
CGD36	0.0	0.0	-0.1	#NUM!	0.7	-1.0
CGD37	0.0	0.0	0.0	#NUM!	0.6	-0.7
CGD38	0.0	4.0	0.7	#NUM!	1.1	0.1
CGD39	0.0	2.6	0.4	#NUM!	0.8	-0.2
CGD40	0.0	0.0	0.5	#NUM!	0.7	-0.8
CGD41	0.0	0.0	0.1	#NUM!	1.0	-0.1
CGD42	0.0	0.0	-0.1	#NUM!	0.8	-0.5
CGD43	0.0	0.0	0.0	-1.6	0.6	-0.9
CGD44	0.0	0.0	0.2	#NUM!	0.7	-0.9

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
CGD45	0.0	0.0	0.1	#NUM!	0.9	-0.7
CGD46	0.0	0.0	0.1	#NUM!	0.9	-0.5
CGD47	0.0	0.0	0.2	-2.0	0.7	-0.5
CGD48	0.0	0.7	0.0	-1.2	0.6	-0.7
CGD49	0.0	0.0	0.4	-1.6	1.2	-0.3
CGD50	0.0	0.0	2.0	#NUM!	0.9	0.7
CGD51	0.0	0.0	1.4	#NUM!	0.6	-0.9
CGD52	0.0	0.0	0.9	#NUM!	1.0	-0.1
CGD53	0.0	0.0	-0.1	#NUM!	0.3	-0.5
CGD54	0.0	0.0	-0.3	#NUM!	0.4	-0.3
CGD55	0.0	0.0	-0.4	#NUM!	0.6	-0.3
CGD56	0.0	0.0	-0.4	#NUM!	0.5	-0.9
CGD57	0.0	0.0	-0.5	#NUM!	0.7	-0.5
CGD58	0.0	0.5	-0.3	#NUM!	0.3	-0.3
CGD59	0.0	0.0	0.2	#NUM!	0.7	-0.6
CGD60	0.0	0.0	0.2	#NUM!	0.6	-0.6
CGD61	0.9	0.0	0.2	#NUM!	0.5	-0.7
CGD62	0.0	1.4	0.0	-2.1	0.3	-0.8
CGD63	0.0	0.0	-0.2	#NUM!	0.3	-0.6
CGD64	0.0	0.0	-0.1	#NUM!	0.3	-0.6
CGD65	0.0	0.0	-0.1	#NUM!	0.4	-0.6
CGD66	0.0	0.0	1.0	#NUM!	0.5	-0.6
CGD67	0.0	0.0	0.2	#NUM!	0.2	-0.7
CGD68	0.0	0.0	0.3	#NUM!	0.3	-0.6
LOD1*			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
LOS4	0.0	0.0	#DIV/0!	#DIV/0!	0.4	-0.4
LOD2	0.0	0.0	#DIV/0!	#DIV/0!	0.5	-0.4
LOD3	0.0	0.0	#DIV/0!	#DIV/0!	0.4	-0.4
LOD4	0.0	0.0	#DIV/0!	#DIV/0!	0.5	-0.8
LOD5	0.0	0.0	#DIV/0!	#DIV/0!	0.2	-1.4
LOS5	0.0	0.0	1.6	#NUM!	0.4	-0.8
LOD5A	0.0	0.0	2.4	#NUM!	0.7	-0.1
LOD6	0.0	0.0	#DIV/0!	#DIV/0!	0.8	-0.1
LOD7	0.0	0.0	0.3	#NUM!	0.5	-0.8
LOD8	0.0	0.0	-0.3	#NUM!	0.3	-1.4
LOD9	0.0	0.0	-0.3	#NUM!	0.3	-0.8
LOD10	0.0	0.0	-0.3	#NUM!	0.6	-1.3
LOK6	0.0	0.0	-1.3	#NUM!	#DIV/0!	#DIV/0!
LOK7	0.0	0.0	-0.3	#NUM!	0.1	-0.7

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
LOK8	0.0	0.0	-0.5	#NUM!	1.1	0.5
LOD11	0.0	0.0	-0.5	#NUM!	0.4	-0.5
LOD12	0.0	0.0	-0.8	#NUM!	0.2	-0.4
LOK11	0.0	0.0	-0.7	#NUM!	0.5	-0.1
LOD13	0.0	0.0	#DIV/0!	#DIV/0!	1.0	0.2
LOD14	0.0	0.0	2.4	#NUM!	0.8	0.1
LOD15	0.0	0.0	2.1	#NUM!	1.0	0.5
LOD16	0.0	0.0	#DIV/0!	#DIV/0!	1.4	0.8
LOK15			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
LOK16	0.0	1.9	0.6	-1.2	0.4	-0.5
LOK17	0.0	0.0	2.5	#NUM!	0.8	0.1
LOK20	0.0	0.0	1.5	#NUM!	0.6	0.4
LOK21			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
LOK22			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
LOK23	0.0	0.0	1.8	#NUM!	1.3	0.2
LOK24	0.0	0.0	#DIV/0!	#DIV/0!	0.3	-0.1
LOK25	0.0	0.0	#DIV/0!	#DIV/0!	0.3	-0.3
LOK26	0.0	0.0	#DIV/0!	#DIV/0!	0.3	-0.1
LOK27	0.0	0.0	#DIV/0!	#DIV/0!	0.4	-0.1
LOK28	0.0	0.0	2.0	#NUM!	1.2	0.7
LOK29	0.0	0.0	2.5	#DIV/0!	1.6	1.3
LOK30	0.0	0.0	2.1	#NUM!	#DIV/0!	#DIV/0!
LOK31			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
LOK32	100.0	0.0	2.5	#DIV/0!	1.4	1.0
LOK33	0.0	0.0	1.6	#NUM!	0.3	-0.1
LOK34	0.0	0.0	1.9	#NUM!	0.4	0.0
LOK35	0.0	0.0	#DIV/0!	#DIV/0!	0.1	-0.2
LOK36	0.0	0.0	2.5	#NUM!	0.2	-0.2
LOK37	0.0	0.0	#DIV/0!	#DIV/0!	0.0	-0.3
LOK38	0.0	0.0	2.4	#NUM!	0.5	0.2
LOK39	0.0	0.0	#DIV/0!	#DIV/0!	0.5	0.3
LBT1	0.0	0.0	-0.1	#NUM!	0.8	-0.6
LBT2	0.0	0.0	-0.5	#NUM!	0.5	-0.9
LBT3	0.0	0.0	0.4	#NUM!	0.1	-0.8
LBT4	0.0	0.0	0.1	#NUM!	0.0	-1.6
LBT5	0.0	0.0	0.2	#NUM!	0.1	-0.8
LBT6	0.0	0.0	0.2	#NUM!	0.1	-1.6
LBT7	0.0	0.0	0.5	#NUM!	-0.5	-1.2
LBT8	0.0	0.0	0.5	#NUM!	-0.2	-0.8

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
LBT9	0.0	0.0	0.4	-1.9	0.0	-0.8
LBT10	0.0	0.0	0.2	#NUM!	0.1	-0.8
LBT1;	0.0	0.0	0.1	#NUM!	0.1	-0.8
LBT12	0.0	0.0	1.9	#NUM!	0.4	-0.4
LBT13	0.0	0.0	1.7	#NUM!	0.5	-0.4
LBT14	0.0	0.0	2.5	#NUM!	0.4	-0.6
LBT15	0.0	0.0	0.6	#NUM!	-0.1	-0.9
LBT16	0.0	0.0	-0.3	#NUM!	0.2	-0.6
LBT17	0.0	0.0	0.6	#NUM!	0.4	-0.4
LBM1	0.0	0.0	0.0	#NUM!	0.1	-0.5
LBM2	0.0	0.0	0.1	#NUM!	0.3	-0.6
LBM3	0.0	0.0	1.7	#NUM!	0.5	-0.6
LBM4	0.0	0.0	1.5	#NUM!	0.3	-0.6
LBM5	0.0	0.0	-0.3	-2.3	0.5	-0.8
LBM6	0.0	0.0	1.0	#NUM!	0.2	-0.8
LBM7	0.0	0.0	-0.8	-2.1	0.2	#NUM!
KBD1	0.0	0.0	0.6		0.4	-0.8
KBK1	0.0	0.0	1.3		0.1	-0.7
KBK2					#DIV/0!	#DIV/0!
KBK3					0.4	-0.5
KBK4					#DIV/0!	#DIV/0!
KBK5					#DIV/0!	#DIV/0!
KBK7	100.0	0.0	2.4		0.4	0.0
KBK8					#DIV/0!	#DIV/0!
KBK9					0.7	-0.1
KBK10					#DIV/0!	#DIV/0!
KBK11					#DIV/0!	#DIV/0!
SB1					#DIV/0!	#DIV/0!
SB4					#DIV/0!	#DIV/0!
SB7					#DIV/0!	#DIV/0!
SB10					#DIV/0!	#DIV/0!
SB14					#DIV/0!	#DIV/0!
SBS2					#DIV/0!	#DIV/0!
SBS4					#DIV/0!	#DIV/0!
SBS5	0.0	0.0	0.4		0.3	-0.1
SBU1	0.0	0.0	0.1		0.4	-0.2
UOB1	0.0	0.0	0.7		0.4	0.2
UOB2	0.0	0.0	0.4		0.4	0.2
UOB3	0.0	0.0	0.7		0.2	-0.1

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
UOB4	0.0	0.0	0.9		-0.1	0.0
UOB5	0.0	0.0	0.2	-1.7	-0.2	-0.4
UOB6	0.0	0.0	0.1		0.1	-0.2
UOB7	0.0	0.0	0.3		0.2	-0.2
UOB8	0.0	0.0	0.3	-1.7	0.2	-0.2
UOB9	0.0	0.0	0.5	-1.8	-0.1	-0.3
UOB10	0.0	0.0	0.4	-1.4	0.0	-0.2
UOB11	0.0	0.0	1.1		0.1	-0.1
UOB12	0.0	0.0	0.9	-1.5	0.1	0.0
UOB13	0.0	0.0	0.6		0.2	0.1
UOB14	0.0	0.0	0.3	-2.0	0.2	-0.4
UOB15	0.0	0.0	0.6		0.6	0.2
UOB16	0.0	0.0	1.0		0.6	0.5
UOB17	0.0	0.0	0.9		0.4	0.1
UOB18	0.0	0.0	1.0	-1.4	0.7	0.4
UOB19	0.0	0.0	0.9		0.8	0.4
UOB20	0.0	0.0	1.4		0.4	-0.1
UOB21	0.0	0.0	1.3		0.5	0.3
UOB22	0.0	0.0	0.6		0.4	0.3
UOB23	0.0	0.0	0.5	-1.8	0.5	-0.2
UOB24					#DIV/0!	#DIV/0!
UOB25	0.0	0.0	0.5	-1.8	0.5	0.0
UOB26	0.0	0.0	0.8		0.6	0.0
UOB27	0.0	0.0	0.7		0.3	-0.1
UOB28	0.0	0.0	0.6		0.3	-0.1
UOB29	0.0	0.0	0.9		0.7	0.4
UOB30	0.0	0.0	0.5	-1.8	0.2	-0.3
UOB31					#DIV/0!	#DIV/0!
UOB32	0.0	0.0	0.3		0.2	-0.2
UOB33	0.0	0.0	0.8		0.3	-0.1
UOB34	0.0	0.0	1.2		0.2	-0.1
UOB35	0.0	0.0	0.8	-1.6	0.2	0.0
UOB36	0.0	0.0	0.6		0.2	-0.1
UOB37	0.0	0.0	0.7		0.1	-0.2
BS1	0.0	0.0	0.6		0.3	-0.2
BS2	0.0	0.0	0.6		0.2	0.0
BS3	0.0	0.0	0.8		0.3	-0.3
BS4	0.0	0.0	0.6		0.3	0.0
BS5	0.0	0.0	0.8		0.3	-0.1

SAMNO	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
BS6	0.0	0.0	0.3		0.3	-0.1
BS7					#DIV/0!	#DIV/0!
BS8					#DIV/0!	#DIV/0!
BS9					#DIV/0!	#DIV/0!
BS10	0.0	0.0	0.5		0.4	0.1
BS11	0.0	0.0	0.5	-1.8	0.3	-0.1
BS12	0.0	0.0	0.9		0.4	0.1
BS13	0.0	0.0	0.8		0.3	0.2
BS14	0.0	0.0	0.5		0.4	-0.2
BS15	0.0	0.0	1.0		0.3	-0.5

APPENDIX VI

Appendix VI: Mean values of each geochemical, kerogen, and palynomorph parameter in each major stratigraphic unit (key to parameters in appendices IV and V).

Key to other abbreviations used in column headers:

Unit	= stratigraphic unit
DCSM	= Dun Caan Shales Mbr. (Bearreraig Sst. Fm.)
USM	= Udairn Shales Mbr. (Bearreraig Sst. Fm.)
HSM	= Holm Sst. Mbr. (Bearreraig Sst. Fm.)
RSM	= Rigg Sst. Mbr. (Bearreraig Sst. Fm.)
?GCM	= ?Garantiana Clay Mbr. (Bearreraig Sst. Fm.)
BSF	= Bearreraig Sst. Fm.
CSF	= Cullaidh Shale Fm.
ESF	= Elgol Sst. Fm.
KM	= Kildonnan Mbr. (Lealt Shales Fm.)
LM	= Lonfearn Mbr. (Lealt Shales Fm.)
LSF	= Lealt Shales Fm.
VSF	= Valtos Sst. Fm.
DF	= Duntulm Fm.
KF	= Kilmaluag Fm.
SF	= Skudiburgh Fm.
UOM	= Upper Ostrea Mbr. (Staffin Bay Fm.)
BSM	= Belemnite Sands Mbr. (Staffin Bay Fm.)
SBF	= Staffin Bay Fm.

Kerogen Variables																
Unit	TOC	phytoc	HI	S2	Tmax	fluor	AOM	tphy	tpaly	stri/bstb	stp/bstb	ban/bstb	pit/bstb	und/bstb	deg/bstb	lt/blk
DCSM	2.12	1.72	196	5.09	425	3.39	15.4	82.2	2.54	87.5	8.33	3.63	0.52	0.83	99.2	38
USM	1.11	0.76	38	0.68	434	2.71	19.6	70	10.2	61.4	30.5	5.46	2.59	1.54	98.5	31
HSM	0.94	0.69	.	.	.	3.29	18.9	74.9	6.15	46	38.5	7.37	8.1	1.88	98.1	19.4
RSM	0.55	0.4	82	0.57	427	3	19.9	73.3	6.68	30.5	25.8	25.7	12.5	2.08	92.4	24.5
?GCM	4.6	2.4	288	15	417	4.75	52.6	45	2.35	0	28.3	13.3	33.3	8.33	66.7	42
BSF	1.57	1.16	166	4.31	427	3.24	20.4	74	5.55	56.2	24.8	11.3	4.72	1.57	95.4	32.9
CSF	1.15	0.48	126	1.52	435	3.5	45.3	43.6	10.8	5.73	46.5	35.6	12.1	0	100	37.7
ESF	1.58	0.62	212	4.25	430	4.27	49.8	37.9	10.4	6.07	32.2	54.6	7.12	0.41	99.6	36.7
KM	1.63	0.54	217	4.6	439	3.59	31.5	36.7	26.4	8.78	40	38.1	13.6	10.2	89.8	36.9
LM	2.74	0.77	330	11.4	435	4.35	46.2	29.2	14.8	11.5	43.4	29.5	15.6	5.3	94.7	40.8
LSF	1.89	0.59	252	6.7	438	3.78	35.3	34.8	23.4	9.49	40.9	35.9	14.1	8.96	91	37.9
VSF	0.75	0.51	53	0.79	432	2.86	14.8	65.7	14.6	3.91	30.3	38.8	27	6.73	93.3	14.1
DF	0.73	0.36	159	2.54	427	3.27	29.2	51.9	18.3	14.4	40.3	28.9	9.96	5.9	87.6	26.6
KF	1.65	0.35	738	17.6	445	4.4	68.5	22.8	5.74	17.7	29.1	38.5	12.9	20.7	79.3	33.5
SF	0.1	0.1	.	.	.	2	1.11	95.7	2.34	7.14	35.7	0	14.3	0	57.1	3.23
UOM	3.13	1.18	300	15.1	429	3.21	24.4	41.9	33.4	2.7	54.2	36.7	5.73	27.3	72.7	25.6
BSM	1.91	1.19	67	2.01	424	2.13	4.96	70.1	24.7	0.47	61.9	33.5	4.17	31.9	68.1	22.8
SBF	2.75	1.18	233	11.3	428	2.91	19	49.7	31	2.08	56.3	35.8	5.3	28.6	71.4	24.8

Palynomorph Variables																
Unit	bot	undif	mp	sporo	tnw/sp	tkw/sp	sp/spor	up/tp	cal/tp	cer/tp	bis/tp	tp/spor	ud/td	smd/td	nan/td	cad/td
DCSM	0.12	4.5	3.9	91	93	4.1	4.6	88	1.1	2.4	8.5	95	50	.	33	1.7
USM	0.14	5.3	3.7	91	97	2.5	6.2	85	1.1	1.6	12	94	48	.	32	4.7
HSM	0.09	4.9	2.1	93	99	0.91	5.1	86	1.1	1.7	11	95	28	.	37	8.7
RSM	0	7.8	3.3	89	100	0	3.1	90	0.13	4.3	5.3	97	62	.	1.1	9.3
?GCM	0	7.3	8.3	84	100	0	2.2	82	0.2	0.61	17	98	82	.	2.2	0
BSF	0.11	4.9	3.8	91	95	2.6	4.8	87	0.95	2	9.8	95	48	.	30	4.1
CSF	15	2.8	6.7	75	92	8.3	6.9	41	0.8	2.1	56	93	28	.	4.2	4.8
ESF	19	1.9	2.8	76	91	9.1	11	38	1.2	3.3	57	89	42	.	0	5.5
KM	19	2.4	6.5	72	84	16	11	55	1.2	2	42	89	31	.	.	13
LM	38	1.8	2.7	58	76	19	6.5	50	1.1	0.84	48	93	35	.	.	.
LSF	24	2.2	5.6	69	82	17	10	53	1.2	1.7	44	90	32	.	.	13
VSF	19	1.3	0	80	79	21	20	68	2.2	0.57	30	80	.	.	.	.
DF	1.8	3.4	30	64	76	22	9.2	70	6	0.49	24	91	22	.	.	.
KF	9.7	2	1.3	87	96	3.7	12	69	2.4	1.1	27	88	36	.	.	.
SF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UOM	1.8	4.3	19	75	97	3.3	22	60	4.2	5	31	78	15	37	.	.
BSM	0.53	5.1	18	76	98	2.2	20	61	1.8	7.9	29	80	7.4	29	.	.
SBF	1.5	4.5	19	75	97	3	22	60	3.6	5.7	30	78	13	35	.	.

Unit	eq/blk	blk/phy	br/phy	co/nbbr	ud/nbbr	psu/nbbr	cu/phy	me/phy	bstr/br	nbstr/br	sp/pal	mp/pal	und/pal	lbr/blk	lbstr/nbstr	#leq/lat
DCSM	62	7.66	91.3	86.5	3.12	10.4	0.02	1.01	6.34	93.7	65.8	14.2	20	1.14	-1.3	0.22
USM	69	12.7	86.8	85.8	8.47	5.76	0	0.51	16.2	83.8	80	9.85	10.2	0.86	-0.73	0.37
HSM	80.6	10.9	88.5	93.5	2.14	4.39	0.02	0.49	2.11	97.9	79.7	9.41	10.9	0.91	-1.7	0.58
RSM	75.5	11.1	88.5	95.8	1.3	2.94	0.06	0.34	1.55	98.5	69.9	12.1	17.9	0.93	-1.8	0.52
?GCM	58	9.13	34.8	75.9	16.5	7.61	39.7	16.4	2.58	97.4	81.3	5	13.8	0.59	-1.5	0.1
BSF	67.1	10.6	87.1	88.6	4.23	7.19	1.23	1.09	6.98	93	74.1	11.7	14.2	0.96	-1.3	0.33
CSF	62.3	12.5	86.3	83.3	7.99	8.67	0.12	1.02	10.3	89.7	91.3	5.36	3.33	0.85	-1.1	0.13
ESF	63.3	18.5	78.5	73.4	18.4	8.24	0.9	2.17	14	86	87.2	4.39	8.41	0.64	-0.82	0.22
KM	63.1	18.4	60.9	59.2	38.1	2.71	8.06	12.7	25.1	74.9	87.9	6.44	5.63	0.55	-0.5	0.22
LM	59.2	21.1	55.3	45.1	46	8.85	3.47	20.1	21.8	78.2	89	2.81	8.21	0.44	-0.63	0.1
LSF	62.1	19.1	59.5	55.6	40.1	4.28	6.88	14.6	24.3	75.7	88.2	5.51	6.29	0.52	-0.54	0.19
VSF	85.9	27.1	67.3	54.1	42.6	3.27	0.98	4.56	13.5	86.5	95.7	0	4.26	0.43	-1.1	1.06
DF	73.4	17.7	78.7	82.8	11.2	5.99	0.96	2.62	11.4	88.6	52.7	28.3	17.6	0.75	-1	0.47
KF	66.5	39.3	53	32.7	63.2	4.06	2.25	5.43	16.6	83.4	94.2	0.68	5.12	0.15	-0.76	0.28
SF	96.8	77	20.7	56	40.1	3.94	0.06	2.25	1	99	88.1	0	11.9	-0.63	-1.8	1.54
UOM	74.4	22.3	75.8	38.2	58.9	2.83	0.64	1.3	17.7	82.3	71.9	17.1	11.1	0.56	-0.76	0.44
BSM	77.2	23.9	75	30.3	68.8	0.92	0.38	0.77	16.1	83.9	64.4	22.9	12.7	0.51	-0.79	0.55
SBF	75.2	22.7	75.6	36	61.7	2.3	0.56	1.16	17.3	82.7	69.8	18.7	11.5	0.55	-0.77	0.47

Unit	bat/td	prv/td	dis/td	cte/td	dur/td	mei/td	gt/td	par/td	sen/td	jman/td	rhy/td	adnat/td	dindiv	dindom	din/mp	ac/mp
DCSM	15	.	.	.	.	.	.	.	.	.	.	.	.	.	84	16
USM	15	.	.	.	.	.	.	.	.	.	.	.	.	.	93	7.1
HSM	26	.	.	.	.	.	.	.	.	.	.	.	.	.	91	6.7
RSM	27	.	.	.	.	.	.	.	.	.	.	.	.	.	87	13
?GCM	15	.	0	.	.	.	.	0	.	.	.	.	.	.	100	0
BSF	17	19	0	.	.	.	.	0	.	.	.	.	.	.	88	11
CSF	21	.	25	.	.	.	.	17	.	.	.	.	.	.	90	10
ESF	18	.	32	.	.	.	.	3.7	.	.	.	.	.	.	92	6.9
KM	11	.	6.7	.	5.5	.	.	4.9	0.52	.	.	.	3.9	85	29	55
LM	4.7	.	22	.	27	.	.	6.6	0.84	.	.	.	.	.	62	32
LSF	8.5	.	12	.	13	.	.	5.5	0.64	.	.	.	3.9	85	37	49
VSF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0
DF	8.1	.	3.2	10	5.3	5.7	.	15	9.6	6.9	.	.	5.9	75	85	1.1
KF	0	.	.	.	0	.	.	64	.	.	.	.	.	.	50	0
SF	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UOM	1.6	.	.	.	17	1.7	11	17	.	.	0.45	0.39	3.8	86	99	0.66
BSM	1.2	.	.	.	13	0.66	20	30	.	.	0	0	3.4	82	100	0.12
SBF	1.5	.	.	.	16	1.5	13	20	.	.	0.33	0.29	3.7	85	99	0.53

Unit	lstst/bp
DCSM	1
USM	1.13
HSM	0.55
RSM	0.16
?GCM	0.15
BSF	0.77
CSF	0.04
ESF	-0.23
KM	-0.03
LM	0.1
LSF	0
VSF	-0.19
DF	0.11
KF	0.05
SF	.
UOM	0.12
BSM	0.24
SBF	0.15

Unit	tas/mp	lei/mp	lspor/mp	lacr/din	lup/bis	lspore/bis
DCSM	0	0	1.4	-0.7	1	-0.3
USM	0.42	0	1.4	-0.4	0.87	-0.3
HSM	2.5	0	1.7	-0.2	0.93	-0.3
RSM	0	0	1.2	0	1.2	-0.2
?GCM	0	0	1	.	0.67	-0.9
BSF	0.43	0	1.4	-0.5	0.98	-0.3
CSF	0	0	1.1	-0.8	-0.1	-0.9
ESF	1.5	0	1.5	-0.7	-0.2	-0.7
KM	0.58	0	1.3	0.54	0.12	-0.6
LM	0	0	1.5	0	0.01	-0.9
LSF	0.44	0	1.3	0.35	0.09	-0.6
VSF	0	0	.	.	0.4	0
DF	0.88	0.1	0.5	-2	0.5	-0.5
KF	50	0	1.9	.	0.43	-0.3
SF	.	.	.	.	.	.
UOM	0	0	0.66	-2	0.3	0
BSM	0	0	0.65	-2	0.32	-0.1
SBF	0	0	0.66	-2	0.31	0

APPENDIX VII

APPENDIX VII: Sampling details

Only those sections with samples included in the final dataset are shown; only the positions of samples included in the final dataset are shown.

Key to Figures A7.1 to A7.12:

Sample lithology

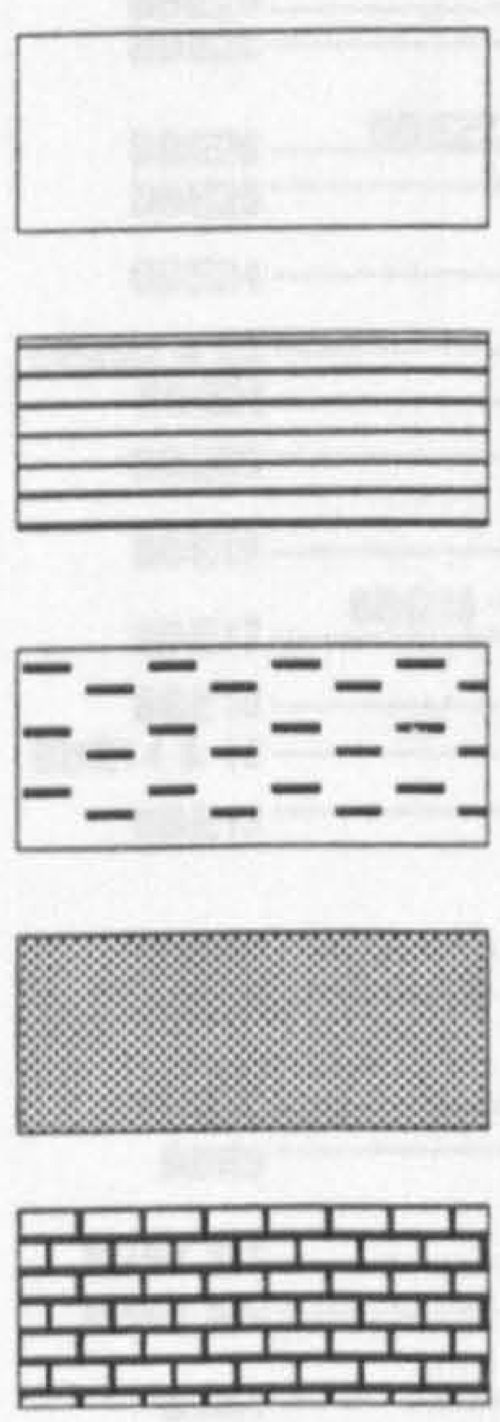
1 = shale
2 = silty shale
3 = shaley silt
4= silt
5 = sandy silt
6 = silty sand
7 = argillaceous sand
8 = clean sand
9 = limestone
10 = shaley limestone
11 = argillaceous limestone
12 = sandy limestone
13 = sandy shale
14 = shaley sand
15 = clay-mudstone

Sample point and code

KE2 ____________

Any lithostratigraphic boundaries are also shown

Gross lithology of bed:



Clay-mudstone

Shale

Silt

Sand

Limestone

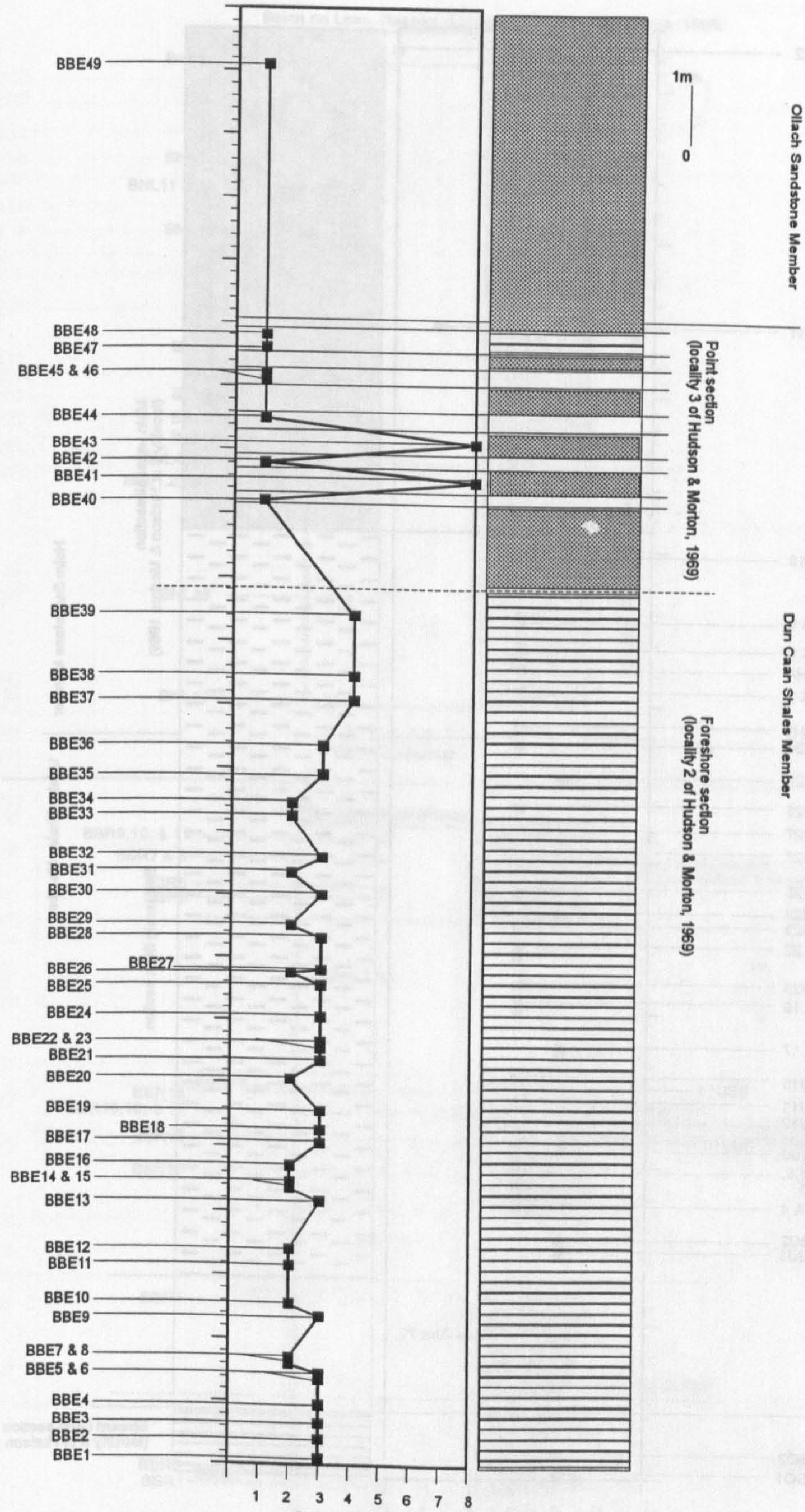


Fig. A7.1. Sample details for the Dun Caan Shales - Ollach Sst. Mbrs. (Bearreraig Sst. Fm.) type section, Bearreraig Bay, Skye (locality 1 of this study).

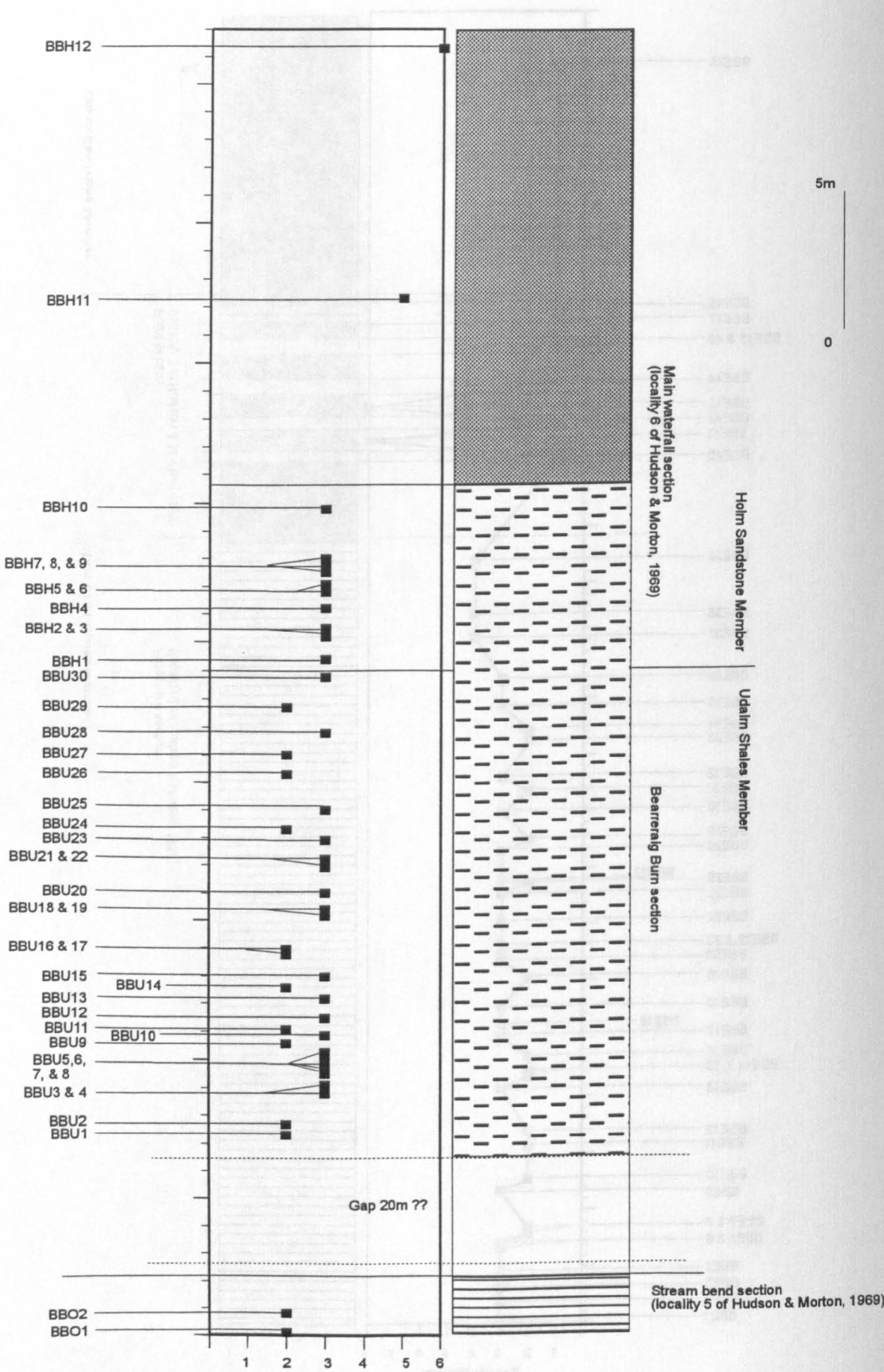


Fig. A7.2. Sample details for the Udairn Shales-Holm Sst. Mbrs. (Bearreraig Sst. Fm.) type section, Bearreraig Bay, Skye (locality 1 of this study).

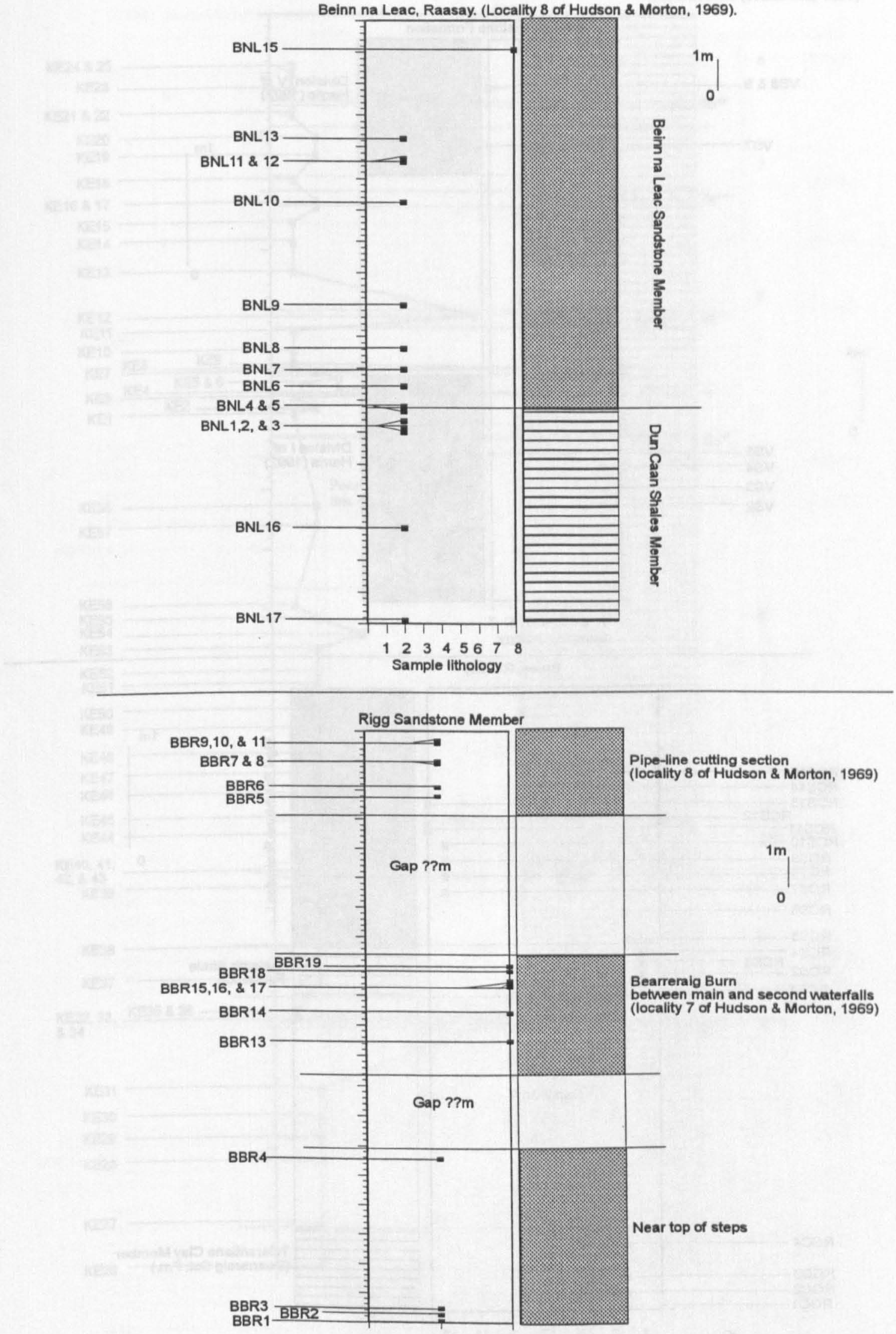


Fig. A7.3. Sample details for the Rigg Sst. Mbr. (Bearreraig Sst. Fm.) type section, Bearreraig Bay, Skye (locality 1 of this study), and the section in the Bearreraig Sst. Fm. at Beinn na Leac, Raasay (locality 4 of this study).

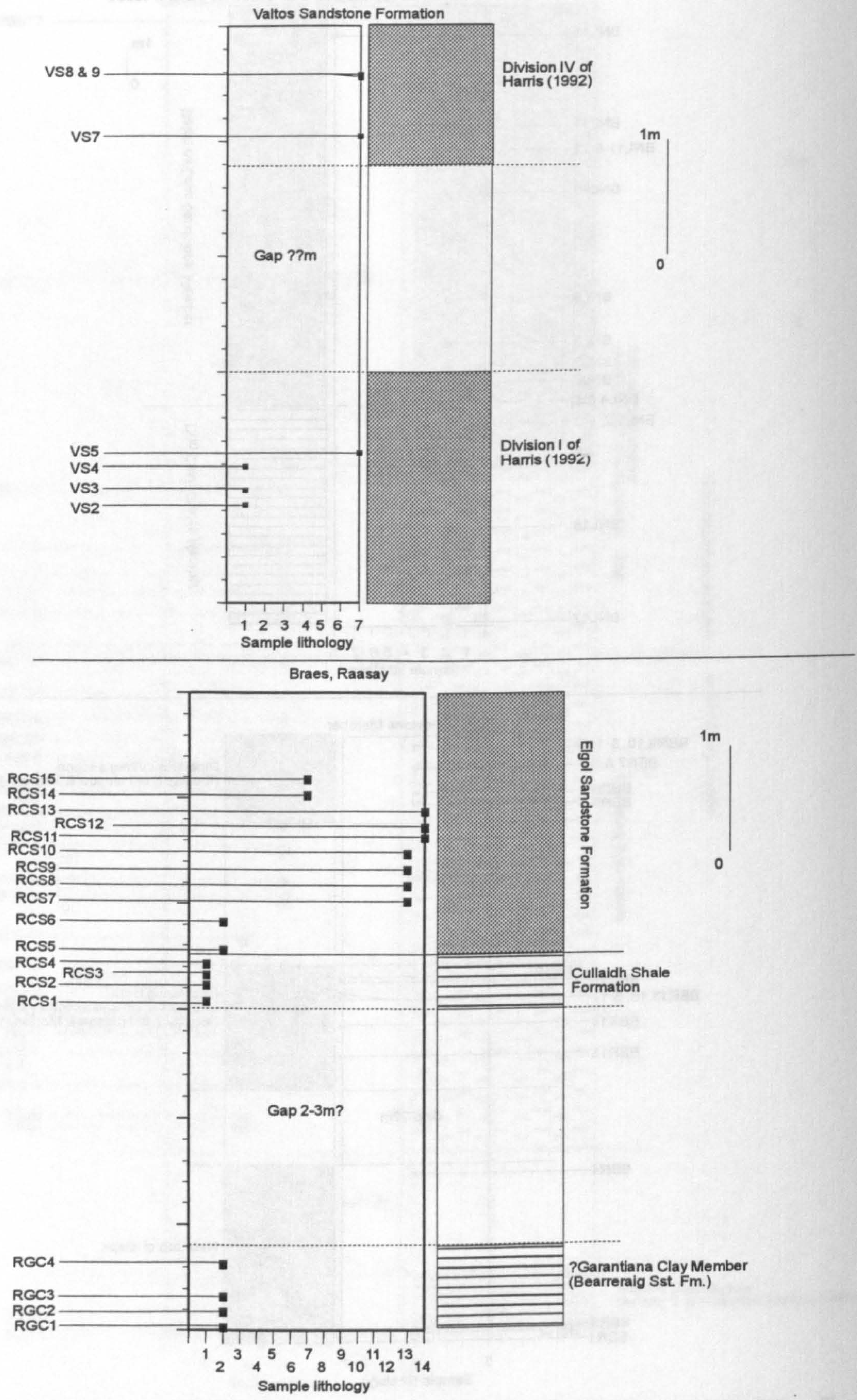


Fig. A7. 4. Sample details for the section through the ?Garantiana Clay Mbr.-Cullaidh Shale Fm.-Elgol Sst. Fm. at Braes, Raasay (locality 5 of this study), and the type section of the Valtos Sst. Fm. at the cliffs below Valtos, Skye (locality 9 of this study).

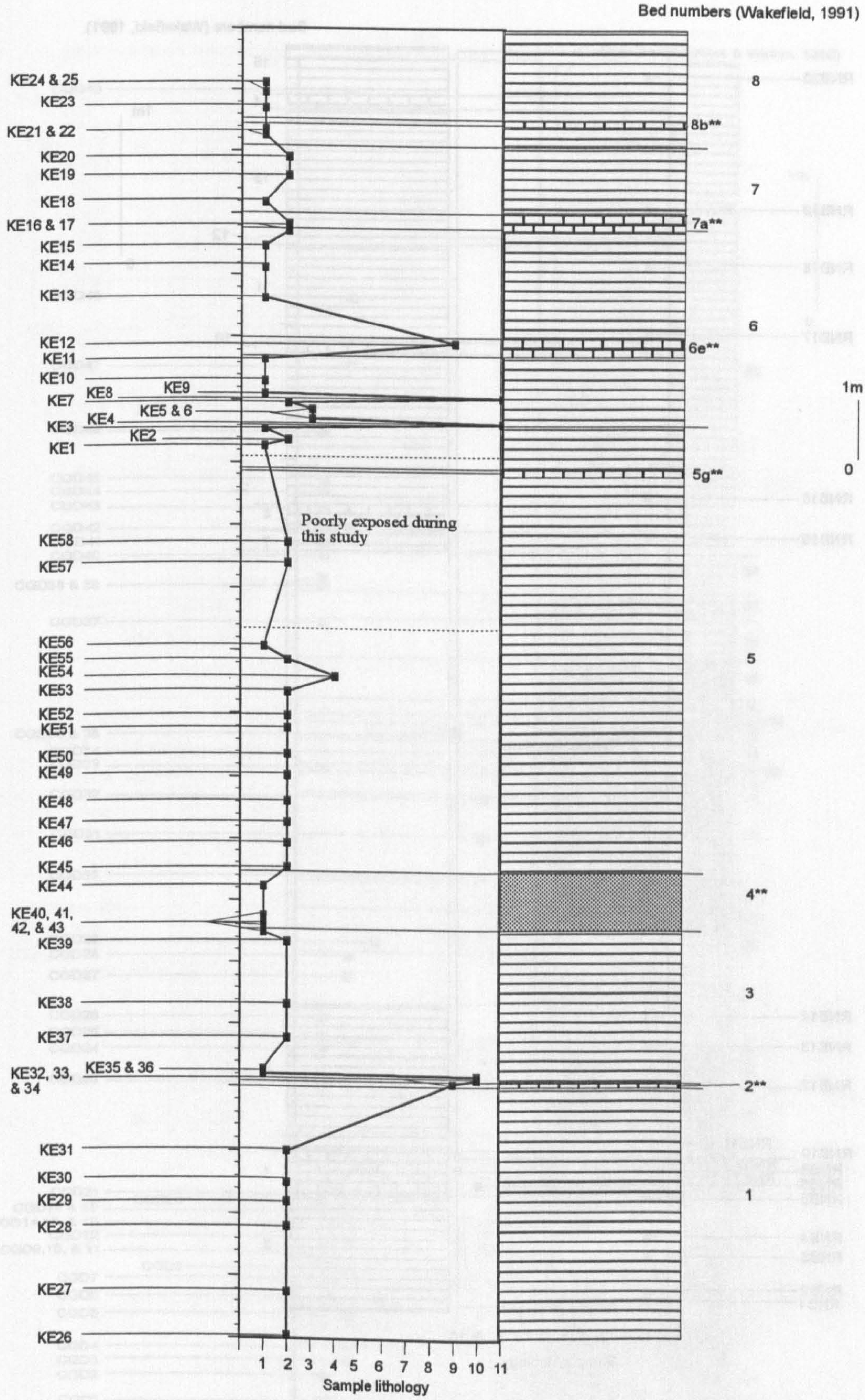


Fig. A7.5. Sample details for the Kildonnan Mbr. (Lealt Shales Fm.) type section, Kildonnan, Eigg (locality 6 of this study). ** = marker bed.

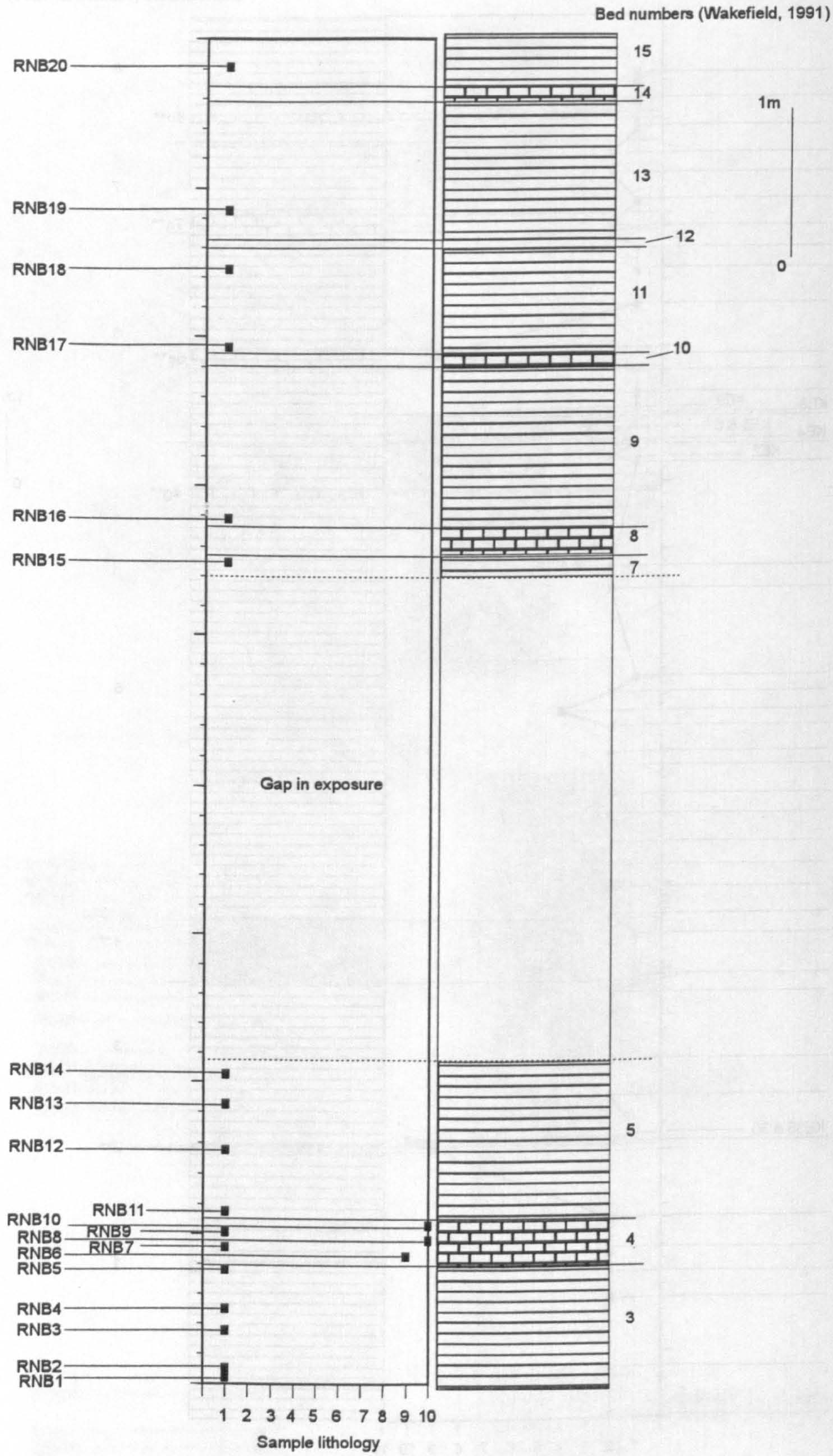


Fig. A7.6. Sample details for the Lonfearn Mbr. (Lealt Shales Fm.) section, Ruhda Nam Braithairean, Skye (locality 7 of this study).

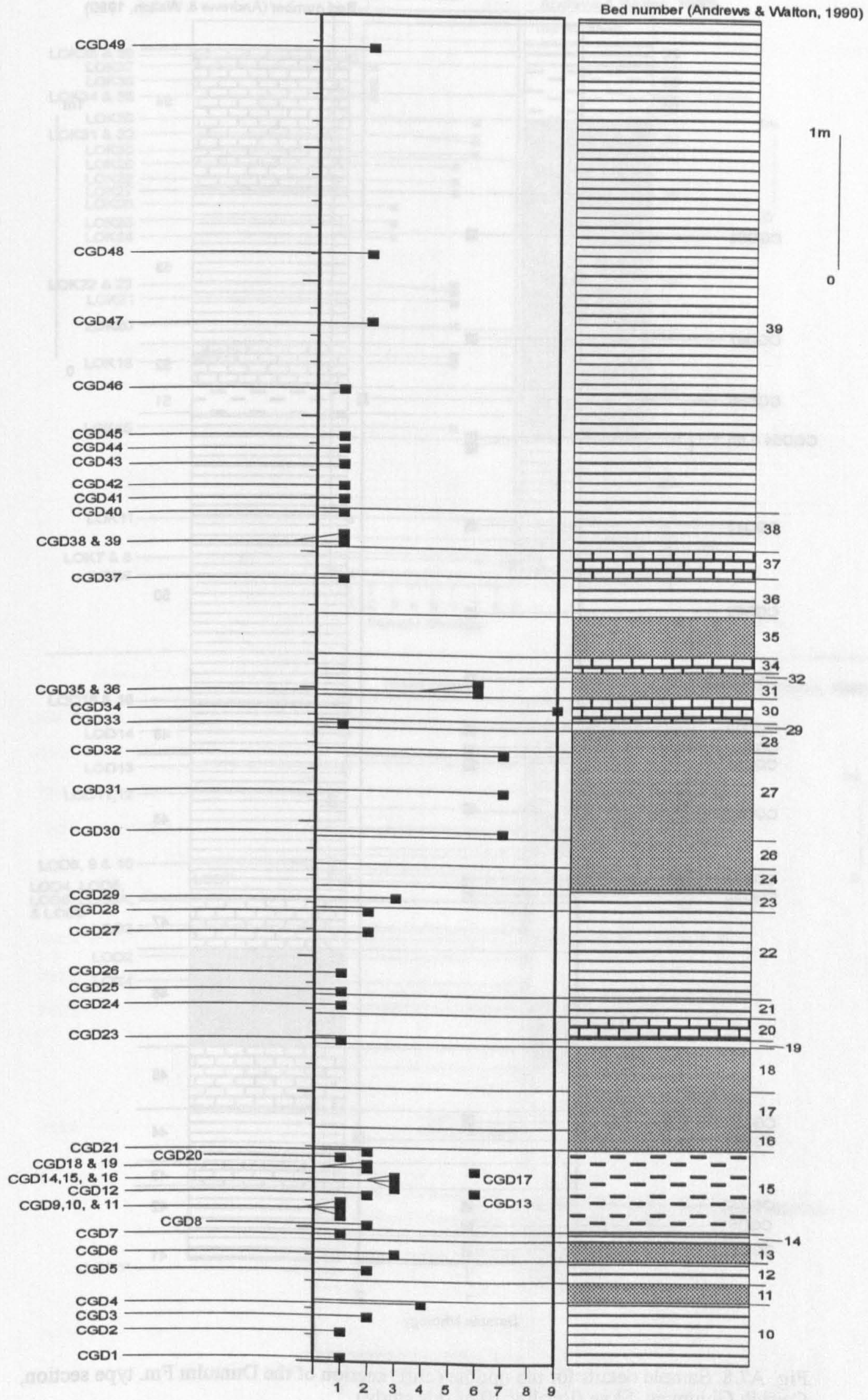


Fig. A7.7. Sample details for the lower (foreshore) part of the Duntulm Fm. type section, Cairidh Ghlumaig, Skye (locality 10 of this study).

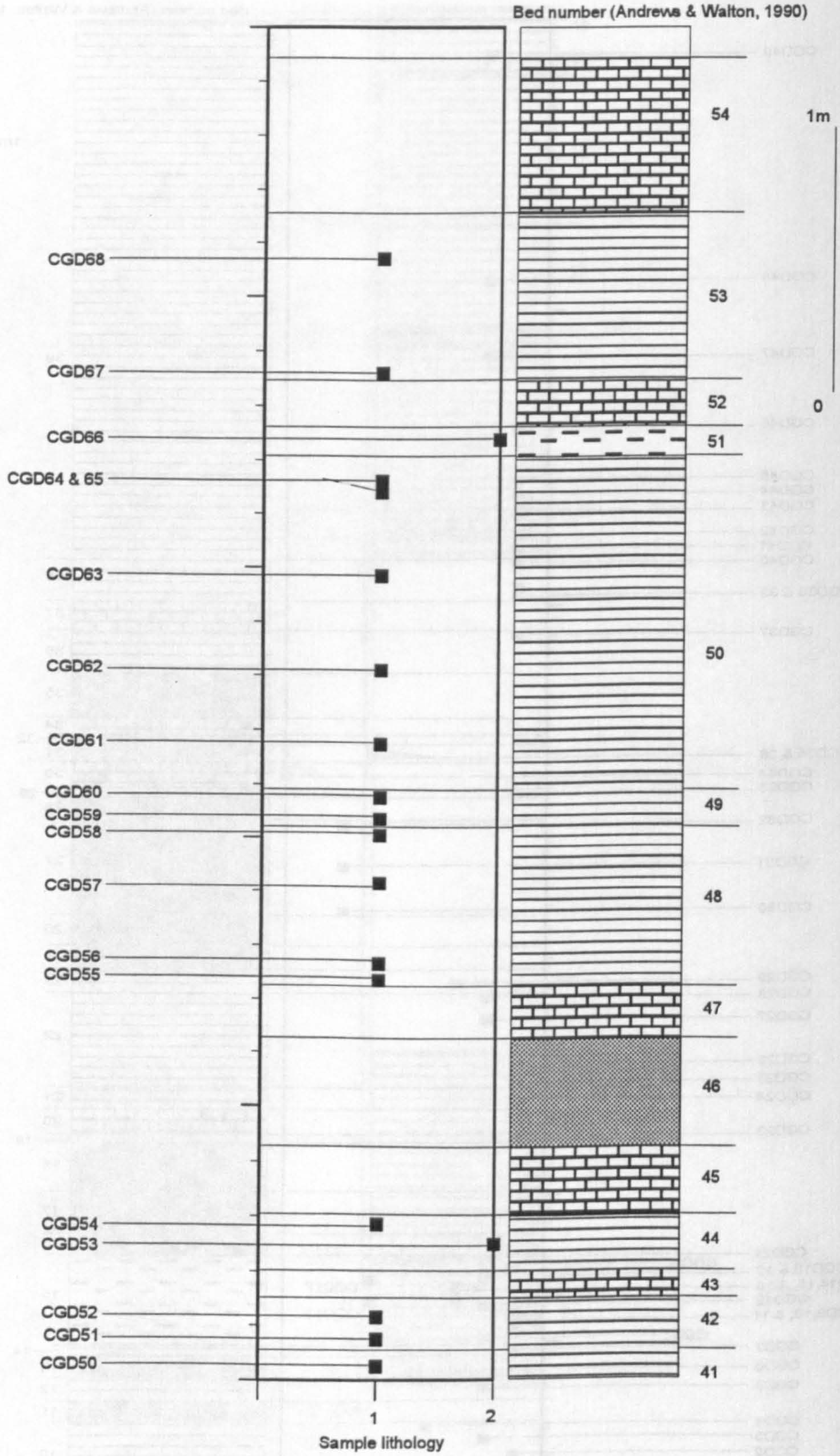


Fig. A7.8. Sample details for the middle (cliff) section of the Duntulm Fm. type section, Cairidh Ghlumaig, Skye (locality 10 of this study).

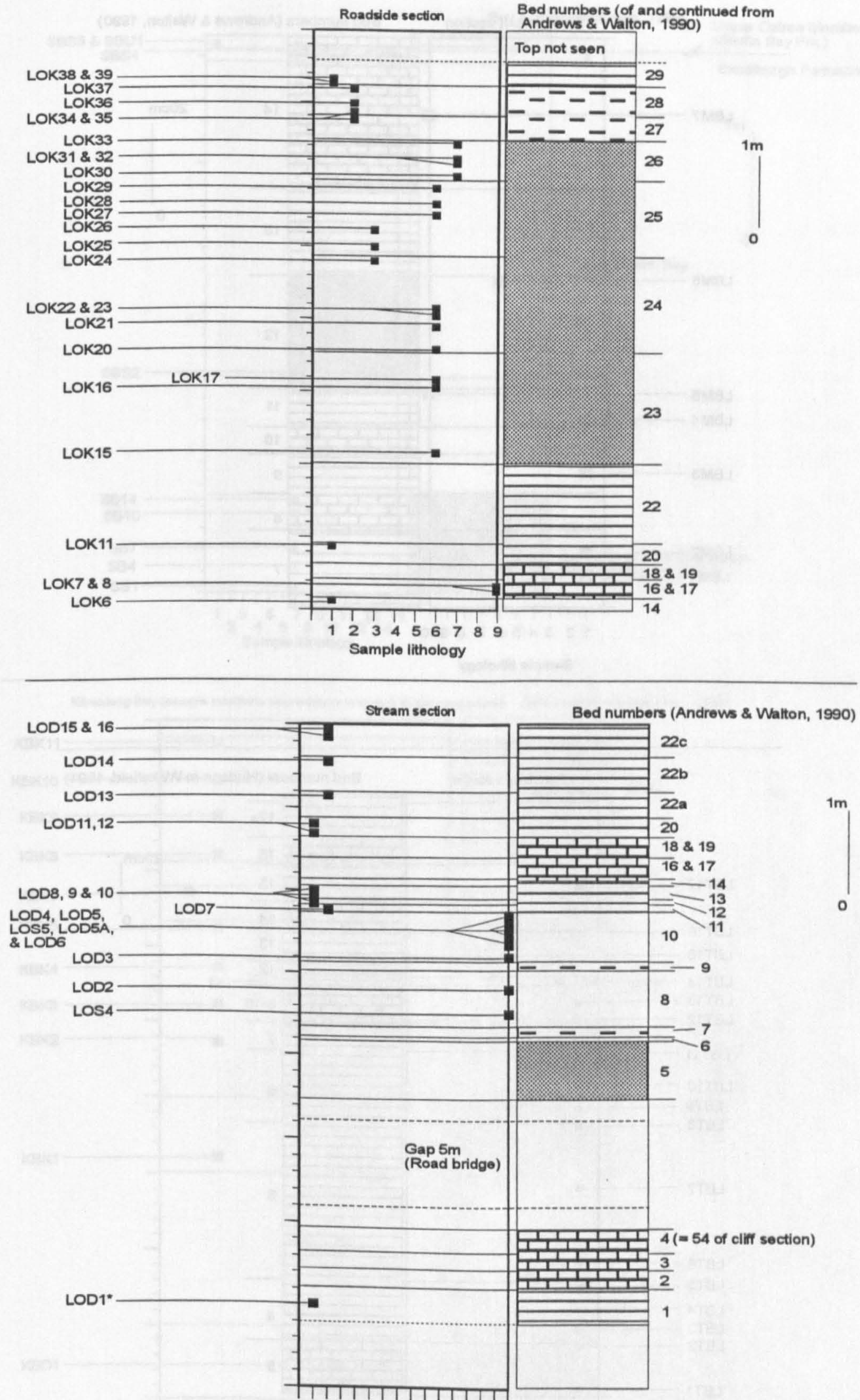
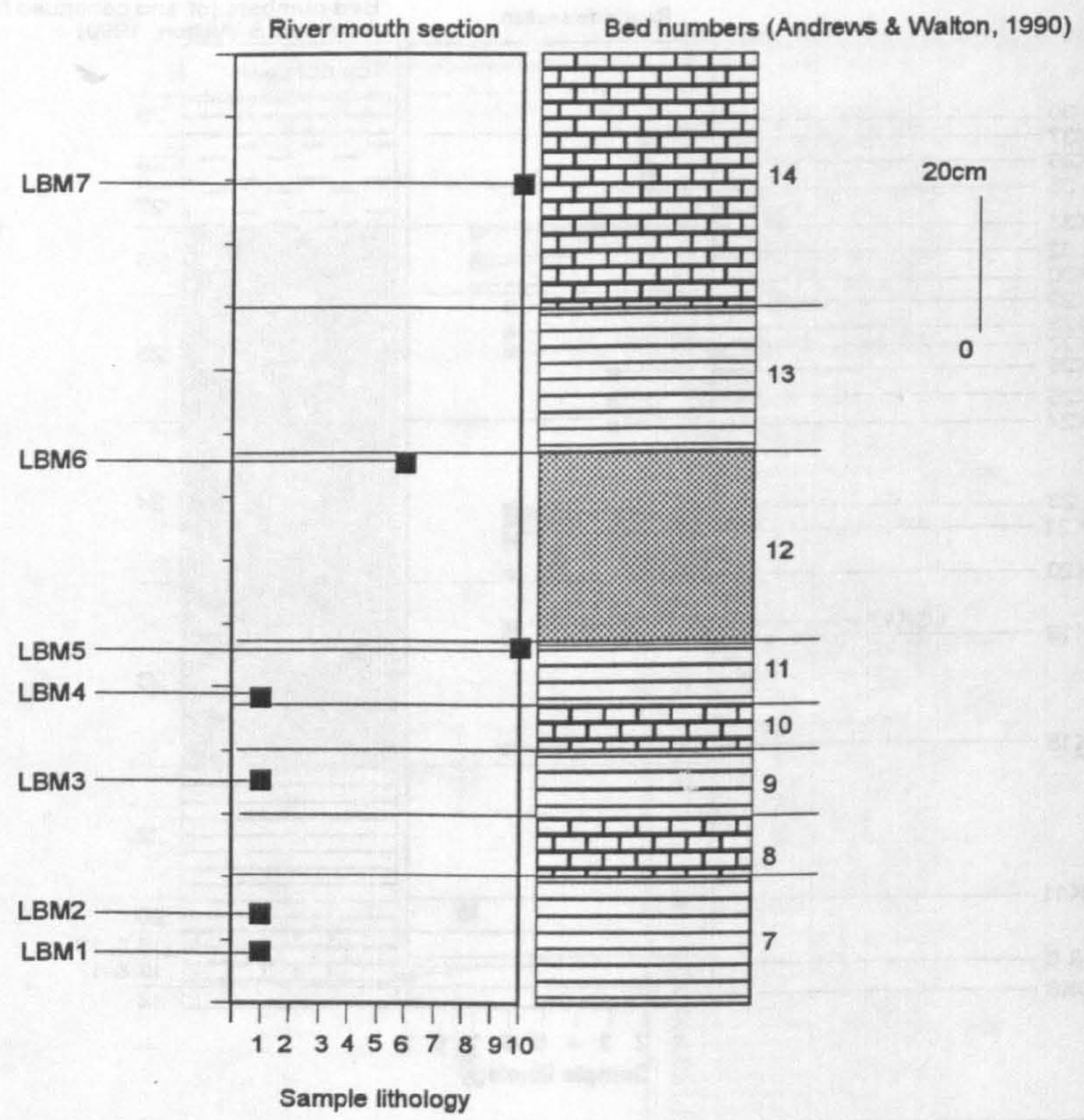


Fig. A7.9. Sample details for the upper part of the Duntulm Fm. type section, Lon Ostatoin, Skye (locality 11 of this study).



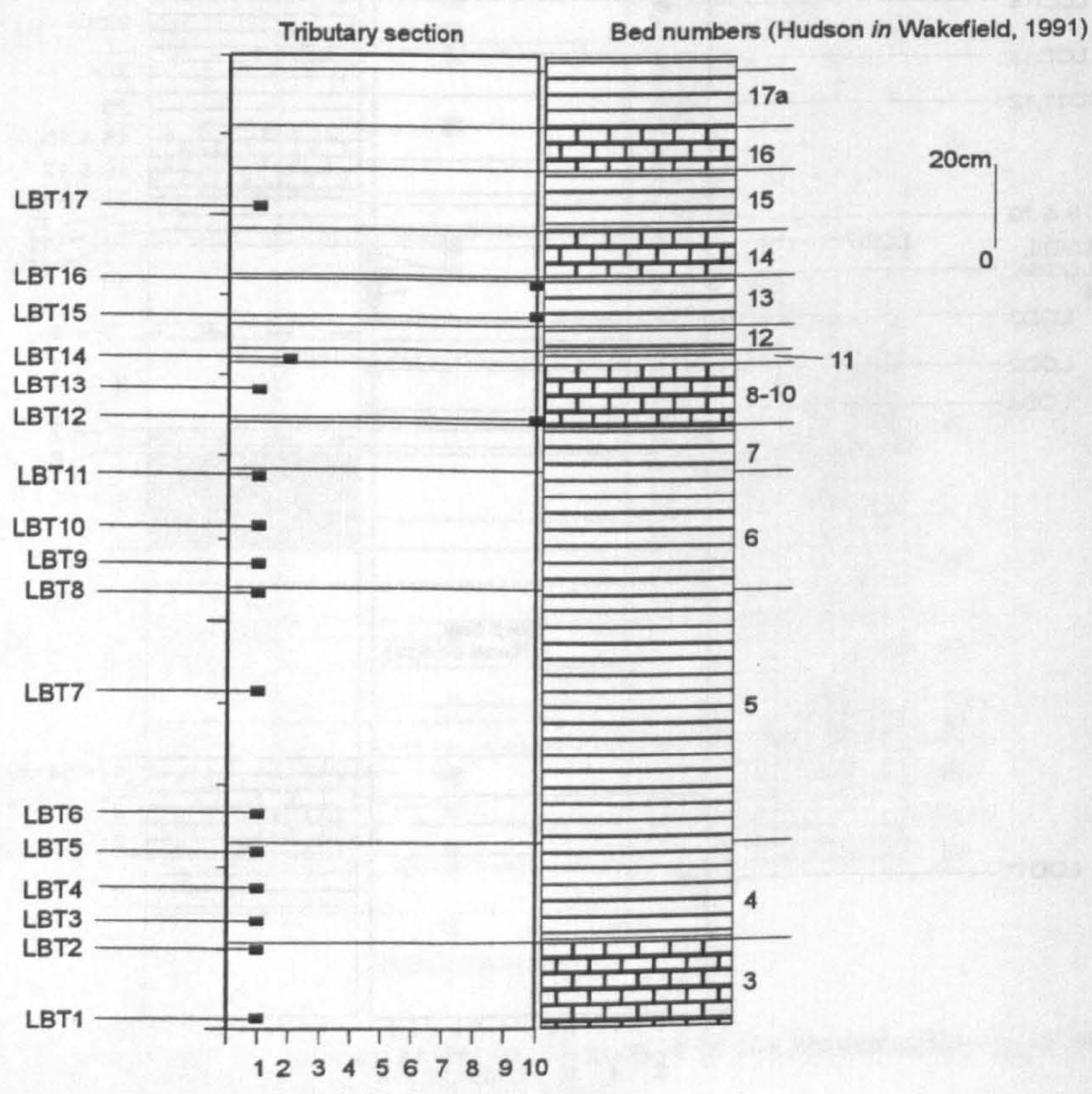


Fig. A7.10 Sample details for the sections of the Duntulm Fm. at Loch Bay river mouth (locality 12 of this study), and river tributary (locality 13 of this study), both Waternish, Skye.

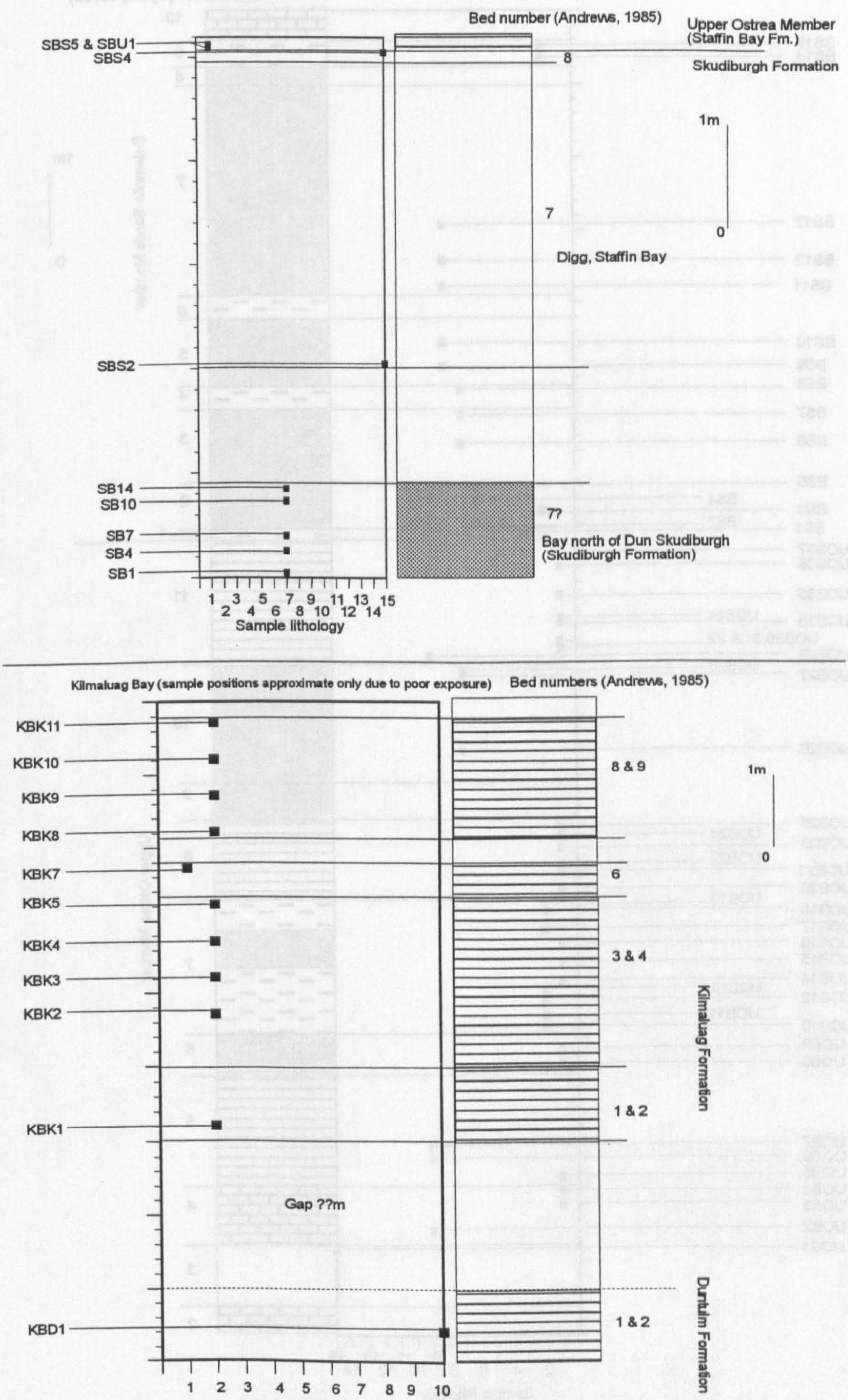


Fig. A7.11. Sample details for the type section of the Kilmaluag Fm., Kilmaluag Bay, Skye (locality 14 of this study), and sections of the Skudiburgh Fm. at Skudiburgh Bay and Staffin Bay, Skye (localities 16 & 17 of this study respectively).

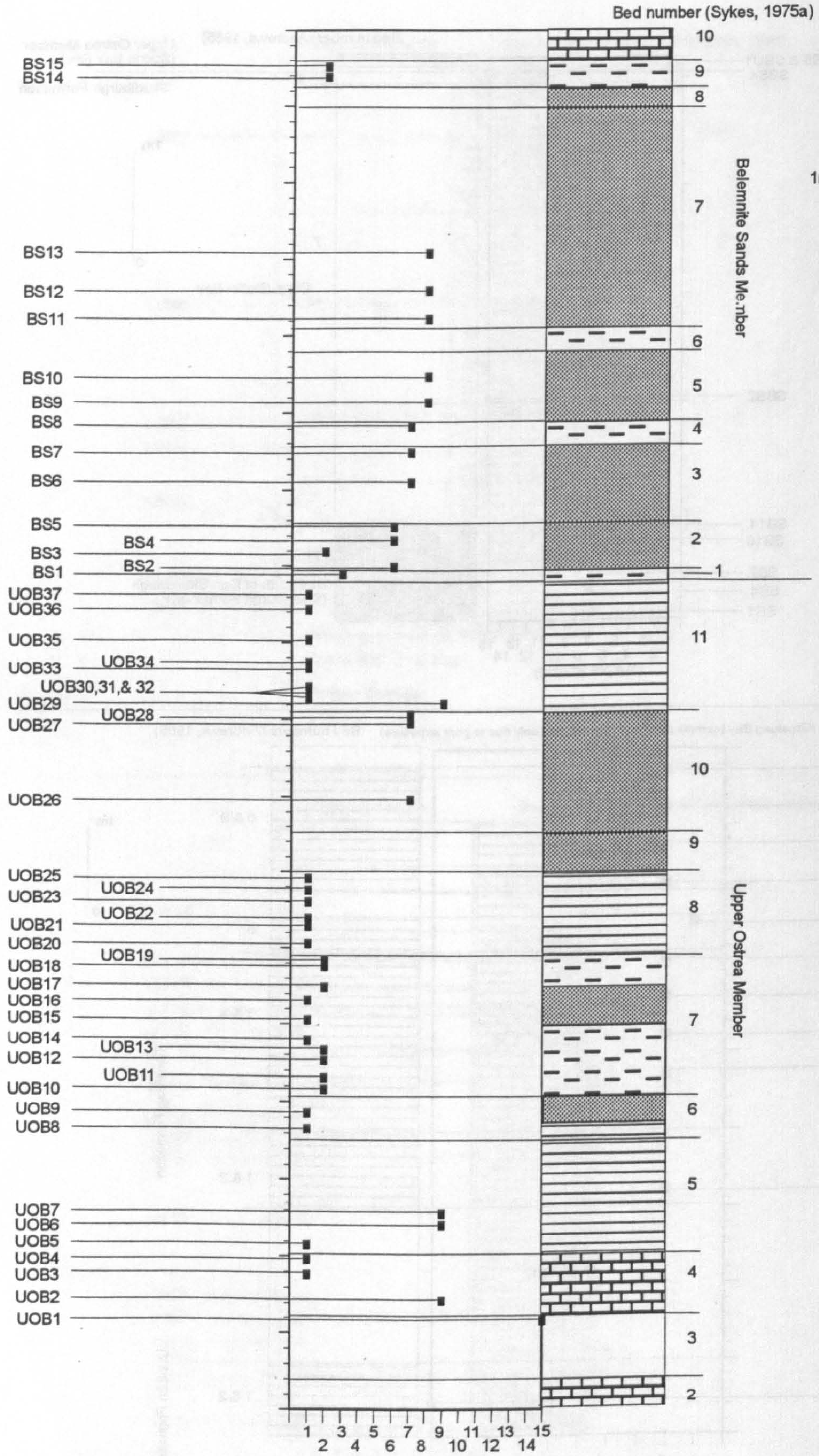


Fig. A7.12. Sample details for the Staffin Bay Fm. type section, Staffin Bay, Skye (locality 18 of this study).