British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

A palynological study of some shallow cores from the Hebridean Slope

Marine and Continental Margins Programme
Internal Report IR/02/038

BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/02/038

A palynological study of some shallow cores from the Hebridean Slope

J. B. Riding

Keywords|:

Palynomorphs, Quaternary, reworking

Bibliographical reference

RIDING, J. B.. 2002. A palynological study of some shallow cores from the Hebridean Slope. *British Geological Survey Internal Report*, IR/02/038. 13pp.

Keyworth, Nottingham British Geological Survey 2002

Foreword

This report comprises the results of a palynological study of fifteen samples from some vibrocores from the Hebridean Slope area.

Contents

Summary

The majority of the samples studied are from dark brown/black clay successions. These proved rich in dinoflagellate cysts indicative of cold, glacial conditions and ages no older than Mid-Late Pleistocene. Some samples include elements pointing to deposition in outer neritic/oceanic depositional settings. Reworking was also extremely common with allochthonous floras of Carboniferous, Jurassic, Cretaceous and Palaeogene ages. The Carboniferous, Jurassic and Cretaceous reworked floras were probably transported from the north and/or west by glacial activity. The Carboniferous and Jurassic material was probably sourced from the Midland Valley and Minch Basin respectively. The small proportions of Cretaceous material reflect the paucity of Cretaceous strata in Scotland. However, the Palaeogene input is likely to be local from the offshore area. Due to the overall similarities in organic facies, they are all of probable

Late Pleistocene age. The vibrocores studied which indicate cold conditions are: 56-10/249 CS, 56-10/250 CS, 56-10/251 CS, 56-10/252 CS and the lowermost three samples in 56-10/255 VE. The single sample from dark sand in 56-10/253 VE produced an abundant, diverse dinoflagellate cyst flora indicative of a Holocene age, interglacial conditions and an outer neritic/oceanic setting. The uppermost sample in vibrocore 56-10/255 VE, also of dark sand, produced a sparser, yet similar flora.

1 Introduction

Fifteen core samples from six shallow vibrocores drilled on the upper slope, west of the Hebrides were submitted for palynological analysis in order to determine age, palaeoenvironment and details of any reworking. This area is unstable and this study was done as part of the Western Frontier Association (WFA) Slope Stability Project. A report on the foraminifera of the vibrocores has already been completed (Wilkinson, 2001).

2 Palynology

In this section, the palynology of the six boreholes examined is presented. Full listings of the palynomorphs recovered, including quantitative data, are held on the respective BGS micropalaeontology/palynology data sheets, which have been archived. The samples are all unlithified and they were prepared using sodium hexametaphosphate, a technique developed recently in the BGS palynology laboratory. This chemical disaggregates unlithified sediment without oxidising the residue and allows palynomorphs to be isolated.

The samples largely produced abundant organic residues and palynofloras, with both indigenous Quaternary and allochthonous palynomorphs present. The Quaternary dinoflagellate cysts are largely indicative of glacial conditions during the Mid-Late Pleistocene/Holocene. However, two samples of dark sands yielded a younger, interglacial flora. Wood fragments and plant material are normally abundant. Resistant mineral grains and amorphous organic material are rare to absent. Table 1 illustrates the numbers of key types of Quaternary dinoflagellate cysts per microscope slide and the presence of reworking by age (Carboniferous, Jurassic, Cretaceous and Palaeogene).

The Carboniferous reworking is dominated by the long-ranging forms *Densosporites* spp. and *Lycospora pusilla*. However, other taxa such as *Cingulizonates* spp., *Cristatisporites* spp., *Endosporites globiformis* and *Tripartites vetustus* are present. Jurassic palynomorphs tend to be dominated by miospores such as *Callialasporites* spp., *Cerebropollenites macroverrucosus*, *Classopollis classoides, Coronatispora valdensis, Ischysporites vaerigatus* and *Perinopollenites elatoides*. Some Jurassic dinoflagelllate cysts were recovered which are more age dianostic than the spores and pollen. Definite Cretaceous stratigraphical recycling proved extremely rare and is largely represented by the occasional occurrence of the typically Early Cretaceous spore plexus *Appendicisporites/Cicatricosisporites* and the dinoflagellate cyst genus *Odontochitina*. By contrast, Palaeogene dinoflagellate cysts such as *Apectodinium* spp., *Cordosphaeridium gracile, Diphyes*, spp., *Eatonicysta ursulae, Glaphyrocysta vicina, Glaphyrocysta* spp., *Homotryblium tenuispinosum, Hystrichokolpoma* spp. and *Wetzeliella* spp. are relatively common. The majority of these forms indicate input from the Eocene.

Presumed indigenous spores/pollen are present and dominated by bisaccate pollen grains. Other taxa recognised include *Erica, Tilia, Laevigatosporites* and *Stereosporites*.

2.1 VIBROCORE 56-10/249CS

This vibrocore was drilled in 657 m of water. Three samples of brown/black clay were studied from 56-10/249CS between 0.50m to 2.41m. All proved rich in indigenous and reworked palynomorphs. The indigenous dinoflagellate cyst floras are overwhelmingly dominated by *Brigantedinium* spp., including *B. simplex* (see below and Table 1). These low diversity associations which are dominated by protoperidinioid cysts are indicative of a relatively nearshore, glacial environment with seasonal or permanent sea-ice. The presence of *B. simplex*

is indicative of a Mid Pleistocene or younger age (Harland, 1992). The palynological content of the three samples from this borehole proved relatively constant and therefore the succession studied appears to be part of the same genetic sequence. Wilkinson (2001) recovered sparse cold water foraminifera from this succession. These were not considered to be *in situ* because of their shallow water preferences. The dinoflagellate cyst association may also be transported because of its inner neritic aspect (Harland, 1983).

Carboniferous, Jurassic, Cretaceous and Palaeogene reworking was observed throughout (Table 1). Much of the Carboniferous reworking is likely to be Westphalian due to the presence in sample 2 of *Endosporites globiformis.* The typically Bathonian-early Callovian dinoflagellate cyst *Ctenidodinium combazii* was also present in sample 2. *Nannoceratopsis pellucida* was recovered in sample 3. This Jurassic dinoflagellate cyst is typical of the Bathonian-Callovian-Oxfordian interval.

Quaternary dinoflagellate cysts present:

Achomosphaera andalousiensis

Bitectatodinium tepikiense

Brigantedinium simplex

Brigantedinium spp.

Operculodinium centrocarpum

Spiniferites spp.

2.2 VIBROCORE 56-10/250CS

The interval between between 1.28m and 3.58m was studied in borehole 56-10/250CS and the three brown/black clay samples yielded indigenous and reworked palynomorphs. The productivity of Quaternary dinoflagellate cysts varies significantly. Samples 4 and 5 proved relatively sparse, whereas sample 6 was extremely rich (Table 1). Samples 4 and 5 produced extremely low in diversity with only *Achomosphaera andalousiensis, Bitectatodinium tepikiense*, *Brigantedinium* spp., *Operculodinium centrocarpum* and *Spiniferites* spp. present. *Brigantedinium* spp. are the most prominent group throughout. In sample 6, *B. cariacoense, B. simplex, Impagidinium patulum, Lejeunecysta paratenella, Selenopemphix nephroides* and *S. quanta* were also observed. These *Brigantedinium*-dominated assemblages indicate a cold, glacial environment with seasonal or permanent sea-ice; the presence of *B. cariacoense* is indicative of a Late Pleistocene or younger age (Harland, 1992). The majority of the species are typical of inner neritic environments, however *Achomosphaera andalousiensis, Bitectatodinium tepikiense* and *Impagidinium patulum* are outer neritic/oceanic forms (Harland, 1983). Samples 4 and 5 are probably part of the same genetic sequence as they are similar in organic facies. However, the high productivity in sample 3 may indicate that there is a depositional break between samples 6 and 5. Wilkinson (2001) recovered a sparse and biostratigraphically and bathymetrically inconclusive, cool water foraminiferal assemblage from 2.49 m.

Carboniferous, Jurassic and Palaeogene reworking was observed throughout; Cretaceous stratigraphical recycling was absent (Table 1). The Carboniferous reworking is relatively rare and confined to long-ranging taxa. No stratigraphically-restricted Jurassic species were recovered, however representatives of the typically Middle Jurassic genera *Meiourogonyaulax* and *Nannoceratopsis* were noted in sample 4. Palaeogene, largely Eocene, dinoflagellate cysts represent the most common allochthonous elements. These include *Apectodinium* sp., *Areoligera* spp., *Charlesdowniea* spp*., Cordosphaeridium gracile, Dracodinium glabrum, Eatonicysta ursulae, Glaphyrocysta* spp*., Heteraulacacysta leptalea?, Homotryblium* spp. and *Wetzeliella* spp.

Quaternary dinoflagellate cysts present:

Achomosphaera andalousiensis

Bitectatodinium tepikiense

Brigantedinium cariacoense

Brigantedinium simplex

Brigantedinium spp.

Impagidinium patulum

Lejeunecysta paratenella

Operculodinium centrocarpum

Selenopemphix nephroides

Selenopemphix quanta

Spiniferites spp.

2.3 VIBROCORE 56-10/251CS

Two samples of black/brown clay were studied from borehole 56-10/251CS between 1.53m and 2.65m. The samples yielded abundant indigenous and reworked palynomorphs in substantially similar proportions. Both were rich in protoperidinioid dinoflagellate cysts, largely the genus *Brigantedinium* (Table 1). These associations indicate a glacial environment with seasonal/permanent sea-ice and the consistent occurrences of *B. cariacoense* is indicative of a Late Pleistocene or younger age (Harland, 1992). The dinoflagellate cyst flora is indicative of a mixed inner/outer neritic setting (Harland, 1983). Both samples are probably part of the same genetic sequence due to their similarities in organic facies. Wilkinson (2001) found this succession to be barren of calcareous microfaunas.

Carboniferous, Jurassic, Cretaceous and Palaeogene reworking was observed throughout (Table 1). The Carboniferous reworking is largely confined to long-ranging taxa. However, the Carboniferous content of sample 8 is more prominent and diverse than that of sample 7; *Cristatisporites* and *Murospora* spp. were recovered from sample 8. The usual assemblage of miospores of Jurassic aspect are present. However, some Jurassic dinoflagellate cysts were also observed; these indicate that more than one Jurassic interval were incorporated into these Quaternary sediments. The Late Jurassic (mid Oxfordian to mid Volgian) species *Glossodinium dimorphum* was observed in sample 7. Sample 8 again proved more diverse. The late Sinemurian marker *Liasidium variabile* and the Callovian-Oxfordian form *Gonyaulacysta jurassica* subsp. *adecta* were recovered from 2.62m-2.65m. Cretaceous material was only found rarely in sample 7. Palaeogene dinoflagellate cysts, however, proved relatively common in both samples. These include *Apectodinium parvum, Cordosphaeridium gracile, Diphes* sp., *Dracodinium simile* and *Wetzeliella* spp. As with the Jurassic dinoflagellate cysts, this association indicates the incorporation of different intervals of Palaeogene sediment. *Apectodinium parvum* is late Thanetian to early Ypresian, whereas *Dracodinium simile* is confined to the mid Ypresian (Powell, 1992).

Quaternary dinoflagellate cysts present:

Achomosphaera andalousiensis

Bitectatodinium tepikiense

Brigantedinium cariacoense

Brigantedinium simplex

Brigantedinium spp.

Operculodinium centrocarpum

Spiniferites spp.

2.4 VIBROCORE 56-10/252CS

The two samples of dark brown clay examined from borehole 56-10/251CS range from 0.75m to 2.99m. The samples yielded variably abundant palynomorphs, with sample 9 proving considerably more palynologically productive and diverse than sample 10 (Table 1). This difference may indicate deposition in different genetic sequences. However, both intervals were rich in the genus *Brigantedinium* and other protoperidinioid dinoflagellate cysts (Table 1). These dinoflagellate cysts indicate a cold, glacial environment with seasonal/permanent sea-ice. The presence of *B. simplex* is indicative of a Mid Pleistocene or younger age (Harland, 1992). The dinoflagellate cyst assemblage is indicative of an inner neritic setting (Harland, 1983) so the flora may have been transported down the slope. Wilkinson (2001) discovered that this succession is virtually barren of foraminifera and other calcareous microfaunas.

Carboniferous to Palaeogene reworking was observed (Table 1). The Carboniferous reworking is largely confined to long-ranging taxa, however, the Westphalian marker *Endosporites globiformis* was observed in sample 9. This sample also yielded *Cingulizonates loricatus*. Jurassic miospores are especially diverse in both samples, however Jurassic dinoflagellate cysts proved extremely rare. The typically Kimmeridgian form *Cribroperidinium globatum* was observed in sample 9. No Cretaceous material was noted in either sample. Palaeogene dinoflagellate cysts were present in low proportions. In sample 9, species of *Glaphyrocysta* and *Wetzeliella* were recorded.

Quaternary dinoflagellate cysts present:

Bitectatodinium tepikiense

Brigantedinium simplex

Brigantedinium spp.

Lejeunecysta paratenella

Operculodinium centrocarpum

Selenopemphix quanta

Spiniferites spp.

2.5 VIBROCORE 56-10/253VE

A single sample of dark sand, number 11 at 3.02m-3.04m, was studied from this vibrocore. The sample produced an extremely abundant and diverse palynoflora (Table 1). Silicious microfossils (diatoms, radiolaria etc.) were also common. The Quaternary dinoflagellate cyst flora is the most diverse in the entire suite studied (see below). This assemblage, which is especially rich in *Nematosphaeropsis labyrinthea* and *Spiniferites* spp., is indicative of interglacial conditions (Harland, 1992). The presence of *Achomosphaera andalousiensis, Nematosphaeropsis labyrinthea* and *Impagidinium* spp. points to an outer neritic or oceanic setting (Harland, 1983). According to Harland (1992), the occurrence of *Votadinium calvum* is indicative of the Holocene. Wilkinson (2001) discovered abundant and diverse foraminifera from this succession which also are consistent with an interglacial phase.

Carboniferous to Palaeogene reworking is also present (Table 1). The Carboniferous reworking is largely confined to long-ranging taxa, such as *Cingulizonates* spp., *Densosporites* spp. and *Lycospora pusilla*. Jurassic miospores are present and include *Cerebropollenites macroverrucosus* and *Callialasporites* spp. By contrast, Jurassic dinoflagellate cysts were rare;

only the typically Toarcian form *Nannoceratopsis deflandrei* subsp. *senex* being recognised. Cretaceous material is entirely absent. Palaeogene dinoflagellate cysts were also present in extremely low proportions.

Quaternary dinoflagellate cysts present:

Achomosphaera andalousiensis

Brigantedinium simplex

Brigantedinium spp.

Impagidinium sphaericum

Impagidinium spp.

Lejeunecysta paratenella

Nematosphaeropsis labyrinthea

Operculodinium centrocarpum

Polykrikos schwartzii

Quinquecuspis concretum

Selenopemphix nephroides

Selenopemphix quanta

Spiniferites spp.

Trinovantedinium capitatum

Votadinium calvum

2.6 VIBROCORE 56-10/255VE

Four samples from vibrocore 56-10/255VE were studied. These are a single sample of dark sand (number 12) at 1.29m-1.32m and three dark brown clay samples between 2.30m and 4.62m (numbers 13 to 15).

Sample 12 yielded an abundant palynoflora (Table 1). The Quaternary dinoflagellate cyst flora is relatively diverse; *Impagidinium sphaericum*, *Nematosphaeropsis labyrinthea, Selenopemphix nephroides* and *Votadinium calvum* are confined to this horizon. *Brigantedinium* spp. and *Nematosphaeropsis labyrinthea* are relatively common and the flora resembles that of sample 11. The lithological similarity and the occurrence of the Holocene marker *Votadinium calvum* (see Harland, 1992) also supports this contention. The prominence of *Nematosphaeropsis labyrinthea* indicates interglacial conditions (Harland, 1992). The occurrences of *Achomosphaera andalousiensis, Nematosphaeropsis labyrinthea* and *Impagidinium* spp. suggest an outer neritic/oceanic setting (Harland, 1983). An assemblage of largely benthic foraminifera described by Wilkinson (2001) from this unit is consistent with an interglacial phase.

The three samples of dark brown clay examined range from 2.30m to 4.62m. They yielded abundant palynomorphs (Table 1). All the horizons proved rich in the genus *Brigantedinium* and other protoperidinioid dinoflagellate cysts (Table 1). These forms indicate a glacial environment with seasonal or permanent sea-ice. The presence of *B. simplex* is indicative of a Mid Pleistocene or younger age (Harland, 1992). The dinoflagellate cyst assemblage is indicative of an inner neritic setting (Harland, 1983) so the flora may have been transported down the slope. Wilkinson (2001) discovered sparse foraminiferal associations from this interval which generally preferred cool water.

Carboniferous, Jurassic, Cretaceous and Palaeogene reworking is present (Table 1). The Carboniferous reworking is largely confined to long-ranging taxa, such as *Cingulizonates* spp., *Densosporites* spp. and *Lycospora pusilla*, however rare *Cirratriradites saturni* were observed in sample 15. Jurassic miospores are present throughout in significant proportions and include *Cerebropollenites macroverrucosus*, *Callialasporites* spp., *Classopollis classoides* and *Perinopollenites elatoides*. By contrast, Jurassic dinoflagellate cysts were extremely rare. The mid Oxfordian to Lower Kimmeridgian marker species *Endoscrinium luridum* was found in sample 14. Cretaceous reworking is also extremely rare, and is only manifested by occasional spores of the *Appendicisporites-Cicatricosisporites* complex in samples 13 and 14. Palaeogene dinoflagellate cysts were also present; these are largely indicative of input from the Eocene. Species recognised include *Cordosphaeridium gracile, Glaphyrocysta* spp., *Homotryblium tenuispinosum* and *Wetzeliella* spp. The typically Eocene pollen grain *Spinizonocolpites echinatus* was also present in sample 14.

Quaternary dinoflagellate cysts present:

Achomosphaera andalousiensis

Bitectatodinium tepikiense

Brigantedinium simplex

Brigantedinium spp.

Impagidinium sphaericum

Nematosphaeropsis labyrinthea

Operculodinium centrocarpum

Selenopemphix nephroides

Selenopemphix quanta

Spiniferites spp.

Votadinium calvum

3 Conclusions

The majority of the samples studied are from dark brown/black clay successions. These proved rich in dinoflagellate cysts indicative of cold, glacial conditions and ages no older than Mid-Late Pleistocene. Some samples include elements pointing to deposition in outer neritic/oceanic depositional settings. Reworking was also extremely common with allochthonous floras of Carboniferous, Jurassic, Cretaceous and Palaeogene ages. The Carboniferous, Jurassic and Cretaceous reworked floras were probably transported from the north and/or west by glacial activity. The Carboniferous and Jurassic material was probably sourced from the Midland Valley and Minch Basin respectively. Some Westphalian taxa were recognised, however the majority of the Carboniferous spores are long-ranging types. Some Jurassic dinoflagellate cysts proved age diagnostic with Late Sinemurian, Toarcian, Bathonian/Callovian, Callovian/Oxfordian and Late Jurassic forms being recognised, normally in small numbers. This indicates that most of the Jurassic succession has been incorporated into the Late Pleistocene and Holocene of this area. The small proportions of Cretaceous material reflects the paucity of Cretaceous strata in Scotland. However, the Palaeogene input is likely to be local from the offshore area. Due to the overall similarities in organic facies, they are all of probable Late Pleistocene age. The vibrocores studied which indicate cold conditions are: 56-10/249 CS, 56-10/250 CS, 56-10/251 CS, 56-10/252 CS and the lowermost three samples in 56-10/255 VE. The single sample from dark sand in 56-10/253 VE produced an abundant, diverse dinoflagellate

cyst flora indicative of a Holocene age, interglacial conditions and an outer neritic/oceanic setting. The uppermost sample in vibrocore 56-10/255 VE, also of dark sand, produced a sparser, yet similar flora.

Appendix 1 Sample Details

This Appendix lists the fifteen samples examined in this study with essential details, including location.

No.	Reg. No.	Borehole	Depth (m)	Lithology
1	MPA 50819	56-10/249 CS	0.50-0.53	dark brown/black clay
2	MPA 50820	56-10/249 CS	1.80-1.83	dark brown clay
3	MPA 50821	56-10/249 CS	2.38-2.41	brown/black clay
4	MPA 50822	56-10/250 CS	1.28-1.31	black clay
5	MPA 50823	56-10/250 CS	2.48-2.51	dark brown clay
6	MPA 50824	56-10/250 CS	3.55-3.58	black clay
7	MPA 50825	56-10/251 CS	1.53-1.56	dark brown clay
8	MPA 50826	56-10/251 CS	2.62-2.65	black clay
9	MPA 50827	56-10/252 CS	0.75-0.78	dark brown clay
10	MPA 50828	56-10/252 CS	2.96-2.99	dark brown clay
11	MPA 50829	56-10/253 VE	3.02-3.04	dark sand
12	MPA 50830	56-10/255 VE	1.29-1.32	dark sand
13	MPA 50831	56-10/255 VE	2.30-2.33	dark brown clay
14	MPA 50832	56-10/255 VE	3.44-3.47	dark brown clay
15	MPA 50833	56-10/255 VE	4.59-4.62	dark brown clay

Locations of the Vibrocores:

56-10/249 CS	56° 14.53' N 009° 13.95' W
56-10/250 CS	56° 14.98' N 009° 15.12' W
56-10/251 CS	56° 14.98' N 009° 12.48' W
56-10/252 CS	56° 16.03' N 009° 14.78' W
56-10/253 VE	56° 16.07' N 009° 12.48' W
56-10/255 VE	56° 22.15' N 009° 10.11' W

Table 1 A table illustrating the numbers of major dinoflagellate cyst types per microscope slide and the age of reworking. R - rare; P - present; C - common. Three dots (…) indicates absence.

Sample Number	Borehole (56-10/)	Depth (m)	No. of Peridinioid dino. cysts	No of other Quaternary dino. cysts	Carboniferous grains	Jurassic grains	Cretaceous grains	Palaeogene grains
1	249 CS	0.50-0.53	540	279	C	P	R	R
2	249 CS	1.80-1.83	196	82	P	P	R	P
3	249 CS	2.38-2.41	172	134	P	P	R	P
4	250 CS	1.28-1.31	81	27	R	R	…	P
5	250 CS	2.48-2.51	86	34	P	R	…	P
6	250 CS	3.55-3.58	1037	239	R	R	…	C
7	251 CS	1.53-1.56	241	82	R	P	R	R
8	251 CS	2.62-2.65	216	162	C	C	…	P
9	252 CS	0.75-0.78	631	230	P	P	…	R
10	252 CS	2.96-2.99	59	22	P	P/C	…	R
11	253 VE	3.02-3.04	295	691	P/R	P	…	R
12	255 VE	1.29-1.32	108	58	R	P	…	…
13	255 VE	2.30-2.33	781	87	P	P	…	R
14	255 VE	3.44-3.47	453	42	P	R	R	R
15	255 VE	4.59-4.62	321	133	P	R	…	R

References

HARLAND, R. 1983. Distribution maps of recent Dinoflagellate Cysts in bottom sediments from the North Atlantic Ocean and adjacent seas. Palaeontology, 26, 321-387.

HARLAND, R. 1992. Dinoflagellate cysts of the Quaternary System. *In*: Powell, A. J. (ed.). *A stratigraphic index of dinoflagellate cysts.* British Micropalaeontological Society Publications Series. Chapman and Hall, London, 253-273.

POWELL, A. J. 1992. Dinoflagellate cysts of the Tertiary System. *In*: Powell, A. J. (ed.). *A stratigraphic index of dinoflagellate cysts.* British Micropalaeontological Society Publications Series. Chapman and Hall, London, 155-251.

WILKINSON, I. P. 2001. Quaternary foraminifera from cores in an unstable area of the Hebridean Slope. *British Geological Survey Internal Report*, **IR/01/189**, 5 p.