#### **BRITISH GEOLOGICAL SURVEY**

#### MARINE REPORT SERIES TECHNICAL REPORT WB/95/11C VOLUME 3: APPENDIX 2 COMMERCIAL-IN-CONFIDENCE

#### ROCKALL CONTINENTAL MARGIN PROJECT FINAL GEOLOGICAL REPORT

#### TECHNICAL REPORT WB/95/11C VOLUME 3: APPENDIX 2 SHALLOW SAMPLING PROGRAMME 1994 STRATIGRAPHICAL SITES

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Geographical index: Rockall Trough, Rockall and George Bligh banks, Rosemary Bank and Anton Dohrn seamounts

Subject index: Lower Proterozoic, Cenozoic, Rockall Continental Margin

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# MACROFAUNAL ANALYSIS OF SHALLOW CORE 58-14/32 FROM THE ROCKALL AREA

#### PULL-OUT KEY TO CORE LOGS

**Cover Photograph:** Two sections of core from an interbedded sequence of upper Paleocene-lower Eocene clastic sediments and fine-grained, basaltic, pillow lavas recovered in borehole 94/3. Three separate pillow lavas were penetrated by this borehole; see Volume 2, Appendix 1, Fig. 10 for stratigraphical details.

The left-hand section (207.87-207.99m) illustrates the contact between the uppermost pillow lava and overlying, shelly, marine sandstones, whilst the right-hand section (208.48-208.62m) shows the contact between the middle pillow lava and overlying, shelly, marine mudstones. In both sections, the outer part of the pillow lavas is cracked, locally fragmented, and partially altered to paler coloured smectite or chlorite. The infiltration of sediment into the cracks suggests that they may represent cooling cracks. The mottled texture of the mudstone (right-hand section) may be due, in part, to the decomposition of the pale coloured, altered, lava fragments enclosed within the sediment.

#### **INTRODUCTION**

#### Background

This report presents a description of the shallow 'stratigraphical' cores collected between April and June 1994 by the British Geological Survey (BGS) as part of the Rockall Continental Margin Project. The shallow sampling programme was funded by members of the Rockall Continental Margin Consortium, consisting:

British Gas Exploration and Production British Geological Survey BP Exploration Operating Co Ltd Conoco (UK) Ltd E E Caledonia Ltd Elf UK plc Enterprise Oil plc Esso Exploration and Production UK Ltd Mobil North Sea Ltd

#### Shallow sampling programme

The shallow sampling programme had two main objectives:

- 1. To collect sediment cores for organic geochemical analysis.
- 2. To collect sediment and rock cores for stratigraphical analysis.

The cores collected for organic geochemistry form the subject of a separate study (see Volume 4: Appendix 3). This report concentrates on the sediment and rock cores recovered from the stratigraphical sites.

Forty-eight stratigraphical sites ('S' sites) were occupied during the survey. These were originally numbered S1-S31 and S40-S56. The sampling equipment used was largely dependent upon the geological objective, sea-bed conditions and the anticipated depth to bedrock. The BGS rockdrill was deployed in all situations where bedrock (Palaeogene and older) occurred within 5m of the sea bed. Where the target prognosis indicated a softer (Neogene and Quaternary) lithology the vibrocorer or gravity corer was utilised; both of these systems had the capability of a 6m core barrel. The operational details of the shallow sampling survey have been presented by Skinner *et al.* (1994).

The location of the 'S' sites is shown in Figure 1. The recovered cores have subsequently been allocated a formal BGS sample number (Table 1). The latter are registered by BGS in chronological order according to degree rectangles. Each degree rectangle covers 1° latitude by 1° longitude. Where more than one attempt was made at a single site, to improve or increase recovery of material, each attempt was assigned a different number. In total, 75 cores were taken from the 48 'S' sites; these are detailed in Table 2, together with their location, water depth and sample summary.

#### Report

All of the cores (including those from the geochemistry sites) were provisionally described on-board the ship. However, the stratigraphical cores were re-examined in the laboratory and logged in greater detail in terms of their lithology and sedimentary structures. These core descriptions form the bulk of this report. They are complimented by the seismic-stratigraphical setting for each site; for profile locations, refer to Figure 1.2 in Volume 1. For ease of reference, the shallow-core descriptions are ordered by their original site numbers - S1-S31 and S40-S56 - as some sites with multiple core recovery have very different BGS numbers, eg. S7 (2 cores: 59-14/8 and 59-14/42).

Specialist palaeontological information, supplied by the BGS and the University of Sheffield, was provided for most of the sites. The subsampled intervals are indicated on the core logs. The details of these studies are presented as separate sections describing the dinoflagellate cyst, calcareous microfauna, calcareous nannofossil and macrofaunal assemblages within the cores. These descriptions have been partly reformatted by the author from the original biostratigraphical manuscripts of Hine (1994a,b), Riding (1994), Wilkinson (1994) and Woods (1994). A summary of the palaeontological ages is presented in Table 3.

Several cores were analysed for igneous and metamorphic petrology, geochemistry and isotopic age dating, the results of which are detailed in Volume 1 and Volume 5, Appendix 4. Additionally, one core (58-14/54: S42) was tested for organic geochemistry due to its effervescent nature upon recovery; this is reported in Volume 4, Appendix 3.

References cited in this report are listed at the back of the respective chapters. This report compliments the geological summary presented in Volume 1.

#### Explanatory notes for shallow-core logs

- All <u>depths</u> referred to on the logs are in metres below sea bed
- Where recovery was poor, the <u>drill-log</u> (cf. Skinner *et al.*, 1994) was used to moreaccurately locate the sampled intervals
- The percentage of <u>core recovery</u> is indicated on the logs.
- The <u>lithological descriptions</u> are based on estimates of grain-size, texture and composition from hand specimens and microscopic analyses.
- The <u>sediments</u> fall into three main lithological groups: siliciclastic, mixed siliciclastic/carbonate and carbonate. These have been further subdivided into textural groups on the basis of the relative proportions of three grain-size components: gravel,

sand and mud. The size limits are those defined by Folk (1954). For the consolidated carbonate rocks, the textural classification is that of Folk (1962) which is based largely on the ratio of lime mud to spar forming the matrix.

- The <u>hardness of muds</u> is based on a field test code ranging from very soft (material exudes between fingers when squeezed in the fist) to firm (moderate finger pressure is required to mould) to very stiff (the material cannot be moulded). The suffix 'stone' is used to indicate hard or consolidated equivalents of the unconsolidated sediments.
- The descriptions of the <u>igneous and metamorphic</u> rocks has been greatly enhanced by specialist petrographical study. This is detailed in Volume 5, Appendix 4 which should be read in conjunction with this report.
- <u>Symbols</u> used to represent the various lithologies are shown in Figure 2. This is located in a plastic wallet at the back of this volume; the pull-out format will enable easy reference with the core logs.
- <u>Bed thicknesses</u> are defined according to Ingram (1954): laminae, less than 1cm; very thin beds, 1-3cm; thin beds, 3-10cm; medium beds, 10-30cm; thick beds, 30-100cm, and very thick beds, greater than 100cm.
- <u>Sediment colour</u> is most conveniently measured by comparison with a colour chart. The colour chart used in this study is the Munsell (1973 edition) soil colour chart. This is an international correlation tool based on common terms so defined as to obtain descriptive uniformity.
- <u>Subsamples</u> are indicated on the logs at their appropriate depth. The abbreviations are explained in Figure 2 (plastic wallet at back of volume). The palaeontological subsamples are referenced by a CSC number, eg. CSC8882, which is an internal Marine Geology and Operations Group reference number. This allows for easy cross-

reference between the borehole logs and the specialist palaeontological reports which retain this number.

• The most-common <u>abbreviations</u> used in the lithological descriptions are explained in Figure 2 (plastic wallet at back of volume).

#### Acknowledgements

The author would like to acknowledge the contributions made by all concerned in the shallow sampling programme. The following people deserve special mention for their contributions to this report:

#### BGS

J B Riding, I P Wilkinson and M A Woods, micropalaeontology; A C Morton, petrography and igneous geochemistry (Volume 5, Appendix 4); E J Gillespie, draughting and IT skills; D Evans for constructive comment.

#### External contributor

N M Hine (Industrial Palynology Unit, University of Sheffield), micropalaeontology.

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Fig. 1. Location of stratigraphical 'S' sites cored during 1994 Rockall Continental Margin Project shallow-coring programme.See Table 1 for correlation with BGS-listed, shallow-core reference number. Bathymetric contours in metres.

#### TABLE 1

ORIGINAL SITE NO:	BGS CORE NO:	ORIGINAL SITE NO:	BGS CORE NO:
S1	59-11/12	S25	56-15/11, 12
S2	59-11/13	S26	57-13/26
S3	59-14/8	S27	57-12/33
S4	59-14/7	S28	57-12/19
S5	59-14/4, 5, 6	S29	57-11/67
S6	59-14/2, 3, 9, 10	S30	57-12/18
S7	59-14/8, 42	S31	57-13/57
S8	58-14/9	S40	58-14/55
S9	58-14/10, 43	S41	57-14/57, 58
S10	58-14/11	S42	58-14/54
S11	58-14/53	S43	59-11/16
S12	58-14/31, 32	S44	59-11/17
S13	58-14/29, 30	S45	58-11/2
S14	58-14/34	S46	58-12/5
S15	57-14/49, 51, 52	S47	57-13/75
S16	57-13/53	S48	57-13/76
S17	57-13/54	S49	58-14/44, 45
S18	57-14/53	S50	58-14/56
S19	57-13/63, 64, 65	S51	58-14/60
S20	57-13/66, 67, 68	S52	58-14/61
S21	57-14/47, 48	S53	58-14/62, 63
S22	57-14/42, 43	S54	58-14/52, 64
S23	57-14/37, 44, 45, 54	S55	58-14/50, 51
S24	56-14/10, 13	S56	57-13/77

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### STRATIGRAPHICAL SITES - ORIGINAL SITE NUMBERS AND NEW BGS NUMBERS

#### TABLE 2

# STRATIGRAPHICAL SITES - LOCATIONS, WATER DEPTHS AND SAMPLE SUMMARIES

BGS NO:	ORIGINAL SITE NO:	GENERAL LOCATION	LAT/LONG	WATER DEPTH (m)	SAMPLE SUMMARY (T.D. metres)
56-14/10	S24	Eastern flank of Rockall Bank	56°54.11'N 13°32.63'W	568	Gravel (5.1)
56-14/13	S24	Eastern flank of Rockall Bank	56°54.13'N 13°32.63'W	570	Muddy and gravelly sands (2.1)
56-15/11	S25	Top of Rockall Bank	56°58.52'N 14°36.38'W	158	Gneiss (1.0)
56-15/12	S25	Top of Rockall Bank	56°58.52'N 14°36.38'W	158	Gneiss (0.85)
57-11/67	S29	Top of Anton Dohm	57°26.61'N 10°53.36'W	727	Interbedded sands and muds (5.1)
57-12/18	\$30	Top of Anton Dohm	57° <b>33</b> .6 <b>2</b> 'N 11°05.87'W	705	Conglomerate - volcanic clasts in carbonate matrix (3.8)
57-12/19	S28	Southern flank of Anton Dohm	57°17.12'N 11°05.79'W	869	Interbedded sands and muds (5.6)
57-12/33	S27	Rockall Trough, SW of Anton Dohm	57°13.79'N 11° <b>22</b> .15'W	2035	Interbedded sands and muds on chalk (3.06)
57-13/26	<b>S2</b> 6	Rockall Trough, SW of Anton Dohm	57°07.55'N 12°05.96'W	1961	Massive, bioturbated muds (3.08)
57-13/53	\$16	North-west Rockall Trough	57°54.22'N 12°43.95'W	1480	Interbedded sands and muds (2.84)
57-13/54	S17	North-east flank of Rockall Bank	57°44.20'N 12°56.39'W	634	Basaltic agglomerate (1.1)
57-13/57	S31	Eastern flank of Rockall Bank	57°19.66'N 12°59.34'W	658	Interbedded sands and muds (5.1)
57-13/63	S19	Eastern flank of Rockall Bank	57°25.68'N 12°56.82'W	610	Gravel (3.5)
57-13/64	S19	Eastern flank of Rockall Bank	57°25.69'N 12°56.89'W	575	Gravel (1.0)
57-13/65	S19	Eastern flank of Rockall Bank	57°25.59'N 12°56.69'W	634	Interbedded sand, gravel and mud on mudstone (3.1)
57-13/66	<b>S2</b> 0	Eastern flank of Rockall Bank	57°21.28'N 12°57.81'W	750	Basaltic boulder (0.9)
57-13/67	S20	Eastern flank of Rockall Bank	57°21.27'N 12°57.82'W	750	No recovery
57-13/68	S20	Eastern flank of Rockall Bank	57°21.29'N 12°57.81'W	750	Muddy sand (0.16)
57-13/75	847	Rockall Trough, NE of Rockall Bank	57°41.68'N 12°36.62'W	1523	Interbedded sands and muds (4.1)
57-13/76		Western margin of Rockall Trough	57°47.73'N 12°53.35'W	970	Interbedded sands and muds (4.48)
57-13/77	856	Eastern flank of Rockall Bank	57°35.25'N 12°56.71'W	617	Gravel on muddy sandstone (5.1)
57-14/37	S23	Eastern flank of Rockall Bank	57°03.43'N 13°19.10'W	429	Sandy gravel (0.4)
57-14/42	S22	Eastern flank of Rockall Bank	57°03.24'N 13°18.55'W	578	Gravel (1.05)
57-14/43	S22	Eastern flank of Rockall Bank	57°03.25'N 13°18.56'W	578	Sandstone (0.95)
57-14/44	823	Eastern flank of Rockall Bank	57°03.43'N 13°19.10'W	438	Gravel (3.77)
57-14/45	S23	Eastern flank of Rockall Bank	57°03.43'N	438	Gravelly sand (2.1)
57-14/47	S21	Western margin of Rockall Trough	57°07.56'N	1078	Sand on massive, bioturbated muds (1.1)
57-14/48	S21	Western margin of Rockall Trough	57°07.54'N	1081	Interbedded mud, sand and gravel on sandstone (2.3)
57-14/49		North-east flank of Rockall Bank	57°57.19'N 13°04.33'W	505	Basaltic pebble (0.05)

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#### TABLE 2 (...continued)

# STRATIGRAPHICAL SITES - LOCATIONS, WATER DEPTHS AND SAMPLE SUMMARIES

BGS NO:	ORIGINAL SITE NO:	GENERAL LOCATION	LAT/LONG	WATER DEPTH (m)	SAMPLE SUMMARY (T.D. metres)
57-14/51	S15	North-east flank of Rockall Bank	57°57.18'N 13°04.34'W	536	Basaltic gravel (2.35)
57-14/52	S15	North-east flank of Rockall Bank	57°57.19'N 13°04.34'W	531	Weathered and fractured basalt - ?boulder or <i>in situ</i> (3.05)
57-14/53	S18	Top of Rockall Bank	57°34.14'N 13°19.80'W	177	Trachyte (3.2)
57-14/54	S23	Eastern flank of Rockall Bank	57°03.43'N 13°19.09'W	423	Interbedded sands and muds on gravel (2.0)
58-11/2	S45	Rockall Trough, SW of Rosemary Bank	58°53.23'N 10°39.65'W	1863	Massive, bioturbated muds (3.54)
58-12/5	S46	Rockall Trough, SW of Rosemary Bank	58°21.80'N 11°21.18'W	1809	Massive, bioturbated muds (3.26)
58-14/8	S7	Top of George Bligh Bank	58°57.73'N 13°45.46'W	442	Conglomerate - volcanic clasts in carbonate matrix (5.1)
58-14/9	S8	Top of George Bligh Bank	58°53.11'N 13°43.04'W	484	Interbedded sands (5.97)
58-14/10	S9	Eastern flank of George Bligh Bank	58°46.76'N 13°13.30'W	1014	Calcareous sandy mudstones (2.6)
58-14/11	S10	Eastern flank of George Bligh Bank	58°46.62'N 13°30.05'W	1033	Gravel on bioclastic sandstone (5.1)
58-14/29	S13	North-east flank of Rockall Bank	58°13.92'N 13°32.02'W	705	Gravel on sandstone and siltstone (5.12)
58-14/30	S13	North-east flank of Rockall Bank	58°13.92'N 13°32.01'W	705	Sandstone and siltstone (4.6)
58-14/31	S12	North-east flank of Rockall Bank	58°20.52'N 13°48.81'W	705	Conglomerate - volcanic clasts in carbonate matrix (3.96)
58-14/ <b>32</b>	S12	North-east flank of Rockall Bank	58°20.52'N 13°48.80'W	705	Limestone on conglomerate - a/a (4.0)
58-14/34	S14	North-west Rockall Trough	58°16.51'N 13°05.11'W	1486	Interbedded sands and muds on mudstone (5.25)
58-14/42	87	Top of George Bligh Bank	58°57.72'N 13°45.45'W	438	Conglomerate - volcanic clasts in carbonate matrix - on basalt (5.12)
58-14/43	S9	Eastern flank of George Bligh Bank	58°46.75'N 13°30.24'W	1028	Gravel on calcareous sandy mudstone (5.1)
58-14/44	S49	North-west Rockall Trough	58°33.00'N 13°08.33'W	1621	Gravel on claystone (5.1)
58-14/45	S49	North-west Rockall Trough	58°33.01'N 13°08.31'W	1622	Gravel on claystone (5.1)
58-14/50	855	Top of Rockall Bank	58°04.13'N 13°20.45'W	244	Gravel (2.75)
58-14/51	855	Top of Rockall Bank	58°04.12'N 13°20.48'W	244	Gravel (0.25)
58-14/52	S54	Top of Rockall Bank	58°04.78'N 13°19.57'W	263	Gravel (3.9)
58-14/53	S11	North-west Rockall Trough	58°37.36'N 13°11.62'W	1595	Mud and gravel on calcareous claystone (5.1)
58-14/54	S42	North-west Rockall Trough	58°43.08'N 13°22.86'W	1433	Sands on sandstone and conglomerate (3.4)
58-14/55	S40	Eastern flank of George Bligh Bank	58°46.47'N 13°29.72'W	1062	Gravel on sandstone on mudstone (5.1)
58-14/56	S50	Eastern flank of George Bligh Bank	58°52.11'N 13°34.12'W	685	Limestone (2.7)
58-14/57	S41	Top of George Bligh Bank	58°56.98'N 13°50.85'W	444	Sand on conglomerate - volcanic clasts in carbonate matrix (4.1)
58-14/58	S41	Top of George Bligh Bank	58°56.96'N 13°50.85'W	444	Sand on conglomerate - a/a (4.05)
58-14/60	\$51	North-west Rockall Trough	58°39.48'N 13°49.72'W	1270	Sands and gravels (1.07)

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#### TABLE 2 (...continued)

# STRATIGRAPHICAL SITES - LOCATIONS, WATER DEPTHS AND SAMPLE SUMMARIES

BGS NO:	ORIGINAL	GENERAL LOCATION	LAT/LONG	WATER	SAMPLE SUMMARY
	SITE NO:			DEPTH (m)	(T.D. metres)
58-14/61	S52	Top of Rockall Bank	58°15.98'N	377	Gravel (5.1)
			13°54.43'W	·	
58-14/62	\$53	North-east flank of	58°14.47'N	916	Gravel (5.1)
		Rockall Bank	13°31.34'W		
58-14/63	\$53	North-east flank of	58°14.48'N	916	Gravel (3.9)
		Rockall Bank	13°31.32'W		
58-14/64	S54	Top of Rockall Bank	58°04.78'N	262	Sandy gravel (3.9)
			13°19.55'W		
59-11/12	S1	Top of Rosemary Bank	59°18.41'N	477	Interbedded ultarpotassic lavas and
			10°04.99'W		thin limestones (5.1)
59-11/13	S2	Top of Rosemary Bank	59°14.87'N	473	Interbedded sands (4.67)
			10°09.98'W		
59-11/16	S43	South-west flank of	59°03.57'N	1013	Interbedded sands and muds (4.35)
		Rosemary Bank	10°25.55'W		
59-11/17	S44	South-west flank of	59°02.09'N	1209	Interbedded muds and thin sands and
		Rosemary Bank	10°27.60'W		gravels (5.25)
59-14/2	S6	Western margin of	59°02.60'N	1342	Gravel (0.05)
		Rockall Trough	13°22.82'W		
59-14/3	<b>S</b> 6	Western margin of	59°02.56'N	1343	Sands and gravel (1.17)
		Rockall Trough	13°22.78'W		
59-14/4	<u>85</u>	Western margin of	59°01.52'N	1445	Gravel (0.75)
		Rockall Trough	13°19.72'W		
59-14/5	S5	Western margin of	59°01.52'N	1445	Claystone (3.7)
		Rockall Trough	13°19.74'W		
59-14/6	S5	Western margin of	59°01.52'N	1445	Claystone on siltstone (5.12)
		Rockall Trough	13°19.75'W		
59-14/7	S4	Western margin of	59°01.04'N	1453	Sandstone on claystone (5.12)
		Rockall Trough	13°18.40'W		
59-14/8	S3	Western margin of	59°00.14'N	1585	Gravel on mudstone and slitstone
	l l	Rockall Trough	1 <b>3°</b> 16.04'W		(4.0)
59-14/9	<u>\$6</u>	Western margin of	59°02.58'N	1341	Gravel on claystone (5.12)
		Rockall Trough	13°22.76'W		
59-14/10	<b>S</b> 6	Western margin of	59°02.57'N	1341	Gravel on interbedded mudstones
		Rockall Trough	13°22.77'W		and thin sandstones (5.12)

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BGS NO:	ORIGINAL	CSC NO:	DEPTH IN		AGE	
	SITE NO:		CORE (m)	DINOFLAGELLATES	FORAMINIFERA	CALCAREOUS NANNOFOSSILS
56-14/13	S24	8813	0.05-0.07	Mid-Pleistocene to Holocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8814	0.28-0.30	a/a	a/a	Mid- to late Pleistocene (NN21)
		8815	0.90-0.93	-	a/a	Late Pleistocene (NN21)
57-11/67	S29	8816	0.00-0.01	Mid- to late Pleistocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8817	0.2	a/a	a/a	Late Pleistocene (NN21)
		8818	1.5	a/a	a/a	a/a
		8819	3.5	a/a	a/a	a/a
		8820	4.9	a/a	a/a	Mid-Pleistocene (NN20)
57-12/18	S30	8900	2.87-2.90		Mid- to late Eocene (NP17-19)	
		8821	3.70-3.73	-		_
57-12/19	S28	8822	0.00-0.03	Mid- to late Pleistocene	Mid- to late Pleistocene	Late Pleistocene (NN21)
		8823	5.3	-	a/a	Late Pliocene (NN18)
57-12/33	S27	8824	0.05-0.10	Holocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8825	1.25-1.30	Pleistocene	a/a	? Early / mid-Pleistocene (NN19)
		8826	2.5	-	(Mid-to late Miocene - ? reworked )	Mid- to late Pliocene (NN15)
57-13/26	<b>S2</b> 6	8827	0.00-0.01	Late Pleistocene to Holocene	Pleistocene to Holocene	Holocene (NN21)
		8828	0.5	a/a	a/a	Late Pleistocene (NN21)
		8829	1.0	a/a	a/a	a/a
		8830	1.5	a/a	a/a	a/a
		8831	2.0	Late Pleistocene	a/a	a/a
		8832	2.5	a/a	a/a	a/a
		8833	3.0	a/a	a/a	a/a
57-13/53	S16	8834	0.00-0.03	Late Pleistocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8835	0.50-0.53	a/a	a/a	Late Pleistocene (NN21)
-		8836	2.80-2.83		a/a	Early / mid-Pleistocene (NN19)
57-13/57	S31	8837	0.00-0.05	Late Pleistocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8838	5.00-5.02	a/a		Mid- / late Pleistocene (NN21)
57-13/65	S19	8839	3.05-3.10		-	
57-13/75	S47	8840	0.00-0.04	Mid-/late Pleistocene to Holocene		Holocene (NN21)
		8841	4.05-4.10			Early / mid-Pleistocene (NN19)
57-13/76	S48	8842	0.00-0.07	Mid- / late Pleistocene		Holocene (NN21)
		8843	4.13-4.18			Late Pliocene (NN16-18)
57-13/77	S56	8844	5.04-5.08			Mid-Eocene (NP15-16)
57-14/43	S22	8845	0.72			
		8846	0.90		(Mid-to late Miocene - ? reworked)	-
57-14/44	S23	8847	Sea-bed		=	
			boulder			

#### TABLE 3. STRATIGRAPHICAL SITES - BIOSTRATIGRAPHICAL DATA

BGS NO:	ORIGINAL	CSC NO:	DEPTH IN		AGE	
	SITE NO:		CORE (m)	DINOFLAGELLATES	FORAMINIFERA	CALCAREOUS NANNOFOSSILS
57-14/48	S21	8848	0.00-0.03	Quatemary		Mid-/late Pleistocene (NN21)
		8849	0.90-0.93	a/a	Mid-Pleistocene to Holocene	Early / mid-Pleistocene (NN19)
		8850	2.00-2.01	(Early Miocene to Quaternary)		Pliocene (NN13-15)
57-14/54	S23	8851	0.65-0.68	Late Pleistocene to Holocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8852	1.80-1.90	Quaternary	_	Mid-Pleistocene (NN20)
		8853	1.90-2.00	Quaternary	Mid-Pleistocene to Holocene	
58-11/2	S45	8854	0.00-0.03	Late Pleistocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8855	3.50-3.54	a/a	a/a	Late Pleistocene (NN21)
58-12/5	S46	8856	0.00-0.03	Late Pleistocene to Holocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8857	3.17-3.20	Late Pleistocene	a/a	Late Pleistocene (NN21)
58-14/8	S7	8901	4.45-4.47			
		8858	4.47-4.49	-		-
58-14/9	S8	8859	0.00-0.03	Mid- / late Pleistocene	Mid-/late Pleistocene	Late Pleistocene (NN21)
		8860	0.35-0.38	a/a	a/a	Mid- / late Pleistocene (NN20-21)
		8861	5.50-5.53	a/a	a/a	Mid-Pleistocene (NN20)
58-14/10	S9	8862	1.80-1.84	(Mid-Pleistocene - ? contaminated)	Early Eccene (NP12-13)	Late Paleocene (NP7-9)
58-14/11	S10	8863	4.72-4.77	-		Late Paleocene (NP6-9)
58-14/ <b>2</b> 9	S13	8905	0.40-0.46		(Eocene - ? reworked)	
		8899	0.46-0.50	_		-
		8864	4.95-5.00	Early to mid-Eocene (NP10/11-15)	Earliest mid-Eocene	-
58-14/31	S12	8865	3.51-3.55	-	(Pliocene to Pleistocene - ? contaminated)	(Pliocene to Pleistocene - ? contaminated)
58-14/ <b>32</b> *	S12	8866	3.11-3.14			? Pliocene (NN12-15)
		8902	3.45-3.48		Pleistocene (? reworked Eocene)	
		8867	3.85-3.90		Pliocene to Pleistocene	? Pliocene (NN12-15)
58-14/34	S14	8868	0.00-0.03	Late Pleistocene	Mid- / late Pleistocene	Late Pleistocene (NN21)
		8869	0.50-0.53	Quaternary	a/a	Mid-/late Pleistocene (NN20-21)
		8870	4.79-4.82		Early mid-Eocene	Mid-Eocene (NP14-17)
58-14/42	S7	8903	4.43-4.45		-	
		8871	4.5	(Early Miocene to Holocene - ? contaminated)		Paleocene
58-14/43	S9	8904	4.65-4.70			
		8872	5.07-5.12			Late Paleocene (NP6-9)
58-14/44	S49	8873	5.04-5.08	-	-	Mid-Eocene (NP16)
58-14/53	S11	8874	3.43-3.47	_	Eocene	Mid-Eocene (NP16)
58-14/54	S42	8875	1.90-1.92	-	Mid- to late Eocene (NP17-19)	Eocene to Pliocene range
		8876	2.52-2.54	-	a/a	a/a
58-14/55	S40	8877	5.05-5.10			Late Paleocene to Pliocene range (NP4-NN16)
58-14/56	<b>S</b> 50	8878	1.01-1.06			-

#### TABLE 3 (...continued). STRATIGRAPHICAL SITES - BIOSTRATIGRAPHICAL DATA

\* Macrofaunal analysis (sample no: CSC 8986) supports a Pliocene to Pleistocene age

BGS NO:	ORIGINAL	CSC NO:	DEPTH IN	-	AGE	
	SITE NO:		CORE (m)	DINOFLAGELLATES	FORAMINIFERA	CALCAREOUS NANNOFOSSILS
58-14/57	S41	8879	3.83-3.89	(Miocene to Holocene - ? partly reworked)	Mid-Pleistocene to Holocene	Mid-Pleistocene (NN21)
		8880	4.10	-	-	Paleocene
58-14/60	S51	8881	0.00-0.02	Holocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8882	1.02-1.07	Quaternary	a/a	Early / mid-Pleistocene (NN19)
58-14/63	\$53	8883	0.81-0.83 *	-		Mid-Eocene (NP15-16) *
59-11/12	S1	8884	1.40-1.43	-	-	
59-11/13	S2	8885	0.00-0.05	Holocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8886	0.60-0.65	Late Pleistocene	a/a	Late Pleistocene (NN21)
		8887	0.80-0.85	a/a	a/a	a/a
	1	8888	4.60-4.67		a/a	Mid-/late Pleistocene (NN21)
59-11/16	\$43	8889	4.30-4.35	(Early to mid-Eocene (NP12-15) - ?reworked)	1	Mid- / late Pleistocene (NN21)
59-11/17	S44	8890	0.00-0.05	Holocene	Mid-Pleistocene to Holocene	Holocene (NN21)
		8891	4.60-4.63	Late Pleistocene	a/a	Mid- / late Pleistocene (NN21)
59-14/6	S5	8892	5.00-5.03	Early to mid-Eocene	_	-
	}	8893	5.05-5.06	Early to mid Eocene (NP12-14)	Latest early Eccene to earliest mid-Eccene	-
					(NP13-14)	
59-14/7	S4	8894	4.00-4.03	-	-	-
		8895	5.07-5.12	Early to mid-Eccene (NP13-15)	–	-
59-14/8	S3	8906	0.95-0.98		_	
		8896	0.98-1.00	-		Early Eccene (NP13)
		8897	3.80-3.83	Palaeogene	<u> </u>	a/a
59-14/9	S6	8898	5.07-5.12			Mid-Eocene (NP15-16)
		8907	5.09-5.12		-	

#### TABLE 3 (...continued). STRATIGRAPHICAL SITES - BIOSTRATIGRAPHICAL DATA

\* Clast in sea-bed gravel

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NB. Barren samples indicated by short dashed line. Lack of entry relates to samples not analysed for that specific microfauna or flora.

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# SHALLOW-CORE DESCRIPTIONS AND SEISMIC-STRATIGRAPHICAL SETTING OF SAMPLE SITES

59-11/12 (S1)

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#### **ROSEMARY BANK**



BGS no: 59-11/12 Original site no: S1 Location: Top of Rosemary Bank Latitude: 59° 18.41' N Longitude: 10° 04.99' W Water depth: 477m

### BGS core no: 59-11/12

### Original site no: S1

T.D. metres: 5.1

Sodimentary Burning Common Constructores		Grain size and	λ				
But the constraint of the const		sedimentary	<u>l</u>		Description	Interpretation	100
1       Paper protection to @1.05m         1       Paper protection         2       Paper protection         3       Paper protection         3       Paper protection         4       Paper protection         4       Paper protection         5       Paper protection         5       Paper protection         4       Paper protection         5       Paper protection         5       Paper protection         6       Paper protection		structures	ê	Sub-	Description	interpretation	Age
Papid perstation to @1.05m	Depth (m)	ອຸດດຽດຮະໄລ ອີ	Ei	Samp	bles		
1     105     Wasthered top /reaction zone with carbonale venned (born into: Some fired venter)     soldated vehanic searcout, probaby schemistic, probaby schemis	<u> </u>			1			
1     105     Weathered top /reaction zone with carbonata veining     isolated vebasic seamount.       1     105     Weathered top /reaction zone with carbonata veining     isolated vebasic seamount.       1     106     Weathered top /reaction zone with carbonata example.     isolated vebasic seamount.       2     Weathered top /reaction zone     isolated isolate and patient seatonate example.     isolated vebasic seamount.       2     Weathered top /reaction zone     isolated isolate and patient seatonate example.     isolated vebasic seamount.       2     Weathered top /reaction zone with carbonate constal weather and matter exploration information.     isolated vebasic seamount.       2     Weathered top /reaction zone with carbonate constal weather and matter exploration information.     isolated vebasic seamount.       3     Weathered top /reaction zone with carbonate veining     in finity crystaline matrix (gib-norm weathered zone and near top of forw.       3     Weathered top /reaction zone     in finity crystaline matrix (gib-norm weathered zone)       4     Weathered top /reaction zone       5     Weathered top /reaction zone       4     Weathered top /reaction zone       5     Weathered top /reaction zone       6     In Regional stratigraphical evidence auggest a late	$\vdash$			1	Rapid penetration to @1.05m		
1     1/2     1/2       1     1/2     1/2       2     1/2     1/2       1     1/2 <t< td=""><td><math>\vdash</math></td><td></td><td><math> \rangle /</math></td><td></td><td></td><td></td><td></td></t<>	$\vdash$		$ \rangle /$				
1     1.05     Weathered top /reaction zone with carbonate veining     Isolated velocatic enservoirt, setting between the bodged velocatic enservoirt, generotemporanecular control operations. Some invelop operations extension the bodged b	F						
1     1.05 } Weathered top /reaction zone with carbonate vening     Isolated interaction     Isolated interaction       10     1.05 } Weathered top /reaction zone with carbonate vening     Isolated interaction     Isolated interaction       10     1.05 } Weathered top /reaction zone     Isolated interaction     Isolated interaction       10     1.05 } Weathered top /reaction zone     Isolated interaction     Isolated interaction       10     1.05 } Weathered top /reaction zone     Isolated interaction     Isolated interaction       10     1.05 } Weathered top /reaction zone     Isolated interaction     Isolated interaction       10     1.05 } Weathered top /reaction zone     Isolated interaction     Isolated interaction       10     1.05 weathered into / item into a many solation into your any solation into your a	F		$  \rangle /$	1 ·			
1       105       Weathered top /reaction zone with cathonale veining       Bodatad velocitic searcount, se	┣─		I X				
1       1.65       Weathered top /reaction zone with carbonate weining       Exclusion reaction in the second of the second reaction in the second reaction reaction in the second reaction reaction in the second reaction reaction reaction in the second reaction reaction in the second reaction reaction reaction in the second reaction react	F		$  \wedge  $		·		
105       Weathered top /reaction zone with carbonale veining       isolated volcanic searce.rtt         105       Weathered top /reaction zone with carbonale veining       isolated volcanic searce.rtt         105       Weathered top /reaction zone with carbonale veining       isolated volcanic searce.rtt         106       Weathered top /reaction zone with carbonale veining       isolated volcanic searce.rtt         106       Weathered top /reaction zone with carbonale veining       isolated volcanic searce.rtt         107       Thick to very-flock-bedded ultra-potassic* live in flows and occasional very thin to thin-bedded volcasic instances.orby path with whe carbonale crystalline infill. Most vesicles only path with whe carbonale crystalline infill. Most vesicles only path with the carbonale veining         2       V/V       path Willed. a runder diage oner runne prophot sector at lives marked top reaction zone with carbonale veining         2       V/V       path Willed. a runder G-Dorm with carbonale veining         2       V/V       sector in zone with carbonale veining         2       V/V       sector zone         2       V/V <td< td=""><td>F</td><td></td><td></td><td></td><td></td><td></td><td></td></td<>	F						
1       105       Weathered top /reaction zone with carbonale veining       isolated volcanic example: proceeding and proceeding of the constance of the	F		/ \				
10       Weathered top /reaction zone with carbonale veining       Isolated vobanic searcount:         10       Weathered top /reaction zone with carbonale veining       Isolated vobanic searcount:         14       Weathered top /reaction zone with carbonale veining       Isolated vobanic searcount:         14       Gem trick. Some finely crystalline carbonale extended backster lines of baskst and partially fills       Isolated vobanic searcount:         2       V/V       Isolated vobanic searcount:       Isolated vobanic searcount:         3       V/V       Isolated vobanic searcount:       Isolated vobanic searcount:         4       V/V       Isolated vobanic searcount:       Isolatestic insciona yearcount:<	F .		/ \				
2     2     2     2     2     4	<u> </u> -1			1.05 1			
3 <ul> <li>And the set of the set of</li></ul>	F			1 3	Weathered top /reaction zone with carbonate veining	Isolated volcanic seamount;	
2     View     Use in the Second instruction matrix, yellow-bown     Image: Second instruction instructin instructin instruction i	Γ			1	Bioclastic limestone - biosparite. Small shells and	5 extrusive basalt flows,	μ <sub>+</sub>
2     V     14     cown into broken surface of basait and perially files     bask sedimentation.       2     V     cown into broken surface of basait and perially files     bask sedimentation.       2     V     Livas are vesicitar and amyodabical throughout with write catbonate crystalline infil. Most vesicles only of flows marked by crange-brown weathered zone at the sedimentation.     bask sedimentation.       2     V     Livas are vesicitar and amyodabical throughout with write catbonate crystalline infil. Most vesicles only of flows marked by crange-brown weathered zone at the sedimentation.     bask sedimentation.       3     V     V     Livas are vesicitar and amyodabical throughout section. Theck versits (5-10mm thick) more prominent near top of flows.     biological transments (0, more prominent near top of flows.       3     V     V     V     V       4     V     V     V       5     V     V     V       5     V     V     V       6     I     Regional straigraphical evidence suggest a tate Meastricitian (tate Cretacous) age     Phono-tephnites (eee Appendix 4)	Γ		A Star	MPai 8884	OBcm thick Some finely crystalline matrix, yellow-brown	penecontemporaneous	EX
2     V/V     Certiles. Some veining?     Dark sedmentation.       2     V/V     Certiles. A construction of the discussion investores.       2     V/V     With write carbonate cyltation influx Most vestores only performed cyltation influx Most vestores on at least 50m thick.       2     V/V     With write carbonate cyltation influx Most vestores on at least 50m thick.       2     V/V     V/V       3     V/V       3     V/V       4     V/V       4     V/V       5     V/V       5     V/V       5     V/V       5     V/V       5     V/V       6     Phono-tephnice (see Appendix 4)				1.4 -	down into broken surface of basalt and partially fills	shallow-marine carbonate	J W H
2     Thick to vey-thick-bedded ultra-potasise' live flows and cocasional vey link to thin-bedded biocastic linestences.     Image: Cocasional vey link to thin-bedded biocastic linestences.       2     V/V     Lavas are vesicular and anygdatoidal throughout with white carbonate crystalline infill. Most vesicles only very of flows marked by crange-brown weathered zone at least Scm thick.     Image: Cocasional vey link to more promisent near top of flows.       3     V/V     State vesics (< trum thick) pervasive throughout sector. Thick veries (<-Donn thick) more promisent near top of flows.       3     V/V       4     V/V       4     V/V       5     V/V       5     V/V       6     I flegional stratigraphical evidence suggest a late Mastrichtian (ate Cretacoous) age			V <sup>7</sup> V <sup>V</sup> V	1.40	cavities. Some veining?	bank sedimentation.	AC
2     VVV     Cocasion/very tim to thm-bedded bioclastic timestores.       2     VVV     Laws are reactional coptainte total. Monitorial total model of the constraint of t	E		V V V	1	Thick to very-thick-bedded ultra-potassic* lava flows and		
2       Laws are vesicular and smydatoidal throughout         2       V/V         4       V/V         3       V/V         3       V/V         4       V/V         4       V/V         4       V/V         5       V/V         5       V/V         6       Phono-tephtites (see Appendix 4)	Ľ			1	occasional very thin to thin-bedded bioclastic limestones.		<u>د</u>
2     vvv     with white carbonate crystalline infill. Nost vesicles only partly filled, a number of large ones remain opens. Tops of flows marked by ornage-brown weathered zone at least 5cm. This.       vvv     vvv     This cacles veins ( <trm. flows.<="" from="" hroughout="" mear="" of="" one="" prevene="" prominent="" reactors="" td="" thick)="" top="">       vvv     vvv     vvv    v</trm.>				{	Lavas are vesicular and amygdaloidal throughout		
Carbonate vein     V	2				with white carbonate crystalline infill. Most vesicles only		
4       V       V         4       V       V         5       V       V         6       Phono-tephrites (see Appendix 4)       Image and phone suggest a late					of flows marked by orange-brown weathered zone at		
4     Y       5     Y       5     Y       6     Finic calcite veins (<1mm: thick) pervasive throughout section. Thicker veins (>-0mm: thick) more prominent near top of forws.	L		vvv	]	least 5cm thick.		
4     VVV       5     VVV       5     VVV       6     Phono-tephrites (see Appendix 4)	F		$ \sqrt{\sqrt{2}} $	1	This calcite veins (<1mm, thick) pervasive throughout		
a     a     255       Weathered top /reaction zone with carbonate veining       a     vvv       vvv     vvv       vvv     vvv       vvv     siloclastic limestone, veilow-brown, skeletal fragments       vvv     in finely crystalline matrix @1cm thick.       vvv     vvv       vvv     vvv       vvv     siloclastic limestone, veilow-brown, skeletal fragments       vvvv </td <td>-</td> <td></td> <td></td> <td>1</td> <td>section. Thicker veins (5-10mm thick) more prominent</td> <td></td> <td></td>	-			1	section. Thicker veins (5-10mm thick) more prominent		
3     Y       3     Y       V     V       V <td><u> </u></td> <td></td> <td>(v v )</td> <td>{</td> <td>near top of flows.</td> <td></td> <td></td>	<u> </u>		(v v )	{	near top of flows.		
Bioclastic Imeetone, yellow-brown, skeletal fragments V V V V V V V V V V V V V V V V V V V	-		V V V	$^{-2.55}$ }	Weathered top /reaction zone with carbonate veining	· · · · · · · · · · · · · · · · · · ·	
3       V v v         3       V v v         V v v       in finely crystalline matrix @tom_thick.         V v v       V v         V v v       V v         V v v       V v         V v v       V v         V v v       V v         V v v       V v         V v v       V v         V v v       Pet         V v v       Pet         V v v       V v         V v v       Pet         V v v       V v         V v v       Pet         V v v       V v         V v v       Pet         V v v       Pet         V v v       V v         V v v       Pet         V v v       V v         V v v       V v         V v v       V v         V v v       V v         V v v       Statigraphical evidence suggest a late         Masstrichtian (late Cretacaous) age       Phono-tephrites (see Appendix 4)         6       Phono-tephrites (see Appendix 4)	-		<u>A-A-A</u>				
3       3         Y       Y         Y	-		vvv				
Bioclastic limestone, yellow-brown, skeletal fragments in firrely crystalline matrix @tom thick.	$\vdash$			1			
4       V	- 3			1			
V V V     V V	F		ſ v v v	ł	Riselectio limestere vellov brown statetel fragmente		
4       V       V         V       V       V	$\vdash$				in finely crystalline matrix @1cm thick.		
4 V	$\vdash$		V V V	-3.3 1	Weathered ton /reaction zone		1
4 VVV VVV VVV VVV VVV VVV VVV VVV VVV VV	F		V V V	1,			
4       V V       PET         4       V V       V         V V       V       V         <	-			1			
4 VVV VVV VVV VVV VVV VVV VVV VVV VVV VV	$\vdash$						
4 V	F		v v v	• PET			
4 V							
4 vvv 4 vvvv 4 vvv 4 vvvv 4 vvv 4 vvv 4 vvv 4 vvv 4 vvvv 4 vvvv 4 vvvv 4 vvvv 4 vvvv 4 vvvv 4 vvvv 4 vvvvv 4 vvvvv 4 vvvvvv 4 vvvvvvvvvv			v v v				1
4.3 } Weathered top /reaction zone          V       V         V	- 4		vvv	1			
4.3       Weathered top /reaction zone         V V V       V         V V V       V         V V V       V         V V V       V         V V V       V         V V V       V         V V V       V         V V V       V         V V V       V         V V V       Carbonate vein         V V V       S.1         Image: Carbonate vein       Image: Carbonate vein         V V V       S.1         Image: Carbonate vein       Image: Carbonate vein         V V V       S.1         Image: Carbonate vein       Image: Carbonate vein         V V V       S.1         Image: Carbonate vein       Image: Carbonate vein         V V V       S.1         Image: Carbonate vein       Image: Carbonate vein         V V V       S.1         Image: Carbonate vein       Image: Carbonate vein	Γ			1			
4.3 } Weathered top /reaction zone          V       V         S.1       5.1         Image: Comparison of the transformed and tratigraphical evidence suggest a late         Maastrichtian (late Cretaceous) age         * Phono-tephrites (see Appendix 4)         Image: Comparison of the transformed and tratigraphical evidence and tratigraphical evidence and tratigraphical evidence and tratigraphical evidence and trate      <	E						
5 Carbonate vein V V V V V V F.1 1 Regional stratigraphical evidence suggest a late Maastrichtian (late Cretaceous) age * Phono-tephrites (see Appendix 4)	Ĺ	-		[ <sup>4.3</sup> }	Weathered top /reaction zone		
5 V							
5       V V V         5       V V V         5.1         1	L		V V V				
5 Carbonate vein 5 V V V V V V V V 5.1 1 Regional stratigraphical evidence suggest a late Maastrichtian (late Cretaceous) age * Phono-tephrites (see Appendix 4)	L		vvv	]			
5       V V V         V V V       5.1         Image: Carbonate vein       5.1         Image: Carbonate vein <td>L</td> <td></td> <td></td> <td>1</td> <td></td> <td></td> <td></td>	L			1			
5 V V V V V V 5.1 T Regional stratigraphical evidence suggest a late Maastrichtian (late Cretaceous) age * Phono-tephrites (see Appendix 4)	F	ł	X VX		Carbonate vein		
	- 5		VVV				
A Phono-tephrites (see Appendix 4)	F			-5.1			
t Regional stratigraphical evidence suggest a late     Maastrichtian (late Cretaceous) age     * Phono-tephrites (see Appendix 4)	F						
t Regional stratigraphical evidence suggest a late Maastrichtian (late Cretaceous) age     * Phono-tephrites (see Appendix 4)	F						
A mastrichtian (late Cretaceous) age     A mastrinten (late Cretaceous) age     A mastrinten (late Cretaceous) age	$\vdash$			+	Regional stratigraphical evidence, succest a late		
* Phono-tephrites (see Appendix 4)	<b> </b>			'	Maastrichtian (late Cretaceous) age		
Phono-tephrites (see Appendix 4)	┝				-		
	⊢			*	Phono-teophrites (see Appendix 4)		
	F				non-tophines (soo Appendix 4)		
└── 6	F						
	└ <u></u> 6				······		

59-11/13 (S2)

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#### **ROSEMARY BANK**



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\* ?Upper Cretaceous (see BH 90/18-main text)

> BGS no: 59-11/13 Original site no: S2 Location: Top of Rosemary Bank Latitude: 59° 14.87' N Longitude: 10° 09.98' W Water depth: 472m

### BGS core no: 59-11/13

### T.D. metres: 4.67\*

### Original site no: S2

Grain size and sedimentary structures	Lithology ss ss ns	Description b mples	Interpretation	Age
0         (5Y53)         △D         %           Olive grey (SY53)         %         (5Y53)         %           Olive (SY53)         0         %         (5Y53)         %           Olive (SY53)         0         %         (5Y53)         %           Olive (SY53)         0         %         (5Y53)         0           Pale grey         7         1         7         1	м м м м м м м м м м м м м м	<ul> <li>Pail8885</li> <li>Sandy grave/sand, massive, graded (pebble-mgr), ps, mixed ot (50:50), biot., scattered c-granule grains.</li> <li>Lithic pebbles clast-matrix- supp, ang-subang qtzite QF rock, encrusted, scattered shells.</li> <li>Sharp, erosive base.</li> <li>Mud on muddy sand, graded, upward fining to sandy mud. Mud, massive, biot. (sand-filled bur), soft, calc., sporadic clasts inc. ang-subang and faceted Qtzite (25mm). Sand, massive, biot., f-grained, scattered crse sand and pebbles inc. faceted, subang grit and basic ig (25mm), scattered shell frags and whole bivalves, calc. Beds 10-20 cm; contacts sharp occas biot. t &gt; c (60:40)</li> </ul>	Isolated bank; predominatly sandy, occasionally gravelly, contourites, with occasional interbed of hemipelagic mud with sporadic ice-rafted dropstones	HOLOCENE (NN21)
White		Thin to thick-bedded sands and muddy sands, massive, pred. f grained, occas. graded m-sand to muddy tops, vps, mixed ct (variable 60->90%), terrig. component often most marked at base of bed, abundant sponge spicules, scattered shell frags, and lithic pebbles inc. sst and basic ig. (10mm) matrix supp. Beds, range 6-37cm, contacts sharp with thin-bedded sandy mud at top of section, massive, abundant sponge spicules, scatt-clasts inc. subang-subrd and faceted basalt (15mm).		
Brownish Olive S 2 (10Y63) a/a D S CT Olive brown a/a S Pale brown		Medium bedded sands and gravels, massive, occas graded-upfining to thin muddy top, and coarse tail up. coarsening to cobble grade. Sands, m-f grained, ps, biot., mixed of (variable > 90% c to 50:50), calc., scattered lithic pebbles to 18mm, subang-subrd, inc. basalt and interbedded f-vf grey sst and grits (TorrORS type), occas. worm-tube encrusted, matrix supp, randomly orientated.		TO
White-pale 5, 5 brown 5, 5 3 Dk olive brown 5, 5 Pale brown-y pale		Gravel, pebb-cobb grade, lithic clasts and shell debris set in vps muddy sand matrix a/a, disorganixed, matrix-to-clast supp., subang-rd, occas-faceled and scratched, some are worm-tube encrusted, inc. basic ig/meta ig (80mm), qtzite, basalt, microgranite. Beds 12-13cm thick, Sharp erosive bases		
- Dive brown to pale brown to pale brown 5 - Olive brown 5 - Olive brown 5 10YR63 5 - S	3. 	<ul> <li>very tritic-very trick bedded sands and muddy sands,</li> <li>massive, bioturbated, fine grained, ps, mixed of</li> <li>(variable 50:50 to &gt;90%c), calc., scattered lithic</li> <li>clasts, subang, occas. faceted, matrix-supp., inc.</li> <li>basic gneiss (17mm), friable white sst and qtzite,</li> <li>randomly orientated, disorganised, scatt. shell</li> <li>frags with abundant scaphopod/bryozoa tubes</li> <li>in basal bed. Beds range 1–67 cm thick, contacts</li> <li>sharp, occas. erosive</li> </ul>		SENE
4 5 Yeliow olive brown 5 5 5 5 5		With occasional med-bedded sandy mud, massive, firm, biot. (mottled, sand-filled burrows), scatt. matrix-supp lithics inc red/purple arkosic sst (Torrid/ORS type) (29mm), sharp base		MID- /LATE PLEISTOC (NN21)
- - - - - - - - -	4.	<ul> <li>Toril-log suggests 5.1m penetration: recovered section may be partly compressed</li> </ul>		
6				

59-14/2,3,9,10 (S6) 59-14/4,5,6 (S5) 59-14/7 (S4) 59-14/8 (S3)

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BGS no: 59-14/2*
59-14/3
59-14/9
59-14/10
Original site no: S6
Latitude: 59° 02.58' N
Longitude: 13° 22.76' W 59-14/9
Water depth: 1341m

\* Poor Recovery

BGS no: 59-14/4\* 59-14/5 59-14/6 Original site no: S5 Latitude: 59° 01.52' N Longitude: 13° 19.75' W 59-14/6 Water depth: 1445m

\* Poor Recovery

BGS no: 59-14/7 Original site no: S4 Latitude: 59° 01.04' N Longitude: 13° 18.40' W Water depth: 1453m

BGS no: 59-14/8 Original site no: S3 Latitude: 59° 00.14' N Longitude: 13° 16.04' W Water depth: 1585m

Location: Eastern flank of George Bligh Bank

### BGS core no: 59-14 /8

### Original site no: S3

T.D. metres: 4.0

	Grain size and	d AG				
	structures	Pe	Sub-	Description	Interpretation	Age
Depth (m)	DODSOE TO B	Ē	Samp	bles		
- 0	<u> </u>		1	**************************************	· · · · · · · · · · · · · · · · · · ·	
Ľ		$\left  \right\rangle /$				
_		ΙX				
-		$ / \rangle$			2Daga maring	
┣━		0.01	0.5	igneous, quartzite and limestone.	gravel-lag contourite	DATA
E		s	4-0.6 -	Massive mudstone vellowist-brown (10YR6/4-5/4).	Shallow-marine	$\sim$
E	\$ 6	3	-	calcareous with abundant forams and sponge spicules.	siliciclastic shelf	
-		<u>ہ</u>	MPal	Sandy poorly sorted upper section with quartz and lithic		
- 1	S .	<u>ج_</u> -آ	MPal 6896	grains of up to v coarse sand grade, and ? glauconite grains of granule to pebble grade, matrix-supported.		
E		s		Pebble-size glauconite also at 3.0 and 3.2m depth.		
F	<i>S</i>		-	Bioturbated throughout with Chondrites and Planolites,		
-		» 	1	possibly Teichichnus present above 1.5m, colour mottled throughout. Very lightweight - 'aereated' due to bioturbation.		
-	<i>s</i>		]			
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F	8					
Ľ			- MPai 8897			
-4		<u></u>	3.95-			
-				Laminated siltstone, blue-grey, non-calcareous. Composed of quartz and lithics, increased basic lithics		
$\vdash$				define darker laminae; laminations 1-3mm and sub-		
E	<b>x</b> -					
				Top is burrowed and infilled with overlying mudstone and v fine sand.		
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### BGS core no: 59-14 /7

### Original site no: S4

T.D. metres: 5.12

Depth (m)	Grain size and sedimentary structures	Lithology	Sub- Samı	Description	Interpretation	Age
			3.53 3.7 - MPail 8894 4.05	Gravel, rounded-subangular coarse pebbles of ? quartzite and dik basic igneous [from 0-1m depth?]         Massive sandy mud, dk yellowish-brown (10YR56) moderately calcareous. Bioturbated, sand-filed burrows. Sand is very poorly sorted, quartz and lithics up to medium-coarse grade. Rare foraminifera. Soft, crumbly. Cracks lined with ddrk mineral.         SHARP CONTACT         Massive calcastous, soft, crumbly, bioturbated in upper section indistinct.         With thin bed of glauconitic sandy mud at 4.0m, firm, bioturbated with dark mileral.         With thin bed of glauconitic sandy mud at 4.0m, firm, bioturbated with derk nerves.         With thin bed of glauconitic sandy mud at 4.0m, firm, bioturbated with green system.         With thin bed of glauconitic sandy mud at 4.0m, firm, bioturbated of glauconitic sandy mud at 4.0m, firm, bioturbated with derk period.         With thin bed of glauconitic sandy mud at 4.0m, firm, bioturbated with green with "crust" of glauconitic sandy mud at 4.0m, firm, bioturbated with derk period.         With thin bed of glauconitic sandy mud at 4.0m, firm, bioturbated with derk is.         With thin bed of glauconitic sandy mud at 4.0m, firm, bioturbated with green with "crust" of glauconitic sandy mud at 4.0m, firm, bioturbated with glae cream sand-filed burrows, green with "crust" of glauconitic sandy mud at 4.0m, firm, bioturbated with glae cream sand-filed burrows, green with "crust" of glauconitic sandy mud at 4.0m, firm, bioturbated with glae cream sand-filed burrows, green with "crust" of glauconitic sandy mud at 4.0m, firm, bioturbated with glae cream sand-filed burrows, green with "crust" of glauconitic sandy mud at 4.0m, firm, bioturbated with glae cream sand-filed burrows, green wi	?Deep-marine, gravel-lag contourite Shallow-marine siliciclastic shelf	EARLY TO MID-EOCENE ZEARLY (NP13-15) ZEARLY TO MID-EOCENE ZEARLY TO
- 6						

## BGS core no: 59-14 /5\*

Original site no: S5

T.D. metres: 3.7

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
			Rapid penetration to @2.0m (* see below)		
3			<ul> <li>-2.2 Massive, claystone, homogeneous, orange-brown, soft and crumbly, non-calcareous, becoming silty at base, paler brown, abundant quartz and black lithic grains.</li> <li>Pebbles in top 40cm of core may be reworked into sediment during drilling</li> </ul>	Shallow-marine siliciclastic shelf	EARLY TO MID-EOCENE 7 see 59-14 /6
	<b></b>		Site also occupied as: 59–14 /4 (TD:0.75m) <u>Gravel</u> , igneous pebbles set in v soft foram-rich sand. 59–14 /6 – see separate description		

## BGS core no: 59-14 /6\*

### Original site no: S5

### T.D. metres: 5.06

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
			According to the set of the	Shallow-marine siliciclastic shelf	EARLY TO MID- EOCENE (NP12-14)
L_ 6			I		

### BGS core no: 59-14 /3\*

### Original site no: S6

T.D. metres: 1.17

	Grain size and sedimentary	ology		Description	Interpretation	Age
Depth (m)		Lith	Sub- Sam	bles		
- 0 -			1	Rapid penetration to @0.75m		
-						
F		$ /\rangle$				
-		.0. :-	-0.59-	Thin to medium-bedded sands and muddy sands,	Deen-marine sandy and	
F		o 0 0 0 0	- 8.87	m-c-grained, modpoorly sorted, carbonate-rich (abundant forams and shell debris). Bed thickness 8-20cm,	gravelly contourites	DATA
			-1.02	snap contacts, beds massive with scattered peoples, occasional peoble-rich base grading upwards into muddy c-sand. Yellow to pale vellow brown.		
F			- 1.17 -	with interbedded thin to medium bedded gravel, up to		
F				cobble grade, poorly sorted, subang-subrd, f-grained igneous clasts, with a matrix of foram-rich muddy sand.		
<u> </u>				thickness 5-(+) 10cm, sharp contacts.		
F						
-						
2						
L			<b>*</b>	Site also occupied as $59-14/2^+$ , $59-14/9$ and $59-14/10$ – see separate descriptions.		
-  -						
F				59-14 /2 (10:0.05m) Gravel, four small pebbles recovered		
F						
- 3						
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F						
- 4						
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F				-		
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### BGS core no: 59-14 /9\*

### Original site no: S6

T.D. metres: 5.12

Depth (m)	Grain size and sedimentary structures	Lithology	Sub– Samp	Description ples	Interpretation	Age
- - - - - - - - - - - -					-	
-			- 1.5 -	Gravel, very poorly sorted, subang-subrd pebbles mainly basic igneous, some shell fragments and micritic limestone with black manganese veins.	? Deep-marine gravel-lag contourite	NO AGE DATA
	<b>*</b>		- 4.67	True depth of claystone unclear		
- - - - -		2 2 2 2	MPal 8696 5.12 ~ MPal 8907	Massive claystone, brown (7.5YH5/8), plastic, calcareous, abundant bryozoa often forming a skeletal framework within the mud matrix, occasional forams and mollusc shell debris. Skeletal debris up to fine pebble grade, rare quartz grains	Shallow-marine, mixed siliciclastic /carbonate shelf	MID-EOCENE (NP15-16)
- - - - - 6			*	Site also occupied as 59-14 /2, 59-14 /3 and 59-14 /10 - see separate descriptions		

### BGS core no: 59-14 /10\*

### Original site no: S6

T.D. metres: 5.12

Depth (m)	Grain size and sedimentary structures	Lithology	Sub- Samp	Description	Interpretation	Age
- - - - - - - - - - - - -					•	
- - -			- 1.24 -	Gravel, very poorly sorted, v angular to rounded clasts of basalt, weathered and friable red-banded igneous rock, shell fragments, granules to small cobbles.	? Deep-marine, gravel-lag contourite	NO AGE DATA
				True depth of claystone unclear		
- - - - - -			- 3.75- - 3.83 ■ PET	Massive, thin to very thin-bedded, bryozoan-rich mudstones and sandy mudstones with thin to very thin beds of bryozoan sands. Sharp bed contacts. Mudstones and sandy mudstones display variable colour – reddish-yellow (7.5Y6/6) to brown (7.5YR5/8) to brownish yellow (10YR5/8) to dark greyish brown (10YR4/2) – dependant on bryozoan content, amount of mud-grade material and dark lithic fine-v fine sand. Bryozoa grain to matrix-supported.	Shallow-marine, mixed siliciclastic / carbonate shelf	6,
- - - 5 -			- 5.12 -	very open framework – grain-supported – of bryozoa with subordinate quartz, lithics and muddy material. Cream-pale brown		7 EOCENE see 59-14
			7	Site also occupied as 59-14 /2, 59-14 /3 and 59-14 /9 - see separate descriptions		

58-14/8 58-14/42 (S7)

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BGS no: 58-14/8 58-14/42 Original site no: S7 Location: Top of George Bligh Bank Latitude: 58° 57.74' N Longitude: 13° 45.51' W 58-14/42 Water depth: 438m

## BGS core no: 58-14 /8\*

### Original site no: S7

### T.D. metres: 5.1

Depth (m)	Grain size and sedimentary structures	Lithology	Sub- Samp	Description	Interpretation	Age
				Rapid penetration to @4.25m, excepting possible gravel band @2.0-2.5m		
- - 						
- - - - 2 -			}	? Gravel band		
- 4 -			4.25	Massive to crudely bedded conglomerate, disorganised, matrix-supported, indistinct bed contacts.		
- - - - -			MPal = 8901 = 8858	Clasts predominantly dark, fine-grained, basic igneous types with subordinate skeletal fragments including molluscs and coral/crinoids. Very poorly sorted, granule to boulder grade (a weathered vesicular/ scoriaceous basalt boulder), sub-rounded, randomly orientated, but some disc-shaped cobbles are occasionally flat-lying.	Clastic-influenced, shallow-marine, open carbonate shelf	PALEOCENE 69: 58-14 /42)
- 5 -			■ PET - 5.1 -	Matrix is predominantly white carbonate comprising biosparite varying from coarsely to finely crystalline texture. Skeletal fragments include crinoid stems, serpulid tubes, molluscs and abundant foraminifera.		s)
				A subordinate but prominent terrigeneous component occurs at top and base of section: qtz and lithics, fine-medium grained, moderately sorted. Dissolution has caused a slightly vugsy appearance. Friable near base		
- - 6			•	Denome manganese (7) present in upper part of section. Site also occupied as 58-14 /42 - see separate description		

### BGS core no: 58-14 /42\*

Original site no: S7

T.D. metres: 5.12

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
			Appid penetration to @ 4.29m         4.9         Mix of pebbles and soft, calcareous sandy mud, olive (SY53).         Massive conglomerate, disorganised, matrix-supported         #370         #6371         Clasts predominantly dark, fine-grained, fresh and weathered basic igneous types. Poorly sorted, granule to enable exit ender or deable and and matrix-supported	Clastic-influenced shallow-marine, carbonate shelf	NO AGE DATA U
- - - - -			are vertica). Subordinate coarsely crystalline shelly [imestone, lithic grains and pebbles. Matrix of carbonate, biosparite includes foraminifera and other skeletal fragments partially recrystallised silightly vuggy due to dissolution.	Extrusive; basalt flow	₩ 
			<ul> <li>Basalt, weathered, grey-brown with reddened top, vericular, quartz-veined</li> <li>Site also occupied as 58–14 /8 – see separate description</li> <li>Regional stratigraphical evidence suggests a pre – NP6 age.</li> </ul>		
59-14/9 (S8)

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BGS no: 58-14/9 Original site no: S8 Location: Top of George Bligh Bank Latitude: 58° 53.11' N Longitude: 13° 43.04 W Water depth: 484m SE

## BGS core no: 58-14 /9

#### Original site no: S8

T.D. metres: 5.97

Grain size and sedimentary	logy		Description	Interpretation	Age
Depth Structures	itho	Sub-			, i igo
		Janny MPel			
Grey D S	·	8859 - 0.28	Stacked sequence of thin to thick-bedded sands and muddy sands massive bioturbated fine-med orgined	Interbedded deep-marine sandy and oraded sandy-	
White 10YR81		8860	poorly sorted, occasionally graded (distribution, upwards-fining) med. sand to mud, occasionally gravelly, calcareous.	to-muddy contourites with occasional hemipelagic muds	
		- 0.71 - 0.75 - 0.83 - 0.87 - 0.9	Mixed c>t (mostly >75->95%), partly reflected in colour, abundant forams. Coarse sand grains to pebbles disseminated throughout.		
to white %		- 1.15	Lithic clasts are matrix-supported, subangsubrd, inc. grey sst (10mm) and fine gr. black igneous., scattered shell frags, randomly orientated.		
- brown 10YR6/3			Variable colour		
- I			Beds range from 4-84cm; bed contacts vary from sharp to gradational, occasionally bioturbated.		
-			With, thin-bedded sandy mud near base of sequence, massive, bioturbated, calcareous, sharp contacts.		
		- 1.99			
brown 10YR63					
Pale		-2.24			)-21)
whiteish %	· •				NN2)
	· · · ·				OCENE
Pale		- 2.78			EISTO
					ц Ш
	· · ·				LAT
F	<u></u>	- 3.32			0 10
Pale brown					Σ
	• -				
- I					
Brown/Pale	 	- 4.05			
White to		- 4.27			
_ Pale brown					
- Brown		- 4.49			
F		- 4.74		-	
White		4.00			
Brown 5 Brownbala	o: • • •	- 5.0			
brown		- 5.14			1
		- 5.24			
		MPal			
- White		5.55	-		
	2.0	3.00			
_ Pale brown					
<u>6</u>		1-5.97		L	

}	58-14/10 & 43 (S9)
	58-14/11 (S10)

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Water depth: 1033m

## BGS core no: 58-14 /10\*

Original site no: S9

T.D. metres: @2.6

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
			Rapid penetration to @1.3m Calcareous sandy mudstone /sparse-packed biomicrite (>10-50% allochems) - biogenic fragments of sand grade set in a micritic matrix. yellow (10YR88), friable, crudely laminated with alignment of biogenic	Clastic-influenced, shallow-marine	
			<ul> <li>Maa</li> <li>debris. Very strongly effervescent: biogenics&gt;</li> <li>terrigeneous (&lt;2%). Thick-bedded. Very poorly sorted.</li> <li>Mar/Indurated calcareous mudstone, a/a but indurated</li> <li>and also grading into ?sparite – more coarsely crystalline at base of bed. Streaky lamination in upper part with alternation of darker micritic laminae and paler, more crystalline laminae. Pale yellow</li> <li>Thick-bedded calcareous mudstone sparse biomicrite, fossiliferous, greenish-grey (SBG6/), frable with occasional cavities infilled with crystalline calcite. Rare carbonaceous (wood?) fragments, but persistent glauconite Yellow-brown spotting/speckling occasionally observed. More consistent/uniform micritic texture than overlying beds. Pyritic. Very poorly sorted.</li> <li>★ Site also occupied as 58-14 /43 - see separate description</li> </ul>	carbonate shelf	LATE PALEOCENE TO EARLY EOCENE (NP7-13)

## BGS core no: 58-14 /43\*

#### Original site no: S9

T.D. metres: 5.12

Depth (m)	Grain size and sedimentary structures	Lithology	Sub– Samp	Description	Interpretation	Age
			- 1.37			
			1.5	Gravel, poorly-sorted, angular-subrounded clasts include dark fine-grained basattic cobble, quartzo-feldspathic basement types and pale grey medium-fine-grained sandstone. Some of clasts may be from sea bed: partly shell encrusted.	gravel lag_contourite	
			= 3.92 = MPail = 8904 = 8872 = 5.12	Calcareous sandy mudstone, very poorly sorted with abundant scattered shell debris up to very coarse sand grade set in medium to very fine sandy muddy matrix with biogenics > terrigenous (latter up to 10%). Fe-rich upper section, (olive yellow, 2.5Y68) between 3.92 and 4.4, includes several crusts/concretions, easily broken by finger pressure, up to 3cm dia. Between 4.4 and 5.12, colour is greenish-grey (5BG61), much reduced, with pyrite. Colour boundary is sharp and cross-cutting – a redox boundary? Core was much broken up on recovery, but seems fairly massive and disorganised	Clastic influenced, shallow-marine carbonate shelf	LATE PALEOCENE (NP6-9)

## BGS core no: 58-14 /11

Original site no: S10

T.D. metres: @5.1

Depth (m)	Grain size and sedimentary structures	Lithology	Descript ub- amples	tion	Interpretation	Age
			Rapid penetration to ( sand ? (see below)	@1.9m – muddy		
	? ROCKHEAD		2.12 Gravel, poorly sorted, a basement, fine-grained below), some of clasts muddy sand. Clasts up precipitate on some of Steady drilling from @	ngular to rounded, includes igneous and sandstone (as coated with very fine foram-rich p to 4cm diameter. Mn f clasts	Gravel lag	NO DATA
			<ul> <li>Bioclastic sandstone, m sorted, predominantly fi sporadic very coarse s and thin beds (3-4cm sand grade set in a fi biogenics &gt; terrigene sess be up to 40%. Interna laminated (imparted by disorganised. Thin she kower bed may have a Down-core colour char greenish-grey (reduced pyritic mudstone at bas)</li> </ul>	nedium-bedded, moderate to poorly ine-coarse grained with sand/gravel grade shell fragments ) of shell debris of very coarse ner sand matrix. Generally eous component though latter may uly the beds vary from crudely y shell fragments) to massive and il beds display sharp contacts; slightly erosive base. nge from yellow (Fe-rich) to 1). Fragments of greenish grey se of sequence.	Clastic-influenced, shallow-marine carbonate shelf	LATE PALEOCENE (NP6-9)

58-14/53 (S11)

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BGS no: 58-14/53 Original site no: S11 Location: North-west Rockall Trough Latitude: 58° 37.36' N Longitude: 13° 11.62' W Water depth: 1595m

## BGS core no: 58-14 /53

### Original site no: S11

T.D. metres: 5.1

	Grain size and sedimentary	logy		Description	Interpretation	Age
Depth (m)	structures	Litho	Sub– Sample	S		ge
		~ %;0;	0.1 - st - 0.2 - G	lud, pale brown (10YR63), scattered pebbles, becoming andy towards base. rravel, angular	?Deep-marine sandy to muddy contourite	NO AGE DATA
-					(gravenag contounte)	
-						
-  -						
2						
-						
-						
	5	الحم الحم م الحم ال	2.8 C	alcareous clay /claystone (marl?), orange-brown but with lack streaks throughout, massive and structureless, hard indurated at too, floo, few, cm) but buttery below	Shallow-marine siliciclastic shelf	
-	55	المحمر المحمر المحمر المحمر المحمر المحمر	Sk CC bl	cattered predominantly matrix-supported fine-very barse sand and gravel grade lithic fragments, mostly lack volcanic grains and ?glauconite in top of section.		-EOCEN 16)
	5		MPai pa 8874 pa 3.47 lo	durated sample veined by ?manganese (dendritic attem on top surface). Occasional black tubes @1cm ng, brittle – relicts of bioturbation. Strongly calcareous av		diw WN)
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Fe						

58-14/31 & 32 (S12)

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AIRGUN

BGS no: 58-14/31<br/>58-14/32Original site no: S12<br/>Location: North-east slope of Rockall Bank<br/>Latitude:  $58^{\circ} 20.52^{\circ} N$ <br/>Longitude:  $13^{\circ} 48.81^{\circ} W$ 58-14/31<br/>Water depth: 705m

## BGS core no: 58-14 /31\*

Original site no: S12

T.D. metres: 3.96

Depth (m)	Grain size and sedimentary structures	Lithology	Sub Samp	Description	Interpretation	Age
				Rapid penetration to @3.51m		
			* 3.96 * * MPai * * MPai * * *	Massive conglomerate, disorganised, matrix-supported. Clasts predominantly dark, fine-grained, weathered, basic igneous types with subordinate 'rip-ups' of matrix material in brecciated basal 10cm. Very poorly sorted, granules to cobble grade, randomly orientated. Some of clasts fractured with infilis of carbonate material. Surface of some clasts highly irregular:solution pitted? Matrix is white to yellowish carbonate: biosparite variably coarsely to finely-crystalline. Skeletal debris includes molluscs, crinoid stems and foraminifera. Subordinate quartz and lithics, fine-medium-grained, moderately sorted, also set in carbonate matrix. Locally friable where sandy. Dendrite manganese present throughout, especially in basal 10cm. Also styolite developement in basal 10cm.	Clastic-influenced, shallow-marine carbonate shelf	INDETERMINATE AGE +

## BGS core no: 58-14 /32\*

T.D. metres: 4.0

### Original site no: S12

Depth (m)	Grain size and sedimentary structures	Lithology	Sub Samp	Description	Interpretation	Age
				Rapid penetration to @3.0m ?Foraminiferal-rich sand, fine-grained, common lithics, includes lumps of underlying limestone and fragments of coral (Little or no recovery – small bag sample)		
	55 - 55		- 3.0 - MPai 8866 MPai 8902 MACR 8986	Bioclastic limestone, pale yellow (2.5Y8/4). Abundant forams and molluscs set in a matrix of crystalline carbonate with subordinate lithic grains. Evidence of erosion and burrowing particularly at top; some of burrows infilled with soft micrite. Porous, much dissolution throughout.	Isolated carbonate bank	PLIOCENE (NN12-15)
4	¥		■ MPat ■ 8867 4.0	<ul> <li>SHARP CONTACT</li> <li>Massive conglomerate, disorganised, matrix-supported (few clast-clast near base).</li> <li>Clasts predominantly dark, fine-grained, weathered basic igneous types, randomly orientated, possible solution-pitted surfaces. Poorly sorted, angular to subrounded, and subordinate clasts may include chert and dark grey sandstone</li> <li>Matrix of carbonate a/a with subordinate terrigenous grains, moderately sorted, fine to medium sand grade. Friable near top where sandy.</li> <li>Dendritic manganese common: appears to grow outward from the rims of igneous clasts into the carbonate matrix.</li> <li>Site also occupied as 58–14 /31 – see separate description</li> </ul>	Clastic-influenced, shallow-marine carbonate shelf	INDETER- MINATE AGE +
			t	- Regional stratigraphical evidence suggests a late Paleocene to early Eocene age.		

58-14/29 & 30 (S13)



## BGS core no: 58-14 /29\*

### Original site no: S13

T.D. metres: 5.12

Depth (m)	Grain size and sedimentary structures	Lithology	Sub Samp	Description	Interpretation	Strat. unit
-	C		MPal 8905 0.4	Gravel, drilled cobble of fine-grained, grey basalt coated in creamy limestone: micrite cement with abundant allochems of coral, forams and bivalves, also smaller pebbles of limestone, dark basic igneous and QF metamorphic basement.	? Deep-marine gravel-lag contourite	
			-0.46 MPai 8899	Massive to crudely way laminated, sitly vf gr.sandstone, orange-brown to grey, variable calcareous, poorly sorted, strongly bioturbated, predominantly <u>Chondrites</u> with subordinate <u>Planolites</u> and a "crescentric-style" burrow (like <u>Zoophycosil</u> ), occasional woody fragments, rare shell fragments, sporadic post-depositional fractures associated with black mineralisation/staining, with occasional thin beds of intraformational pebbly sandstone, dk brown mudst/clayst rip-up clasts (1-2cm), matrix-supported, randomly orientated, bioturbated. Indistinct bed contacts	Delta-front / marginal marine	
			O ← G ● MPai 8864 -5.12 ★	range-brown Colour change @3.28m rey ? GRADATIONAL CONTACT Massive to crudely laminated siltstone, grey, non- calcareous, strongly bioturbated with abundant <u>Chondrites</u> concentrated in specific horizons (1.5–6cm thick) Site also occupied as 58–14 /30 – see separate description	Delta advance Prodelta / Shallow marine siliciclastic shelf	EARLY TO MID-EOCENE (NP10 /11-15)
- - - 6						

## BGS core no: 58-14 /30\*

### Original site no: S13

T.D. metres: 4.6

Depth (m)	Gra sec str	ain siz diment ucture	e and tary s .∑™ §	Lithology	Sub San	  nples	Interpretation	Age
						Rapid penetration to @0.68m		
-  -  -  1	SNOE		<u></u>		0.68	Crude planar to wavy laminated/bedded, silty very fine gr. sandstone, poorly sorted, variably calcareous, moderate to strongly bioturbated with abundant <u>Chondrites</u> , <u>Planolites</u> , extensively colour mottled, orange-brown, burrow-fills include pale and dark brown mud,	· · · · · · · · · · · · · · · · · · ·	
	Calcare		- <u>*</u> * = *	 		with occasional thin bed (10cm) of intraformational conglomerate, glauconite and sand/silt rip-ups to pebble grade, clast to matrix-supported, randomly orientated, rare shell clasts, bed is burrowed.		
		<u>+</u>	N		•	Occasionally cut by thin vein-like fractures some of which have black mineralisation or staining along them.		
- 2 - - -				· · - ·			Delta-front/marginal marine	
-			-/		•			
			5			Orange-brown Colour change @3.28m		8-14 /29)
- - -	Calcareous				•	Grey		OCENE (see 5
- 4  -			× × × × × ×		2 • • •	<ul> <li>— GRADATIONAL CONTACT ———————————————————————————————————</li></ul>	Delta advance	EARLY TO MID-E
		.9.		 	4.6	In section 4-4.6m, <u>Chondrites</u> occur in discrete bands 1.5-6cm thick.	Procetta / shallow marine, siliciclastic shelf	
- - - - 5								
						★ Site also occupied as 58-14 /29 - see separate description		
	_							

58-14/34 (S14)



BGS no: 58-14/34 Original site no: S14 Location: North-west Rockall Trough Latitude: 58° 16.51' N Longitude: 13° 05.11' W Water depth: 1486m NE

## BGS core no: 58-14 /34

### Original site no: S14

T.D. metres: 5.25

	Grain size and sedimentary	logy		Description	Interpretation	٨٩٥
Depth (m)	structures	Litho	Sub Samp	bles	morprotation	Aye
	Pale office 5Y63 Yelkow brown 107R5v4 S	0 - 0 - 0	MPal 8868 = 0.11 0.14 = 0.25	Medium-bedded, slightly gravelly muddy sands, massive, calc., bioturbated, f gr., ps. Mixed c>t (>75->90%) abundant forams. Sporadic matrix-supp. lithic clasts, subang-subrd, inc. basic igneous, scatt. shell frags., (randomly orientated, sharp to erosive bases with, thin	Interbedded deep-marine sandy and muddy contourites, and hemipelagic muds with sporadic ice-rafted	
	IoyR43		■ MPal 8889 - 0.63	Massive graded beds: basal c-vc sand fines up to muddy fgr sand and sandy mud. Basal unit > 90% terrig., erosive base. Overlying sand carb. rich > 75%, inc. forams. Bioturbated inc. <u>Planolites</u> and sand-filled burrows in mud, scattered lithics inc. basic igneous, ang-subang, 35mm, matrix-supp. Calc.	dropstones	
1 	Pale olive brown 2.5Y5/4			Mud, massive, bioturbated, abundant sand-filled burrows to 1.0m, colour mottled throughout, scattered black sulphidic specks, soft and buttery (in lower part) but occasional firmer horizon, becomes sandy towards base which is indistinct through bioturbation.		
	n ~ % ~ %			Scattered lithic clasts, matrix-supp., inc. subang, grooved grey siltstone (15mm). Calcareous		4N20-21)
- 2 - -	Brown to pale 5		-2.06-	Interbedded medium-thick-bedded muddy sands and sandy mud a'a, massive to crudely bedded, occ. graded. Sands m-f gr, vps, mixed c>t (>25->90%), bioturbated.		eistocene (n
- - -	Ulive brown %	0 0 0	-2.45	inc. igneous/meta. types to 45mm, some fractured, randomly orientated. Gradational to sharp and occas. erosive bed contacts.		TO LATE PLI
- 3	Pale brown %	•••• ••• •••	- 3 17			MID
- - 	55		0.11	Mudstone (clayey), soft-firm, massive, buttery but flaky crumbly fracture, weakly calcareous, bioturbated, black sulphidic specks in lower part, sporadic mud rip-up clasts and quarz/lithic vc sand/granules, matrix- supp, occasional slightly sandy texture - infilled burrows?	Shallow-marine siliciclastic shelf	
- - - 4	Brownish yellow (10YR64) to yellow (10YR7/8)	     				
-	5 S					VP14-17)
	~		MPal 8870			MID-EOCENE (1
	~		- 5.25 —			
- -				-		
- -						

57-14/49,51,52 (S15)

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SW



BGS no: 57-14/29\* 57-14/51\* 57-14/52Original site no: S15 Location: North-east slope of Rockall Bank Latitude:  $57^{\circ} 57.19'$  N Longitude:  $13^{\circ} 04.34'$  W 57-14/52Water depth: 531m

\* Poor Recovery

## BGS core no: 57-14 /52\*

### Original site no: S15

#### T.D. metres: 3.05

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Strat. unit
			Rapid penetration to 0.05m, then steady drilling to @ 3.0m		
- - - - - - 3			<ul> <li>2.71 Basalt (?), slightly weathered, fractured, cut by network of calcite veins, porphyritic with feldspar clasts floating in fine, dk. matrix.</li> <li>PET Top surface partly bryozoan encrusted</li> </ul>	? Boulder or <u>in situ</u> [Extrusive; basalt flow]	NO AGE DATA
- - - - - - - - 4 -			★ Site also occupied as:		
- - - - - - 5 -			57–14 /49 (TD: 0.05m) Pebble of amygdaloidal basalt 57–14 /51 (TD @ 2.35m), Basaltic pebbles		
- - - - -			-		

57-13/53 (S16)

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NE



BGS no: 57-13/53 Original site no: S16 Location: North-west Rockall Trough Latitude: 57° 54.22' N Longitude: 12° 43.95' W Water depth: 1480m

## BGS core no: 57-13 /53

#### Original site no: S16

T.D. metres: 2.84

Grain size and	<u>Арс</u>			
structures	oloci Sub	Description	Interpretation	Age
	i Sam	ples		
(Olive)-brown         %           10YR62         %           0.05-0.33)         %           0live-brown         %           (10YR4/3)         %           Olive grey         %           (10YR4/1)         %	0	<ul> <li>Sand, massive, f grained, mod sort., foram-rich, calc., occas. small pebbles, matrix-supp., sharp-irreg. biot.</li> <li>base, sand extends down to 0.08</li> <li>Mud, massive, bioturbated (Zoophycos and Chondrites), inc. sand-filled burrows, black sulphide knots in lower half of core, mottled throughout, mod. calcareous, soft-firm, sporadic matrix-supp. lithic pebbles to 1cm.</li> </ul>		E PLEISTOCENE HOLOCENE 21)
- 0.65-0.92 - 10YR41 - 1.092-1.0 - 1.0YR54 - 1-1.2 - 10YR73 	0.00 0.00	Medium beds of muddy gravelly sand/muddy sandy gravel, graded, upwards coarsening (CT) and fining (D), massive texture, partly bioturbated in muddy sand intervals, vps, sand is f-m grained, abundant forams, gravel content varies mostly lithic but with large gastropod shell and smaller bivalve shells at top of section, matrix-to-clast supp., mostly black lithics but also dk red brown/purple sst, rd-subang, randomly orientated. Mod. calcareous. Bed contacts sharp: erosive at base with large clast.	Interbedded, deep-marine, sandy, occasionally gravelly, contourites and hemipelagic muds with sporadic ice-rafted dropstones	LATI 10 NN
- 10YR5/3 5 - 5 - 5 - 2 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5	     	Mud, massive, bioturbated (inc. <u>Chondrites</u> ), occas. matrix- supp. clasts inc. lithics and mud rip-ups', occas. sand-filled burrows		
□ 10YR73-63	2.33	Transitional contact, graded, laminated muddy sands/ sandy muds with large dropstone of gneiss. Sand, massive-crudely bedded, bioturbated (inc. <u>Planolites</u> ). F-m grained, m-p sorted, sporadic small lithic pebbles, matrix-supp. pred. black igneous types, foram-rich, calcareous. Sharp irregular base, slightly bioturbated with massive mud below		EARLY /MID- PLEISTOCENE (NN19)

57-13/54 (S17)



## BGS core no: 57-13 /54

#### Original site no: S17

T.D. metres: 1.1

	Grain size and sedimentary structures	nology	Sub-	Description	Interpretation	Age
Depth (m)		E	Samp	bles		
			1	Rapid penetration to @ 0.44		
-						
E		$ / \setminus$				
<b>–</b>	-	25	- 0.44 -	Massive baseltic applomente very poorly sorted		NO AGE
-		2 C	PET	disorganised, matrix-to-clast-supported.	Extrusive; voicaniciastic	DATE
Ľ				Clasts predominantly basic igneous types, many		1
-			1	decomposing to white, non-calcareous material, granule to coarse pebble grade, randomly orientated.		
<u> </u> 1		0		In lower part of core, clasts set in a "skeletal"		
Ę	······		ר ייי	carbonate matrix, crystalline, vein-like and occasionally		
<b>-</b>				clasts in lower 10cm.		
-						
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-			t t	Regional stratigraphical evidence suggests a late		
F				Paleocene to early Eocene age (possibly affected by cataclasis)		
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57-14/53 (S18)

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BGS no: 57-14/53 Original site no: S18 Location: Top of Rockall Bank Latitude: 57° 34.14' N Longitude: 13° 19.80' W Water depth: 177m

## BGS core no: 57-14 /53

### Original site no: S18

T.D. metres: 3.2

Depth (m)	Grain size and sedimentary structures	کن OO Description برج Sub- Samples	Interpretation	Age
0   		Rapid penetration to 0.64m	-	
		V V V V V V V V 0.77 V V V V V 0.86 V V V V V 0 V V V V V 0 V V V V V 0 V 0	Extrusive; trachyte flow	ш
- 2 		v v v v v v v v v v v v v v v v v v v		LATE PALEOCENE TO EARLIEST EOCENI
- - - - - - - 4 - - - -		32		

# 57-13/63,64,65 (S19)

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\*Poor Recovery
# BGS core no: 57-13 /65\*

Original site no: S19

T.D. metres: 3.1

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
-			2.2     Sand, well-sorted, very fine-grained, massive, terrigenous > biogenics (<1%), non-calcareous, dark yellowish brown (10YR44)     2.5     Gravel, single clast of acid igneous (4.5cm)     Mud, slightly sandy, massive, non-calcareous, dark yellowish brown (10YR44)     2.8     Gravel poorty sorted, subangular-well rounded, include	Deep-marine sandy and gravelly contourites, and hemipelagic muds	NO AGE DATA
- - - - -			2.9 dark fine-grained igneous and porphyritic igneous, MPai leucocratic basement and volcanic conglomerate. Band is very discrete – sharp contacts Mudstone, massive, non-calcareous, dark yellowish brown (10YR44)	? Deltaic /marginal marine	INDETERMINATE AGE
- - 4 -	-		★ Site also occupied as: 57–13 /63 (TD: 3.5m; recovery, 0.5m) <u>Gravel</u> poorly sorted, angwell rded basaltic clasts, traces of sandy mud, soft to firm, dk yellowish brown (10YR36)		
- - -	 		57–13 /64 (TD:1.0m; recovery 0.17m) <u>Gravel</u> , basaltic clasts in matrix of dk yellowish brown (10YR4/4) sandy mud		
- - - -			i Hegional stratigraphical evidence suggests a late early to mid-Eccene (NP13-14)		
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57-13/66,67,68 (S20)

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\* Very Poor Recovery

NE

# BGS core no: 57-13 /66\*

## Original site no: S20

T.D. metres: 0.9

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
				-	
-		$\bigcirc$	? Single large cobble, ~17cm max. diameter, of PETdark_fine-grained_igneous_rock.	Lag gravel	NO AGE DATA
1 					
-					
-					
- 2					
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_			$\star$ Site also occupied as :		
-			57–13 /67 (TD:5.12m) No recovery		
-			57-13 /68 (TD:0.16m) Muddy sand, 90% carbonate (forams, bivalves, bryozoa), pale grey (2.5Y7/2)		
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57-14/47 & 48 (S21)

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# BGS core no: 57-14 /47\*

#### Original site no: S21

T.D. metres: 1.1

Sand, masker, skiptby gravely,	Depth (m)	Grain size and sedimentary structures	Lithology	Sub– Samp	Description	Interpretation	Age
* Site also occupied as 57-14 /48 - see separate 		× × × × × × × ×		-0.21 -0.22	Sand, massive, slightly gravelly, m–f gr., mod–poorly sorted, carb. rich (forams), strongly calcareous, bioturbated (sand–filled burrows), bioturbated base extends 5–6cm into mud. Pale yellow (5Y74) Mud massive, v soft, bioturbated (sand–filled burrows, inc. <u>Zoophycos</u> ), slightly, sandy, sporadic matrix–supported lithic clasts, pred. basic igneous, ang, –well–rd, to 3cm, scattered shell frags., sporadic sulphidic specks, moderately calcareous. Olive brown (2.5Y44)	Deep-marine sandy contourite Deep-marine hemipelagic muds with sporadic ice-rafted dropstones	PLEISTOCENE (see 57-14 /48)
				-1.1 - *	Site also occupied as 57-14 /48 - see separate description		

# BGS core no: 57-14 /48\*

## Original site no: S21

T.D. metres: 2.3

	Grain size sedimenta	and	γgo				
Deoth	structures	• 7	hole	Sub-	Description	Interpretation	Age
(m)	۵۰۵۶۰E-۶ ۱۱۱۱۱۱	clay	Ē	Samp	les		
F		<sup>%</sup> %	<u></u>	MPal 8848	Mud, massive, soft, light olive brown (2.5Y54), bioturbated (sand-filled burrows and burrowed top to 3-4cm	Deep-marine,	ENE ENE
È		55 55			depth: from sea bed veneer?), scattered matrix-supported clasts, inc. basement gneiss (2cm), and shell debris, mod. to	sporadic ice-rafted	STOC
-		% «			weakly calcareous. Sharp base.		PLEI
F		s. "	<u> </u>		This hedded sand machine if a grained poorly poted		LATE
-		\$\$	 		carbonate rich (90%) inc. forams and comminuted		۲ <sub>£</sub>
F			0000 0000	-0:82-	Medium-bedded sandy gravel, slightly muddy, very poorly	Deep-marine sandy	ARL√ NH9-:
<u> </u>	4	5~~~	<u>~ ~ ~ ~</u>	-1.0	predominantly lithics up to 3cm, clast-to-matrix	Deeo-marine.	<u> </u>
<b> </b>		5	·		brown (2.5Y54). Sharp base, erosive with rip-up clasts	sandy contourites	
L		5			Muddy vf sand/sandstone, massive, bioturbated		
<b></b>		s			skeletal debris, subordinate lithics, sporadic indurated bands scattered lithic, orains mod-strong calc, white		
				1	(5Y8/2).		
-	Y	)					
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F				*	Site also occupied as 57-14 /47 - see separate		
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57-14/42 & 43 (S22)

57-14/37,44,45,54 (S23)

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# BGS core no: 57-14 /42\*

## Original site no: S22

T.D. metres: 1.05

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
- 0 			Rapid penetration to 0.7m: outer barrel smeared with muddy sand	-	
- - 		$\sim$	<ul> <li>0.7</li></ul>	? Deep-marine gravel lag contourite	NO AGE DATA
- 2 					
- -					
- 					
			★ Site also occupied as 57–14 /43 - see separate description		
- 4 - - -	. 7				
- - - - 5					
- - - - 6			~	-	

## BGS core no: 57-14 /43\*

## Original site no: S22

T.D. metres: 0.95

	Grain size and	gy				
	sedimentary	90	Sub	Description	Interpretation	Age
Depth (m)	aoagoe₊za à	Lith	Samp	bles		
— `0			1			
		$  \rangle /$		Rapid penetration to 0.65m: muddy sand cover? SEE 57-14 /42		
-						
-						
		$ / \setminus$				
-			- 0.65 - MPal	Sandstone, massive, moderate to poorly sorted, slightly	2 Deltaic /maroinal	虎世十
-			- 8845 MPal	muddy/muddy, very fine- to fine grained, non-calcareous, predominantly quatz and lithics with some	marine	
		· <u>·</u> ···	8846 - 0.95 -	carbonaceous debris – wood fragments (?) up to		THE S
- '				throughout, friable.		
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			<del>*</del>	<ul> <li>Site also occupied as 57-14 /42 - see separate description</li> </ul>		
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			†	Regional stratigraphical evidence suggests a late		
- 3				early to mid-Eocene age (NP13-14)		
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# BGS core no: 57-14 /54\*

## Original site no: S23

T.D. metres: 2.0

Depth (m)	Grain size and sedimentary structures	Lithology	Sub- Samp	les	Description	Interpretation	Age
	S S S S S S S S S S S S S S S S S S S		MPal 8851 0.65 0.73 0.8 1.21 MPal 8852 1.9 1.9	Thin-bedde mixed terrig White (5Y8/ (Thin-bedde poorly sorte brown (2.5) Beds 7-8cr Thick-bedd (mottled), vf with both fi Common m udstone ( scattered s Beds range Variable co lower bed i	d sand, massive, vf-f gr., mod-poorfy sorted, g /carb. (pred. carb: abundant forams). 2). Sharp base. d muddy sands, massive, bioturbated, vf-f gr., ad, mixed terrig./carb. (pred. terrig.), olive Y44) to dk. greyish brown (2.5Y42). m thick, sharp contacts. led gravelly muddy sands, massive, bioturbated i-crse, poorly sorted, pred. terrig. Graded ining and coarsening-up sequences. matrix-supported clasts include basalt and soft (up to 10cm), randomly orientated, with skeletal debris and forams. e from 41-69cm thick; bed contacts are sharp. Hour: upper bed is olive brown (2.5Y44); is dk. olive grey (5Y3/2).	Deep-marine sandy contourites	VID-PLEISTOCENE TO HOLOCENE NN20-21)
- 2 -	L		- 2.0) - MPal 8853	hackly fract	ture, fossiliferous with bivalves, grey]	<u>contourite</u>	
			*	Site also o 57–14 /37 57–14 /44 57–14 /45	<ul> <li>(TD:0.4m) <u>Sandy gravel</u>, vps, pred. lithics, basic igneous but also friable grey brown fine-grained sst., ang-subrd, up to 6cm. Some are corbonate-encrusted; occasional carbonate clasts. Sandy matrix, vps, muddy, calc., olive (5Y5/3).</li> <li>(TD:3.77m; recovery 0.44m) <u>Gravel</u>, inc. 26cm drilled cobble/boulder of grey sittstone/ fine sst [MP8847], laminated /thin-bedded, hard, indurated. Smaller igneous pebbles.</li> <li>(TD:2.1m) <u>Gravelly sand</u>, black, med-crse gr., glauconitic(?), vps, igneous pebbles and drilled cobble of bioturbated grey fine-grained sst. or siltstone.</li> </ul>		

56-14/10 & 13 (S24)

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# BGS core no: 56-14 /13 $^{\rm t}$

## Original site no: S24

T.D. metres: 2.1 \*

Grain size and sedimentary structures	<u>Andread Sup-</u> Sami	Description	Interpretation	Age
7 Oxidised top of bed	•         •	Thin-to-medium-bedded sands and pebbly sands with rare very thin-bedded mud. Sands are moderate- poorly sorted, predominantly medium-coarse grained and occasionally slightly muddy. A variable colour – white (5Y8/)/blive (5Y6/–3)/grey(5Y61–7/2)-reflects a variable terrigenous/biogenic ratio. Rare brownish colouration at top of bed suggests partial oxidation. Beds range from 4–16cm thick; bed contacts vary from sharp to gradual and indistinct. Internally the sands are predominantly massive and disorganised with irregular concentrations of lithic pebbles and shell debris. Possible graded bedding observed in the lower ball of the section; includes coarsening unwarde(	Deep-marine Sandy contourites; occasional muddy contourites	MID- JATE PLEISTOCENE TO HOLOCENE (NN21)
	2.1	fining-upwards, couplet. Minor bioturbation including (vertical pipes and sand-filled, ovoid lenses) has produced occasional colour mottling.		
- - - 	*	Drill-log suggests 2.1m penetration: recovered section may be partly compressed; some of lower section may also have been lost.		
- - 		Site also occupied as: 56–14 /10 (TD:5.1; recovery 0.1m) Gravel poorly sorted, mostly basic igneous clasts, occasional grey sandstone, several coherent lumps of shelly muddy sand, clasts up to 4.5cm diameter.		
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56-15/11 & 12 (S25)

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BGS no: 56-15/11 56-15/12 Original site no: S25 Location: Top of Rockall Bank Latitude: 56° 58.52' N Longitude: 14° 36.38' W Water depth: 158m

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# BGS core no: 56-15 /11

#### Original site no: S25

T.D. metres: @1.0

	Grain size and sedimentary	оду	Description	Internetation	_
Depth	structures		Sub- Samples	interpretation	Age
-		$\left  \right\rangle /$			
		Ň			
		$ / \setminus$	Gravel, angular lithic pebbles/cobbles, partly worm-	Lag gravel	
		050	-0.76 encrusted (worm tubes). Clasts predominantly gneissose and dark fine-grained igneous types.		
	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	$\approx$	-1.0 Gneiss, very coarsely crystalline, partly foliated, leucocratic	Metamorphic basement	ZOIC
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## BGS core no: 56-15 /12

## Original site no: S25

T.D. metres: 0.85

Depth (m)	Grain size and sedimentary structures	Lithology	Sub- Samj	Description	Interpretation	Age
	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		- 0.62 -	Gneiss, coarsely crystalline, banded leucocratic and melanocratic layers. Top is weathered and partly encounted with borozoa and worm tubes	Metamorphic basement	ZOIC
			0.85			ARLY
				100		
-				Sm–Nd date of 1914Ma		
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#### ROCKALL TROUGH



BGS no: 57-13/26 Original site no: S26 Location: Rockall Trough, south-west of Anton Dohrn Latitude: 57° 07.55' N Longitude: 12° 05.96' W Water depth: 1961m

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## BGS core no: 57-13 /26

Original site no: S26

T.D. metres: 3.08

	<u> </u>						
	Grain size ar	nd	} ₹				
	sedimentary		ő		Depariation	Internet it	1.
	structures		ō	Sub	Description	Interpretation	Age
Depth			÷	Sub-			
(m)				Samp	nes		
	\$			MPal	Mud massive homeseese week to ask homesing for		
Γ		. I		8827	downcore, bioturbated with Zoophycos common in		E E
F		" f		1	top 1.7m, also possible Planolites, Teichichinus (vertical		hğ_r
F		ł		1	spreite), chondrites, some of burrow-fills slightly sandy,		1251
F	5	ł		1	some burrows still open, Black sulphidic specks		ΥŽ
<u> </u>		.		MPal 8828	scattered below 0.5m, becoming common below 1.7m includes patches and brack and discrete		
F		°⊦			black lumps. Acid-induced hydrogen sulphide odour.		
F		ŀ			moderately calcareous		
L-		L				-	1
F	μ (1)						
<u> </u> 1	~			MPai			
L'		L		- 8829	Colour variation:	Deep-marine	
L		Б			0.025-11 pale plive orev (5762)	nemperagic muds	
		Γ			1.1-3.08, olive grey (5Y4/2)		NZY NZY
Γ	\$	Γ					z
Γ	"	F		MBal			빌
<b>—</b>		ŀ		8830			Ш. С
F		st					Ď
F		+		<	Slightly 'firmer' horizon @1.72m: Planolites abundant		EIS
$\vdash$	a.	H			at this level, <u>Zoophycos</u> above and below.		Ы
F	/» ~	· F					Щ
<u> </u>		H		MPal 8831			3
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		ĺŀ.		<ul> <li>MPai</li> <li>8833</li> </ul>			
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57-12/33 (S27)

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BGS no: 57-12/33 Original site no: S27 Location: Rockall Trough, south-west of Anton Dohrn Latitude: 57° 13.79' N Longitude: 11° 22.15' W Water depth: 2035m

## BGS core no: 57-12 /33

## Original site no: S27

T.D. metres: 3.06

	<u> </u>	1			T	
	Grain size and				1	
	sedimentary	ŏ		Description	Interpretation	
	structures	Q	Sub-	Description	Interpretation	Age
Depth		主	Same			
			Sam	0163		
Ľ	Π	20,00	MPal	Medium-bedded (muddy) gravelly sand massive	Interpedded deep mariae	
	) » <u>«</u>	10	8824	graded, m-f grained, poorly sorted, mixed c>t	sandy and gravely	
Γ	۰ <u>۲</u>	$\sum_{i=1}^{n}$	0.25	(abundant forams), calcareous, bioturbated, clasts	contourites, and	
Γ	<u> </u>	÷.	- 0.36	matrix-supported, inc. gneiss 5cm, pale brown (10YR63)	hemipelagic muds with	
F	\~ «		0.39	This to thick bodded stude statist that I (	sporadic ice-rafted	
<u> </u>	- 13	<u> </u>	1	vellowish brown (102785/4) colour bacded sand-filled	diopsiones	년 년 년
F	<del>*</del> ~		1	burrows, scattered black sulphidic streaks		CE 19-
<b>-</b>	5		-			δĮΣ
-			1	With v. thin beds of muddy sandy gravel, very poorly		EIS
┝		~ <u>~</u>	¥ Q.91	soried, sharp contacts		석떬
<u>├</u> 1	L"	<u> </u>	0.99	Thin to medium-bedded sands, massive, m grained,		βŎ
F	a 	<u> </u>	1 13	m ps, mixed ot, foram-rich, common t grains to crse		≶₽
<b>-</b>		ют. т. <u>г</u>	- 1.15	grade, occ. lithic gravel to 15mm, matrix-supp., random		AR
F	× ×	0.00	MPal 8825	sharp, biot, and erosive basal contacts, brownish vellow		ωř
F			1.32		Deep marine polocidia/	~~~~
	\$	L	۱ <u>۱</u>	With medium-bedded sandy mud, massive, bioturbated	hemipelagite biogenic 0074	
L	s s	· · · ·	}	(sand-lilled burrows), sporadic lithic gravel,	gitt biogorito oues	
L		ļ., , ,	]	brown (10YR7/4).		
L	n .		1			
Ľ	S		1	Chalk, white (2.5Y8/2-5Y8/3), massive,		
Ē,	55	L	1	Chondrites, (mottled texture throughout) firm to		
<u> </u>	\$	L	1	stiff (crumbly/hackly), calcaereous.		N15
Γ		1				Ž
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$\vdash$	\$		MPai 8826			ā
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BGS no: 57-12/19 Original site no: S28 Location: Southern flank of Anton Dohrn Latitude: 57° 17.12' N Longitude: 11° 05.79' W Water depth: 869m

# BGS core no: 57-12 /19

# Original site no: S28

T.D. metres: 5.6

	Grain size and						
	sedimentary		00	Sub	Description	Interpretation	Age
Depth			l t	Sub-	bles		
<u>⊢</u> 0	ЦЦІ	un i 🚊		MPal			
F		8		8822	Mud, massive, homogenous, soft, plive grev 5Y42.		
E		5			bioturbated (colour mottled) and, incsand-filled		£
Ľ		~			burrows, scattered sulphide specks below 0.3, sporadic shell frags. (pebble size), matrix-supp., occasional		NN
<u> </u>		۳ ~			lithic clasts.		Щ. Ш
┝		5			Core disturbance at base of unit, indistinct base.		CE
F		$\sim$					ISTC
Ľ		\$~					PLE
		~					TE
F .		<u>%</u>		-1.1			З
-	. []		— -	- 1.15	Inin-bedded sand, med-grained, poorly sorted, mixed c>t (foram-rich), massive, calcareous, scattered lithic pebbles,	latochaddad daan marina	
╞	٢V	ຶ່%			pale yellowish-brown (2.5Y6 /4), on	hemipelagic muds with	
	•	[		- 1.42 -	Sandy mud, massive, bioturbated (sand-filled burrows),	sporadic ice-rafted dropstopes and muddy and	
					coral frags. at base (pebble grade), c>t (abundant	sandy contourites.	
-		%	÷		yellowish brown (2.5Y7/4-6/4). Sharp base, Graded ?		
F			°.		Medium-thick-bedded sand, muddy, massive (to crudely		
-			· o·		bedded), m-grained (but f-vc range), vps, mixed Vc, abundant large planktonic forams, scattered lithic clasts		
<u> </u>		\$			and shell fragments up to pebble grade, matrix-supported,		
Ľ		\$	o		yellow (10YR6/8), sharp, partly bioturbated base.		
-		« <i>«</i>		- 2.22-	Mud (very clayey), massive, soft and buttery,		
-		» ج			homogenous, bioturbated (colour mottling) inc. Planolites		
┝					sporadic matrix-supported lithic pebbles and		
F		» %	°-		occas. rip-up clasts.		
Ľ		%~			Sharp base		
F		\$					2
- 3		s ~					
-		s			Brownish vellow 10YR6/8		
F		~		<	3.22 Colour change		
Ľ		%			Dark grey 5Y41		
L		~ %					
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-		56					118)
		$\sim$ %					NN)
5	r			- 5.05	· · · · ·	1	ž I
Ľ		55			Medium to thick-bedded sands, massive, m-c grained, vps, mixed t/c (abundant planktonic forams)		ö
┝	LJ LJ			a MPai	bioturbated (colour mottling) inc. Planolites and crse		٦ ٦
┝		ъ	·	8823	sand-miled burrows, scattered matrix-supp. lithic pebbles, sharp bed contacts, Colour change.		ATE
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57-11/67 (S29)

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\* Based on borehole 90/15,15A - see main text

BGS no: 57-11/67 Original site no: S29 Location: Top of Anton Dohrn Latitude: 57° 26.61' N Longitude: 10° 53.36' W Water depth: 727m

# BGS core no: 57-11/67

## Original site no: S29

T.D. metres: 5.1

	Grain size and sedimentary	logy		Description	Interpretation	Але
Depth (m)	structures	Litho	Sub- Samı	bles		/ gc
	s s		MPal 88 - 0.08 - MPal 8817	ne Thin-bedded, sand, massive, fine-medium grained, mud sorted, carb. rich (60%), sporadic lithic to small pebble grade, strongly calc. Olive. Sharp erosive base.		ILOCENE
	5 5 7 7 7		- 0.75 -	Mud (very clayey), massive, bioturbated (inc. sand-filled burrows) some still open. Sporadic matrix-supported lithic clasts to 2cm, subangular, scattered carbonate frags., also sulphidic specks near base. Olive grey to light olive brown (5Y4/2-2-5Y5/4). Gradational base, bioturbated.		<u>Р</u> Н
			0.99 1.05 - 1.08 - 1.14	(V. thin-medium-bedded) sand, and gravels, massive, graded, upwards coarsening to fining sequence, becoming muddy towards, top, bioturbated. Sands, carb. rich, m-vc grained, mod-sorted, massive, pale olive-pale yellow. Gravel, mixed t/c (50/50), massive, mod- sorted, clast-supported, relatively rapid grading from	Interbedded deep-marine sandy contourites, occasionally gravelly, and hemipelagic muds with sporadic ice-rafted	
-	۶ ۶ ~		MPal	m. sand below to c. sand above. Muddy sand, thin-bedded, massive, slightly pebbly, vps, 1-mgrained. occasional coarser grade, mixed <i>V</i> c. Sharp erosive base.	dropstones	
		+	- 1.7 -	Mud (clayey), massive, bioturbated (sand-filled burrows). Scattered matrix-supp. clasts inc. mud rip-ups, calcareous, pale olive brown (2.5Y5/4). Sharp, slightly bioturbated base.		(
			2.03 2.15 - 2.26 -	Stacked, medium-thick-bedded sands and sandy gravels, graded (upwards fining). Vf-vc grained (pred. f-c grained), mod-poorly sorted, mixed t/c Abundant forams. Clasts are matrix to clast supported, mostly lithic with carbonate (inc. whole shells) in basal bed, and sandy fine-ups in too bed		CENE (NN20-2-
  -  -	<u>s</u>		- 2.61 -	Sands: bioturbated (mottled) to massive. Base of sequence is erosional: overlying beds, bases		PLEISTO
	\$ \$	• —:  		Thin-medium-bedded muds and sands, massive, bioturbated, pale olive-brown, calcareous.		ro late
	× ~ ~ × ×			Sands, f-m grained, mod-poorly sorted, inc.c grains, mixed trc. Sharp bed contacts.Bioturbated. Sporadic lithic clasts to 2cm,matrix-supp. Bed thickness @5-12cm.		aim
	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		MPal 8819	Mud, massive, bioturbated (inc. sand-filled burrows, <u>Zoophycos</u> , mottling), very clayey, sporadic matrix-supp. lithic clasts, abundant black sulphidic specks.		
- - 	~ s s ~ s		€	Pale olive-brown Olive-grey Colour change		
	√ · · · · · · · · · · · · · · · · · · ·	, , , , ,	- 4.23 -	Sand, massive, bioturbated (mottled texture), f-m grained grading up to m-c grained at top of bed, mod-poorly sorted carbonate-rich (abundant forams and granule /pebble grade shell frags.), subord. lithic frags. Colour mottled, pale yellow /olive throughout. Small scale variation in grain size may reflect original bedding.		
- 	\$ \$		MPai 6820 = 5.1 -	•		
			V.1 -			
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57-12/18 (S30)

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BGS no: 57-12/18 Original site no: S30 Location: Top of Anton Dohrn Latitude: 57° 33.62' N Longitude: 11° 05.87' W Water depth: 705m

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# BGS core no: 57-12 /18

## Original site no: S30

## T.D. metres: 3.8

Depth (m)	Grain size and sedimentarγ structures	Lithology	Sub Samp	Description	Interpretation	Age
				Rapid penetration to @ 2.8m. Sandy Mud found adhering to clast at top of bedrock section: olive brown (2.5Y4/4), very soft, mixed carbonate/terrigenous		
- - - - - - -			■ MPal 8900	Massive to crudely-bedded conglomerate, disorganised, matrix-supported. Clasts predominantly dark, fine-grained, basic igneous rocks with subordinate skeletal fragments (? oysters); also subordinate yellow-brown carbonate clasts, recrystallised skeletal fragments and minor lithic grains. Very poorly sorted, granule-to-cobble-grade, rounded to sub-angular, randomly orientated atthough occasionally some display flat-lying alignment of long axes. Some of clasts fractured and veined by carbonate.	Clastic-influenced, shallow-marine carbonate bank; isolated seamount	MID - TO LATE EOCENE (NP 17-19)
			3.8	Stylolite at top of section.		
		X		-		

57-13/57 (S31) - .\* ...


BGS no: 57-13/57 Original site no: S31 Location: Eastern slope of Rockall Bank Latitude: 57° 19.66' N Longitude: 12° 59.34' W Water depth: 658m NE

### BGS core no: 57-13 /57

### Original site no: S31

T.D. metres: 5.1

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			l G				
	seuimen	ιαιγ	18	<b>c</b> , (	Description	Interpretation	Age
Dep		5	t	Sub-	-		
(m	)×0E* 			Sam	pies		
	$\nabla_{-}($		.0.0.0	MPa 8837			
Γ	V D	<u> </u>		0.18	Very thin to thick-bedded sands, firm, massive to	Deep-marine sandy,	<b>1</b>
Γ				0.24	grained, very poorly sorted, occasionally gravely with	occasionally gravelly,	E
			<u> </u>	-0.38	discrete pebbly concentrations at bases or tops of	occasional interbeds of	8
			0.0.0	<b>+ 0:4</b> 3	(distribution + coarse-tail). Mixed c>t (>85%)	hemipelagic muds with	P P P
L				0.55	occas. t up to 40-50%), scattered lithic clasts - granules	ice-railed uropsiones	
F .			0.00	8.70	and small pebbles and scattered shells. Beds 2-32cm thick; bed contacts mostly sharp occas oradetional and		
F :	≩	-1	<u></u>	0.78	interbedded with v thin-thin beds of mud and sandy		
F	$+ \sqrt{D}$		ŏ		mud, soft, very poorly sorted. Beds 2-10cm thick;		
<u> </u> 1	₩ ₩ ₩ ₩ ₩ ₩ ₩ ₩ ₩ ₩ ₩ ₩ ₩ ₩		<u> </u>	1.01	sharp contacts		
- ·		<u>s"</u>	2.2	1.06			
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	×+			- 1.26			
F	white		····	1.36			
F		_		- 1.48			
F	\$ L		<u> </u>	- 1.6 - 1.65			
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L	able		··· ·				
F	white		ŀ	1			
$\vdash$		ĸ		2.44 -	Mud, massive, bioturbated - sand-filled burrows and		
F			·	ļ	colour mottling (?Planolites) - soft to firm, sporadic	Deep-marine	
╞		\$	<u> </u>		matrix-supported lithic clasts, subang-subrd, inc.	hemipelagic muds with	
$\vdash$					shell debris, weakly calcareous	dropstones	
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58-14/55 (S40)

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## BGS core no: 58-14 /55

Original site no: S40

#### T.D. metres: 5.1

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
			Slow penetration to @2.0m-gravel?	Shallow-marine siliciclastic shelf	
- - - - - - 5 -			orange-brown, strongly calcareous, friable. Very poorly sorted, very fine-grained, mixed terrigenous/ carbonate (Fe-stained qtz, lithics, and forams, mollusc debris, coral fragments to fine gravel grade). Bedding depicted by shell-rich and -poor bands.	siliciclastic shelf	LATE PALEOCENE TO LATE PLIOCENE RANGE
- - - - - - -			Scattered sand grains, vf grained, lithics near base.	-	

57-14/57 & 58 (S41)

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BGS no: 58-14/57 58-14/58 Original site no: S41 Location: Top of George Bligh Bank Latitude: 58° 56.98' N Longitude: 13° 50.85' W Water depth: 444m

## BGS core no: 58-14 /57\*

Original site no: S41

#### T.D. metres: 4.1

Depth (m)	Grain size and sedimentary structures	Lithology	Sub- Sam	_ Description  ples	Interpretation	Age
				Rapid penetration to @3.58m		
	2		- 3.58 - • MPat • 8879 - 3.89 • PET MPat • 8680 • 4.1	Sand, massive, (7) upwards-fining, variable composition: predominantly terrigenous at base becoming foram-rich up-section. Pale yellowish brown (10YR64). Conglomerate, massive, disorganised, predominantly matrix-supported. Clasts include weathered conglomerate clasts comprising basic igneous rocks of granule to pebble grade, with sand-sized grains, set in a recrystallised carbonate matrix; also includes slightly banded, yellow-brown limestone. Poorly sorted, granules to coarse pebble grade, randomly orientated. Some of clast surfaces are highly irregular – solution pitted? Matrix consists of slightly recrystallised, offwhite foram-rich carbonate with abundant medium to fine gr. quartz and lithic grains. Friable where 'sandy' in texture. Basal sample appears veined, with disc-like igneous pebbles set in yellow brown limestone. Unsure if a clast or part of rock section.	7Deep-marine sandy contourite Clastic-influenced, shallow-marine carbonate shelf	MID- PLEISTOCENE (NN21) T PALEOCENE

## BGS core no: 58-14 /58\*

### Original site no: S41

T.D. metres: 4.05

Depth (m)	Grain size and sedimentary structures	Lithology	Sub– Samp	Description	Interpretation	Age
	ΡΛ		- 2.65	Rapid penetration to @1.7m Slower penetration 1.7-@2.65m	Deep-marine sandy contourite	
			- 3.88 - Lue depths and relations unclear	And abundant forams). Poorly sorted upper and lower beds, gravelly, lithic clasts include basalt and sandstone, matrix is vf-vc sand, grading – upwards-fining. Middle bed, well-sorted, vf-fine, foram-rich. Olive grey (5Y62) to pale grey (2.5Y77) to white (2.5Y82). Sharp bed contacts Abundant bryozoan fragments in upper bed. SHARP CONTACT Massive conglomerate, disorganised, matrix-supported. Clasts include mainly basic igneous types with subordinate yellow-brown recrystallised limestone and (?) existing conglomerate clasts. Very poorly sorted, granules to cobbles, subangular to well-rounded, randomly orientated. Matrix predominatly coarsely to finely crystalline carbonate, varies from 'sandy' texture (friable), white, to 'smoothy' crystalline with littlefho terrigenous grains, and a more yellowish colour banded appearance. Much styolite development. Partial dissolution is evident. Regional stratigraphical evidence suggests a pre – NP6 age	Clastic-influenced, shallow-marine carbonate shelf	PLEISTOCENE

58-14/54 (S42) - -.... ---



BGS no: 58-14/54 Original site no: S42 Location: North-west Rockall Trough Latitude: 58° 43.08' N Longitude: 13° 22.86' W Water depth: 1433m

## BGS core no: 58-14 /54

### Original site no: S42

#### T.D. metres: 3.4

Grain size and sedimentary structures	Cithology Descrip Sub- Samples	otion	Interpretation	Age
- 1 - 1 - 2 - CT √ 5 5	Thin-bedded sands a fine-medium-grained, Foram-rich but with c Beds are @4cm thic Basal contact is indist 1.7 weathered, and sedim 1.78 Medium-bedded, forai MPail GEOCHbut with common lithi 200 2.06 sand grade, and scat disorganised with ind basal contact. Thin-bedded coebby	@1.7m: soft sediment cover – is as below. and muddy sands, moderately sorted, grey (5Y54)-dark grey (5Y4,52). common terrigenous component. k; bed contact is relatively sharp. inct – underlying sandstone is tents may derive from the sandstone. m-rich sandstone, white to pale grately sorted, medium-grained cs/glauconite up to very coarse thered small pebbles. Massive and istinct, possibly gradational	Deep-marine sandy contourites Shallow-marine siliciclastic shelf: high-concentration turbidites Shallow-marine siliciclastic shelf	NO AGE DATA
- 3	2.38 MPai MPai MPai Most display evidence grading and scoured Medium-bedded, gred Medium-bedded, gred Medium-bedded, gred Medium-bedded, gred Medium-bedded, gred Drill-mush of crushed	of dk fine sstsitist, banded shelly udst and 'sooty' (?pyritic) clasts. of solution-pitting. Coarse-tail base. , mottled sandstone, massive, d, foram-rich with sporadic specks ery coarse sand-grade.		MID- TO LATE EOCENE (NP17-19)
	3.4			
- 5			:	

59-11/16 (S43)

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## BGS core no: 59-11/16

### Original site no: S43

T.D. metres: 4.35\*

Grain size and sedimentary			уgо						
Struct	ures	'	loh	Sub	Description	Interpretation	Age		
	05~22	clay	Lit	Samp	les				
Olive-yeliowish	T	<u>~</u> ~~	· · · O	-0.06	Interbedded thin to thick-bedded sands and muds,	Interbedded. deep-marine,			
-		%			occasionally gravelly.	sandy, occasionally gravelly, contourites, and hemipelagic			
(10YR7/3)	5	s.			Sands, massive to crudely bedded, bioturbated, f-c grained,	muds with sporadic			
<u> </u>		\$			sorted, slightly gravelly, disseminated vc and grains and				
-	5	\$			Mixed of (t. occas. up to 60%), common planktic forams,				
		\$		-076	occas. rich in sponge spicules, calcareous. Lithic clasts, matrix-clast-supp., ang-rd, some worm-tube encrusted.				
	<u> </u>	<u></u>		-0.8° -0.87	inc. basalt (35mm), fine gr qtzite, and psammite, scatt.	11			
		s	<u>•</u> –	- 0.99	sharp, occas. erosive, occas. gradational and bioturbated.				
	¥	\$	20-9	- 1.13	Muds, massive, v soft-firm, bioturbated (mottled and				
V pale brown	-	~ *			sand-filled burrows), black sulphidic specks, calcareous, sporadic matrix-supp, lithic clasts, ano-rd, occas.				
10YR7/4		$\sim$			faceted and scratched, inc. basic igneous (55mm), grey				
-	5	5 55	<u> </u>		mudstone(1012mm), soft white chalk, and grey 'grit'				
-	[	\$5	· • .O.	-1.57	(10mm), scattered occasional shell frags. Beds range 7–95cm; bed contacts sharp to occas. gradational				
(10YR8/3-7/3)	\$				and bioturbated.				
-		ss							
- 2	\$		• •						
	L	×	·	- 2.16					
<ul> <li>Pale yellow brown pale olive brown</li> </ul>	wn	~ "	<u>-</u> -						
(2.516/4-5/4)-v p brown (10YR7/4) with brownish	sale %								
yellow blobs (10	)YR6/6)	~ %							
-	55	s							
-	-	ູ່	·						
-	5	\$	°	- 2 00					
V pale brown			0	- 2.99					
(10YR8/3)		s	~						
-	ъ		•.—						
V cele bown	5	8		- 3.4					
(10YR7/4-Z/3) to yellow (10YR	7/8) ((	<u>۶</u>							
grey (10YR62)	n  '	%	<u></u>						
L	5	หิ					AT E AT		
4		5					20		
-		2 K			Abundant mundred and the mid France (NR 1942 15)		L L L L L L L L L L L L L L L L L L L		
Ľ				MPal 8889	dinoflagellate cysts		SPE 2		
-	2			4.35					
<u>⊢</u> .	•.								
E									
F									
F									
5				*	Drill-log suggests 5.1m penetration: recovered section may be partly compressed				
-					· · · · · · · · · · · · · · · · · · ·				
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F									
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59-11/17 (S44)

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### BGS core no: 59-11/17

### Original site no: S44

T.D. metres: 5.25

Grain size and sedimentary	ology	Description	Interpretation	Age
Depth (m)vous vote∽∞ & vous vote∽∞ & vous vote∽∞	Lity Sar	o- nples		
Olive S Pale grey (IOYR72) is pale brownish grey (2.5Y6.2) ~ % S S S S S S S S S S S S S	0.00 	<ul> <li><sup>218890</sup> Thin to very thick-bedded muds, v soft-firm, massive, bioturbational mottling and common sand-filled burrows, with <u>Zoophycos</u> and <u>Planolites</u>, calcareous, sporadic matrix-supported, randomly orientated lithic clasts, ang-subrd, occasionally faceted, inc. soft dk grey mudstone (10mm), black igneous (27mm), gneiss (19mm) and granite (10mm), scattered shell fragments inc. corals and scaphopods, occasional layers rich in sponge spicules. Some beds are graded with mixed t/c sandy and gravelly basal layers rapidly fining-upward into mud. Beds range 5–325cm thick; bed contacts sharp, graded beds locally erosive bases,</li> <li>with interbedded thin beds of sand, massive, 1-m-grained, well to poorly sorted, mixed c &gt; t (variable 60–99%), abundant forams, calcareous, scattered shell frags and occasional lithic clasts,</li> <li>and muddy sandy gravel, very poorly sorted, pred. terrig, inc. subrd-subang black igneous clasts (27mm), matrix-to-clast supported. Beds range 5–8cm thick; bed contacts gradational to sharp and occasionally erosive.</li> </ul>	Predominantly deep-marine, hemipelagic muds with sporadic ice-rafted dropstones, with occasional thin interbeds of sandy and gravelly contourites	HOLOCENE (NN21)
~ ~ ~				10
~	·····			
- 3 - Pale brown (10YR63)- very pale brown (10YR74) - ~				
Colour change				
		Pal 91		MID- TO LATE PLEISTOCENE (NN21)
		-		

58-11/2 (S45)

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#### **ROCKALL TROUGH**



BGS no: 58-11/2 Original site no: S45 Location: Rockall Trough, south-west of Rosemary Bank Latitude: 58° 53.23' N Longitude: 10° 39.65' W Water depth: 1863m

## BGS core no: 58-11/2

#### Original site no: S45

T.D. metres: 3.54

Depth (m)	Grain size sedimentar structures	and y	Lithology	Sub Samp	Description	Interpretation	Age
	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5			MPal 8654	Muds, massive, homogenous, v soft-soft, bioturbated with abundant <u>Zoophycos</u> in top 2m. also <u>Planolites</u> , mottled throughout, occasional sand/silt-filled burrows. Sporadic matrix-supp. lithic clast, well rd (but broken) f gr., grey qtzite/sst. Sporadic black sulphidic knots, moderately calcareous. Colour varies: White 2.5Y82, 0-0.03m Pale grey 2.5Y7/2, 0.03-0.5m Pale olive grey 5Y62-olive grey 5Y5.5.52, 0.5-0.99m Olive grey 5Y5.5/2, 0.97-3.54m	Deep-marine hemipelagic muds with rare ice-rafted dropstones	HOLOCENE (NN21)
- - - - - - - - - - - - -	. ş	* ~ * * *					TO
- - - - 3 - - -	9 9 9	5 5 5 5 5 5 5		MPal 8855 3.54			LATE PLEISTOCENE (NN21)

58-12/5 (S46)

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## BGS core no: 58-12 /5

### Original site no: S46

T.D. metres: 3.26

Depth	Grain size sedimenta structures	e a ary	nd	thology	Sub-	Description	Interpretation	Age
(m)		- 10 11	clay		Samp	les		
		% %	~ %		Colour change	Muds, massive, siltier in top 0.35m, more homogenous below 0.35, also pale olive grey (5Y62–52) in top 0.35, olive grey (5Y52) below, bioturbated, abundant <u>Zoophycos</u> to 1.29m, plus <u>Planolites</u> (top 0.5m), more homogenous between 1.3 to @2.2, colour mottled below 2.2.	Deep-marine hemipelagic muds with rare ice-rafted dropstones	JLOCENE N21)
- - - - - - - -		~ * * * ~	ی جو جو			Black sulphidic specks and knots throughout. Occasional matrix-supp. lithic clasts, angular, inc. dk grey psammitic rock (6-7m). Weakly to moderately calcareous. H2S odour from HCI application		Ϊć
- 2		~ *	ک م					TO
- - - - - 3 -		\$ \$ ~	* ~ *		MPatí ■ 8857 - 3.26			LATE PLEISTOCENE (NN21)

57-13/75 (S47)

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BGS no: 57-13/75 Original site no: S47 Location: Rockall Trough, north-east of Rockall Bank Latitude: 57° 41.68' N Longitude: 12° 36.62' W Water depth: 1523m

## BGS core no: 57-13 /75

#### Original site no: S47

T.D. metres: 4.1

Grain s sedime structu	size and entary res	ithology	Sub-	Description	Interpretation	Age
			Sam MPal 8840	Sand, massive, f-gr., mixed c>t (foram-rich), mod. sorted, pale grey (10YR7/2), sharp irregular base Mud, massive, homogenous, bioturbated with Zoophycos, brown (10YR5/3) becoming paler to base.		DLOCENE N21)
- - - - -	5 5 5		-0.36 -0.51	also silitier and sandier to base possibly due to bioturbation, weakly calcareous Medium-thick-bedded muddy sands, massive, f-m grained, ps, mixed c>t (foram-rich), calcareous, scattered c-vc grains and small lithic pebbles, clast-to-matrix-supported, randomly orientated, scattered shell frags. Upper bed, pale brown (10YR63) - v pale brown (10YR73); lower bed brown (10YR53). Sharo bed contacts, bioturbated lower basal contact.	-	ΪZ
	5 5		- 1.07 -	Mud, massive, soft, homogenous, bioturbated (colour mottled), sandy down to 1.55 and also sandy towards base due to bioturbation (possibly), black sulphidic knots common below 1.8, sporadic matrix-supp. Ithic pebbles inc. mud rip-ups/soft friable mudstone, weakly calcareous	interbedded deep-marine sandy contourites and hemipelagic muds with sporadic ice-rafted dropstones	
2	5			With thin-bedded sand, massive, foram-rich near base, indistinct bioturbated contacts		
- White 10YR8/2 - Brownish - Brown to	5 5 5 5 5 5		- 2.57 - - 2.65 - 2.75 - 2.84	Thin to medium-bedded sands, slightly muddy, massive, f-m gr., mod-ps, mixed c>t, foram-rich, scattered matrix-supp. lithic clasts, bioturbated, variable colour (darker reps, a slight increase in t component), calcareous, indistinct bed contacts.		
	× × × × × × × × × × × ×		- 3.12 -	Mud, massive, bioturbated, scattered lithics and black sulphides, soft, weakly calcareous, thin sandy laminae, brown, sharp to indistinct bed contacts		
- - - - 4	5 5 5 5 5 5	·•••••••••••••••••••••••••••••••••••••	- 3.56 -	Sand, massive to crudely bedded (thin gravelly laminae), f-m gr., m-ps, mixed c>t (foram-rich), much orange (Fe) staining, scattered lithic pebbles, matrix-supp., firm, yellowish brown (10YR56)		EARLY /MID- PLEISTOCENE (NN19)
			8841			
- - - 5 -						.*
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57-13/76 (S48)

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## BGS core no: 57-13 /76

### Original site no: S48

T.D. metres: 4.48

	Grain size an sedimentary	logy		Description	Interpretation	Ane
Depth (m)	structures	Litho	Sub- Samp	bles		rige
$\begin{array}{c} \text{Depth} \\ (m) \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ $	Structures		Sub- Sam; - MPal - 8842 - 0.27 - 1.11 - - 1.11 - - 1.11 - - 3.36 - 3.42 - 3.72 - 8843 - 4.48 -	Sand, massive, f-m gr., mod-sorted, c>t (foram rich), scattered c sand and granules, and shell frags, calcareoux, pale olive grey (SY62), sharp but bioturbated base Mud, massive, homogenous, biot. (sand-filled burrows), v soft, scatt. matrix-supp. Ithic clasts, weakly calc., pale olive brown (2.5Y54) disturbed base – due to coring? Sands and sandy gravel, massive to crudely bedded, graded, coarsening – fining-upwards, m-vc gr., mod-vps and muddy, firm, compact, mixed of, abundant forams and occas, shell-rich bands, calcareous, variable colour banding: white/cream to brownish (pale olive brown 2.5Y54, pale pellow brown SY64, pale yellow 2.5Y74, pale brownish grey 2.5Y62), bioturbated (sand + mud-filled burrows) (inc. Planolites) Mud, massive, v soft-firm, bioturbated with common sand-filled burrows (occas, incorporating shell frags), sporadic lithic clasts to pebble grade, matrix-supp, common to abundant in upper part of section, inc. large rip-up clast (f2cm long) of muddy vps sand (mixed kc), pale yellow (5Y83), parity fragmented and broken. Weak to mod. calcareous. Sharp base Light olive brown (2.5Y54) – pale yellowish brown (2.5Y64) Thin to thick-bedded sands, massive, bioturbated, pred. coarse grained, occas, gravelly, locally graded, upwards-coarsening, f-c grained, poorly sorted throughout. Mixed c >t (70-90%), abundant forams and shells frags. Gravel fraction mostly disseminated through beds, matrix-supp, randomly orientated, ang-rded, inc. sand rip-ups, red-purple sst, and basalt (partly worm-tube encrusted,), shell frags, occasional thin pebbly laminae/enses (inc. shell debris). Beds range from 6-54cm thick; bed contacts are sharp. Variable colour.	Interbedded deep-marine sandy, occasionally gravelly, contourites and hemipelaic muds with sporadic rip-up clasts and ice-rafted dropstones	LATE PLIOCENE HOLOCENE (INN16-18) (INN21)
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58-14/44 & 45 (S49)

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## BGS core no: 58-14 /44\*

#### Original site no: S49

T.D. metres: 5.1

Depth (m)	Grain size and sedimentary structures	Lithology	Sub- Sample	Description	Interpretation	Age
			F	Rapid penetration to @1.1m	-	
-			1.1 P to 1.39 C	Poorly sorted gravel consisting predominantly of angular or rounded pebbles of basalt, partially incorporated 7 due to drilling) in matrix of orange-grey clay /sandy lay, highly calcareous, foram-rich (60%).	7 Deep-marine gravel lag contourite	NO AGE DATA
			4.45			
- - - - 5			MPal 6873	Massive claystone, friable, orange-brown, strongly alcareous, bioturbated, common foraminifera. Burrow-tube-fills include silt/vf gr. sand and black rystalline material. Scattered black lithics /crystals of silt/v fine sand grade.	Shallow-marine siliciclastic shelf	MID-EOCENE (NP16)
			*s	Site also occupied as 58-14/45 - see separate description		

## BGS core no: 58-14 /45\*

Original site no: S49

T.D. metres: 5.1

Depth (m)	Grain size and sedimentary structures	Lithology	Sub- Sam	Description	Interpretation	Age
				Rapid penetration to @1.0m		
			- 1.0 -	Gravel, basaltic pebbles	?Deep-marine gravel-lag contourite	NO AGE DATA
- - 	55 55 55 55	د د د	- 5.1 -	Massive claystone, friable /crumbly, orange-brown, strongly calcareous, bioturbated, common foraminifera. Scattered black lithics /crystals, silt/vf sand size.	Shallow-marine siliciclastic shelf	MID-EOCENE 808 58-14 /44
			k	Site also occupied as 58-14 /44 - see separate description.	-	

# 58-14/56 (S50)

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BGS no: 58-14/56 Original site no: S50 Location: Eastern flank of George Bligh Bank Latitude: 58° 52.11' N Longitude: 13° 34.12' W Water depth: 685m
## BGS core no: 58-14 /56

Original site no: S50

T.D. metres: 2.7

Depth (m)	Grain size and sedimentary structures	Lithology	Sub– Samı	Description	Interpretation	Age
				Rapid penetration to @0.86m		
			■ 0.86 ■ MPal 8878 ■ MACR 8987 - 2.7 †	Bioclastic limestone, very coarse calcarenite /calcirudite, framework supported, recrystallised but shells and fragments evident, porous to non-porous depending on degree of dissolution that has occurred, most porous section Fe-stained. Massive to crudely bedded/aminated, some of larger flatter shells impart a subhorizontal lamination /alignment. Variable re-crystallization (porous /nonporous) may reflect original bedding. Grain size fairly consistent, poorly sorted, forarns form part of finer fraction, skeletal mollusc shells coarser fraction. Common lithic clasts, v crse sand – small pebble grade of basic igneous type, matrix-supported. Crearny white to orange-brown (Fe-stained) Carbonate veins, 5–10mm thick in top 15cm, with associated dendritic manganese.	Clastic-influenced, carbonate bank: morphology of sample site similar to a carbonate knoll	INDETERMINATE AGE
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58-14/60 (S51)

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BGS no: 58-14/60 Original site no: S51 Location: North-west Rockall Trough, adjacent to George Bligh Bank Latitude: 58° 39.48' N Longitude: 13° 49.72' W Water depth: 1270m

## BGS core no: 58-14 /60

### Original site no: S51

T.D. metres: 1.07\*

	Grain	size	and				1	1
	sedim	enta	rv	l G				
	structi	Irac	. 7	6	CUL	Description	Interpretation	Aae
D				l Ħ	Sub-			
Ľ					Sam	Dies		
F		\$	α		0.03	Thin to thick-bedded sands massive bioturbated	Deen-marine anoth	
F		5			0.16	(colour mottled), f-c grained, poorly sorted, locally gravely	and gravely contourites	
F.	Colur mottled: white	T	s	000000		and muddy, occasional basal grading (upward-fining:		- Ā Ε
-	(10YR7/3), v pale	s			·	tang. component decreases up-bed).		88
	brown (10YR7/4), pale yellowish brown	)	%		1	Mixed $c > t$ (mostly >90%), abundant forams.	-	LIST N
$\vdash$	(10YR4/4). DA	, ,		• • •		V crsa sand grains and gravel disseminated through hade		L L L
$\vdash$	ΔĽ				0.69	ang-well rd clasts, lithic, matrix-supp., randomly orientated,		l ₿Ω
<u>ب</u> ا	White (10YR6/2) to		«	•:•••		inc. gneiss (55cm) and black igneous, scattered shell frags,		5 5
· ۱	pale brown (10YR6/3)	\$	"			occasional v thin pebble bed.		고고
	1			$\dot{o}$	MPal	Bed thickness 3-48cm; bed contacts sharp. Variable colour.		14 12 12
┝		L			1.07			
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$\vdash$					¥	Drill log suggests 1 Em. constration: measured and		
F.					~	may be partly compressed		
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58-14/61 (S52) ....



## BGS core no: 58-14 /61

### Original site no: S52

T.D. metres: 5.1

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
			Rapid penetration to @2.5m Steady penetration @2.5-5.1m (Core depth approximate, based on drill-log)		
		0.00 000 000	<ul> <li>2.5 Gravel, poorly sorted, lithic includes drilled cobble at least 9cm dia, clasts inc. basalt and "volcanic" conglomerate, ang-subrd.</li> </ul>	Lag gravel	NO AGE DATA
			-5.1		

58-14/62 & 63 (S53)

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## BGS core no: 58-14 /62\*

Original site no: S53

T.D. metres: 5.1

	Grain size and sedimentary	logy		Description	Interpretation	٨٥٥
Depth	Structures	-itho	Sub San		interpretation	Age
F.o.			1	Rapid penetration to @0.8m		
F		$  \rangle /$		Steady drilling to @1.0m Rapid penetration @1.0-4.7m		
E		$\vee$		Steady penetration @4.7-5.1m (Core depth approximate)		
<u> </u>		$  \wedge  $			-	
E		$ / \setminus$			-	
-		/ rQr	- 0.8	Gravel ann-subann poorty sorted inc basalt and	2 Gravel lag contourito	NO AGE
<b>—</b> 1	L		-0.9	Volcanic' conglomerate	1 diaverag contourte	DATA
-						
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## BGS core no: 58-14 /63<sup>t</sup>

## Original site no: S53

T.D. metres: 3.9

Depth (m)	Grain size and sedimentary structures	Lithology	Sub Samp	Description	Interpretation	Age
		X		Rapid penetration to @0.55m		
			-0.55 - *MPai* 8883 -0.83	Gravel, poorly sorted, ang-subang, inc. 'volcanic' conglomerate and f grained igneous. Sample of mud adhering to drill-rig: soft, pale olive brown (2.5Y5/4), mod. calc.	? Gravel-lag contourite	NO AGE DATA
			-3.9	Mpal from Mudstone clast – reworked Eocene (NP15–16) sediments Site also occupied as 58–14 /62 see separate description		
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58-14/50 & 51 (S55)

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58-14/52 & 64 (S54)

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**ROCKALL BANK** 

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BGS no:58-14/50<br/>58-14/51BGS no:58-14/52<br/>58-14/64Original site no:S55<br/>Latitude:Original site no:S54<br/>Latitude:Longitude: $13^{\circ} 20.45^{\circ} W$ 58-14/50Longitude: $13^{\circ} 19.55^{\circ} W$ Water depth:244m244m58-14/64

Location: Northern margin of Rockall Bank

## BGS core no: 58-14 /64\*

### Original site no: S54

T.D. metres: 3.9

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
- - - - - - - - - - - - - - - - - - -			Rapid penetration to @2.4m		
			<ul> <li>2.4 Sandy gravel, poorly sorted, angsubang clasts inc. basalt and f grained grey quartzite with disseminated pyrite, set in a matrix of muddy sand, 80% terrig., subordinate forams and shell frags., crse-grained, slightly more muddy at base, v soft, strongly calcareous, v dk grey (5Y3/1).</li> <li>3.9</li> </ul>	Sandy gravel lag	NO AGE DATA
			★ Site also occupied as: 58–14 /52 (TD:3.9m; recovery 0.28m) Gravel, subang- subrd, poorly sorted, pred. basalt clasts set in a m-cgr. muddy sand matrix, mixed t/c (50:50), grey (7.5YR5N5)		

## BGS core no: 58-14 /50\*

### Original site no: S55

T.D. metres: 2.75

Depth (m)	Grain size and sedimentary structures	Lithology	Description Sub- Samples	Interpretation	Age
			Rapid penetration to @1.0m		
			2.61 Gravel, pebbles of predominantly basalt with single clast of ?andesite 2.75 Clast of ?andesite Site also occupied as: 58–14 /51 (TD:0.25m) Gravel, angular to subrounded pebbles and cobbles of basalt and ? andesite	Lag gravel	NO AGE DATA

57-13/77 (S56)

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## BGS core no: 57-13 /77

T.D. metres: 5.1

### Original site no: S56

Depth (m)	Grain size and sedimentary structures موجوعه کومور	Lithology	Sub- Sam	Description - ples	Interpretation	Age
			- 3.5 -	Rapid penetration to @ 3.5m (Core depths approximate)		
			3.9 -	Gravel, very poorly sorted, small pebble to cobble grade, rounded to angular, inc. basalt with adhered foram-sand, limestone, grey sittstone/fine-gr. sst., some of clasts are worm-tube-encrusted.	? Deep-marine gravel-lag contourite	NO AGE DATA
4	. • •		- 4 82-			
	5 5 5		+.32 <sup>-</sup> MPei ■ 8844 - 5.1 -	Sandstone, muddy, f-vf grained, massive, friable, very poorly sorted, carbonate rich inc. forams and skeletal frags., subord. terrig., slightty ferruginous, scattered detrital glauconite, bioturbated with white/cream silt-filled burrows, strongly calcareous, olive yellow (2.5Y66). Patchy to "vein-like" concentration of black material – manganese?	Shallow-marine siliciclastic shelf	MID- EOCENE (NP15-16)

# DINOFLAGELLATE CYST ANALYSIS OF SHALLOW CORES FROM THE ROCKALL AREA

### DINOFLAGELLATE CYST ANALYSIS OF SHALLOW CORES FROM THE ROCKALL AREA

#### J.B. Riding

#### Introduction

Eighty-seven shallow core samples (CSC8813 to 8899) from 44 sites on the Rockall Continental Margin were submitted for palynological analyses in order to attempt detailed age and/or palaeoecological determinations. The samples yielded variably abundant residues and palynofloras. Palynomorph preservation varied from fair to good. The majority of the productive samples produced dinoflagellate cyst assemblages characteristic of the Quaternary System, although several samples yielded dinoflagellates indicative of the Eocene. Preparation techniques employed avoided the use of aggressive oxidising reagents in order to prevent the possible damage to, and loss of, relatively fragile and chemically susceptible dinoflagellate cysts (Dale, 1976). The biologically-based nomenclatural scheme of Harland (1982) is utilised for the Quaternary dinoflagellate genus *Protoperidinium*.

#### Palynology

The palynofloras extracted from the 44 sites are described below, listed in BGS sample order.

#### <u>56-14/13 - S24 (CSC8813 to 8815)</u>

This locality, originally site number 24, yielded muddy and gravelly sands on a cobble layer to 0.90-0.95m. Samples CSC8813 (0.05-0.08m) and CSC8814 (0.28-0.30m) produced abundant, well-preserved dinoflagellate cyst floras of Quaternary aspect and dominated by *Operculodinium centrocarpum*. By contrast, sample CSC8815 (0.90-

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0.93m) yielded an extremely sparse organic residue, virtually barren of palynomorphs. No evidence of reworking was observed.

The presence of *Protoperidinium conicoides* (CSC8813), *Protoperidinium conicum* (CSC8813 and 8814), *Protoperidinium leonis* (CSC8813) and *Protoperidinium pentagonum* (CSC8813 1) indicates that this succession to 0.3m is probably no older than mid-Pleistocene (de Vernal *et al.*, 1992; Harland, 1992). The nature of the sediments are consistent with this assessment. The remaining species, e.g. *Achomosphaera andalousiensis, Bitectatodinium tepikiense, Nematosphaeropsis labyrinthea, Operculodinium centrocarpum*, round brown cysts *sensu lato, Polykrikos schwartzii* and *Spiniferites* spp. are extremely characteristic of North Atlantic Quaternary sediments (Harland, 1983; 1992). No evidence of the lower Pleistocene or the Pliocene/Miocene (Neogene) was encountered.

The richness of samples CSC8813 and 8814, with an average of 745 specimens per slide, together with the abundance of *Operculodinium centrocarpum* and presence of *Protoperidinium* spp. is indicative of an interglacial, ameliorative climatic episode, under the influence of relatively warm, North Atlantic water. The lack of *Impagidinium* spp. (and the presence of common *Protoperidinium* spp.) indicates probable shelfal sedimentation. Because the section studied is relatively thin, it is not possible to state unequivocally whether the assemblages are referable to the Windermere Interstade and/or latest Pleistocene-Holocene or an intra mid-/late Pleistocene episode. However, due to the high productivity, it seems most likely that both these samples are Holocene, as opposed to late Pleistocene or older (see Harland, 1988).

#### <u>57-11/67 - S29</u> (CSC8816-8820)

Five samples were prepared from site S29. This succession comprises interbedded sands and muds to 4.9m. The samples, especially CSC8818 (1.5m) to CSC8820 (4.9m), produced sparse organic residues. Reworking of Jurassic-Lower Cretaceous miospores was noted in samples CSC8816 (0.00-0.01m) and CSC8817 (0.2m). *Lycospora* sp., a Carboniferous spore was noted in sample CSC8817.

Sample CSC8816, however, did yield a relatively common (87 specimens per slide) dinoflagellate cyst assemblage. The flora is dominated by *Operculodinium centrocarpum* and round, brown cysts (*Protoperidinium* spp.). The association is of Quaternary aspect and also includes *Bitectatodinium tepikiense*, *Impagidinium patulum*, *Nematosphaeropsis labyrinthea* and *Spiniferites* spp. The occurrences of *Protoperidinium conicum* and *Protoperidinium pentagonum* indicate that this sample is probably no older than mid-Pleistocene. No Tertiary elements were encountered.

The low dinoflagellate cyst recovery and dominance of *Operculodinium centrocarpum* and round, brown *Protoperidinium* species points to a cold, arctic-like glacial climate of deposition (Harland, 1992). The relatively large proportions (35.6%) of round brown cysts is indicative of seasonal or permanent sea ice. The dinoflagellate cyst spectrum is entirely consistent with those from the Late Devensian (Harland, 1988), but this age cannot be unequivocally invoked without independent evidence.

Samples CSC8817 to 8820 yielded extremely sparse palynofloras. Rare dinoflagellate cysts of Quaternary aspect were noted, but none of these have significant biostratigraphical value. Furthermore, the sparseness of the associations precludes meaningful climatostratigraphical analyses.

#### <u>57-12/18 - S30</u> (CSC8821)

A single sample from site S30 was analysed. This was a calcareous conglomerate from the top of the Anton Dohrn Seamount. The sample, CSC8821 (3.30-3.73m) produced an extremely sparse organic residue, virtually barren of palynomorphs. Occasional woody fragments and a single, poorly-preserved dinoflagellate cyst was recovered. Due to the

indeterminate nature of this single specimen, assessments of age and palaeoenvironment are precluded.

#### 57-12/19 - S28 (CSC8822 to 8823)

Two samples were taken from site S28, where interbedded sands and muds to 5.3m from the southern flank of the Anton Dohrn Seamount were recovered. Sample CSC8822 (0.00-0.03m) produced a sparse organic residue comprising woody material, dinoflagellate cysts of Quaternary aspect and Carboniferous and Jurassic reworked grains. The presumably indigenous Quaternary dinoflagellate cyst flora comprises rare Operculodinium centrocarpum and Protoperidinium conicoides, together with relatively persistent round brown Protoperidinium species. The occurrence of Protoperidinium conicoides indicates that the sample is probably no older than mid-Pleistocene (Harland, 1992). Because of the relatively sparse palynoflora, assessment of the palaeoclimate is more speculative. The preponderance of round, brown dinoflagellate cysts points to a cold, glacial palaeoclimate; the low numbers of specimens, however, make this a tentative conclusion.

Sample CSC8823 (5.30m) produced a residue virtually barren of organic remains; rare fungal spores were encountered. Therefore age/palaeoenvironmental assessments are not possible.

#### 57-12/33 - S27 (CSC8824 to 8826)

Three samples were analysed from site S27 in the Rockall Trough, south-west of the Anton Dohrn Seamount. The lithologies recovered here were interbedded muds and sands resting on Chalk. Sample CSC8824 (0.05-0.10m) proved the only palynologically productive sample from this site. The sample yielded abundant dinoflagellate cysts of Quaternary aspect. The assemblage was dominated by *Operculodinium centrocarpum* (78.7%), with subordinate *Bitectatodinium tepikiense*, *Impagidinium* spp.,

Nematosphaeropsis labyrinthea, Protoperidinium spp. and Spiniferites spp. The occurrence of Protoperidinium conicum, Protoperidinium pentagonum and Spiniferites elongatus indicates that the sample is probably no older than mid-Pleistocene (de Vernal et al., 1992; Harland, 1992). The dinoflagellate cyst richness (606 specimens per slide) and the spectrum of species points to an interglacial ameliorative interval, under the influence of relatively warm North Atlantic waters and in a shelfal setting. It is difficult to speculate on the precise positioning of this interglacial interval within the Quaternary due to the isolated nature of the sample. However, the high recovery means that a Holocene age is most likely (Harland, 1988). Rare possibly reworked Mesozoic pollen was recovered from sample CSC8824.

Samples CSC8825 and CSC8826 (1.25-1.30m and 2.5m respectively) produced extremely sparse organic residues, virtually barren of palynomorphs. Sample CSC8825 yielded a single questionable round brown *Protoperidinium* dinoflagellate cyst and both levels produced rare indeterminate miospores. Therefore, age and palaeoenvironmental assessments are precluded. However, the limited dinoflagellate cyst evidence from sample CSC8825 tentatively suggests a Quaternary age.

#### 57-13/26 - S26 (CSC8827 to 8833)

Seven samples were taken from site S26 in the Rockall Trough, south-west of Anton Dohrn Seamount, where 3m of massive, bioturbated muds were proved. The samples proved variably palynologically productive, with dinoflagellate cysts of Quaternary aspect dominating the associations.

The dinoflagellate cyst floras are variously dominated by *Operculodinium centrocarpum* and *Protoperidinium* spp. (largely round, brown morphotypes). *Bitectatodinium tepikiense, Nematosphaeropsis labyrinthea* and *Spiniferites* spp. are also sporadically common. The succession is probably no older than late Pleistocene due to the presence of *Protoperidinium avellana* in samples CSC8829 (1.0m) to CSC8833 (3.0m) (Harland,

1992). This contention is supported by the presence of *Protoperidinium conicoides*, *Protoperidinium conicum*, *Protoperidinium leonis*, *Protoperidinium pentagonum* and *Spiniferites elongatus* (all probably no older than mid-Pleistocene).

The dinoflagellate cyst spectrum divides into two distinct climatostratigraphical units. Samples CSC8827 to 8830 (0.00-0.01m to 1.50m) are dominated by *Operculodinium centrocarpum*; the interval represents an interglacial ameliorative episode, under the influence of relatively warm North Atlantic waters and in a shelfal setting. The dinoflagellate cyst productivity is variable (274 to 1446 specimens per slide); late Pleistocene and Holocene ages are possible (see Harland, 1988). Samples CSC8831 to 8833 (2.00m to 3.00m) are, by contrast, dominated by *Protoperidinium* spp (principally round, brown cysts), pointing to a cold, arctic-like palaeoclimate. Seasonal sea-ice conditions are invoked due to the relatively large proportions of round brown cysts. However, the presence of relatively common *Bitectatodinium tepikiense* in sample CSC8833 indicates some influence of meltwater (Harland, 1992). The probable no-younger-than late Pleistocene dating of this interval means that a Late Devensian age is possible for this unit (compare Harland, 1988).

Samples CSC8830 to 8833 exhibit evidence of reworking; typically Jurassic and Lower Cretaceous miospores (*Callialasporites* spp., *Cyathidites* spp. and *Vitreosporites pallidus*) were encountered in samples CSC 8832 and 8833. Samples CSC8830, 8832 and 8833 yielded the recycled Carboniferous spores *Densosporites* spp. and *Lycospora* spp.

#### 57-13/53 - S16 (CSC8834 to 8836)

Three samples were prepared from site S16 in the western Rockall Trough, which proved a succession of muds and sands to 2.44m. Samples CSC8834 and 8835 yielded relatively abundant, fairly well preserved palynofloras; dinoflagellate cyst diversity proved relatively low and concentrations were also rather small (average of 152 specimens per slide). Sample CSC8836 proved barren of dinoflagellate cysts. The dinoflagellate cyst assemblages in samples CSC8834 and 8835 were dominated by *Bitectatodinium tepikiense* and round, brown forms (*Protoperidinium spp.*). Other, less common, taxa comprise *Impagidinium spp.*, *Operculodinium centrocarpum* and *Spiniferites elongatus*.

The presence of *Protoperidinium avellana* in sample CSC8835 indicates a probable noolder-than late Pleistocene age for both productive samples (Harland, 1992). This conclusion is supported by the occurrences of *Protoperidinium conicoides*, *Protoperidinium conicum*, *Protoperidinium leonis* and *Spiniferites elongatus*.

The productive assemblages are indicative of a cold, arctic glacial palaeoenvironment. Any sea ice was likely to have been seasonal as the relatively high proportions of *Bitectatodinium tepikiense* (average 40.6%) point to less than fully marine meltwater regime (Harland, 1992). By comparison with the Witch Ground Formation of the North Sea (Harland, 1988), it is difficult to invoke deposition during the Younger Dryas or an older (?Devensian) glacial stage with precision. The dinoflagellate cyst concentrations and levels of reworking in samples CSC8834 and 8835 are such that such a distinction cannot be made. Rare reworked Mesozoic grains were encountered in all three samples and occasional Carboniferous spores were recovered from samples CSC8834 and 8835.

#### 57-13/57 - S31 (CSC8837 and 8838)

Two samples were taken from site S31, which proved 5.83m of interbedded sands and muds. The samples yielded sparse organic residues comprising low diversity, low concentration dinoflagellate cyst floras. Preservation was fair throughout. The associations are dominated by round, brown cysts (*Protoperidinium spp*). Other taxa recovered were *Bitectatodinium tepikiense, Operculodinium centrocarpum, Protoperidinium conicum, Protoperidinium pentagonum* and *Spiniferites* sp.

The occurrence of *Protoperidinium avellana* in both samples strongly suggests that the succession is no older than late Pleistocene (Harland, 1992). This contention is supported by the presence of *Protoperidinium conicoides*, *Protoperidinium conicum and Protoperidinium pentagonum*.

Both assemblages are indicative of a cold, arctic-like glacial palaeoenvironment. The overwhelming dominance of round, brown cysts, together with the rareity of *Bitectatodinium tepikiense*, points to the presence of sea ice, possible permanent (i.e. non-seasonal) (Harland, 1992). The relatively low dinoflagellate cyst concentrations are not unequivocally biostratigraphically useful. However, coupled with significant reworking they may indicate a correlation with the Late Devensian (Harland, 1992). This is somewhat speculative and due to the relatively wide sample spacing, the two samples may even represent separate glacial events.

Undifferentiated skolochorate dinoflagellate cysts, reworked from the Mesozoic/Tertiary were relatively common in both samples and rare Carboniferous spores (*Densosporites* spp.) were encountered in sample CSC8838.

#### <u>57-13/65 - S19</u> (CSC8839)

The single sample from the site S19 produced a palynologically barren residue. The mudstone sample (CSC8839 at 3.05-3.10m) yielded resistant mineral grains and rare woody tissue. Therefore an age and palaeoecological assessment is not possible.

#### <u>57-13/75 - S47</u> (CSC8840 and 8841)

Two samples from were prepared from site S47, which proved 4.10m of interbedded sands and muds. Sample CSC8840 (0.00-0.04m) produced an abundant (492 dinoflagellate cyst specimens per slide) and well-preserved palynoflora. The association is dominated by *Operculodinium centrocarpum* (75%), with subordinate *Bitectatodinium* 

tepikiense, Impagidinium sphaericum, Nematosphaeropsis labyrinthea, Protoperidinium spp. and Spiniferites spp.. No reworking was discerned. Sample CSC8841 (4.05-4.10m), by contrast, proved virtually barren of palynomorphs.

The presence of *Protoperidinium conicoides*, *Protoperidinium conicum*, *Protoperidinium pentagonum* and *Spiniferites elongatus* is indicative of a probable age no older than mid-Pleistocene (de Vernal *et al.*, 1992; Harland, 1992). The *Operculodinium centrocarpum*dominated dinoflagellate spectrum is indicative of an interglacial episode, under the influence of relatively warm North Atlantic waters and in a shelfal setting. An age/palaeoenvironmental analysis of sample CSC8841 is not possible.

#### 57-13/76 - S48 (CSC8842 and 8843)

Site S48 proved 4.48m of interbedded sands and muds. Two samples were prepared, CSC8842 and CSC8843, (0.00-0.07m and 4.13-4.18m respectively). Sample CSC8842 produced a relatively abundant palynoflora, dominated by *Bitactatodinium tepikiense* (43.21%) and round brown *Protoperidinium* spp. (30.86%). Also present are *Operculodinium centrocarpum*, *Nematosphaeropsis labyrinthea*, *Protoperidinium conicum*, *Protoperidinium pentagonum* and *Spiniferites* spp.. Sample CSC8843 yielded a virtually palynologically barren residue.

The presence of *Protoperidinium conicoides*, *Protoperidinium conicum*, *Protoperidinium leonis* and *Protoperidinium pentagonum* is indicative of a probable no older than mid-Pleistocene age. It is not possible to state uneqivocally whether the sample is referable to the Younger Dryas or an older glacial interval. The dominance of *Bitectatodinium tepikiense* and round, brown cysts points to a cold, glacial palaeoenvironment. The presence of a less than fully marine meltwater regime is postulated due to the abundance of *Bitectatodinium tepikiense*. Reworked grains from sample CSC8842 were not encountered. An age/palaeoenvironmental analysis of sample CSC8843 is not possible.

#### <u>57-13/77 - S56</u> (CSC8844)

The single sample from siteS56 proved virtually barren of palynomorphs. The muddy sandstone at 5.04-5.08m (CSC8844) only yielded rare, indeterminate fungal spores, sporadic woody fragments and resistant mineral grains. An age/palaeoenvironmental assessment is therefore precluded.

#### <u>57-14/43 - S22</u> (CSC8845 and 8846)

Two samples were taken from site S22; nearly one metre of sandstones and silty mudstones were proven. Both samples, at 0.72m and 0.90m (CSC8845 and CSC8846 respectively) produced extremely sparse residues and palynofloras. Both horizons yielded undifferentiated angiosperm and bisaccate (gymnosperm) pollen and sample CSC8845 produced questionable specimens of *Protoperidinium* and *Spiniferites*. Residual mineral grains and woody fragments were also present at both levels. Due to the sparse associations age and/or environmental conclusions are not possible.

#### <u>57-14/44 - S23</u> (CSC8847)

A possible sea-bed boulder from site S23 was sampled. This sample, CSC8847 produced an extremely sparse palynoflora. Undifferentiated angiosperm pollen and fungal spores were recovered, together with rare *?Spiniferites* spp. and indeterminate skolochorate dinoflagellate cysts. The principal constituents of the residue, however, are wood fragments and resistant minerals. The paucity of the palynoflora means that an age dating and palaeoenvironmental assessment are not feasible.

## <u>57-14/48 - S21</u> (CSCCSC8848 to 8850)

Three samples were taken from site S21. Lithologies encountered were interbedded muds and gravelly sands on white chalky mudstone. All samples proved paliniferous, but the diversities and concentrations of palynomorphs proved low. No age diagnostic species were recovered, but the taxa are of Quaternary aspect. Sample CSC8848 (0.00-0.03m) only produced 13 dinoflagellate cysts per slide. These were dominated by *Operculodinium centrocarpum* (61.5%), with subordinate round, brown cysts (*Protoperidinium* spp.) and *Spiniferites* spp. Ordinarily, a flora of this type, dominated by *Operculodinium centrocarpum*, would be interpreted as representing an interglacial episode in a shelfal setting. However, the low number of specimens means that this contention has to be tentative.

A relatively sparse association dominated by *Bitectatodinium tepikiensis* ((87.7%) was recovered from sample CSC8849 (0.90-0.95m). Round, brown cysts (*Protoperidinium* spp.) and indeterminate forms (presumably reworked) were also observed. This assemblage type is interpreted as representing cold glacial conditions with significant meltwater influence (Harland, 1992). The basal sample, CSC8850 (2.00-2.01m) yielded an extremely sparse palynoflora. *Bitectatodinium tepikiense* and round, brown cysts (*Protoperidinium* spp.) were recorded rarely (2 and 1 specimens respectively). This association, if in significant numbers, would signify cold glacial conditions, with meltwater influence. However, due to the sparsity of the flora, this conclusion must be regarded as tentative.

#### <u>57-14/54 - S23</u> (CSC8851 to 8853)

Three samples were taken from the site S23; interbedded sands and muds on ?gravel/boulders were observed to 2.0m. Sample CSC8851 (0.05-0.08m) produced an abundant palynoflora, wheras samples CSC8852 and 8853 (1.20-1.30m and 1.30-1.40m respectively) yielded relatively sparse assemblages

The occurrence of *Protoperidinium avellana* in sample CSC8851 indicates that this horizon is probably no older than late Pleistocene (Harland, 1992). The additional presence of *Protoperidinium conicoides*, *Protoperidinium conicum*, *Protoperidinium* 

*leonis* and *Protoperidinium pentagonum* is supportive of this contention. Samples CSC8852 and 8853 are devoid of age-diagnostic Quaternary taxa.

Sample CSC8851 is dominated by *Operculodinium centrocarpum* (73.3%), with subordinate *Bitectatodinium tepikiense*, *Nematosphaeropsis labyrinthea*, *Polykrikos schwartzii*, *Protoperidinium* spp. and *Spiniferites* spp. This configuration is characteristic of interglacial ameliorative episodes, under the influence of warm North Atlantic waters. The absence of *Impagidinium* spp. and presence of significant *Protoperidinium* spp and *Spiniferites* spp. suggests acccumulation in a shelfal setting (Harland, 1992). No evidence of reworking was observed.

Samples CSC8852 and 8853 produced relatively sparse palynofloras; the dinoflagellate cyst concentration is 39 and 17 specimens per slide respectively. Therefore, any palaeoenvironmental conclusions are relatively speculative; a fact borne out by the somewhat ambiguous results from the two, adjacent samples. The proportions of *Operculodinium centrocarpum* and round, brown cysts are similar in sample CSC8852. This situation makes the assemblage difficult to interpret, but the presence of round, brown cysts may indicate at least seasonal ice cover. Significant levels of presumably reworked Eocene/Oligocene dinoflagellate cysts were observed in this sample. *Operculodinium centrocarpum* dominates sample CSC8853 (58.8%); this may indicate interglacial conditions.

#### <u>58-11/2 - S45</u> (CSC8854 and 8855)

Two samples of massive, bioturbated muds were taken from site S45. Both proved palynologically productive, yielding well preserved dinoflagellate cyst associations. Both floras are dominated by round, brown cysts (*Protoperidinium* spp.). Other forms recognised include *Bitectatodinium tepikiense*, *Impagidinium* spp., *Operculodinium centrocarpum* and *Polykrikos schwartzii*.

The occurrence of *Protoperidinium avellana* in sample CSC8855 (3.50-3.54m) means that the succession is probably no older than late Pleistocene in age (Harland, 1992). The presence of *Protoperidinium conicoides* and *Protoperidinium conicum* in sample CSC8854 (0.00-0.03m) support this contention. The overwhelming dominance of round, brown forms is indicative of a cold, glacial, arctic-like episode (or episodes as the samples are some 3m apart). The lack of significant proportions of *Bitectatodinium tepikiense* suggests permanent (i.e. non-seasonal) sea ice conditions. It is not feasible to correlate these floras to the Younger Dryas or older, late Pleistocene glacial episodes. Reworked Carboniferous spores were observed in both samples and sample CSC8855 produced rare reworked Mesozoic miospores. Sample CSC8854 proved rich in silicoflagellates and diatoms.

#### <u>58-12/5 - S46</u> (CSC8856 and 8857)

Two samples were taken from site S46. A succession of massive, bioturbated muds was proved to 3.20m. Both samples, CSC8856 and 8857 (0.00-0.03m and 3.17-3.20m respectively) yielded abundant, well-preserved palynofloras. The presence of *Protoperidinium avellana* in sample CSC8857 indicates that the succession is probably no older than late Pleistocene in age (Harland, 1992).

Sample CSC8856 proved extremely productive, with a dinoflagellate cyst concentration of 1962 specimens per slide. The assemblage is dominated by *Operculodinium centrocarpum* (52.6%), with subordinate *Bitectatodinium tepikiense*, *Impagidinium* spp., *Nematosphaeropsis labyrinthea*, *Polykrikos schwartzii*, *Protoperidinium* spp. and *Spiniferites* spp. Round, brown cysts, however, are relatively common (16.5%). The productivity and dominance of *Operculodinium centrocarpum* indicate an interglacial ameliorative episode. The relative abundance of *Protoperidinium* spp. and *Spiniferites* spp., together with the paucity of *Impagidinium* spp, is indicative of a shelfal setting.

Sample CSC8857, however, is interpreted as representing cold, glacial conditions. The evidence is the relatively low productivity (228 dinoflagellate cyst specimens per slide), low diversity and dominance of round, brown cysts. The relatively small proportions (1.8%) of *Bitectatodinium tepikiense* strongly suggests the existence of permanent (i.e. non-seasonal) sea ice conditions. Reworking of Carboniferous and Jurassic/Cretaceous miospores was observed in this sample.

#### <u>58-14/8 - S7</u> (CSC8858)

A single sample, CSC8858 (4.47-4.49m), was taken from site S7. The lithology proved to 5.10m was conglomerate (limestone with basalt clasts). The single sample proved to be extremely sparse and virtually palynologically barren. Palynomorphs identified comprised rare bisaccate pollen undifferentiated pollen and fungal spores. Woody tissue and resistant mineral grains were relatively common. The sparsity of the palynoflora means that an age/palaeoenvironmental assessment is impossible.

#### <u>58-14/9 - S8</u> (CSC8859 to 8861)

Three samples from site S8 were taken. At this locality, 5.53m of sands were proved. All the samples proved variably sparse, the maximum productivity being 68 dinoflagellate cysts per slide in sample CSC8859 (0.00-0.03m). Sample CSC8860 (0.35-0.38m) proved extremely sparse, the only determinable dinoflagellate cyst being *Bitectatodinium tepikiense*. Sample CSC8861 (5.50-5.53m) produced a similar assemblage to sample CSC8859, i.e. dominated by *Operculodinium centrocarpum*. The presence of *Protoperidinium conicoides, Protoperidinium conicum, Protoperidinium pentagonum* and *Spiniferites elongatus* in samples CSC8859 and 8861 indicates that the probable age of the succession is no older than mid-Pleistocene (Harland, 1992). The *Operculodinium centrocarpum*-dominated dinoflagellate cyst spectrum of samples CSC8859 and 8861 is indicative of interglacial, ameliorative conditions in a shelfal setting. The relatively low numbers of specimens in sample CSC8861, however, makes this contention somewhat

speculative. The Carboniferous spore *Densosporites* sp was observed rarely from sample CSC8859. Low levels of Upper Cretacous/Paleogene reworking was noted in sample CSC8861.

#### <u>58-14/10 - S9</u> (CSC8862)

The single sample, CSC8862 (1.80-1.84m) taken from site S9 yielded an extremely sparse palynoflora. The mudstone sample produced a residue dominated by resistant mineral grains. The only palynomorphs recognised were undifferentiated fungal spores, and two questionable dinoflagellate cyst specimens *(?Protoperidinium pentagonum* and *?Protoperidinium* sp.). This sparse association means that an unequivocal age dating and a precise palaeoenvironmental assessment are not feasible. However, the presence of questionable *Protoperidinium pentagonum* indicates that the most likely age is no older than mid-Pleistocene (Harland, 1992).

#### <u>58-14/11 - S10</u> (CSC8863)

A sandstone sample, CSC8863 (4.72-4.77m), from site S10 proved palynologically barren. The residue was dominated by light amorphous material and resistant mineral grains. Rare, undifferentiated fungal spores were encountered. Thus age/palaeoenvironmental analyses are not possible.

#### 58-14/29 - S13 (CSC8899 and 8864)

Two samples were taken from the 5m of sandstone on siltstone recovered from site S13. Sample CSC8899 (0.46-0.50m) proved to be virtually palynologically barren. The residue was dominated by residual mineral grains and woody tissue. Only rare, poorly-preserved miospores and fungal spores were recognised, indicating that a detailed age/palaeoenvironmental synthesis is precluded. Sample CSC8864 (4.95-5.00m), however, yielded an abundant residue which is totally dominated by light plant tissue. The palynoflora, which is not abundant, is dominated by dinoflagellate cysts of Eocene aspect. Prominent species include Areoligera spp., Cordosphaeridium gracile, Thalassiphora pelagica and Spiniferites spp. The occurrence of Deflandrea phosphoritica means that the sample is no older than earliest Eocene (earliest Ypresian) (Powell, 1992; Stover et al., 1994). Furthermore, the presence of Areoligera senoniensis and Glaphyrocysta ordinata is indicative that the sample is no younger than mid-Eocene (Lutetian) (Powell, 1992). The overlapping ranges of these three taxa therefore indicate an early mid-Eocene (Ypresian to Lutetian) age for this sample, spanning Calcareous Nannoplankton Zones NP10/11 to intra NP15 (Powell, 1992). The presence of ?Cerodinium depressum, Cleistosphaeridium? insolitum, Cordosphaeridium gracile, Phthanoperidinium cf. stockmansii and Thalassiphora pelagica are consistent with this determination. Moreover, the presence of relatively common marine microplankton is indicative of an open marine setting. The low proportions of peridinacean dinoflagellate cysts may point to an offshore shelfal depositional regime. Reworked grains were not observed.

#### 58-14/31 - S12 (CSC8865)

Sample CSC8865 (3.51-3.55m) from a conglomerate at site S12 proved virtually palynologically barren. Resistant mineral grains and wood fragments dominate the sparse residue. Occasional pollen grains and fungal spores were, however, present. This means that an age and/or palaeoenvironmental assessment is not possible.

#### 58-14/32 - S12 (CSC8866 and 8867)

Two samples from site S12 were prepared for analyses. This site proved 3.90m of limestone on a conglomerate. The samples, CSC8866 and 8867 (3.11-3.14m and 3.85-3.90m respectively), yielded extremely sparse palynofloras. Rare pollen and fungal spores

were recovered; the residues proved rich in resistant mineral grains and plant tissue. This means that an age/palaeoenvironment assessment is not possible.

#### <u>58-14/34 - S14</u> (CSC8868 to 8870)

Three samples from site S14 were analysed, taken from 5m-thick section of interbedded sands and muds on yellow claystone. Only sample CSC8868 (0.00-0.03m) proved rich in palynomorphs. This sample yielded a fairly abundant palynoflora dominated by dinoflagellate cysts. *Operculodinium centrocarpum* is the dominant species, comprising 74.6%) of the association. Other forms present include subordinate *Bitectatodinium tepikiense, Nematosphaeropsis labyrinthea,* round, brown cysts (*Protoperidinium spp*) and *Spiniferites* spp. The presence of *Spiniferites elongatus* and *Spiniferites frigidus* means that the probable age of this sample is no older than mid-Pleistocene (Harland, 1992). From modern analogs, this assemblage is interpreted as repersenting an interglacial, ameliorative phase, under the influence of North Atlantic waters. The relative abundances of *Spiniferites* spp. and *Protoperidinium* spp. (6.8% and 1.1% respectively), together with the absence of *Impagidinium* spp., points to shelfal deposition. Reworking was not observed in this sample.

Samples CSC8869and CSC8870 (0.50-0.53m and 4.79-4.82m respectively) yielded extremely sparse residues, dominated by resistant mineral grains. Sample CSC8869 produced rare dinoflagellate cysts of Quaternary aspect (*Bitectatodinium tepikiense* and *Operculodinium centrocarpum*). These taxa are not deemed to be age- or palaeoenvironmentally diagnostic, especially given their sparsity in this sample. If they are *in situ* and representative of the actual dinoflagellate cyst flux, a similar, interglacial, palaeoenvironment to that of sample CSC8868 is suggested. Rare miospores were also recovered. The deepest sample, CSC8870, proved barren of dinoflagellate cysts, only occasional indeterminate miospores and fungal spores were recognised. Hence an age/palaeoenvironmental analysis is impossible.
## <u>58-14/42 - S7</u> (CSC8871)

Sample CSC8871 (4.50m) from a conglomerate from site S7 yielded a sparse palynoflora. The residue was dominated by mineral grains and wood fragments, however, indeterminate moispores, fungal spores and a single specimen of the dinoflagellate cyst *Bitectatodinium tepikiense* were recovered. The range of *Bitectatodinium tepikiense* is early Miocene to Holocene (Powell, 1992; Harland, 1992). However, a single palynomorph specimen should not be viewed as an unequivocal age index. Similarly, a palaeoenvironmental assessment is not possible on such a sparse flora. Mionor levels of both Carboniferous and Jurassic/Lower Cretaceous reworking was discerned.

#### <u>58-14/43 - S9</u> (CSC8872)

Sample CSC8872 (5.07-5.12m) yielded an extremely sparse palynoflora. This sample of mudstone from site S9 produced a residue composed largely of resistant mineral grains. Rare, undifferentiated miospores were present. This association is not age-diagnostic and a palaeoenvironmental assessment is similarly precluded.

## 58-14/44 - S49 (CSC8873)

A claystone sample, CSC8873 (5.04-5.08m) from site S49 was analysed. The residue proved virtually palynologically barren, with rare, undifferentiated angiospermous pollen and fungal spores only present. The residue is dominated by resistant mineral grains and woody tissue. Hence an age/palaeoecological determination is precluded.

## <u>58-14/53 - S11</u> (CSC8874)

Sample CSC8874 (3.43-3.47m), an orange-brown claystone, yielded a palynologically sparse sample. The residue is dominated by residual mineral grains and plant material. The only palynomorphs recovered were rare foraminiferal test linings, fungal spores and

undifferentiated pollen grains. A single reworked *Lycospora* sp., a reworked Carboniferous spore, was recognised. Hence, an age and/or palaeoenvironmental asssessment is not possible.

#### 58-14/54 - S42 (CSC8875 and 8876)

Two samples, CSC8875 and 8876 (0.20-0.22m and 0.82-0.84m respectively), were prepared from sandstone recovered from site S42. Both yielded residues rich in mineral grains and sparse in palynomorphs including undifferentiated pollen grains and fungal spores. Sample CSC8876 produced single specimens of *Operculodinium centrocarpum* and *Spiniferites mirabilis*. This assemblage is characteristic of the Quaternary, but this cannot be regarded as a definitive age dating (Harland, 1992). The paucity of the flora precludes a palaeoecological interpretation. Rare indeterminate skolochorate dinoflagellate cysts were also observed from sample CSC8876; these are interpreted as being reworked from the Mesozoic/Tertiary.

## <u>58-14/55 - S40</u> (CSC8877)

A single sample, CSC8877 (0.85-0.90m), was prepared from mudstone from site S40. The sample yielded an extremely sparse palynoflora comprising rare angiospern pollen and fungal spores. Mineral grains and wood dominated the residue. An age/palaeoenvironmental analysis is, therefore, not possible.

#### <u>58-14/56 - S50</u> (CSC8878)

A limestone sample at 1.01-1.06m was taken from the site S50. Sample CSC8878 proved to be essentially palynologically barren, the only palynomorphs recovered being rare bisaccate pollen grains and fungal spores. The residue was, however, rich in mineral grains and wood. This virtually barren nature of this sample precludes an age/palaeoenvironmental determination.

## 58-14/57 - S41 (CSC8879 and 8880)

Site S41 proved to be a sand succession resting on conglomerate. Two samples, CSC8879 and 8880 were taken at 3.83-3.89m and 4.10m respectively. The residues proved extremely sparse palynologically and are dominated by mineral grains and woody tissue. Palynomorphs recognised in sample CSC8879 include ?Bitectatodinium tepikiense, (spine-bearing) dinoflagellate Senoniasphaera skolochorate cysts and sp.. Bitectatodinium tepikiense ranges from the Miocene to the Holocene (Powell, 1992; Harland, 1992), suggesting that the other dinoflagellate cysts may be reworked. The Jurassic/Lower Crertaceous pollen Perinopollenites elatoides was also observed; this form is probably reworked. However, the paucity of the flora dictates that no firm conclusions are tenable.

Sample CSC8880 proved virtually barren, with a single indeterminate dinoflagellate cyst, undifferentiated pollen grains and fungal spores present.

#### <u>58-14/60 - S51</u> (CSC8881 and 8882)

Two samples from the site S51 were prepared for analyses. This locality proved a succession of interbedded sands to 1.07m. Sample CSC 8881 (0.00-0.02m) yielded a rich dinoflagellate cyst assemblage (2394 specimens per slide) dominated by Operculodinium centrocarpum (55.6%). Also present in lower proportions were Achomosphaera andalousiensis, Bitectatodinium tepikiense, Impagidinium spp., Nematosphaeropsis labyrinthea, Polykrikos schwartzii, Protoperidinium conicum, Protoperidinium pentagonum, round, brown forms (Protoperidinium spp.) and Spiniferites spp. The occurrence of Protoperididinium avellana indicates that the probable age of the sample is no older than late Pleistocene (Harland, 1992). This conclusion is supported by the presence of Protoperidinium conicoides, Protoperidinium conicum, Protoperidinium leonis Protoperidinium pentagonum and Spiniferites elongatus. This rich association is compatible with the Holocene associations (compare Harland, 1988). The flora is indicative of interglacial ameliorative conditions, under the influence of North Atlantic waters. The dominance of *Protoperidinium* spp. and Spiniferites spp. over *Impagidinium* spp. is indicative of a shelfal setting. Reworking was negligible.

Sample CSC8882 (1.02-1.07m) proved much less productive, with 46 dinoflagellate cysts per slide. No age-diagnostic elements were present. However, the dominance of *Operculodinium centrocarpum* (56.5%) over *Bitectatodinium tepikiense* (39.1%) is again suggestive of a Quaternary age and indicative of interglacial conditions. Relatively low, yet significant levels of reworked Jurassic/Lower Cretaceous pollen were noted.

## 58-14/63 - S53 (CSC8883)..

A single mudstone sample at 0.81-0.83m was taken from site S53. Sample CSC8883 yielded an extremely sparse palynoflora, the residue being dominated by mineral grains and wood. Dinoflagellate cysts recognised include *Operculodinium centrocarpum* and rare round, brown *Protoperidinium* species. This assemblage is reminiscent of Quaternary successions but the paucity does not allow a palaeoclimatological determination to be made. No evidence of reworking was noted.

#### <u>59-11/12 - S1</u> (CSC8884)

A single sample from site S1 was taken at 1.40-1.43m. This locality proved limestone interbedded with basalt flows. Sample CSC8884 produced a virtually palynologically barren residue, being dominated by mineral grains and woody tissue. No microplankton was recognised, the only palynomorphs being rare *Botryococcus* and undifferentiated pollen. Therefore, an age/palaeoecological analysis is not feasible.

#### <u>59-11/13 - S2</u> (CSC8885 to 8888)

Four samples were prepared from site S2, which proved a suuccession of interbedded sands to 4.67m. The youngest three samples (CSC8885-8887) yielded abundant palynofloras all dominated by the dinoflagellate cyst Operculodinium centrocarpum. Other species present include Achomosphaera andalousiense, Bitectatodinium tepikiense, Impagidinium spp., Nematosphaeropsis labyrinthea, Protoperidinium conicum, Protoperidinium pentagonum, round, brown forms (Protoperidinium spp.) and Spiniferites spp. Productivity was especially great in sample CSC8885 (0.00-0.05m), where there are 1170 dinoflagellate cysts per slide. The presence of Protoperidinium avellana is indicative of a probable no-older-than late Pleistocene age for this sample. The occurrences of Protoperidinium conicoides, Protoperidinium conicum, Protoperidinium pentagonum and Protoperidinium leonis supports this contention. These Operculodinium centrocarpum-dominated floras in samples CSC8885 to 8887 are indicative of interglacial, ameliorative conditions, influenced by relatively warm, North Atlantic waters. The predominance of Protoperidinium spp. and Spiniferites spp. over Impagidinium spp. signals deposition in a shelfal environment. The relatively high productivity in sample CSC8875 indicates a possible Holocene age for this horizon (Harland, 1988). This sample also produced a single grain of Lycospora sp., a reworked Carboniferous spore. Rare reworked Carboniferous and Mesozoic/Tertiary grains were also observed in sample CSC8886 (0.60-0.65m). Sample CSC8888 (4.60-4.67m) proved virtually barren of dinoflagellate cysts.

#### <u>59-11/16 - S43</u> (CSC8889)

A single sample, CSC8889 (4.30-4.35m), from site S43 was taken from a succession of interbedded sands. This sample yielded an abundant palynoflora, dominated by dinoflagellate cysts of Eocene aspect. The assemblage is abundant, diverse and well-preserved. Prominent forms include *Areoligera* spp., *Glaphyrocysta* spp. and *Spiniferites* spp. The assemblage is rich in species which characterise the early to mid-Eocene

(Ypresian-Lutetian), for example ?Dracodinium condylos, Glaphyrocysta? vicina, Lejeunecysta hyalina, Wetzeliella lunaris and Wetzeliella cf. meckelfeldensis. The presence of Areoligera lauloma, however, suggests that the sample is mid-Eocene in age (Lutetian, Calcareous Nannoplankton Zones NP14-NP16) (Powell, 1992). Areoligera tauloma is relatively rare and an age dating based on this small population is deemed to be somewhat speculative. The sample is therefore considered to be early to mid-Eocene (Ypresian-Lutetian) on the evidence of Glaphyrocysta? vicina and Wetzeliella lunaris. The presence of these key taxa indicate a Ypresian to early Lutetian age (Calcareous Nannoplankton Zones NP12/13 to early NP15) (Powell, 1992). The occurrence of abundant marine microplankton is indicative of an open marine depositional setting. The presence of significant proportions of peridiniacean dinoflagellate cysts suggests a nearshore marine regime. Rare reworked spores of Carboniferous (Densosporites spp., Lycospora spp.) and Early Cretaceous age (Cicatricosisporites sp.) were observed.

#### <u>59-11/17 - S44</u> (CSC8890 and 8891)

Two samples from site S44 were prepared from a mud-rich succession to 4.63m. The samples produced rich, well-preserved palynofloras. Productivity was high with dinoflagellate cyst concentrations of 996 and 480 specimens per slide for samples CSC8890 (0.00-0.05m) and CSC 8891 (4.60-4.63m) respectively.

Sample CSC8890 yielded an assemblage rich in *Operculodinium centrocarpum* (56.6%). Other, relatively minor, elements include *Achomosphaera andalousiensis*, *Bitectatodinium tepikiense*, *Nematosphaeropsis labyrinthea*, *Polykrikos schwartzii*, *Protoperidinium conicum*, *Protoperidinium pentagonum*, round, brown cysts (*Protoperidinium spp.*) and *Spiniferites* spp. This flora is indicative of an interglacial, ameliorative episode, with deposition in a shelfal setting. No unequivocal reworked palynomorphs were observed.

Sample CSC8891, by contrast, is dominated by round, brown cysts (*Protoperidinium* spp.) (55.8%). The remainder of the indigenous dinoflagellate cyst association comprises

Polykrikos schwartzii and Spiniferites spp. The presence of Protoperidinium avellana at this horizon indicates that the entire succession is probably no older than late Pleistocene (Harland, 1992). This is supported by the occurrences of Protoperidinium conicoides, Protoperidinium conicum, Protoperidinium leonis and Protoperidinium pentagonum. The preponderance of round, brown forms is indicative of a cold, arctic-like, glacial episode, with permanent (i.e. non-seasonal) ice-cover. This sample also contains relatively high levels of reworked palynomorphs. The reworking is multiphase, with Carboniferous Lycospora Jurassic (Callialasporites (Densosporites spp.), dampieri. spp., Callialasporites turbatus, Cyathidites australis, Nannoceratopsis gracilis) and Paleogene (e.g. Eatonicysta ursulae, Lejeunecysta hyalina, Homotriblium spp.) elements present.

#### <u>59-14/6 - S5</u> (CSC8892 and 8893)

Two virtually stratigraphically adjacent samples were prepared from site S5, which proved 5.06m of claystone. Sample CSC8892 (5.00-5.03m) produced a sparse residue and palynoflora, largely comprising dinoflagellate cysts of Eocene aspect. The presence of *Areoligera* cf. *senoniensis, Hystrichodinium* cf. *salacium* and *Thalassiphora pelagica* are strongly suggestive of an early/mid-Eocene age (Powell, 1992).

The underlying sample 81 (CSC 8893, 5.05-5.06m) yielded an extremely rich, wellpreserved palynofloral association, again dominated by typically Eocene dinoflagellate cysts. The association is totally dominated by Thalassiphora pelagica see also Appendix 2). The most stratigraphically significant species present is Dracodinium politum, which typifies the early Eocene. Powell (1992) stated that the full range of this distinctive species is intra-Ypresian (Calcareous Nannoplankton Zone NP12) to earliest Lutetian (Calcareous Nannoplankton Zone NP14). However, as Dracodinium politum was present in significant proportions, a correlation with the Ypresian Ccl dinoflagellate cyst zone of Powell (1992) considered likely. The presence of Achilleodinium biformoides, is most Charlesdownia Adnatosphaeridium multispinosum, the coleothrypta group, Cordosphaeridium gracile, Deflandrea phosphoritica, Homotryblium tenuispinosum,

*Hystrichokolpoma cinctum, Rottnestia borussica, Wetzeliella lunaris* and *Wetzeliella meckelfeldensis* supports this Ypresian-?Lutetian age determination. The presence of abundant marine microplankton is indicative of an open marine depositional setting. Due to the presence of significant proportions of peridiniacean forms, an inshore marine regime is suggested. Rare Carboniferous spores (*Lycospora* sp.) were observed.

#### <u>59-14/7 - S4</u> (CSC8894 and 8895)

Site S4 proved a succession of 5.12m of sandstone on mudstone. Two samples were taken, CSC 8894 and 8895 (4.00-4.03m and 5.07-5.12m respectively). Sample CSC8894 proved virtually palynologically barren, with only rare fungal spores present. However, sample CSC8895 yielded a relatively abundant, well-preserved dinoflagellate cyst flora. The presence of *Areoligera senoniensis Areosphaeridium* cf. *diktyoplokos*. and cf. *Eatonicysta ursulae* means that the sample is of early mid-Eocene age (Ypresian to Lutetian, Calcareous Nannoplankton Zone NP13 to NP15) (Powell, 1992). This contention is supported by the occurrences of *Achilleodinium biformoides, Cordosphaeridium gracile, Homotryblium abbreviatum, Homotryblium tenuispinosum, Hystrichokolpoma cinctum* and *Thalassiphora pelagica*. The presence of marine microplankton is indicative of an open marine setting. Furthermore, the dominance of gonyaulacacean species suggests deposition in an offshore shelfal regime. No evidence of reworking was observed.

## <u>59-14/8 - S3</u> (CSC8896 and 8897)

Two samples were taken from site S3 which proved a mudstone succession. Sample CSC8896 (0.98-1.00m) produced an extremely sparse, non age-diagnostic palynoflora comprising fungal debris, and indeterminate pollen grains. The underlying sample CSC8897 (3.80-3.83m) also yielded a sparse association, dominated by woody tissue. The (rare) presence of the dinoflagellate cyst *Thalassiphora pelagica* indicates a probable Paleogene age. This species has its range base in the Maastrichtian (Stover *et al.*, 1994),

but a Late Cretaceous age is precluded on lithological grounds. The range top is in the earliest Miocene (Powell, 1992), however, at this level the species is rare, hence a Paleogene age is most likely. Reworking of the Carboniferous spore *Lycospora* sp. was noted.

## <u>59-14/9 - S6</u> (CSC8898)

A single sample was taken from site S6, a mudstone succession proved to 5.09m. Sample CSC8898 (5.07-5.09m) proved to be virtually palynologically barren, with only fungal debris and indeterminate pollen grains present. The residue is dominated by mineral grains; some of these grains appear to have structure. It is possible that some are mineralised microfossils, however, if so, they are not identifiable due to the intense mineral induration. An age/palaeoenvironmental assessment is therefore impossible.

## SUMMARY

This suite of samples yielded variably productive palynomorph assemblages. Of the paliniferous samples, the majority proved to be of probable Mid-Late Pleistocene age based on dinoflagellate cyst associations. Of these, both interglacial and glacial episodes were represented. Samples CSC 8864, 8889, 8892, 8893, 8895 and ?8897 are Eocene (Ypresian/Lutetian) based on dinoflagellate cyst floras. Carboniferous, Jurassic/Lower Cretaceous and Paleogene reworking was frequently observed.

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# FORAMINIFERAL ANALYSIS OF SHALLOW CORES FROM THE ROCKALL AREA

## FORAMINIFERAL ANALYSIS OF SHALLOW CORES FROM THE ROCKALL AREA

## I.P. Wilkinson

## Introduction

A suite of samples from the Rockall Area were submitted for micropalaeontologoical analysis. They were examined for foraminifera and although other groups were also noted, e.g. ostracods, Bolboformids and radiolaria, there was insufficient time to utilise them in any meaningful way. The full list of species for each sample is located within the biostratigraphy records of the BGS and selected species are discussed in this report. All samples are considered to be of no older than the mid-Pleistocene (and several are probably Holocene in age) unless otherwise stated. The planktonic assemblages are related to the faunal provinces defined by Bé (1977). Due to time constraints, not all of the samples in the batch CSC8813 to 8899 were examined, whilst several additional samples - CSC8900 to 8907 - were submitted from key cores. The microfauna extracted from the samples are described below, listed in BGS sample order.

#### Results

### <u>56-14/13 - S24</u> (CSC8913-8915)

#### **CSC8913**

Paromalina crassa and Cibicides lobatulus are abundant and Planulina ariminensis and Cibicides refulgens are frequent. Amongst the rare species are Pullenia quinqueloba, Lagena williamsoni, Trifarina angulosa, Pyrgo williamsoni, Uvigerina peregrina and Textularia agglutinans. Conditions are considered to be as of those for the upper continental slope, and the high proportions of attached species is comparable with the assemblage dicussed under CSC8814. The planktonic association is dominated by common G. inflata and frequent N. pachyderma (both sinistral and dextral forms are present) but G. bulloides, G.bradyi and small O. universa were rare. This assemblage is indicative of the warmer part of the Subarctic Province.

#### **CSC8814**

The fauna is dominated by abundant benthonic *Cibicides lobatulus* and *Paromalina* crassa, together with planktonic *Globorotalia inflata* and (mainly sinistral) Neogloboquadrina pachyderma. Hoeglundina elegans, Uvgerina peregrina, Rupertia stabilis, Cibicides refulgens and Trifarina angulosa are also present in small numbers within the benthos and frequent *Globigerina bulloides* and rare *Globigerina glutinata* and *Globorotalia truncatulinoides* occur in the plankton.

Of the benthos, taxa that have an attached mode of life, such as *Paromalina crassa*, species of *Cibicides*, such as *C. lobatulus and C. refulgens*, and *Planulina ariminensis* are characteristic elements between about 700 and 1500m depth and Pujos (1970) suggested that the distribution of these species is related to the presence of the core of Mediterranean water. Weston (1985) suggested that this attached association was able to colonise parts of the continental slope that were unfavourable to other species due to instability in the environment. Perhaps low oxygen or salinity levels are indicated. In the Western Approaches and Porcupine Seabight they are characteristic of continental slope in 700-1400m water depths, but are often found in the outer shelf/upper slope environments to depths of 500m (Murray, 1971;Weston, 1985). The substrates used may be pebbled, plants, bryozoa, shell debris, bundles of sponge spicules etc.

*Rupertia stabilis,* another attached form, is characteristic of the lower slope/lower bathyal, in water depths of between1750-4000m, but it occurs in depths as shallow as 1156m in the cold waters of the Faeroe-Shetland Channel. Its rarity in the present sample may indicate that it is at the limit of its endurance. *Hoeglundina elegans* is characteristic of the 2500-3800m interval of the North Atlantic Seaboard of the USA on silty clay and temperatures of 2-3°C, but it occurs higher on the slope off northwestern Europe. Finally *Uvigerina pergrina* is found on fine-grained sediment with over 1% organic carbon and reach high percentages where oxygen content of the water is at a minimum. It is known from the outer shelf on, for example the Gulf of Mexico and on the outer shelf and slope off Europe in waters of 200 to 3000m and at depths of between 1000 and 2660m off the Atlantic Seaboard of North America.

The planktonic element is dominated by taxa characteristic of the Subarctic faunal province (sensu Bé, 1977) and the high proportion of sinsitrally coiled *N. pachyderma* implies the colder part of this province where the April isotherm is less that 7.2°C.

#### **CSC8815**

The fauna in this sample is similar to that of CSC8814. There are minor differences such as the inceased numbers of *Trifarina angulosa* and the occurrence of rare *Cassidulina laevigata* and *Planulina ariminensis*, in the benthos, and a larger proportion of dextrally coiled *N. pachyderma* together with very rare *Globorotalia crassaformis* and *Globorotalia truncatulinoides* in the planktonic element. The surface waters are probably slightly warmer than CSC8814 as *G. crassaformis* is not found in waters colder than the transitional zone according to Bé (1977).

*Planulina ariminensis* is an important element in the *Paromalina crassa/Cibicides lobatulus* assemblage described from 442-1095m water depth in the Porcupine Seabight and Western Approaches (Weston, 1985). This species are often attached to sponges that extend to about 150mm from the sea floor where it can take advantage of water movement. *Trifarina angulosa* is apparently controlled by temperature as it is found in waters of less than about 8°C in the Atlantic Seaboard of USA and is present on the shelf as well as the slope. Hence, whereas the surface waters appear to be slightly warmer, the bottom conditions remain relatively cold.

#### <u>57-11/67 - S29</u> (CSC8916-8920)

#### CSC8816

Benthonic foraminifera are rare and of poor preservation so that their provenance must be in doubt. Shallow water species *Ammonia batavus* is present indicating contamination from near shore areas. The planktonics include small morphs of *Orbulina universa*, a species that is widespread in tropical and subtropical areas Where the larger morph is present, but rare in the transitional province, becoming small in dimension when close to their northern limit. This, together with the presence of rare specimens of *N. pachyderma* in an essentially sinistrally coiled population, may indicate a position close to the transitional/Subarctic boundary.

## CSC8817

The benthos is in a poor state of preservation, however, rare specimens of *Cibicides* lobatulus, Paromalina crassa Cibicides pseudungerianus, Rupertia stabilis, Uvigerina peregrina and Hoeglundina elegans indicates a similar environment to that of CSC8814. The planktonic element is dominated by flood proportions of cold water, sinistrally coiled *N. pachyderma* and the Arctic Province is indicated.

## **CSC8818**

The benthos is very rare and comprises mainly of species of *Cibicides* and *Paromalina* crassa, and the planktonic element comprises mainly of the cold water, sinistral *N*. pachyderma (see comments for CSC8814).

#### CSC8819

Microfossils are very rare. *N. pachyderma* is mainly sinistral and the benthos comprises mainly of the attached forms described for CSC8814.

## CSC8820

The benthos is dominated by abundant *Paromalina crassa*, together with subordinate *Hoeglundina elegans*, *Cibicides refulgens*, *C. lobatulus*, *C. pseudoungerianus* and *Planulina ariminensis*. It is similar to that of CSC8814. However, the absence of *Rupertia stabilis*, which is particularly characteristic of the lower slope/lower bathyal (1750-4000m), implies somewhat shallower water depths. Species such as *P. crassa*, *C. lobatulus* and *Planulina ariminensis* are characteristic elements between about 700 and 1500m. A reworked specimen of *Elphidium* cf *albiumbilicatum* indicates off-shelf

contamination. Of the planktonic specimens, abundant sinistral *N. pachyderma* and *Globigerina bulloides* also indicates cold surface waters, although very rare specimens of the small morph of *Orbulina universa* indicates the influence of waters from the transitional province.

57-12/18 - S30 (CSC8821 and 8900)

CSC8821 The microfauna is identical to that of CSC8820.

CSC8900 As for CSC8875

57-12/19 - S28 (CSC8822 and 8823)

#### **CSC8822**

*Hoeglundina elegans* was not found in the sample, but otherwise the fauna (both benthonic and planktonic) is identical to that of CSC8820.

## **CSC8823**

Although slightly more diverse than CSC8820, the fauna is essentially similar.

<u>57-12/33 - S27</u> (CSC8824 to 8826)

## **CSC8824**

The benthonic part of the assemblage is dominated by *Cibicides lobatulus* and *Planulina wuellerstorfi*. The latter species is characteristic of the assemblages off Norway between c.1000m and c.3000m where it is found with *Epistominella exigua* (a species that has not been recognised in CSC8824) and is often found associated with the North Atlantic Deep

Water and the Norwegian Sea Bottom Water. It is better developed in the latter compared to the former, presumably due to the low temperatures (-2°C compared to 2.5-4.0°C)

Rare *Pullenia bulloides* occurs in the present sample, together with *Sigmoilina* schlumbergeri and as these species range down to depths of about 1500m off Norway and Bay of Biscay, it may be that the present sample was deposited shallower water depth than that in which *E. exigua* shows preference. An alternative is that the absence of this species is a result of sample failure, because other species of deeper water origin, such as very rare *Rupertia stabilis*, are present. The occurrence of very rare Ammonia batavus indicates reworking from near shore conditions.

The planktonic association comprises common *N. pachyderma* (mainly sinistrally coiled, but including a dextral element) and *G. bulloides*, with frequent *G. inflata*, *Globorotalia sciula* and larger specimens of *Orbulina universa*. The presence of the last named implies that the the area came under the influence of waters from the transitional province.

#### **CSC8825**

The presence of frequent *Cibicides lobatulus*, *P. wuellerstorfi* and *Hoeglundina elegans* together with rare *Sigmoilina Schlumbergeri* and *Paromalina crassa* is similar to the assemblage of CSC8824. Although *R stabilis* and *P. bulloides* were not recorded, the environment of deposition appears to be similar. The high proportion of dextrally coiled *N. pachyderma* together with the rare. large, *O. universa* and the frequent *Globorotalia truncatulinoides*, indicates the influence of the Transitional province.

#### **CSC8826**

Foraminifera are rare and poorly preserved. Specimens tentatively assigned to *Bolboforma* reticulata and *B. badensis* point to a mid- to late Miocene age.

#### <u>57-13/26 - S26</u> (CSC8827 to 8833)

## **CSC8827**

The occurrence of *Globigerinapsis index* and *Globigerina* cf *triangularis* with a sparse Pleistocene to Recent assemblage indicates either Eocene reworked with a younger assemblage or and Eocene sample with younger contamination caused during sampling.

## CSC8828

The benthonic association is sparse, but include frequent *Planulina wuellerstorfi*. The planktonic element comprises abundant *Globigerina bulloides*, common *Orbulina universa* (large morph) and *G. inflata* as well as frequent dextral *N. pachyderma* and rare *G. truncatulinoides*. It is considered to be indicative of the Transitional province sensu Bé (1977).

#### **CSC8829**

The plankton comprises abundant *Globigerina bulloides*, common *Globorotalia scitulus* and *Globorotalia inflata*, frequent dextrally coiled *Neogloboquadrina pachyderma*, rare *Globorotalia hirsuta* and very rare *Orbulina universa* (large morph). This implies a position well within the Transitional Province. Although the benthos is sparse, *Pullenia bulloides* is present, a species characteristic of the slope down to about 1500m. Very rare specimens tentatively assigned to *Bulimina mexicana* were also found, but the significance of this is unclear due to taxonomic problems and lack of data.

#### **CSC8830**

Although rare, the foraminifera have a moderately high diversity, including *Planulina* wuellerstorfi, *Planulina ariminensis*, *Sigmoilina schlumbergeri*, *Hoeglundina elegans*, *Pullinia* cf bulloides, *Triloculina trigonula*, *Pyrgo williamsoni* and *Hansenisca soldanii*, but all are rare or very rare. Species of the attached taxa *Cibicides spp.,Paromalina* crassa and *Rupertia stabilis* are notably absent, presumably due to the lack of a suitable substrate. *Planulina wuellerstorfi* is found off Norway between c.1000m and c.3000m and

Pullenia bulloides together with Sigmoilina schlumbergeri range down to depths of about 1500m off Norway and Bay of Biscay. Hoeglundina elegans is characteristic of the 2500-3800m interval of the North Atlantic Seaboard of the USA on silty clay and temperatures of 2-3°C, but it occurs higher on the slope off northwestern Europe (between 725 and 950m in the Porcupine Seabight and Western Approaches) and between 180-275m off Tristan d'Acunha in the South Atlantic. The plankton include abundant sinistrally coiled N. pachyderma and G. bulloides, frequent G. inflata, rare G. scitulus and very rare O. universa (small morph) indicating cold surface waters of the Subarctic Province.

## **CSC8831**

With the exception of very rare *Cassidulina laevigata* and *Pullenia bulloides*, benthonic foraminifera are absent. The reason for this absence is unknown, but perhaps low oxygen is the answer. However, it should be pointed out that species tolerent of low oxygen levels are also absent. The planktonic population is larger, although relatively rare compared to many other samples from the area, with abundant sinistral *N. pachyderma*, rare *Globigerinita bradyi* and *Globirotalia inflata* and very rare *Globigerinella glutinata* and *Globigerina bulloides*. Cold surface waters of the Arctic province is indicated with water temperatures of less than about 5 °C.

#### CSC8832

Again, the benthonic element is lacking, being confined to very rare *P. ariminensis* and *Trifarina angulosa*. The planktonic element is similar to that in CSC8831 and similar environmental conditions are indicated.

#### **CSC8833**

Although the benthos is a little richer compared to the above two samples, it is very sparse. *Cassidulina laevigata*, *P. ariminensis*, *Pullenia bulloides* and *Lenticulina peregrina* were recovered. Little can be concluded, except that, if the fauna is in situ, water depths were probably less than1500m if comparison is made with the assemblages off Norway. The planktonic element is similar tto that of CSC8831, but *Globorotalia* 

*scitulus* is also present suggesting that temperatures are not quite as cold. This species is not present in the Arctic Province and it implies the colder part of the Subarctic Province where surface water temperatures are below the 7.2°C Spring isotherm.

#### <u>57-13/53 - S16</u> (CSC8834 to 8836)

## **CSC8834**

The benthos is sparse, but there is a return to the *Planulina wuellerstorfi*, *Cibicides lobatulus, Hoeglundina elegans, Sigmoilina schlumbergeri* assemblage seen above. *Melonis barleeanum is* also present in very small numbers and although present on the outer shelf, it is a typical slope species which prefers temperatures of between-0.5 and 10°C, active bottom currents and muddy or silty substrates. It is found living between 370 and 1900m off nothwestern Europe, for example. The planktonic association is identical to that of CSC8833.

#### CSC8835

Floods of sinistral *N. pachyderma* together with rare *G. bulloides* is typical of the Arctic Province. However, the presence of rare *G. inflata* may indicate that the sample is from a position low within the province as that species is not normally found north of the Subarctic Province. The benthos is again sparse, but includes rare or very rare *Cibicides lobatulus, Sigmoilina schlumbergeri, Trifarina angulosa* and *Hoeglundina elegans*.

#### CSC8836

A diverse benthonic population was recovered, although individual species are rare or very rare. Hoeglundina elegans, Sigmoilina sclumbergeri, Rupertia stabilis, Pyrgo murrhhana, Cibicides refulgens, Planulina wuellerstorfi,, Rectoglandulina cf rotundata, Quinqueloculina agglutinans, Cibicides pseudoungerianus, Cibicides lobatulus, Bulimina marginata and Bulimina cf mexicana. Many of these were discussed for CSC8814, however, Bulimina marginata is normally associated with the shelf and upper slope, and is found living down to depths of about 510m on the upper slope. Considering Rupertia

stabilis is a deep water form, The specimens of *B. marginata* probably represent off-shelf reworking. Of the planktonics, sinistral *N. pachyderma* is abundant, *G. inflata* is common, *G. bulloides* is frequent and *G. truncatulioides* and *O. universa* (small) are very rare. The colder part of the Subarctic Province is indicated, although the influence of Transitional Province is implied by the occurrence of O. universa.

#### 57-13/57 - S31 (CSC8837 and 8838)

#### **CSC8837**

This sample yielded a diverse benthonic assemblage dominated by abundant Paromalina crassa, but with frequent Cibicides lobatulus, Textularia agglutinans, Cibicides refulgens, Mississipina concentrica, Uvigerina peregrina and Trifarina angulosa. Rupertia stabilis and Globocassidulina subglobosa are very rare. The fauna is essentially similar to CSC8814, although there are several additional taxa. Mississippi concentrica, for example, was recorded off the Shetland in depths of 70-90 (128-164m) fathoms during the "Challenger" Cruise and it is also recorded living off Norway in water depths of between 205 and 293m in temperatures of 8.71°C and salinities of 35.25 mille. Trifarina angulosa is particularly characteristic of the shelf and uppermost slope, down to a depth of about 800m off northwestern Europe in water temperatures of about 5-9 C and salinities in excess of 35 mille and often associated with coarser sediment. The significance of the attached forms was outlined for CSC8814. Rupertia stabilis is characteristic of the lower slope/lower bathyal, in water depths of between1750-4000m, but it occurs in depths as shallow as 1156m in the cold waters of the Faroes Channel. There appears then to be two distinct assemblages represented here, one characteristic of the upper slope and one more indicative of the lower slope. It can only be assumed that down-slope reworking has taken place.

The planktonic association comprises abundant, mainly (but not entirely) sinistrally coiled *N. pachyderma* and *G. bulloides* together with frequent *G. inflata, G. scitulus* and *O universa* and very rare *G. truncatulinoides* implying that the fauna is from the Subarctic Province with influence from the Transitional Province in the form of O. universa. The

sample also contained rare specimens tentatively indentified as *Calcarina stellata*. This unusual species is totally out of place in that it is recorded from the Eocene of France. It must be considered to be reworked.

## CSC8838

Not examined.

## 57-13/65 - S19 (CSC8839)

## CSC8839

Foraminifera very rare and poorly preserved (a specimen of *N. pachyderma* and an indeterminate fragment). Provenance is questionable. No conclusions can be drawn.

57-13/75 - S47 (CSC8840 and 8841)

Not examined.

57-13/76 - S48 (CSC8842 and 8843)

Not examined

<u>57-13/77 - S56</u> (CSC8844)

Not examined

57-14/43 - S22 (CSC8845 and 8846)

## CSC8845

Very rare *N. pachyderma*, *G. bulloides* and *G. inflata*. The provenance of these specimens is questinable and no conclusions are drawn.

#### CSC8846

Barren of foraminifera, but very rare specimens of *Bolboforma* were seen. *Bolboforma metzmacheri*, if correctly identified, is indicative of the mid- to late Miocene.

<u>57-14/44 - S23</u> (CSC8847)

#### **CSC8847**

Barren

#### <u>57-14/48 - S21</u> (CSC8848 to 8850)

#### **CSC8848**

Foraminifera are not common. Paromalina crassa, Cibicides pseudoungerianus, Sigmoilina schlumbergeri, Melonis barleeanum, Lenticulina peregrina, Cibicides lobatulus, Rupertia stabilis, Bulimina sp, Cassidulina teretis, Elphidium clavatum are recorded. The last two named are assumed to be reworked from the shelf, but the remainder are for the most part similar to those described for CSC8834 although attached forms are more common. Both sinistrally and dextrally coiled specimens of *N. pachyderma* were common and found together with frequent Globigerina bulloides and rare Globorotalia inflata, Globigerina quinqeloba and Orbulina universa (small). A position low in the Subarctic Province is inferred.

## CSC8849

Paromalina crassa and Cibicides refulgens are frequent and Cibicides pseudoungerianus, Sigmoilina schlumbergeri, Pyrgo murrhyna, Melonis pompilioides, Hansenisca soldanii and Rupertia stabilis are rare. Attached species form a significant part of the assemblage (see above for a discussion). The fauna is similar in many respects to that of CSC8848, but part of the fauna is abraided implying reworking. The planktonic species are also similar, although N. pachyderma is manily sinistrally coiled indicating slightly colder conditions within the Subarctic Province.

## CSC8850

The benthos is sparse though diverse. It is esentially similar to CSC8849. The planktonic element is less rich than in many other sample and comprises frequent *G. bulloides*, rare *G. inflata* and *N. pachyderma*. The Subarctic province is likely

<u>57-14/54 - S23</u> (CSC8851 to 8853)

#### CSC8851

As for CSC8813.

## CSC8852

Very sparse microfauna comprising very rare *Cibicides refulgens*, *Trifarina angulosa* and *N. pachyderma* (dextral and sinistral). No conclusions are drawn. The benthonic element is probably derived from the shelf.

## CSC8853

A rare fauna comprising *Trifarina angulosa*, *Cibicides refulgens*, *C. lobatulus*, *Globocassidulina subglobosa*, sinistral *N. pachyderma* and fragments of other very rare foraminifera. This is possibly reworked *T. angulosa/C. lobatulus* Species Assemblage (*sensu* Mackensen et al., 1985) from the outer shelf to upper slope off Norway. Very rare specimens of (?)Bolboforma are also present implying possible Miocene reworking.

<u>58-11/2 - S45</u> (CSC8854 to 8855)

## CSC8854

Foraminifera are rare, particularly the benthonic element. Frequent G. *inflata* and G. *bulloides* and rare O. *universa* (small) and sinistral N. *pachyderma* form the planktonic association indicative of the colder part of the Subarctic Province.

## CSC8855

Foraminifera are very rare; only a single benthonic specimen was seen. Of the planktonics, sinistrally coiled *N. pachyderma* is frequent and *G. bulloides* and *G. inflata* are rare. A position high in the Subarctic Province or low in the Arctic Province seems most likely.

## <u>58-12/5 - S46</u> (CSC8856 to 8857)

## CSC8856

Benthonic specimens are exceedingly rare. Abundant G. bulloides and G. inflata together with rare dextral N. pachyderma, small O. universa and G. quinqueloba as well as very rare G. bradyi and G. scitulus places the fauna into the high transition or low Subarctic provinces.

#### CSC8857

A flood of *N. pachyderma* (sinistrally coiled) and only very rare *G. inflata* places the fauna into the Arctic Province. Benthonics are again very rare, the total fauna comprising *P. ariminensis* and *P. wuellerstorfi* and *Lenticulina* sp all being represented by only one or two specimens.

<u>58-14/8 - S7</u> (CSC8858 and 8901)

Not examined

<u>58-14/9 - S8</u> (CSC8859 to 8861)

#### **CSC8859**

The diverse benthonic fauna is dominated by common Uvigerina peregrina, frequent Quinqueloculina seminulum, Cibicides lobatulus, Paromalina crassa and rare Bigenerina nodosaria, Hoeglundina elegans, Cibicides refulgens, Planispirinoides sp and Oridorsalis umbonatus. Reworked speciens from the outer shelf such as Bulimina *marginata* and *Melonis barleeanum* are very rare. The large numbers of *U. peregrina* is indicative of low oxygen level according to some authors, whereas Miller & Lohmann (1982) show it to be related to maximum values of organic carbon and silt in the substrate and hence the low oxygen content of the substrate and not the overlying water. The species is the dominant taxon in Variomax Factor 10 (of Weston, 1985) which is present at a depth of about 2000m (ie. lower slope-upper rise) in the Porcupine Seabight although it occurs on the outer shelf, slope as well as in bathyal regions off Europe and America. The species shows a preference for cold water ( $3-4^{\circ}$ C). Sinistral *N. pachyderma* occurs in flood proportions and *G, bulloides* is common (*G. inflata, G. bradyi* and small *O. universa* are very rare). Surface waters of the Arctic Province is inferred.

#### **CSC8860**

Flood of sponge spicules and radiolaria. Of the benthonic foraminifera, abundant *Paromalina crassa* and frequent *Uvigerina peregrina* and *Trifarina angulosa* dominate the assemblage. Rarer attached species are aso present such as *Cibicideslobatulus* and *C. pseudoungerianus*. Cold water, upper slope conditions are indicated with maximum values of organic carbon and silt in the substrate and the low oxygen content of the substrate. Abundant *G. bulloides* and rare *G. quinqueloba* and sinistral *N. pachyderma* comprise the planktonic association and a high Subarctic or low Arctic Province is implied.

## **CSC8861**

The planktonic element of the fauna is dominated by abundant *Globorotalia inflata*, common, mainly sinistral, *N. pachyderma*, frequent *Globigerina bulloides* and very rare, small *Orbulina universa*. The abundance of *G. inflata* is indicative of theTransitional Province, although the sinistrally coiled *N. pachyderma* implies colder waters(Subarctic Province). The reason for this mixing may be due to reworking, but this is not clear.

The benthonic fauna is dominated by abundant *Paromalina crassa* and other species are rare or very rare, but include *Pyrgo murrhyana*, *Trifarina angulosa*, *Cibicides lobatulus*, *C. pseudoungerianus*, *C. refulgens*, *Sigmoilina schlumbergeri*, *Melonis barleeanum*, *Cassidulina laevigata*, *Bolivina spathula*, *Bulimina marginata* and *Oolina*  *melo*. This fauna appears to be from the upper slope, perhaps fitting within the *angulosa/lobatulus* assemblage from offshore Norway (Mackensen et al., 1985).

## <u>58-14/10 - S9</u> (CSC8862)

#### CSC8862

The fauna is sparse and poorly preserved. *Planulina wuellerstorfi, Cibicides lobatulus, Gyroidina neosoldanii* and *Pullenia quinqueloba* are present with abundant bryozoa and echinoid spines. The preservation and sparse nature of the fauna precludes conclusions. Several specimens from this sample appear to be poorly preserved Eocene taxa (*Alabamina* cf *wilcoxensis, Globorotalia* cf *esnaensis, Globigerina* cf *linaperta, Globigerrina* cf *boweri*). *Globigerina linaperta* is a fairly long-ranging species, with its inception in the Palaeocene but ranging up to the basal part of foram zone P16 (i.e. earliest late Eocene). *Globorotalia cf esnaensis* are indeed that species, this is also a Palaeocene to early Eocene indicator. It would seem that an early Eocene age is likely.

#### <u>58-14/11 - S10</u> (CSC8863)

## **CSC8863**

Calcareous microfossils are rare and poorly preserved. No conclusions are possible.

58-14/29 - S13 (CSC8864, 8899 and 8905)

#### **CSC8864**

Foraminifera are rare. Although the planktonic taxa (sinistral *N. pachyderma* and *G. quinqueloba*) are very rare and undoubtedly Pleistocene in age, the benthonic specimens are not. They are similar to those from the deep water, dysaerobic conditions characteristic of the Eocene in the North Sea. *Rabdammina* cf discreta fragments, *Reticulophragmium amplectens* (of King, 1989), crushed *Trochammina* sp. and

Haplophragmoides sp. cf walteri, Karrerulina conversa and other agglutinatined forms. Rectophragmium amplectens suggests an age no younger than the earliest part of the mid-Eocene at which level it has its First Down-hole Occurrence. Perhaps significant is the fact that Cenosphaera sp which has its FDO approximately at the mid-/early Eocene boundary was not observed, but Karrerulina conversa is present, the inception of which is near the base of the Mid Eocene. Age: mid-Eocene.

#### **CSC8899**

Not examined

#### CSC8905

A very sparse fauna of very poor preservation. Very rare *Cibicides lobatulus* and *Paromlina crassa* were recognised together with a poor specimen tentatively identified as *Reticulophragmium amplectens*. It is not clear whether this is reworked from the Eocene or whether the specimen is in situ.

## <u>58-14/31 - S12</u> (CSC8865)

#### **CSC8865**

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Paranomalina crassa, Textulariella agglutinans, Gyroidina neosoldanii, Planulina ariminensis, Uvigerina peregrina, Cassidulina laevigata, Planulina wuellerstorfi, Cibicides pseudoungerianus and Trifarina angulosa are present. The benthonic fauna is similar to that in CSC8860. Dextral *N. pachyderma* is also present indicating the low Subarctic Province. The indurated rock chips of the sample have a fauna which is difficult to deal with due to the encrusting material, but many look to be Pleistocene to Pliocene forms. Further work on this material may be beneficial.

## 58-14/32 - S12 (CSC8866, 8867 and 8902)

#### CSC8866

Not examined

## CSC8867

As for CSC8865, although diversity is lower.

#### CSC8902

Pleistocene faunas are common in this sample, however Eocene planktonic foraminifera are also common including *Globigerina* cf *boweri*, *Globigerinita* cf unicava primitiva, *Globigerina* cf *boweri* together with what appears to be a broken *Nummulites*.

<u>58-14/34 - S14</u> (CSC8868 to 8870)

#### **CSC8868**

A flood of sinistrally coiled *N. pachyderma* with rare *G. inflata, G. bulloides* and very rare *G. truncatulinoides* is indicative of the high Subarctic and low Arctic provinces. The benthonic element is sparse, but includes the deep, cold water species *Rupertia stabilis* together with *Planulina wuellerstorfi, Cibicides lobatulus, Sigmoilina schlumbergeri* and *Pullenia bulloides*. Deposition at 1000-1500m seems likely. Rare specimens more characteristic of the shelf (eg. *Fissurina lucida*) are present and probably reworked.

## CSC8869

Although the benthonic association is similar to that of CSC8868, the planktonic taxa show distinct differences. Sinistral *N. pachyderma* is frequent, though not abundant, and dextrally coiled forms are also present, although very rare *Globorotalia inflata* and *Globigerina bulloides* are common and *Globigerina quinqueloba*, *Globorotalia truncatulinoides* and small *Orbulina universa* are very rare. However, this fauna is

probably indicative of the more temporate part of the Subarctic Province, where waters temperatures exceed 7.2°C in Spring.

#### **CSC8870**

As for 8864, but Ammoglobigerina cf globigerinaeformis, Glomospira charoides and Spiroplectammina spectabilis are present. The last named has been used as a biomarker in the North Sea as it has a first Down-hole Occurrence in the mid-Eocene. Rectophragmium amplectens is also present suggesting the age is no younger than the earliest part of the mid-Eocene at which level it has its FDO. The occurrence of Karrerulina conversa precludes an early Eocene age. Age: mid-Eocene

58-14/42 - S7 (CSC8871 and 8903)

**CSC8871** 

Not examined

## CSC8903

Very rare *Globigerinita bradyi*, *Cibicides* sp, indet frags. No conclusions are possible. Foraminifera occur in rock chips, but could not be identified or liberated. Thin section work is required.

<u>58-14/43 - S9</u> (CSC8872 and 8904)

**CSC8872** 

Not examined

## **CSC8904**

Bryozoa occurs in floods, together with shell fragments. Microfossils are not common, but are moderately diverse. *Hoeglundina elegans*, *Oridorsalis umbonata*, *Cibicides peudoungerianus*, *Trifarina angulosa*, *Cibicides lobatulus*, *Cornuspira carinata* and *Eponides repandus.* This association can probably be placed within the *Trifarina* angulosa/Cibicides lobatulus association of Mackesen et al. (1985).

## 58-14/44 - S49 (CSC8873)

## CSC8873

This sample yielded a very sparse fauna comprising only specimens of very small dimensions. It seems likely that this is the product of the accumulation of winnowed material. No conclusions are made.

#### <u>58-14/53 - S11</u> (CSC8874)

#### **CSC8874**

The Pleistocene to Recent planktonic taxa Neogloboquadrina pachyderma (sinistral) is frequent and Globigerina bulloides and Globorotalia cf inflata are rare. This assemblage structure may indicate the Arctic Province, but the sparsity of the fauna means that this conclusion is very tentatively suggested. The benthos includes frequent "Rhizammina" sp., but all other species are very rare and not well preserved. These include Hyperammina subnodosum, Pullenia bulloides, Planorbulina mediterranensis, Cassidulina reniforme, Trifarina angulosa, Glomospira charoides and Alveophragmium sp cf scitulum. Some of these taxa, for example Glomospira charoides, are probably reworked. This is supported by the fact that rare specimens of Bolboforma are present (?Miocene) together with Globigerina cf yeguaensis and Pseudohastigerina cf wilcoxensis (Eocene). No further conclusions are possible.

#### <u>58-14/54 - S42</u> (CSC8875 and 8876)

## **CSC8875**

The poorly preserved fauna is difficult to identify so that conclusions here should be treated with caution. The rock chips within the sample are composed of more than 90%

foraminifera, although these are very difficut to extract from the indurated sediment. Globorotalia cf esnaensis, Globigerina cf linaperta, Truncrotalites cf rohri, Globigerinita cf unicava primitiva and Globigerina cf eocaena were noted. Globigerinita unicava primitiva is a mid-Eocene (foram zone P14) to Oligocene species. Its presence, together with G. linaperta (see CSC8862) and large spherical radiolaria (present in the Eocene of the North Sea - particularly the early Eocene), suggests an Eocene age.

## CSC8876

The deposit is similar to CSC8875. Common specimens of *Globigerina* cf *eocaena* were noted together with rare *Globigerina* cf *venezuelana*. These are Eocene forms. The Pleistocene element in the assemblage comprises rare *Stilostomella bradyi*, *Hoeglundina elegans*, *Sigmoilina schlumergeri*, *Globigerina* cf *bulloides* and *Orbulina* sp, but little can be drawn from the sparse fauna which is most probably the result of down-core contamination.

<u>58-14/55 - S40</u> (CSC8877)

Barren

<u>58-14/56 - S50</u> (CSC8878)

Barren

58-14/57 - S41 (CSC8879 and 8880)

#### CSC8879

Attached forms including abundant Paromalin crassa, frequent Cibicides lobatulus, C pseudoungerianus and C. refulgens dominate the assemblage, other species (including Gyroidina neosoldanii, Uvigerina peregrina, Pyrgo murrhyna, Planulina ariminensis, Sigmoilina schlumbergeri, Hoeglunina elegans and Trifarina angulosa) are rare or very rare. The fauna is similar to that described for CSC8820. Of the planktonic specimens, abundant sinistral *N. pachyderma* and common *Globorotalia inflata* and *Globigerina bulloides* also indicates cold surface waters of the Subarctic Province, although very rare specimens of the small morph of *Orbulina universa* may indicate the influence of waters from the transitional province if reworking is not ruled out.

#### **CSC8880**

This sample contains inducated rock chips containing foraminifera. Identication is not possible, although thin section work may prove useful. No specimens could be released from this matrix for identification. No conclusions are possible.

#### <u>58-14/60 - S51</u> (CSC8881 and 8882)

#### **CSC8881**

The planktonic element is composed of a flood of sinistrally coiled *N. pachyderma* together with rare *G. inflata, G. bulloides* and *G. truncatulinoides*. The structure of this association implies the Arctic Province, but the occurrence of rare *G. inflata* and *G. truncatulinoides* implies that the assemblage must be close to the Arctic/Subarctic province boundary, as both species not normally found further north than the Subarctic Province. The benthos is very sparse, but includes frequent *Rupertia stabilis* together with rare *Sigmoilina schlumbergeri* and *Cibicides pseudoungerianus*. The frequent *R. stabilis* is indicative of cold, deep water. It is characteristic of the lower slope/lower bathyal, in water depths of between1750-4000m, but it occurs in depths as shallow as 1156m in the cold waters of the Faeroe-Shetland Channel. Its frequent occurrence in the present sample is interesting as it is unlike other assemblage described from the European slope.

## CSC8882

This sample contained a diverse benthonic assemblage, but individual species were rare or very rare, with the exception of frequent *Sigmoilina schlumergeri*, the environmental requirements of which are inadequately known. It occurs on the slope in at least bathyal

depths. Of the remainder, *Cibicides lobatulus*, *C. pseudoungerianus*, *C. refulgens* and *Bigenerina nodosaria* are rare and *Pyrgo williamsoni*, *Hoeglundina elegans*, *Eggerella bradyi*, *Uvigerina peregrina*, *Gyroidina neosoldanii*, *Paromalina crassa* and *Melonis barleeanum*. Despite the smaller numbers, the assemblage is not unlike those described previously (eg. CSC8814)

58-14/63 - S53 (CSC8883)

Not examined

## <u>59-11/12 - S1</u> (CSC8884)

#### **CSC8884**

A very sparse fauna comprising rare *Hoeglundina elegans*, *Pullenia bulloides*, *N. pachyderma*, *G. bulloides* and very rare *Gyroidina* sp. Indeterminate specimens were noted in the indurate grains and only thin section work would solve problems here. No conclusions are drawn from this sparse fauna.

<u>59-11/13 - S2</u> (CSC8885 to 8888)

## CSC8885

*Cibicides lobatulus* is common and *C. refulgens* and *Uvigerina peregrina* are frequent. With these are rare *Trifarina angulosa*, *Melonis barleeanum* and *Hoeglundina elegans*. The upper slope is indicated, the fauna apparently being a mixture of the *Trifarina angulosa* Assemblage and *Trifarina angulosa/Cibicides lobatulus* Assemblage of Mackensen et al. (1985) which are characteristic of the outer shelf and upper slope, down to about 700m, off the coast of Norway. The planktonic association comprises common , mainly dextral *N. pachyderma*, *G. bulloides* and *G. inflata*, while moderately large specimens of O. universa are frequent. This assemblage structure is indicative of the warmer part of the Subarctic Province and, perhaps, the colder parts of the Transitional Province, although the characteristic species that define the Transitional Province, such as *Globigerinoides ruber*, *Hastigerina pelagica* and *Globigerinella aequilateralis*, were not observed.

#### CSC8886

Sponge spicules are abundant in this sample and (?)diatoms are also common. Foraminifera are similar to those of CSC8885, although less diverse and sinistrally coiled *N. pachyderma* are more common indicating colder surface waters, colder than the  $7.2^{\circ}$ C Spring isotherm, and a position in the colder part of the Subarctic Province is inferred.

#### **CSC8887**

Sponge spicules abundant. Frequent *Cibicides lobatulus, C. refulgens* and *Quinqueloculina seminulum* dominate the assemblage, while *Trifarina angulosa, Textularia aspera, Uvigerina peregrina* and *Cibicides peudoungerianus* are rare. This is an outer shelf to upper slope association and would not be out of place off northwestern Europe today. *Globigerina bulloides* and mainly sinistral *Neogloboquadrina pachyderma* are common, *Globorotalia inflata* is frequent and *Globigerina quinqeloba* and *Globigerinita bradyi* are rare. The colder part of the Subarctic Province is implied rather than the Arctic Province.

#### **CSC8888**

Paromalina crassa and Cibicides lobatulus are abundant here with rare Cibicides pseudoungerianus, Textularia agglutinans, Trifarina angulosa and very rare Rectoglandulina rotundata, Hoeglundina elegans, Cassidulina laevigata and Planulina wuellerstorfi. Shelf species such as Elphidium subarcticum, are reworked. Although slightly more diverse, this assemblage, as well as the planktonic association, is essentially similar to CSC8887
## <u>59-11/16 - S43</u> (CSC8889)

#### **CSC8889**

Foaraminifera are very rare, dominated by frequent specimens of the cold water, sinistrally coiled *N. pachderma*. Rare *Rupertia stabilis* is also present, indicating cold deep water. The assemblage is so sparse, however, that no further conclusions are possible.

## 59-11/17 - S44 (CSC8890 and 8891)

#### **CSC8890**

The benthos is sparse, comprising rare *Rupertia stabilis*, *Cibicides lobatulus*, *C. pseudoungerianus*, *Sigmoilina schlumbergeri* and *Trifarina angulata*, together with very rare *Uvigerina peregrina*, *Pullenia bulloides*, *Spiroloculina depressa* and *Melonis barleeanum*. This is an outer shelf to upper slope fauna. The planktonic association is dominated by common *G. inflata* and *G. bulloides*, frequent *Globorotalia scitulus*, moderately large *O. universa* and frequent sinistral *N. pachyderma* and rare *G, bradyi*, dextral *N. pachyderma* and *G. truncatulinoides*. The Subarctic province is indicated, and although there are a number of sinistrally coiled specimens of *N. pachyderma*, the presence of the dextral form and the large *O. universa* and the common *G. inflata*, a position in the warmer part of the province seems most likely.

## CSC8891

The benthonic fauna is dominated by frequent *Bulimina marginata*, the remaining species being rare or very rare (*Bulimina elongata, Elphidium incertum, Elphidium excavatum, Triloculina trifera* and *Cassidulina laevigata*). This is a shelf or upper slope fauna, although it includes reworked near shore taxa, such as species of *Elphidium*. It shows some similarities with the *Bulimina marginata* association of Murray (1991) of the European Atlantic Seaboard. This association is found in muddy sands, salinities of about 35 mille and temperatures of  $5.5^{\circ}$ C and  $13^{\circ}$ C.

Sinistral *N. pachyderma* is abundant and *G. inflata* is frequent, but the only other planktonic species, *G. bulloides* and *G. glutinata* are rare. A position high within the Subarctic or low within the Arctic Province seems most likely.

<u>59-14/6 - S5</u> (CSC8892 and 8893)

## CSC8892

Foraminifera very rare comprising only rare sinistral and very rare dextral *N. pachyderma*, rare *G. bulloides* and *G. infata* and very rare *G scitulus*. No benthonics were seen. No conclusions can be made on this sparse assemblage.

#### **CSC8893**

The Pleistocene to Recent fauna is represented by rare *N. pachyderma, G. inflata* and *G. quinqueloba.* However, *Caenosphaera* sp together with '*Cenodiscus*' sp (probably crushed *Cenosphaera*) are abundant. These radiolaria are characteristic of the earliest mid-Eocene and latest early Eocene (i.e. immediately above and immediately below the Ypresian/Lutetian boundary. In the North Sea this is an important biomarker and King (1989) places it in the NSP6 planktonic Zone. The absence of calcareous benthonics and planktonic foraminifera is another characteristic of the zone.

<u>59-14/7 - S4</u> (CSC8894 and 8895)

#### **CSC8894**

Foraminifera extremely rare comprising very rare Uvigerina peregrina and Cassidulina laevigata and planktonic G. inflata, and N. pachyderma (both dextral and sinistral). Fish debris is also present. Little can be drawn from the this sparse assemblage.

#### **CSC8895**

Sponge spicules are common, but the foraminifera comprise very rare *N. pachyderma*, *G. inflata* and *?G. bulloides*. No conclusions are possible.

#### 59-14/8 - S3 (CSC8896, 8897 and 8906)

#### CSC8896

Not examined

## **CSC8897**

Sponge spicules and radiolaria abundant but the foraminiferal fauna is composed of very rare sinistral *N. pachyderma* and *O. universa*. No conclusions are possible.

## **CSC8906**

Fish teeth are present. The foraminiferal assemblage is very sparse, comprising frequent sinistral *N. pachyderma* and very rare *G. inflata, G. bradyi, Cibicides lobatulus, Pullenia bulloidea* and *?Planulina wuellerstorfi*. Apart from pointing out that the sinistral *N. pachyderma* suggests cold conditions (high Subarctic or Actic Province), little can be inferred from the sample.

59-14/9 - S6 (CSC 8898 and 8907)

CSC8898 Not examined

## CSC8907

Bryozoan flood. The foraminiferal assemblage is moderately diverse, although individual species are rare or very rare, the exception being *Cibicides lobatulus*, which is frequent. Species include *Hoeglundina elegans*, *Bulimina* sp., *Valvulineria laevigata*, *Cornuspira* sp., *Lagena costata*, *Patellina corrugata*, *Stilostomella bradyi Orbulina universa* and sinistral *N. pachyderma*. This is a shelf assemblage of the Subarctic Province.

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# CALCAREOUS NANNOFOSSIL ANALYSIS OF SHALLOW CORES FROM THE ROCKALL AREA

## CALCAREOUS NANNOFOSSIL ANALYSIS OF SHALLOW CORES FROM THE ROCKALL AREA

N.M. Hine

#### Introduction

The aim of this investigation was to provide biostratigraphical information by way of calcareous nannofossil analysis of eighty-seven samples (CSC8813 to 8899) collected from the Rockall Area. Calcareous nannofossils provide a tool with which to date marine calcareous sediments from the Late Triassic to Holocene. Of particular relevance to this study is their application to late Quaternary sedimentary sequences. Following the work of Weaver (1983), Gard (1988, 1989), Pujos (1988), Hine (1990) and Baumann & Matthiessen (1992), amongst others, a sequence of calcareous nannofossil events have been identified which occur throughout the north-east Atlantic and adjacent areas. Figure 3 presents a summary of these events for the Quaternary and Figure 4 depicts the standard calcareous nannofossil zonation scheme of Martini (1971) for the entire Cenozoic.

## Quaternary calcareous nannofossil biostratigraphy

The Quaternary of the north-east Atlantic has been subdivided into a number of intervals based on a combination of datum events and taxa acme zones. A summary of those zones recorded in this investigation are presented below and are depicted in Figure 3. The abbreviations LAD and FAD, used throughout this report, refer, respectively, to last appearance datum and first appearance datum.

<u>Small Gephyrocapsa acme zone</u> (Hine, 1990): A zone in which small Gephyrocapsa dominate the assemblage. This zone spans 600 to 860 ky BP, which is equivalent to lower oxygen isotope Stage 15 to Stage 25. The principal species which constitute the Small Gephyrocapsa zone include G. aperta and the small G. caribbeanica. This zone



Fig. 3. Summary of calcareous nannofossil events and zones occurring over the last 1 million years. Symbols: \*, first appearance datum (FAD); +, last appearance datum (LAD).

	S. ciperoensis	NP25
L	S. distentus	NP24
G	S. predistentus	NP23
OCENE	H. reticulata	NP22
	E. subdisticha	NP21
	S. pseudoradians	NP20
	I. recurvus	NP19
	C. oamaruensis	NP18
	D. saipanensis	NP17
E	D. tani nodifer	NP16
° C	N. fulgens	NP15
EN	D. sublodoensis	NP14
E	D. lodoensis	NP13
	T. orthostylus	NP12
1	D. binodosus	NP11
	T. contortus	NP10
	D. multiradiatus	NP9
	H. riedelii	NP8
PA	D. mohleri	NP7
LA	H. kleinpellii	NP6
E	F. tympaniformis	NP5
E	E. macellus	NP4
NE	C. danicus	NP3
Γ	C. tenuis	NP2
Γ	M. inversus	NPI

P L	E. huxleyi	NN21
Ē	G. oceanica	NN20
ST	P. lacunosa	NN19
PLIOCENE	D. brouweri	NN18
	D. pentaradiatus	NN17
	D. surculus	NN16
	R. pseudoumbilica	NN15
	D. asymmetricus	NN14
	C. rugosus	NN13
	A. tricorniculatus	NN12
MIOCENE	D. quinqueramus	NNII
	D. calcaris	NN10
	D. hamatus	NN9
	C. coalitus	NN8
	D. kugleri	NN7
	D. exilis	NN6
	S. heteromorphus	NN5
	H. ampliaperta	NN4
	S. belemnos	NN3
	D. druggii	NN2
	T. carinatus	NNI

Fig. 4. Calcareous nannofossil zonation scheme for the Cenozoic (after Martini, 1971).

can be distinguished from the Small Gephyrocapsa Zone of Gartner & Emiliani (1976) by the lower frequency of both *P. lacunosa* and *Reticulofenestra*.

<u>Gephyrocapsa caribbeanica Acme Zone</u> (Hine, 1990): A zone in which Gephyrocapsa caribbeanica dominates the assemblage. This zone spans 280-600 ky BP, that is, oxy gen isotope stages lower 8 to lower Stage 15.

<u>Gephyrocapsa aperta Acme Zone</u> (Hine, 1990): A zone in which Gephyrocapsa aperta dominates the assemblage. This zone range from 156-280 ky BP, which is equivalent of oxygen isotope Stages lower 6, 7 and upper Stage 8. The first evolutionary appearance of *E. huxleyi* is a globally synchronous event occurring at 270 ky BP and was used by Martini (1971), to define the base of the *Emiliania huxleyi* Zone (NN21) which continues to the present day. All samples containing *E. huxleyi* have, therefore, been deposited less than 270 ky BP.

<u>Transitional Zone</u> (Hine, 1990): A zone in which no one species predominates, although *G. muellerae* is often abundant. This zone spans oxygen isotope stages 4,5 and upper Stage 6 (66-156 ky BP). The LAD of *G. ericsonii* occurs within this zone. Although the LAD of this species is a globally diachronous event (Pujos 1988) being recorded between 20 and 150 ky BP, it has a mean LAD of 122 ky BP in the high latitude northeast Atlantic Ocean (Pujos 1988; Hine 1990). The LAD of *G. ericsonii*, for the purpose of this investigation, is considered to occur within oxygen isotope Stage 5 (112 ky BP). In consequence, all samples containing *G. ericsonii* can be considered as older than oxygen isotope Stage 5.

<u>Emiliania huxleyi</u> Acme Zone (Gartner, 1977): A zone in which *E. huxleyi* dominates the assemblage. The base of this zone is defined by a reversal from assemblages dominated by species of *Gephyrocapsa*, to assemblages dominated by *E. huxleyi*. The base of this zone is slightly time transgressive in the north-east Atlantic, occurring first in low latitudes (85 ky BP; isotope stage 5b) and at progressively younger ages in higher latitudes (Thierstein et al., 1977; Gard 1988). For the purpose of this investigation this event is taken at the oxygen isotope Stage 3/4 boundary. All samples in which *E. huxleyi* is dominant are, therefore, considered to have been deposited between 65 and 0 ky BP.

<u>Coccolithus pelagicus bloom:</u> A bloom of *C. pelagicus* is characteristic of Holocene highlatitude assemblages in the North East Atlantic. The base of this bloom occurs near to the the base of the Holocene (Gard, 1988, 1989; Baumann & Matthiessen, 1992).

## Neogene calcareous nannofossil biostratigraphy

Recognition of Miocene sediments at high latitudes by way of calcareous nannofossils is often problematic due to the absence of warm water discoasters which are used extensively in standard zonation schemes. High-latitude Miocene and Pliocene calcareous nannofossil assemblages tend to be dominated by a single *Reticulofenestra* species. Backman (1980) used the mean size of these to differentiate Miocene from Pliocene sediments in high latitudes of the north-east Atlantic, assigning the larger sizes to the Miocene and the smaller to the Pliocene. Although this is not a very satisfactory methodology, at times it is the only one available to enable Miocene assemblages to be distinguished from Pliocene assemblages.

#### Methods

Standard smear slides were prepared for light microscope analysis from raw sediment strews. Scanning electron microscopy (SEM) analysis was beyond the remit of this investigation. Abundance counts were made either of a minimum of 300 specimens, or a maximum of 25 fields of view, following the technique of Backman & Shackleton (1983). The results of the calcareous nannofossil analysis are presented below in order of their official CSC number.

## Results

## <u>56-14/13 - S24</u> (CSC8813 to 8815)

#### **CSC8813**

<u>Depth: 0.05-0.07m</u>: This is a rich assemblage composed of high numbers of both *C. pelagicus* and *E. huxleyi*. Accessory taxa include *G. aperta, C leptoporus, S. histrica* and *Helicosphaera carteri*. The occurrence of such high numbers of coccoliths suggests the sediment was deposited under interglacial conditions, with surface-water mixing making nutrients available, resulting in this burst of high productivity.

Zonation: Holocene - *Emiliania huxleyi* Zone, NN21 (Martini, 1971); *Emiliania huxleyi* Acme Zone (Gartner, 1977); *Coccolithus pelagicus* bloom (Baumann & Matthiessen, 1992).

#### CSC8814

<u>Depth: 0.28-0.30m</u>: The assemblage is composed of *Emiliania huxleyi*, *Gephyrocapsa* aperta, *Gephyrocapsa caribbeanica*, *Gephyrocapsa muellerae*, *Coccolithus pelagicus*, *Calcidiscus leptoporus*, *Syracosphaera histrica* and *Pontosphaera* sp.. SEM analysis is necessary to determine the ratio of *Gephyrocapsa* to *Emiliania* although light microscope analysis suggests the ratio is positive (ie. more *Gephyrocapsa* than *Emiliania*). The occurrence of *E. huxleyi* (FAD, 266 ka; oxygen isotope stage 8) and the absence of *Pseudoemiliania lacunosa* (LAD, 465 ka) restricts this sample to the late Quaternary *Emiliania huxleyi* Zone, NN21, of Martini (1971). There is no evidence of the *Coccolithus pelagicus* bloom which occurs at the base of the Holocene. Assuming the ratio of *Gephyrocapsa:Emiliania* is positive, the sample can be assigned to the Transitional Zone of Hine (1990). The absence of *Gephyrocapsa ericsonii* (LAD 112 ka), further supports the assignment of this sample to the upper part of the Transitional Zone.

The absence of a significant terrigenous input combined with the high numbers of coccoliths suggests the sediment was deposited under interglacial conditions, with surface water mixing making nutrients available, resulting in this burst of high productivity.

Zonation: Mid-/late Pleistocene - *Emiliania huxleyi* Zone, NN21 (Martini, 1971); ?Transitional Zone (Hine, 1990).

## CSC8815

<u>Depth:</u> 0.90-0.93m: A rich and diverse assemblage composed of *G. caribbeanica, G. aperta, C. pelagicus, G. oceanica, C. leptoporus, S. histrica, and H. kamptneri. E. huxleyi* is recorded in the light microscope counts but SEM analysis is necessary to confirm this. The occurrence of *E. huxleyi* restricts the sample to Zone NN21 of Martini (1971), however, the dominance of *Gephyrocapsa* spp. suggests the sample should be assigned to the Transitional Zone of Hine (1990).

Specimens of *Reticulofenestra* cf. *doronicoides* are recorded in the counts. This species has its last appearance datum in the Early Pleistocene (c.800 ky BP). These recordings are considered to be evidence of reworking, supported by the absence of *Pseudoemiliania lacunosa*.

Zonation: Mid-/late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); (Emiliania huxleyi Acme Zone, Gartner, 1977/Transitional Zone, Hine 1990)

## <u>57-11/67 - S29</u> (CSC8816 to 8820)

## CSC 8816

<u>Depth: 0.00-0.01m</u>: This is a rich assemblage composed of high numbers of both *C. pelagicus* and *E. huxleyi*. Accessory taxa include *G. aperta, C leptoporus, S. histrica* and *Helicosphaera carteri*. The occurrence of such high numbers of coccoliths suggests the sediment was deposited under intergalcial conditions, with surface water mixing making nutrients available, resulting in this burst of high productivity.

Zonation: Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977); Coccolithus pelagicus bloom (Baumann & Matthiessen, 1992).

#### CSC 8817, 8818 & 8819

<u>Depth: 0.2m, 1.5m & 3.5m</u>: All three assemblages are characterised by the occurrence of rare *E. huxleyi*. Accessory taxa include*G. aperta, G. caribbeanica, G. muellerae* and*S. histrica*. The proportion of terrigenous material and reworked nannofossils increases with depth. There is no evidence of the *C. pelagicus* bloom.

Zonation: Late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977).

## CSC 8820

<u>Depth: 4.9m</u>: The assemblage is dominated by *G. caribbeanica* with little in the way of accessory taxa. SEM analysis is necessary to determine if *E. huxleyi* is present, but this species is not recorded in the light microscope counts. There is no evidence of *P. lacunosa*.

Zonation: Mid-/late Pleistocene - Gephyrocapsa oceanica Zone, NN20 (Martini, 1971); upper part of the *G. caribbeanica* Zone of Hine (1990).

NB. If *E. huxleyi* was identified the sample would be assigned to NN21 of Martini (1971) and the Transitional Zone of Hine (1990).

#### <u>57-12/18 - S30</u> (CSC8821)

## CSC8821

<u>Depth: 3.70-3.73m</u>: Barren of calcareous nannofossils (no specimens recorded in 25 fields of view). After extensive scanning of the slide two small specimens of badly preserved placolith were recorded. These are tentatively attributed to *?Cyclagelosphaera*, a genus which ranges from the mid-Jurassic to the Palaeocene.

Zonation: None.

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#### <u>57-12/19 - S28</u> (CSC8822 to 8823)

## CSC 8822

<u>Depth:</u> 0.00-0.03m: This sample yields only rare specimens of *E. huxleyi* and is characterised by reworked nannofossils and a high terrigenous component. There is no evidence of the *C. pelagicus* bloom.

Zonation: Late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977).

#### CSC8823

<u>Depth: 5.3m</u>: The assemblage is dominated by small *Reticulofenestra* and *Dictyococcites* spp. (such as *R. productella D. antarcticus, R. minutula* and *R. minuta*). Additional taxa include *Coccolithus pliopelagicus, Calcidiscus macintyrei, Calcidiscus fuscus* and *Helicosphaera kamptneri*. No whole specimens of *Discoaster* are recovered, although individual arms of *D.* cf. *broweri* are recorded. Reworked Cretaceous calcareous nannofossils are common in this sample. In addition to this a number of small prinseaceans which can be assigned to *Gephyrocapsa caribbeanica* are recorded. The assemblage, in general, has a late Pliocene character, however, in view of the absence of whole discoasters, and the recording of only individual arms (which may be reworked), a slightly later NN19 age (lowermost Pleistocene age) cannot be excluded for this sample. Zonation: Late Pliocene (NN18).

## 57-12/33 - S27 (CSC8824 to 8826)

#### **CSC 8824**

<u>Depth: 0.05-0.10 m</u>: The assemblage consists of abundant *E. huxleyi* together with *C. leptoporus, C. pelagicus, S. histrica* and *G. muellerae*.

Zonation: ?Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977); (?C. pelagicus bloom).

#### CSC 8825

<u>Depth: 1.25-.30 m</u>: The assemblage contains rare specimens of *Pseudoemiliania lacunosa*, the NN19 zonal marker of Martini (1971). SEM analysis is required to determine whether or not *E. huxleyi* occurs. Based on the assumption that *P. lacunosa* is not reworked, the sample, which has a diverse and abundant nannofossil assemblage, is assigned to the Small *Gephyrocapsa* Acme Zone of Hine (1990).

Zonation: ?Early/mid-Pleistocene - *P. lacunosa* Zone, NN19 (Martini, 1971); Small *Gephyrocapsa* Acme Zone (Hine, 1990).

## **CSC8826**

<u>Depth: 2.5m</u>: Nannofossil assemblages are dominated by *Reticulofenestra* spp. and *Discoaster* spp.. Marker species include *Helicosphaera sellii*, *Sphenolithus abies*, *Discoaster brouweri*, *D.scoaster tristellifer*, *P. lacunosa* and *Calcidiscus macintyrei*. <u>Zonation</u>: NN15, *Reticulofenestra pseudoumbilica* Zone of Martini (1971).

## <u>57-13/26 - S26</u> (CSC8827 to 8833)

## CSC 8827

<u>Depth: 0,00-0.01 m</u>: The assemblage is composed of abundant specimens of *E. huxleyi* together with *C. leptoporus*, *C. pelagicus*, *S. histrica* and *G. aperta*. *C. pelagicus* counts are relatively high and may indicate the base of the *C. pelagicus* bloom. Zonation: ?Holocene - *Emiliania huxleyi* Zone, NN21 (Martini, 1971); *Emiliania huxleyi* 

Acme Zone (Gartner, 1977); (?C. pelagicus bloom).

#### CSC 8828, 8829, 8830, 8831, 8832, 8833

<u>Depth: 0.5m, 1.0m, 1.5m, 2.0m, 2.5m and 3.0m</u>: The uppermost assemblage is composed of abundant specimens of *E. huxleyi* together with *C. leptoporus, C. pelagicus, S. histrica, G. caribbeanica* and *G. aperta*. Both the terrigenous component and reworked nannofossils increase in number down core and the number of in-situ Quaternary nannofossils correspondingly decrease. In all samples the ratio of *Gephyrocapsa*  *Emiliania* is negative, so the samples can be assigned to the Emiliania huxleyi Acme zone of Gartner (1977). There is no evidence of the *Coccolithus pelagicus* bloom which occurs at the base of the Holocene.

Zonation: Late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977).

#### <u>57-13/53 - S16</u> (CSC8834 to 8836)

## CSC 8834

<u>Depth: 0.00-0.03m</u>: The assemblage is composed of abundant specimens of *E. huxleyi* and *C. pelagicus* together with *C. leptoporus*, *S. histrica* and *G. aperta* 

Zonation: Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner 1977); C. pelagicus bloom (Baumann & Matthiessen 1992).

## CSC 8835

<u>Depth: 0.50-.53m</u>: This sample yields specimens of *E. huxleyi* together with *C. leptoporus, C. pelagicus, S. histrica* and *G. aperta* although the amount of reworked and other terrigenous material has increased by comparison with sample CSC8834. The numbers of Quaternary nannofossils decrease and reworked material (of Cretaceous and Tertiary age) increases with depth.

Zonation: Late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977).

## CSC 8836

<u>Depth: 2.80-2.84m</u>: The assemblage is dominated by small *Gephyrocapsa* (*G. aperta, G. caribbeanica* and *G. "protohuxleyi"*); *P. lacunosa* is also present.

Zonation: Early/mid-Pleistocene - P. lacunosa Zone, NN19 (Martini, 1971); Small Gephyrocapsa Acme Zone (Hine, 1990).

## 57-13/57 - S31 (CSC8837 to 8838)

## CSC8837

<u>Depth: 0.00-0.05m</u>: This is a rich assemblage composed of high numbers of both *C*. pelagicus and *E. huxleyi*. Accessory taxa include *G. aperta*, *C leptoporus*, *S. histrica* and *Helicosphaera carteri* (see also CSC 8813).

Zonation: Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977); Coccolithus pelagicus bloom (Baumann & Matthiessen, 1992).

#### CSC 8838

<u>Depth:5.00-5.02m</u>: This sample contains rare in situ nannofossils together with high proportions of terrigenous material and reworked nannofossils (Cretaceous and Tertiary). The *in situ* forms include *G. caribbeanica*, *G. aperta*, *G. muellerae*, *E. huxleyi*, *S. histrica* and *C. pelagicus*. The ratio of *Gephyrocapsa* to *Emiliania* is positive (ie. more *Gephyrocapsa* than *Emiliania*), and on this basis the sample is asssigned to the Transitional Zone of Hine (1990). The occurrence of *E. huxleyi* should, however, be confimed by SEM analysis.

Zonation: Mid-/late Pleistocene - *Emiliania huxleyi* Zone, NN21 (Martini, 1971); Transitional Zone (Hine, 1990).

## <u>57-13/65 - S19</u> (CSC8839)

#### CSC8839

<u>Depth: 3.05-3.10m</u>: Barren of calcareous nannofossils (no specimens recorded in 25 fields of view).

Zonation: None.

#### <u>57-13/75 - S47</u> (CSC8840 and 8841)

### CSC 8840

<u>Depth: 0.00-0.04m</u>: This sample yielded abundant specimens of *E. huxleyi* and *C. pelagicus* together with *C. leptoporus, S. histrica, G. aperta, G. caribbeanica, G. muellerae* and *H. carteri*.

Zonation: Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977); Coccolithus pelagicus bloom (Baumann & Matthiessen, 1992).

#### **CSC8841**

<u>Depth: 4.05-4.10m</u>: A rich and diverse assemblage including abundant specimens of *G. caribbeanica* together with *G. oceanica* and *G. aperta*. The assemblage also contains *Pseudoemiliania lacunosa*, the NN19 zonal marker of Martini (1971); and *Calcidiscus macintyrei* which has its last occurrence at 1.45 Ma (Backman & Shackleton, 1983). Based on the co-occurrence of *P. lacunosa*, *G. caribbeanica*, *G. oceanica* and *C. macintyrei*, the sample is assigned to mid NN19 (=CN13b of Okada & Bukry 1980). Zonation: Early/mid-Pleistocene - *P. lacunosa* Zone, NN19 (Martini, 1971).

57-13/76 - S48 (CSC8842 and 8843)

## **CSC8842**

<u>Depth: 0.00-0.07m</u>: This is a rich assemblage composed of high numbers of both *C*. *pelagicus* and *E. huxleyi*. Accessory taxa include *G. aperta, C leptoporus, S. histrica* and *Helicosphaera carteri* (see also CSC8813 & CSC8837).

Zonation: Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977); Coccolithus pelagicus bloom (Baumann & Matthiessen, 1992).

#### **CSC8843**

<u>Depth: 4.13-4.18m</u>: This is a low diversity, poorly preserved assemblage dominated by small *Reticulofenestra* and *Dictyococcites* spp. (such as *R. productella*, *D. antarcticus*, *R. minutula* and *R. minuta*). Additional taxa include *Calcidiscus macintyrei*, *Sphenolithus* spp and *Calcidiscus fuscus*. This assemblage suggests a Late Pliocene age, however the occurrence of small prinseaceans which can be assigned to *Gephyrocapsa caribbeanica* and the absence of whole discoasters may indicate a slightly younger age. This assemblage is similar to that recovered from CSC8823 although has a much lower diversity assemblage and is more poorly preserved.

Zonation: Late Pliocene (?NN16-18). The absence of discoasters prevents designation to a more precise stratigraphic age.

#### <u>57-13/77 - S56</u> (CSC8844)

#### **CSC8844**

<u>Depth: 5.04-5.08m</u>: A rich and diverse assemblage composed of high numbers of *Reticulofenestra* spp. (including *R. callidus, R. hillae, R. dictyoda, R. minuta* and *R. minutula*), together with *R. bisecta, Chiasmolithus oamaruensis, Zygrhablithus bijugatus, Sphenolithus moriformis, R. scissura* and *Nannoturbida* sp. *Pontosphaera* and *Transversopontis* spp. are also common. The co-occurrence of these species suggest an Eocene age assignment. Reworking of older Palaeocene material is common throughout the assemblage.

Zonation: Mid-Eocene - NP15-16 Nannotetrina fulgens-Discoaster tanii nodifer Zone, (Martini, 1971)

57-14/43 - S22 (CSC8845 and 8846)

CSC8845, 8846

<u>Depth: 0.72 & 0.90m</u>: Barren of calcareous nannofossils (no specimens recorded in 25 fields of view).

Zonation: None.

## <u>57-14/44 - S23</u> (CSC8847)

#### **CSC8847**

<u>Depth:</u> Sea-bed boulder: Barren of calcareous nannofossils (no specimens recorded in 25 fields of view). After extensive scanning of the slide a single specimen of the long ranging Cenozoic species *Ericsonia ovalis* was identified.

Zonation: None.

#### <u>57-14/48 - S21</u> (CSC8848 to 8850)

## CSC 8848

<u>Depth: 0.00-0.03 m</u>: This sample yielded specimens of *E. huxleyi* together with *C. leptoporus, C. pelagicus, S. histrica, G. aperta* and *G. caribbeanica.* Reworked nannofossils and other terrigenous material are high. The sample is assigned to Martini's NN21 Zone due to the occurrence of *E. huxleyi*, and to the Transitional Zone of Hine (1990) due to the ratio of *Gephyrocapsa:Emiliania* being positive.

Zonation: Mid-/late Pleistocene - *Emiliania huxleyi* Zone, NN21 (Martini, 1971); Transitional Zone (Hine, 1990).

## CSC 8849

<u>Depth: 0.90-.93m</u>: The assemblage is dominated by *G. caribbeanica* together with *G. aperta, S. histrica, C. leptoporus* and *P. lacunosa* with little in the way of accessory taxa. SEM analysis is necessary to determine if *E. huxleyi* is present, but this species is not recorded in light microscope counts. Due to the occurrence of *P. lacunosa* the sample can be assigned to Zone NN19 of Martini (1971) and based on the predominance of small *Gephyrocapsa*, to the Small *Gephyrocapsa* Zone of Hine (1990).

Zonation: Early/mid-Pleistocene - *P. lacunosa* Zone, NN19 (Martini, 1971); Small *Gephyrocapsa* Zone of Hine (1990).

## CSC8850

<u>Depth: 2.00-2.01m</u>: The assemblage is dominated by *Reticulofenestra* spp. and *Discoaster* spp.. D. tristellifer, D. surculus, D. antarcticus, Coccolithus pliopelagicus, Gephyrocapsa spp. (large) H. sellii, Sphenolithus abies, S. verensis and Calcidiscus macintyrei.

Zonation: Pliocene (NN13-15) (Martini, 1971), although the mean size of placoliths (esp. D. antarcticus) which are medium-sized suggests that a latest Miocene to earliest Pliocene age cannot be discounted.

## <u>57-14/54 - S23</u> (CSC8851 to 8853)

#### CSC8851

<u>Depth: 0.65-0.68m</u>: This sample yields abundant specimens of *E. huxleyi* and *C. pelagicus* together with *C. leptoporus*, *S. histrica*, *G. aperta*, *G. caribbeanica*, *G. muellerae* and *H. carteri*.

Zonation: Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977); C. pelagicus bloom (Baumann & Matthiessen, 1992).

## CSC8852

<u>Depth:</u> 1.80-1.90m: This sample yields very few nannofossils, only 5 specimens of G. *caribbeanica* being recorded in 25 fields of view. Although no positive zonal assignment is made due to the paucity of data, a G. *caribbeanica* (NN20) zonal assignment seems the most probable.

Zonation: ?Mid-Pleistocene - G. caribbeanica Zone (Hine, 1990).

#### CSC8853

<u>Depth: 1.90-2.00m</u>: Barren of calcareous nannofossils (no specimens recorded in 25 fields of view).

Zonation: None.

#### <u>58-11/2 - S45</u> (CSC8854 and 8855)

#### **CSC 8854**

<u>Depth: 0.00-0.03m</u>: This sample yielded abundant specimens of *E. huxleyi* and *C. pelagicus* together with *C. leptoporus, S. histrica, G. aperta, G. caribbeanica, G. muellerae* and *H. carteri*.

Zonation: Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977); C. pelagicus bloom (Baumann & Matthiessen, 1992).

## CSC8855

<u>Depth: 3.50-3.54m</u>: This sample yielded specimens of *E. huxleyi* together with *G. aperta* and *G. caribbeanica*. The amount of reworked specimens and other terrigenous material has greatly increased relative to sample CSC8854. There is no evidence of the *C. pelagicus* bloom.

Zonation: Late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977).

#### <u>58-12/5 - S46</u> (CSC8856 and 8857)

#### CSC 8856

<u>Depth: 0.00-0.03m</u>: The assemblage is composed of abundant specimens of *E. huxleyi* and *C. pelagicus* together with *C. leptoporus, S. histrica, G. aperta, G. caribbeanica, G. muellerae* and *H. carteri*.

Zonation: Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977); C. pelagicus bloom (Baumann & Matthiessen, 1992).

## CSC8857

<u>Depth: 3.17-3.20m</u>: This sample yielded specimens of *E. huxleyi* together with *G. aperta* and *G. caribbeanica* although the amount of reworked and other terrigenous material has greatly increased by comparison with sample CSC 8856.

Zonation: Late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977).

58-14/8 - S7 (CSC8858)

#### **CSC8858**

<u>Depth: 4.47-4.49m:</u> Barren of calcareous nannofossils (no specimens recorded in 25 fields of view).

Zonation: None.

<u>58-14/9 - S8</u> (CSC8859 to 8861)

## CSC 8859

<u>Depth: 0.00-0.03m</u>: This sample yielded abundant specimens of *E. huxleyi* together with *Gephyrocapsa* spp., *C. pelagicus*, *C. leptoporus*, *S. histrica*, *H. carteri*, and *Pontosphaera*.

Zonation: Late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977)

## CSC8860

<u>Depth: 0.35-0.38m</u>: The assemblage is dominated by *G. caribbeanica* together with *G. aperta, G. muellerae, C. pelagicus, C. leptoporus* and *S. histrica.* SEM analysis is necessary to determine if *E. huxleyi* is present, but this species is not recorded in light microscope counts. There is no evidence of *P. lacunosa.* 

Zonation: Mid-/late Pleistocene - G. oceanica Zone, NN20 of Martini (1971); upper part of G. caribbeanica Zone of Hine (1990). If E.huxleyi was identified in SEM analysis the sample would be assigned to the Transitional Zone (NN21) of Hine (1990).

## **CSC8861**

<u>Depth: 5.50-5.53m</u>: The assemblage is dominated by *G. caribbeanica* together with *G. aperta, G. ericsonii, G. muellerae, G. oceanica, C. pelagicus, C. leptoporus* and *S. histrica.* Very rare specimens of a form resembling *P. lacunosa* are recorded, but there are no positive identifications, and they may be reworked.

Zonation: Mid-Pleistocene - G. oceanica Zone, NN20 of Martini (1971); upper part of G. caribbeanica Zone of Hine (1990).

## <u>58-14/10 - S9</u> (CSC8862)

#### **CSC8862**

<u>Depth:</u> 1.80-1.84m: This is a low diversity poorly preserved nannofossil assemblage consisting of lower Tertiary forms with Cretaceous reworking. The assemblage is dominated by the genus *Toweius* (*T. eminens, T. pertusus*). Additional species include *Braarudosphaera bigelowii, Markalius inversus, Coccolithus pelagicus Sphenolithus primus* and *Prinsius bisulcus*. Further specimens can be assigned to *Chiasmolithus* a genus which has its last occurrence in the Oligocene.

Zonation: Late Palaeocene, NP7-NP9, Martini (1971).

## <u>58-14/11 - S10</u> (CSC8863)

## **CSC8863**

<u>Depth: 4.72-4.77m</u>: The assemblage is composed of extremely rare, badly preserved nannofossils dominated by the genus *Toweius* (*T. martinii*, *T. cf. pertusus*). Additional species include *Braarudosphaera bigelowii*, *Markalius inversus*, *Coccolithus pelagicus* and *Hornibrookina* cf. *australis*. Further specimens can be assigned to the genera *Syracosphaera* and *Pontosphaera* both of which have their first occurrence in the late Palaeocene.

Zonation: Late Palaeocene, NP6-NP9, Martini (1971).

#### <u>58-14/29 - S13</u> (CSC8899 and 8864)

CSC8899

<u>Depth: 0.46-0.50m</u>: Barren of nannofossils. <u>Zonation</u>: None.

CSC 8864 <u>Depth: 4.95-5.00m</u>: No nannofossils recorded. <u>Zonation</u>: None.

<u>58-14/31 - S12</u> (CSC8865)

CSC 8865

<u>Depth: 3.51-3.55m</u>: The assemblage is dominated by *Gephyrocapsa caribbeanica* and a bloom of small-sized *Reticulofenestra productella* (NN10-21). Accessory taxa include abundant *C. pelagicus*, *C. leptoporus* (Miocene to Recent) and *S. histrica*. There are no records of any sphenoliths (last occurrence NN15), discoasters or *P. lacunosa*, and there is no evidence of Cretaceous or Eocene material.

Zonation: Plio-Pleistocene; NN16-19, Martini (1971).

<u>58-14/32 - S12</u> (CSC8866 and 8867)

CSC8866, CSC 8867

<u>Depth: 3.11-3.14m and 3.85-3.90m</u>: Both these assemblages are dominated by small Dictyococcites and Reticulofenestra spp. (such as R. productella, D. antarcticus, R. minutula, R. haqii and R. minuta). Additional taxa include Coccolithus pliopelagicus, Calcidiscus macintyrei, Calcidiscus leptoporus, Sphenolithus neoabies, S. abies and Helicosphaera spp. No discoasters were recorded from the sample. In their absence, the sample is assigned to the Pliocene based on the predominance of small Dictyococcites and Sphenolithus spp. Cyclicargolithus floridanus is, however, recorded in the counts. This species has its last occurrence in the Miocene (NP6/7). It is here attributed to reworking. <u>Zonation</u>: Pliocene (NN12-15). The absence of discoasters prevents designation to a more precise biostratigraphic zone.

#### <u>58-14/34 - S14</u> (CSC8868 to 8870)

## CSC 8868

<u>Depth: 0.00-0.03m</u>: This sample yields abundant in situ nannofossils together with reworked Cretaceous forms. Specimens of *E. huxleyi* dominate the assemblage together with *Gephyrocapsa* spp., *C. pelagicus*, *C. leptoporus*, *S. histrica*, *H. carteri*, and *Pontosphaera*. sp.

Zonation: Late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977).

## CSC8869

<u>Depth: 0.50-.53m</u>: The assemblage is dominated by *Gephyrocapsa caribbeanica*. Other accessory taxa include *G. ericsonii*, *G. aperta* and *C. pelagicus*. SEM analysis is necessary to determine if *E. huxleyi* is present, but this species is not recorded in light microscope counts. There is no record of *P. lacunosa*.

<u>Zonation</u>: Mid-/late Pleistocene - *G. oceanica* Zone, NN20 of Martini (1971): upper part of *G.caribbeanica* Zone of Hine (1990). If *E.huxleyi* was recorded the sample would be assigned to the Transitional Zone (NN21) of Hine (1990).

#### **CSC8870**

<u>Depth: 4.79-4.82m</u>: The sample is dominated by large *Reticulofenestra* spp. (*R. hillae, R. umbilicus, R. scissura, R. reticulata, R. minuta*); Chiastozygus spp. (*C. solitus, C. grandis, C. expansus*), and *Neococcolithes* spp. (*N. minutus, N. dubius*). No discoasters were recorded. There is no evidence of any younger material in this assemblage and it is considered to be *in situ*.

Zonation: Mid-Eocene, NP14-17 of Martini (1971).

## <u>58-14/42 - S7</u> (CSC8871)

#### **CSC8871**

<u>Depth: 4.5m</u>: Barren of calcareous nannofossils (no specimens recorded in 25 fields of view). After extensive scanning of the slide three specimens were recorded; *Sphenolithus* sp., *Cyclagelosphaera sp.* (last occurrence in the Palaeocene) and *?Toweius* sp. (genus ranges from the Palaeocene to the Eocene).

Zonation: Tertiary (?Palaeocene).

#### <u>58-14/43 - S9</u> (CSC8872)

#### CSC8872

<u>Depth: 5.07-5.12m</u>: The assemblage is composed of rare nannofossils including *Prinsius bisulcus*, *Toweius pertusus*, *Sphenolithus* spp. and *Hornibrookina australis*. There is no evidence of any younger material in this assemblage and, in consequence, this is considered to be *in situ*, despite the poor state of preservation. Zonation: Late Palaeocene, NP6-NP9, Martini (1971).

## <u>58-14/44 - S49</u> (CSC8873)

#### **CSC8873**

<u>Depth: 5.04-5.08m</u>: This is a rich and diverse assemblage composed of high numbers of *Reticulofenestra* spp. (including *R. callidus, R. hillae, R. umbilicus, R. reticulatum, R. minuta* and *R. minutula*), together with *Chiasmolithus solitus, C. grandis, N. dubius* and *Discoaster deflandrei*. The co-occurrence of these species suggest an Eocene age assignment.

Zonation: Mid-Eocene - Discoaster tanii nodifer Zone, NP16 (Martini, 1971)

## 58-14/53 - S11 (CSC8874)

#### **CSC8874**

<u>Depth: 3.43-3.47m</u>: This is a rich and diverse assemblage composed of high numbers of *Reticulofenestra* spp. (including *R. callidus, R. hillae, R. umbilicus,, R. minuta* and *R. minutula*), together with *Chiasmolithus solitus, Ch. grandis,* and *Discoaster barbadiensis. Transversopontis* spp. are also common. The co-occurrence of these species suggest an Eocene age assignment. Reworking of older Palaeocene material is common throughout the assemblage.

Zonation: Mid-Eocene - Discoaster tanii nodifer Zone, NP16 (Martini, 1971)

#### 58-14/54 - S42 (CSC8875 and 8876)

## CSC8875

<u>Depth: 1.90-1.92m</u>: The assemblage is dominated by small *Reticulofenestra* and *Dictyococcites* spp. including *D. productus*, *D. antarcticus*, *R. minutula* and *R. minuta*. Additional taxa include *Sphenolithus* spp and *Coccolithus pliopelagicus*.

Zonation: Pliocene (?NN16). The absence of discoasters precludes designation to a more precise stratigraphic age.

#### **CSC8876**

<u>Depth: 2.52-2.54m</u>: This sample is similar to CSC8875 but contains an increased terrigenous component and a nannofossil assemblage that is very poorly preserved, suffering from extensive secondary calcite overgrowth.

The assemblage is dominated by Coccolithus pelagicus (C. cf. pliopelagicus). Additional taxa include small Reticulofenestra and Dictyococcites spp.such as R. productella (NN10-21), D. antarcticus, D. productus, R. minutula (NN1-18) and R. minuta (NP13-18). Helicosphaera and Calcidiscus spp. are recorded but are rare. The small size of the Reticulofenestra and Dictyococcites spp. suggests a Pliocene age. However, due to the poor state of preservation, few species have been identified to species level and so confidence is low. Despite this, the assemblage is not considered to be older than Neogene. Further to this there are a number of reworked forms recorded. These include *Chiasmolithus* spp. with no central areas (last occurrence of genus coincides with the Oligocene/Miocene boundary), *Reticulofenestra* cf. *scrippsae* (NP16-25) and *Toweius* spp. (last occurrence of genus coincides with the NP15/16 boundary). These suggest assignment to the Upper Eocene NP16 nannofossil zone.

As with previous analyses, the younger Pliocene material is considered to be *in situ*, however, due to the low degree of confidence in this analyses, an older Eocene age is possible.

Zonation: None (Eocene to Pliocene range).

## <u>58-14/55 - S40</u> (CSC8877)

## CSC8877

<u>Depth: 5.05-5.10m</u>: Nannofossils are extremely rare and when recorded are poorly preserved. Only three specimens were recorded in fifty fields of view (*Sphenolithus* sp. and *Reticulofenestra* sp.).

<u>Zonation</u>: Tertiary. The occurrence of *Sphenolithus* provides a maximum age of NP4 to NN16, and the occurrence of large *Reticulofenetra* further restricts the sample to an Eocene-Pliocene age range.

<u>57-14/56 - S50</u> (CSC8878)

**CSC8878** 

<u>Depth: 1.01-1.06m</u>: Barren of calcareous nannofossils (no specimens recorded in 25 fields of view).

Zonation: None.

#### <u>58-14/57 - S41</u> (CSC8879 and 8880)

## CSC 8879

<u>Depth: 3.83-3.89m</u>: The assemblage is dominated by small *Gephyrocapsa* including *G. aperta, G. ericsonii* and *G. caribbeanica.* Accessory taxa include *E. huxleyi, H. carteri, Thoracosphaera* sp., *S. histrica, C. leptoporus* and holococcoliths. A form resembling *Reticulofenestra* with slits in its outer shield was occasionally encountered. This sample can be assigned to Zone NN21 of Martini (1971) based on the occurrence of *E huxleyi*, to the *Gephyrocapsa aperta* Zone of Hine (1990).

Zonation: Mid-Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Gephyrocapsa aperta Zone of Hine (1990).

### CSC8880

<u>Depth: 4.10m</u>: Barren of calcareous nannofossils (no specimens recorded in 25 fields of view). After extensive scanning of the slide three specimens were recorded, two of *Cyclagelosphaera alta* (last occurrence in the Palaeocene) and a single specimen of the Tertiary genus *Ericsonia ovalis*. Based on this evidence the sample is tentatively assigned to the Palaeocene.

Zonation: Palaeocene.

<u>58-14/60 - S51</u> (CSC8881 and 8882)

#### CSC 8881

<u>Depth: 0.00-0.02 m</u>: The assemblage consists of abundant *E. huxleyi* and *C. pelagicus* together with *C. leptoporus*, *S. histrica* and *G. caribbeanica*. <u>Zonation</u>: Holocene - *Emiliania huxleyi* Zone, NN21 (Martini, 1971); *Emiliania huxleyi* Acme Zone (Gartner, 1977); *C. pelagicus* bloom (Baumann & Matthiessen, 1992).

#### CSC 8882

<u>Depth:</u> 1.02-.07m: The assemblage is dominated by *G. caribbeanica* and *G. aperta* together with *S. histrica, C. leptoporus* and *P. lacunosa*. Based on the occurrence of *P. lacunosa* the sample can be assigned to Zone NN19 of Martini (1971) and based on the predominance of small *Gephyrocapsa*, to the Small *Gephyrocapsa* Zone of Hine (1990). <u>Zonation</u>: Early/mid-Pleistocene - *P. lacunosa* Zone, NN19 (Martini, 1971); Small *Gephyrocapsa* Zone of Hine (1990).

#### 58-14/63 - S53 (CSC8883)

#### CSC 8883

<u>Depth: 0.81-0.83m (clast in sea-bed gravel)</u>: The assemblage is dominated by large *Reticulofenestra* spp. (*R. callidus, R. umbilicus, R. dictyoda, R. minuta*) and *Chiastozygus* spp. Accessory taxa include *N. dubius* and discoasters (*D. gemmeus, D. siapensis*). As there is no evidence of any younger material, this assemblage is considered to be *in situ*. <u>Zonation</u>: Mid-Eocene, NP15-16 of Martini (1971).

## <u>59-11/12 - S1</u> (CSC8884)

## **CSC 8884**

<u>Depth: 1.40-1.43m</u>: Barren of nannofossils (no specimens recorded in 25 fields of view). After extensive scanning of the slide two badly preserved calcareous nannofossils were located, however, due to the poor state of preservation no specific identification was possible. Both specimens were of small, circular placoliths, probably belonging to the long ranging genus *Cyclagelosphaera*. Zonation: None.

#### <u>59-11/13 - S2</u> (CSC8885 to 8888)

#### **CSC8885**

<u>Depth: 0.00-0.05m</u>: The assemblage consists of abundant *E. huxleyi* and *C. pelagicus* together with *C. leptoporus, S. histrica* and *G. caribbeanica*. The high numbers of *C. pelagicus* indicate the base of the *C. pelagicus* bloom.

Zonation: Holocene - *Emiliania huxleyi* Zone, NN21 (Martini, 1971); *Emiliania huxleyi* Acme Zone (Gartner, 1977);*C. pelagicus* bloom (Baumann & Matthiessen, 1992).

#### CSC8886 and 8887

<u>Depth: 0.60-0.65 and 0.80-0.85m</u>: Both assemblages are dominated by *E. huxleyi* together with *C. pelagicus, C. leptoporus,, S. histrica* and *G. caribbeanica, H. carteri* and *G. muellerae.* Sample CSC8886 records a huge increase in both the terrigenous component and reworked nannofossils and a drop in the *in situ* nannofossil numbers. The sample at 0.80m records a return to high numbers of *in-situ* nannofossils.

Zonation: Late Pleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977).

#### **CSC8888**

<u>Depth: 4.60-4.67m</u>: The assemblage consists of rare specimens of *E. huxleyi* together with *G. caribbeanica*. The terrigenous component has increased relative to sample CSC8887, as have the number of reworked nannofossils. The sample is assigned to Martini's Zone NN21 due to the occurrence of *E. huxleyi*, and to the Transitional Zone (of Hine 1990) due to the ratio of *Gephyrocapsa:Emiliania* being positive.

Zonation: Mid-/late Pleistocene - *Emiliania huxleyi* Zone, NN21 (Martini, 1971); Transitional Zone (Hine, 1990).

#### <u>59-11/16 - S43</u> (CSC8889)

#### **CSC 8889**

<u>Depth: 4.30-4.35m</u>: In situ nannofossils are very rare and the terrigenous component and reworked nannofossils are high. The assemblage consists of *G. caribbeanica, G. aperta, E. huxleyi* and *C. pelagicus*. The occurrence of *E. huxleyi* restricts the sample to Zone NN21 of Martini (1971). As data is so scarce and positive identification of *E. huxleyi* requires SEM analysis, it is not possible to assign the sample to the *E. huxleyi* Acme Zone with any degree of certainty, although based on the limited data available, this seems likely.

The sample also contains much reworked material including pulses of Upper Cretaceous, Palaeocene and Eocene reworking. The Eocene assemblage includes species such as *Toweius callosus* (NP12-15), *Campylosphaera dela* (NP10-16) and *Cruciplacolithus cribellum* (NP9-11).

Zonation: Mid-/latePleistocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); (Emiliania huxleyi Acme Zone, Gartner, 1977/Transitional Zone, Hine 1990)

#### <u>59-11/17 - S44</u> (CSC8890 and 8891)

## CSC8890

<u>Depth: 0.00-0.05m</u>: This sample yielded abundant specimens of *E. huxleyi* and *C. pelagicus* together with *C. leptoporus, S. histrica, G. aperta, G. muellerae* and *G. caribbeanica.* 

Zonation: Holocene - Emiliania huxleyi Zone, NN21 (Martini, 1971); Emiliania huxleyi Acme Zone (Gartner, 1977); C. pelagicus bloom (Baumann & Matthiessen, 1992).

## CSC8891

<u>Depth: 4.60-4.63m</u>: *In situ* nannofossils are very rare and the terrigenous component and reworked nannofossils high. The assemblage consists of *G. caribbeanica, G. aperta, E. huxleyi* and *C. pelagicus*. The occurrence of *E. huxleyi* restricts the sample to Zone NN21

of Martini (1971). Positive identification of *E. huxleyi* requires SEM analysis. Based on the limited data available the sample may belong to the Transitional Zone as the ratio of *Gephyrocapsa* to *Emiliania* is positive..

Zonation: Mid-/late Pleistocene - *Emiliania huxleyi* Zone, NN21 (Martini, 1971); ?Transitional Zone (Hine, 1990).

59-14/6 - SS5 (CSC8892 and 8893)

CSC8892

<u>Depth: 5.00-5.03m</u>: Barren of calcareous nannofossils (no specimens in over 25 fields). <u>Zonation</u>: None.

CSC 8893

Depth: 5.05-5.06m: Barren of nannofossils.

Zonation: No zonation.

<u>59-14/7 - S4</u> (CSC8894 and 8895)

CSC8894, 8895

<u>Depth: 4.00-4.03 and 5.07-5.12m</u>: Barren of calcareous nannofossils (no specimens recorded in 25 fields of view).

Zonation: None.

59-14/8 - S3 (CSC8896 and 8897)

#### CSC8896, 8897

<u>Depth: 0.98-1.00 and 3.80-3.83m</u>: These samples yielded rich and diverse assemblages. Preservation is only moderate and in many instances the central area structures of placoliths have been lost. The assemblages are dominated by *Reticulofenestra dictyoda* and *Transversopontis* spp. Other common floral elements include *Chiasmolithus solitus*, Sphenolithus radians and C. pelagicus. Discoasters include Discoaster keupperi, D. lodoensis, D. bronnemason and D. distinctus. The sample also contains species of Nannoturbida sp. (N. spinosa and N. robusta).

The co-occurrence of these species suggest an Eocene (NP13) age assignment. There is no evidence of older reworking; however, the sample does contain a high percentage of siliceous material in the form of diatoms and silicoflagellates. Zonation: Early Eocene - *Discoaster lodoensis* Zone, NP13 (Martini, 1971).

#### <u>59-14/9 - S6</u>

#### CSC 8898

<u>Depth: 5.07-5.12m</u>: The assemblage is formed of calcareous nannofossils of three different ages: Late Cretaceous, early Eocene and mid-Eocene. The youngest, mid- Eocene assemblage is considered to be *in situ*. It is dominated by large *Chiasmolithus* spp. (*C. solitus*, *C. grandis*, *C. gigas*, *C. expansus*), *Neococcolithes* spp. (*N. minutus*, *N. dubius*) and small noelaerhabdaceans including species of *Toweius*, *Dictyococcites*, *Cribrocentrum* and *Reticulofenestra*. Additional taxa include *Discoaster* sp. and *Zygrhablithus bijugatus*. This assemblage provides an NP15-16 age assignment.

In addition to this, the assemblage also includes some Upper Cretaceous and lower Eocene material. The latter nannoflora is characterised by taxa such as *Toweius pertusus*, *T. eminens*, *Neochiastozygus distensus*, *N. rosenkrantzii* and *Discoaster elegans* derived from lower Eocene (NP10-11) strata.

Zonation: Mid-Eocene, NP15-16 of Martini (1971).

#### <u>Summary</u>

Eighty-seven samples were analysed for their calcareous nannofossil component to aid in the chronostratigraphical interpretations of the Rockall area. Seventy-two samples yielded calcareous nannofossils which represented a biostratigraphical range from the late Palaeocene to the Holocene. There is no evidence of any *in-situ* Cretaceous material. All recordings of Cretaceous calcareous nannofossils are attributed to reworking.

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# MACROFAUNAL ANALYSIS OF SHALLOW CORE 58-14/32 FROM THE ROCKALL AREA

## M A Woods

# Introduction

One sample of bioclastic limestone was submitted for macrofaunal analysis from shallow core 58-14/32; sample details and a summary of the palaeontological age are as follows:

CSC No:	Depth (m)	Palaeontological Age
8986	3.45-3.50	Pliocene to Holocene

#### Results

The fauna is as follows:

Anthozoa:	solitary corals?
Brachiopoda:	cf. Fallax dalliniformis
	Terebratulina abyssicola?
	T. caputserpentis?
	rhynchonellid of unknown affinity
Gastropoda:	indeterminate internal mould
Bivalvia:	Capulus aff. unguis?
	Lima aff. subauriculata
	pectinacean (juv.)
T.1.1.1.1.	•

Echinoidea: spine

- **b** -

Lack of comparative material inhibits precise devermination of species. The current status of some of the above taxa is uncertain in the absence of comprehensive modern literature.

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## Interpretation

*Fallax dalliniformis* is an extant brachiopod species, recorded at @1300m in the Bay of Biscay by Cooper (1981). *Terebratulina caputserpentis*, the type species of the genus *Terebratulina* (Moore, 1965), is similarly Holocene, known from around Norway, the Faeroe Islands, the Hebrides, and west of Ireland, in water depths from @160m to @1400m (Davidson, 1874; Moore, 1965). Fossil examples of the latter occur in the Coralline Crag (Pliocene) of East Anglia (Davidson, 1852). *Terebratulina abyssicola* is a Holocene species recorded by Cooper (1973) from around South Africa, at depths between @80m and @160m. The remainder of the fauna is difficult to interpret, but some elements (eg. *Capulus unguis, Lima subauriculata*) occur in the Pliocene and Pleistocene faunas detailed by Harmer (1914-1924) and Wood (1848-1882).

**Conclusion:** Pliocene to Holocene

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LITHO	LOGY AND SEDIMENTAR	RY STR	UCTURES	Fig.	2 Key abl sha	y to symbols and common previations used on the allow-core logs.
	Clay/Claystone			Chalk		
	Mud/Mudstone			Limesto	ne	
****	Calcareous mudstone			Basic ig	neous	
	Silt/Siltstone		DDA DDA	Agglom	erate	
	Sand/Sandstone			Gneiss		
000	Gravel/Conglomerate		$\boxtimes$	No reco	very :	
0	Sporadic clast	~	Mineral vein		$\triangle$	Upward fining
L	Shell/sheli fragment		Stylolite		$\nabla$	Upward coarsening
	Organic debris	1	Fracture (post-de	positional)	D	Distribution grading
IV	Sponge spicules	~	Monosulphidic kno streaks	ots and	α	Coarse-tail grading
O Fe	Iron concretions	55	Bioturbation			Sharp, planar contact
G	Glauconite	×.	Parallel lamination	n		Gradational contact
7	Dendritic manganese	≋	Wavy lamination		$\sim$	Erosive, acoured contact

# COMMON ABBREVIATIONS

Sub-sa	mples	Gr	ain size		Other	
Mpai MACRO PET GEOCH	Micropalaeontology Macrofauna Petrology Geochemistry	a v t E	silt very fine fine medium	Mud Sand	gr. mps. vps. matrix-supp.	grained moderately poorly sorted very poorly sorted matrix-supported
RD 8826	Radiometric age date BGS palaeontological sub-sample reference number	с <b>у</b> с р р с р	coarse very coarse pebble cobble bouider	} Gravel	inc. biot. calc. rd. subang. a/a	including bioturbated calcareous rounded subangular as above
				t c	terrigenous carbonate	t/c, t>c relative proportions of

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