



**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Preliminary geological results of sea-bed sampling in the Hebrides- Rockall area from the *RRS James Clark Ross* in 2001

Continental Shelf and Margins Programme
Internal Report IR/02/049



**British
Geological Survey**
NATURAL ENVIRONMENT RESEARCH COUNCIL

BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/02/049

Preliminary geological results of sea-bed sampling in the Hebrides- Rockall area from the *RRS James Clark Ross* in 2001

Compiled by Ken Hitchen, Eileen Gillespie and Alick Leslie

The National Grid and other
Ordnance Survey data are used
with the permission of the
Controller of Her Majesty's
Stationery Office.
Ordnance Survey licence number
GD 272191/1999

Key words

Sea-bed sampling. Hebrides.
Rockall

Front cover

Location of sample stations
occupied during 2001 cruise.

Bibliographical reference

HITCHEN, K, GILLESPIE, E J
AND LESLIE, A B. (COMPILERS)
2002. Preliminary geological
results of sea-bed sampling in the
Hebrides-Rockall area from the
RRS James Clark Ross in 2001 .
*British Geological Survey
Internal Report, IR/02/049.*

BRITISH GEOLOGICAL SURVEY

The full range of Survey publications is available from the BGS Sales Desks at Nottingham and Edinburgh; see contact details below or shop online at www.thebgs.co.uk. The London Information Office maintains a reference collection of BGS publications including maps for consultation.

The Survey publishes an annual catalogue of its maps and other publications; this catalogue is available from any of the BGS Sales Desks.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects. It also undertakes programmes of British technical aid in geology in developing countries as arranged by the Department for International Development and other agencies.

The British Geological Survey is a component body of the Natural Environment Research Council.

Keyworth, Nottingham NG12 5GG

☎ 0115-936 3241 Fax 0115-936 3488
e-mail: sales@bgs.ac.uk
www.bgs.ac.uk
Shop online at: www.thebgs.co.uk

Murchison House, West Mains Road, Edinburgh EH9 3LA

☎ 0131-667 1000 Fax 0131-668 2683
e-mail: scotsales@bgs.ac.uk

London Information Office at the Natural History Museum (Earth Galleries), Exhibition Road, South Kensington, London SW7 2DE

☎ 020-7589 4090 Fax 020-7584 8270
☎ 020-7942 5344/45 email:
bgs london@bgs.ac.uk

Forde House, Park Five Business Centre, Harrier Way, Sowton, Exeter, Devon EX2 7HU

☎ 01392-445271 Fax 01392-445371

Geological Survey of Northern Ireland, 20 College Gardens, Belfast BT9 6BS

☎ 028-9066 6595 Fax 028-9066 2835

Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB

☎ 01491-838800 Fax 01491-692345

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU

☎ 01793-411500 Fax 01793-411501
www.nerc.ac.uk

Contents

Contents.....	4
Introduction	6
Report organisation.....	7
Glossary of terms used in thin section descriptions	8
Notes on geochemical analyses of igneous samples	11
SAMPLE 56-08/920.....	22
SAMPLE 56-08/921.....	29
SAMPLE 56-08/923.....	36
SAMPLE 56-08/924.....	40
SAMPLE 56-08/925.....	47
SAMPLE 56-08/926.....	51
SAMPLE 56-09/383.....	54
SAMPLE 56-09/384.....	57
SAMPLE 56-09/385.....	64
SAMPLE 56-09/386.....	68
SAMPLE 56-09/387.....	74
SAMPLE 56-09/388.....	78
SAMPLE 56-15/13.....	85
SAMPLE 56-15/14.....	89
SAMPLE 56-15/15.....	93
SAMPLE 56-15/16.....	99
SAMPLE 56-15/17.....	102
SAMPLE 56-15/18.....	105
SAMPLE 56-15/19.....	112
SAMPLE 56-15/20.....	116
SAMPLE 56-15/21.....	118
SAMPLE 56-15/22.....	120
SAMPLE 56-15/23.....	122
SAMPLE 56-15/24.....	124
SAMPLE 56-16/32.....	126
SAMPLE 56-16/33.....	128
SAMPLE 56-16/34.....	130
SAMPLE 57-09/530.....	132
SAMPLE 57-09/531.....	136
SAMPLE 57-09/532.....	140
SAMPLE 57-09/533.....	144
SAMPLE 57-09/534.....	148
SAMPLE 57-09/535.....	152
SAMPLE 57-09/536.....	157
SAMPLE 57-09/537.....	163
SAMPLE 57-12/41.....	174
SAMPLE 57-12/42.....	181
SAMPLE 57-14/57.....	184
SAMPLE 57-14/58.....	190
SAMPLE 57-14/59.....	197
SAMPLE 57-14/60.....	202
SAMPLE 57-14/61.....	206
SAMPLE 57-15/14.....	209
SAMPLE 57-15/15.....	212

SAMPLE 57-15/16.....	217
SAMPLE 57-15/17.....	220
SAMPLE 57-15/18.....	223
SAMPLE 57-15/19.....	226
SAMPLE 57-15/20.....	229
SAMPLE 57-15/21.....	233
SAMPLE 57-15/22.....	236
SAMPLE 57-15/23.....	240
SAMPLE 57-15/24.....	246
SAMPLE 57-15/25.....	249
SAMPLE 57-15/26.....	252
SAMPLE 57-16/16.....	255
SAMPLE 57-16/17.....	261
SAMPLE 57-16/18.....	269
SAMPLE 57-16/19.....	277
SAMPLE 57-17/5.....	284
SAMPLE 57-17/6.....	294
SAMPLE 57-17/7.....	298
SAMPLE 57-17/8.....	305
SAMPLE 57-17/9.....	319
SAMPLE 58-08/227.....	328
SAMPLE 58-08/228.....	332
SAMPLE 58-08/229.....	339
SAMPLE 58-08/230.....	343
SAMPLE 58-12/9.....	350
References.....	358

FIGURES

Figure 1	Regional map of sample locations.....	13
Figure 2a	Sample site map, Hebrides Shelf.....	14
Figure 2b	Sample site map, Rockall Trough.....	15
Figure 2c	Sample site map, Rockall Bank.....	16

TABLES

Table 1	Correlation of original site numbers to official BGS sample numbers.....	17
Table 2	Summary of site details.....	18

Introduction

In 2001 the British Geological Survey (BGS) was awarded survey time on the NERC vessel *RRS James Clark Ross*, normally operated by the British Antarctic Survey. Originally a cruise length of up to four weeks duration had been anticipated. However, owing to problems encountered during a refit on the Tyne, the ship was eventually only available for two weeks. The *RRS James Clark Ross* sailed from Leith on 6th August 2001 and reached the first site the following day. A report on the operational procedures, and performance of the equipment, was given by Skinner (2001). The cruise was funded through the BGS Science Budget.

Aims

The principal aims of the cruise were:

- 1) to acquire samples of metamorphic basement in order to identify and characterise the different Pre Cambrian terrains west of Scotland,
- 2) to acquire samples of igneous rocks for inorganic geochemical and isotopic analysis and age dating in order to elucidate the temporal, spatial and evolutionary development of UK Atlantic volcanic continental margin and
- 3) to acquire other sedimentary cores, in the vicinity of the Hebrides Terrace Seamount, mainly to study slope processes.

The BGS rockdrill was deployed to collect hard rock cores. The vibrocore and gravity core were deployed to collect soft sediment cores.

Site selection and numbering

In advance of the cruise, an informal catalogue of potential sites was produced by Ken Hitchen, after consultation with other geologists. Each potential site was allocated a site number prefixed by one or two initials to designate the geologist who had selected that site (e.g. JD20, K127 etc).

JD	Derek Ritchie (BGS)	K	Ken Hitchen (BGS)
RH	Richard Holmes (BGS)	S	Stephen Daly (University College Dublin)
CM	Clara Morri (Dunstaffnage Marine Laboratory)		

Various seismic datasets were utilised in the selection of potential sites including the commercial Rockall Consortium data of 1992 and 2000. The 'S' sites, in Irish waters on Rockall Bank, were selected by reference to an Admiralty chart only. A regional map of the attempted sites is shown as Fig 1. Precise locations for the Hebrides Shelf, Rockall Trough and Rockall Bank are shown in Figs 2a, 2b and 2c respectively.

Once an attempt had been made at a particular site, an official BGS sample number was allocated. This comprises the latitude and longitude of the south-west corner of the quadrant in which the sample was collected followed by an accession number (e.g. 56-08/920). The correlation between original site number and official BGS sample number is given in Table 1. A summary of each site is given in Table 2. During the cruise 82 attempts were made at 60 different sites.

The RH sites (RH1 to RH6, 56-10/248 to 56-10/255) are the subject of a separate report and are not discussed here.

Report organisation

The report is organised in official BGS sample number order (from 56-08/920 to 58-08/230). For each sample there is a page of site details, followed by a lithological summary log and seismic line(s) across the site. Note that the summary log is that produced on the ship and will be subject to amendment as further work is conducted on the cores. Subsequent pages depend on the lithology of the core collected and which analyses have been conducted since acquisition. The report has been compiled by Ken Hitchen, Eileen Gillespie and Alick Leslie.

Geological personnel involved

(all BGS unless indicated)

Robert Gatliff	Shipboard geologist
Charles Gowing	Inorganic geochemistry of igneous rocks
Ken Hitchen	Regional geologist
Pamela Kempton	Shipboard geologist
Jackie Lees*	Nannofossil analysis
Alick Leslie	Sedimentology
Graham Lott	Volcaniclastic and sedimentological thin section descriptions
Emrys Phillips	Igneous and metamorphic basement thin section descriptions
Jim Riding	Palynological analysis
Ian Wilkinson	Foraminiferal analysis

*Industrial Nannoplankton Laboratory (BioChron),
c/o University College London, Gower Street, London WC1E 6BT.

Glossary of terms used in thin section descriptions

Amphibolite – A metamorphosed basic igneous rock with a mineral assemblage comprised largely of amphibole and plagioclase, usually with quartz and epidote.

Atoll structure – A structure developed in metamorphic rocks consisting of a core of one mineral entirely surrounded by a rim of another mineral. For example garnet forming a core entirely surrounded by plagioclase.

Augen gneiss – A gneissose metamorphic rock with abundant *augen* (eyes) represented by porphyroblasts (typically K-feldspar) enveloped by the foliation.

Alkali – A prefix applied to igneous rocks which contain either: (a) modal feldspathoids and/or alkali amphibole or pyroxenes; or (b) normative feldspathoids or acmite.

Alkali basalt – Term originally used for basalts containing accessory feldspathoids. These rocks typically contain a Ti-augite and olivine as their main ferromagnesian phases. Now defined geochemically using the Total Alkali-Silica diagram as a variety of basalt.

Alkali gabbro – A variety of gabbro which is alkaline in character due to the presence of analcime or nepheline and ferromagnesian phases such as barkevikite, kaersutite and/or Ti-augite.

Andesite – An intermediate volcanic rock, usually porphyritic, consisting of plagioclase (frequently zoned from labradorite to oligoclase), pyroxene, hornblende and/or biotite. Now defined modally on a Quartz-Alkali feldspar-Plagioclase-Feldspathoid diagram or geochemically using the Total Alkali-Silica diagram.

Basalt – A volcanic rock consisting essentially of calcic plagioclase and pyroxene. Olivine and minor feldspathoids may also be present. Now defined modally on a Quartz-Alkali feldspar-Plagioclase-Feldspathoid diagram or geochemically using the Total Alkali-Silica diagram.

Cleavage – A fabric developed within a metamorphic rocks defined by a sub-parallel set of closely spaced approximately planar surfaces produced during rock deformation. Defined by the preferred alignment of platy or elongate mineral grains (usually phyllosilicate minerals such as muscovite, biotite, chlorite).

Corona or reaction rim – A texture developed in metamorphic rocks composed of a monomineralic or polymineralic rim totally surrounding a core of another mineral phase. It typically represents an arrested reaction between the core phase and other components within the rock.

Cryptocrystalline – A term used to describe crystals in an igneous rock which are too small to be identified even with the petrological microscope.

Crystallinity – (a) *Holocrystalline*, an igneous rock composed of 100% crystals; (b) *holohyaline*, an igneous rock composed of 100% glass; and (c) *hypocrystalline*, intermediate between the two end-members and can be described more precisely by stating the relative proportions of crystals and glass.

Decussate structure – A term used to describe interlocking, randomly orientated, elongate, prismatic or subhedral crystals in a metamorphic rock which are generally of a single mineral phase.

Dolerite – An igneous rock of intermediate grain size between a basalt and gabbro (i.e. synonym for *microgabbro*), and composed of essentially plagioclase, pyroxene and opaque minerals. Often contains an ophitic texture. If olivine is present may be called an olivine-dolerite; if quartz, a quartz-dolerite.

Equigranular – All the crystals in an igneous or metamorphic rock are approximately the same size.

Gneiss – A coarsely banded high-grade metamorphic rock consisting of alternating, mineralogically distinct layers.

Granoblastic texture – An aggregate consisting of equidimensional, typically rounded to anhedral crystals in a metamorphic rock which are of approximately equal size.

Granulite – A high-grade metamorphic rock typically with a granoblastic texture and with an assemblage containing pyroxene and anorthite-rich plagioclase.

Grain size – Refers to the size of crystals present in igneous and metamorphic rocks: (a) coarse-grained, crystals > 5.0 mm in size; (b) medium-grained, crystals 1.0 to 5.0 mm in size; (c) fine-grained, crystals < 1.0 mm in size.

Hornfels – A hard, fine- to medium-grained granoblastic metamorphic rock produced by high-grade contact metamorphism.

Inequigranular – Term used to describe crystals present within an igneous or metamorphic rock which are of substantially different grain sizes. Common variety, porphyritic texture, can be subdivided into: (a) *microporphyritic*, phenocrysts ≤ 2.0 mm in size; and (b) *macroporphyritic*, phenocrysts > 2.0 mm in size.

Microcrystalline – crystals in an igneous rock which can only be identified with a petrological microscope. Crystals only just large enough to show polarisation colours (< 0.01 mm in size) are called *microlites*.

Olivine-basalt – A commonly used term for a basalt containing olivine as an essential constituent.

Phyllite – A well-cleaved metamorphosed mudstone characterised by a distinctive sheen on foliation surfaces; generally of intermediate grain size and metamorphic grade between slate and schist.

Poikiloblast – A term used to describe porphyroblasts present within a metamorphic rocks which contain abundant mineral inclusions.

Porphyroblast – A metamorphic mineral (e.g. garnet) that has grown to much larger size than the minerals of the surrounding matrix.

Porphyroblastic – A term used to describe a metamorphic rock containing large porphyroblasts within a finer grained matrix.

Porphyroclast – A large relict crystal, or crystal fragment in a fine-grained matrix of a deformed rock.

Post-tectonic growth – Growth of metamorphic minerals or parts of a mineral which occurred after deformation had ceased.

Pressure shadow – A region of low strain developed immediately adjacent to a rigid or competent object in a rock (e.g. a garnet porphyroblast).

Pre-tectonic growth – Metamorphic mineral growth before deformation has occurred.

Pseudomorph – A mineral or aggregate of minerals having taken the form/shape of another mineral phase that it/they have replaced.

Seriate texture – Refers to a continuous range in crystal size of principal minerals in an igneous rock.

Schist – A metamorphic rock of broadly pelitic composition (i.e. a metamorphosed mudstone) with a well-developed schistosity.

Schistosity – A planar structure developed in a metamorphic rock defined by the alignment of elongate minerals such as micas and amphibole.

Trachyte – A volcanic rock consisting essentially of alkali feldspar. Now defined modally on a Quartz-Alkali feldspar-Plagioclase-Feldspathoid ternary diagram or geochemically using the Total Alkali-Silica diagram.

Trachyandesite – A term originally used for volcanic rocks intermediate in composition between trachyte and andesite and containing equal amounts of alkali feldspar and plagioclase. Later used for volcanic rocks containing feldspathoids as well as alkali feldspar and plagioclase. Now defined geochemically using the Total Alkali-Silica diagram.

Trachybasalt – Term mainly used for basaltic volcanic rocks containing labradorite and alkali feldspar. Now defined geochemically using the Total Alkali-Silica diagram.

Trachytic texture – The sub-parallel alignment of microcrystalline feldspar in the groundmass of a *holocrystalline* or *hypocrystalline* igneous rocks. Sub-divided into *pilotaxitic* texture and *hyalopilitic* texture depending on whether the material between the feldspar is crystalline or glassy. *Trachytoid* texture, alignment of tabular, bladed or prismatic crystals which is visible to the naked eye. The terms *flow* and *fluxion* texture are sometimes used as synonyms for trachytic and trachytoid textures. However, they are best avoided due to their genetic implications.

Notes on geochemical analyses of igneous samples

Charles Gowing

Deputy X-Ray Fluorescence Spectrometry Section Manager

(on behalf of Mark Ingham, X-Ray Fluorescence Spectrometry Section Manager)

The following samples were analysed:

56-08/920	Metamorphic basement	Hebrides Shelf
56-09/384	Metamorphic basement	Hebrides Shelf
56-09/388	Metamorphic basement	Hebrides Shelf
56-15/18*	Metamorphic basement	Rockall Bank
57-14/58	Gabbro	Rockall Bank
58-08/228	Metamorphic basement	Hebrides Shelf
58-08/230	Metamorphic basement	Hebrides Shelf

* two depths analysed

Samples received on: 17 December 2001

Analysis commenced on: 18 January 2002

Report Date: 14 February 2002

All samples were received in good condition. Unless previously agreed otherwise in writing, samples will be retained for three months from the date of issue of this report prior to disposal. Please contact the Laboratory if you wish to make alternative arrangements.

Analysis Details

Determinands	Test Method	Procedure	Notes
Loss on Ignition (LOI)	Physical measurement	AGN 2.1.3	
SiO ₂ , TiO ₂ , Al ₂ O ₃ , Fe ₂ O _{3t} , Mn ₃ O ₄ , MgO, CaO, Na ₂ O, K ₂ O, P ₂ O ₅ , Cr ₂ O ₃ , SrO, ZrO ₂ , BaO	XRFS fused glass beads	AGN 2.1.4	
SO ₃ , NiO, CuO, ZnO, PbO	XRFS fused glass beads		N
Sc, V, Cr, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Zr, Mo, Ag, Cd, Sn, Sb, Te, Ba, W, Tl, Pb, Bi	XRFS pressed powder pellets		N
Y, Nb, Cs, La, Ce, Pr, Nd, Sm, Eu, Tb, Gd, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, Th, U	ICP-MS		N

Tests marked N in the above table are not included in the UKAS Accreditation Schedule for this Laboratory.

The samples were dried overnight at 105°C before analysis for XRFS fused glass beads and LOI. Loss on ignition was determined after 1 hour at 1050°C. A negative LOI represents a net weight gain after heating for 1 hour at 1050°C. Fe₂O_{3t} represents total iron expressed as Fe₂O₃. SO₃ represents sulphur retained in the fused bead after fusion at 1200°C. N.D. represents not determined due to unspecified interferences that have not been corrected for.

High Sr concentrations in samples with Sr >1000 ppm will effect Sc, V, Cr, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Zr, Ba, W, Tl, Pb and Bi data, as the Sr concentrations are above the trace element program calibration limit. The specified trace element data have not been corrected for this effect.

High Ba concentrations in samples with Ba >1000 ppm will effect Sc, V, Cr and Ba data, as the Ba concentrations are above the trace element program calibration limit. The specified trace element data have not been corrected for this effect.

For the elements determined by ICP-MS, the samples were subjected to an HF/HClO₄/HNO₃ mixed acid attack and any residue fused with NaOH. The resulting solutions were combined before analysis by ICP-MS. The quality control data for Ta indicate that the error at the concentrations in the samples is of the order of ±0.2 mg/kg, compared to the usual ±10% for other elements away from the detection limit.

Because of limitations with the current software used for reporting data, the number of significant figures quoted in the attached table may not be representative of the actual uncertainty. Data should be considered accurate to no more than three significant figures.

The client should note that trace elements, whose characteristic x-ray lines lie on the long wavelength side of the iron absorption edge, i.e. Sc, V, Cr, Co and Ba, are effected by absorption from major elements which are not corrected for by this calibration method. Therefore, these trace elements are not as accurate as others determined by X-ray Fluorescence Spectrometry (XRFS); measurement by other techniques, e.g. ICP-MS are likely to be more reliable. The XRFS calibration lines were established using numerous reference materials (RMs) and by placing the slope to give best fit through the average of the predominantly 'silicate' RM matrices. Thus, if the sample matrix differs widely from this average it may produce erroneous results.

The client should also note that the data for major elements in pressed powder pellets will not be as accurate as those produced by XRFS on fused glass beads because they too are not corrected for matrix effects. However, over 200 RMs were measured for the calibration, followed by a limited validation exercise using stream and lake sediment RMs and International Soil Exchange (ISE) proficiency testing samples.

The report of geochemical analyses is issued under complete status. All analyses requested have been completed and results are issued with full compliance of data verification subject to the statements above.

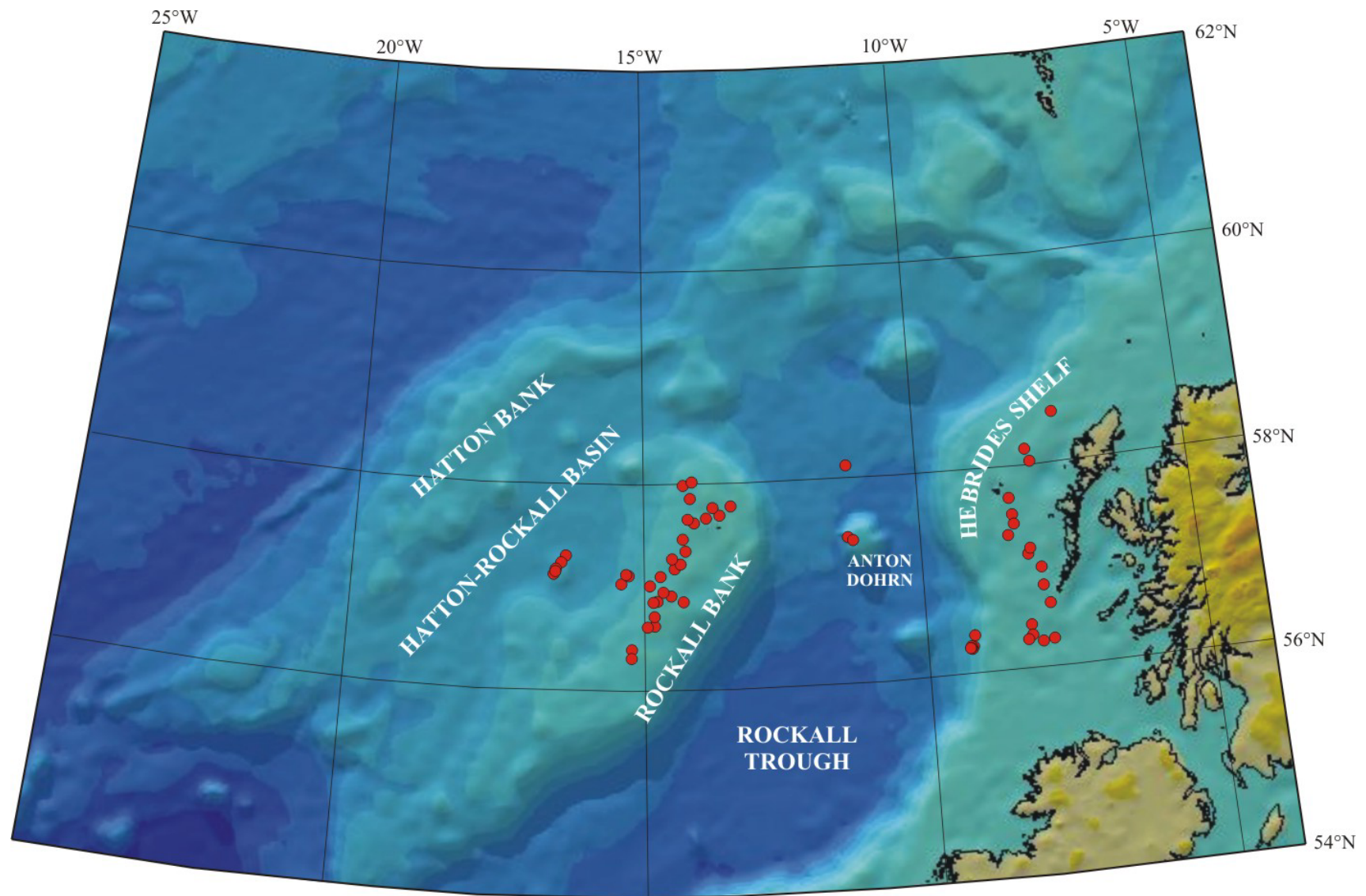


Fig. 1 Regional map of sample locations

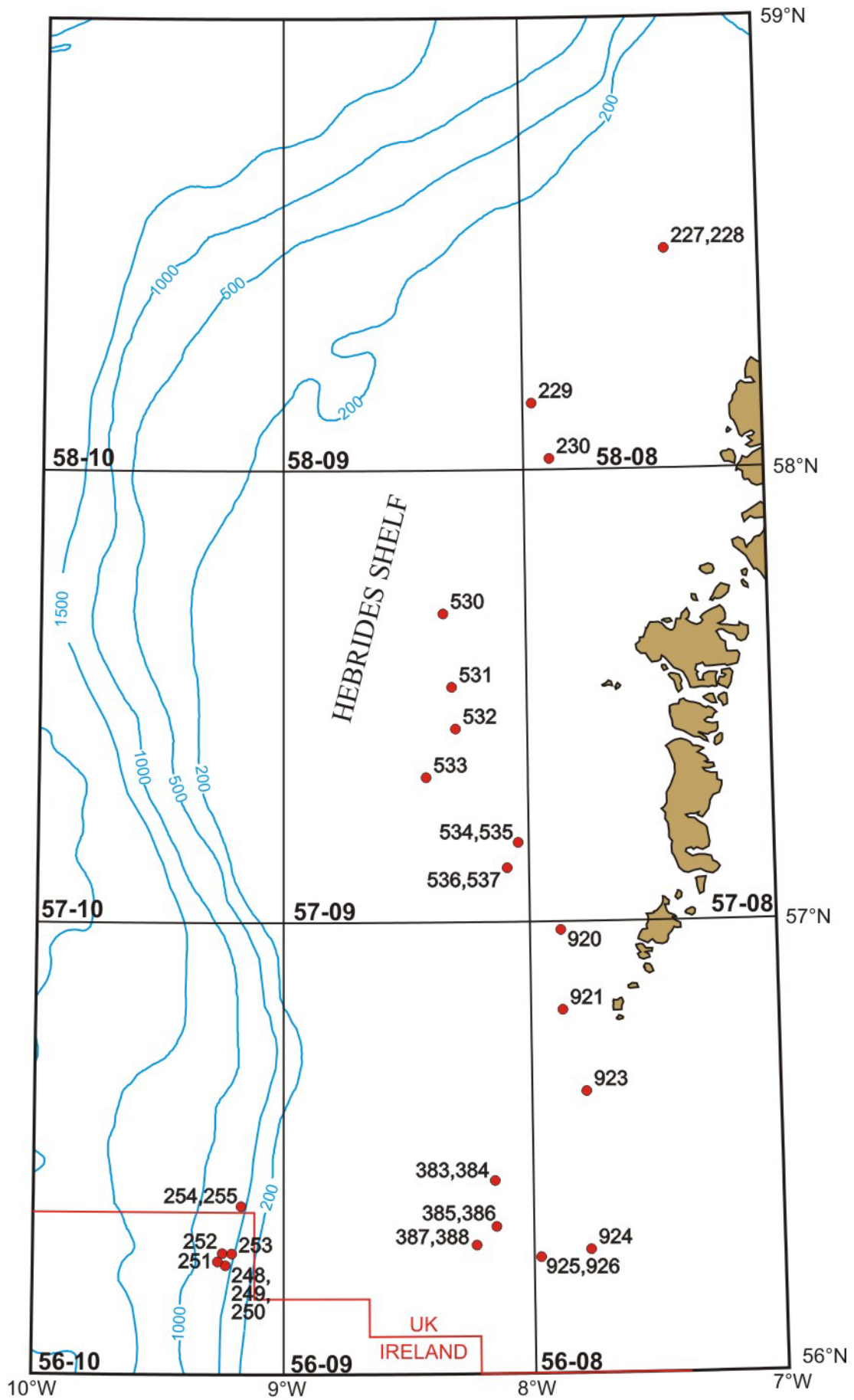


Fig 2a. Sample site map, Hebrides Shelf

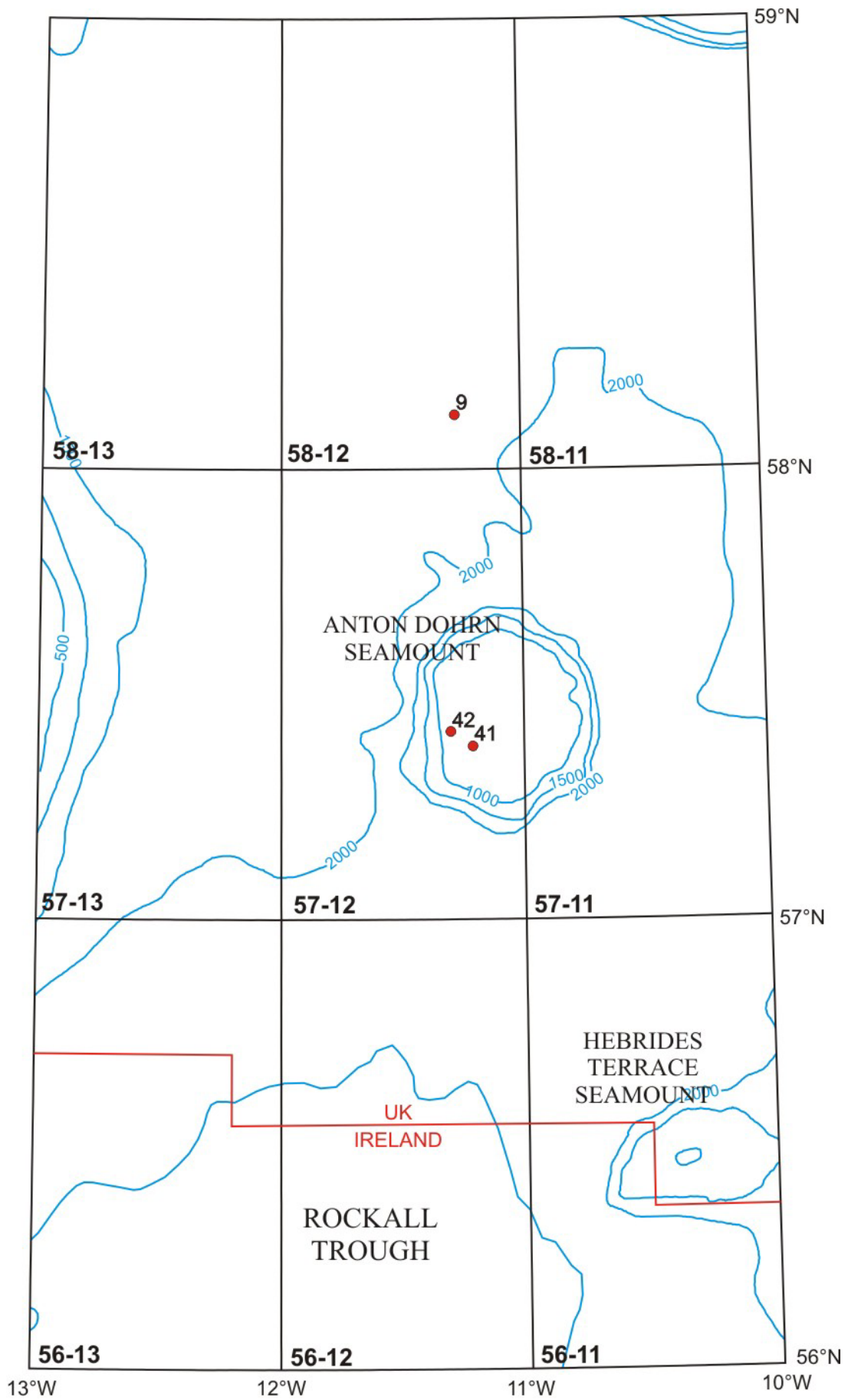


Fig 2b. Sample site map, Rockall Trough

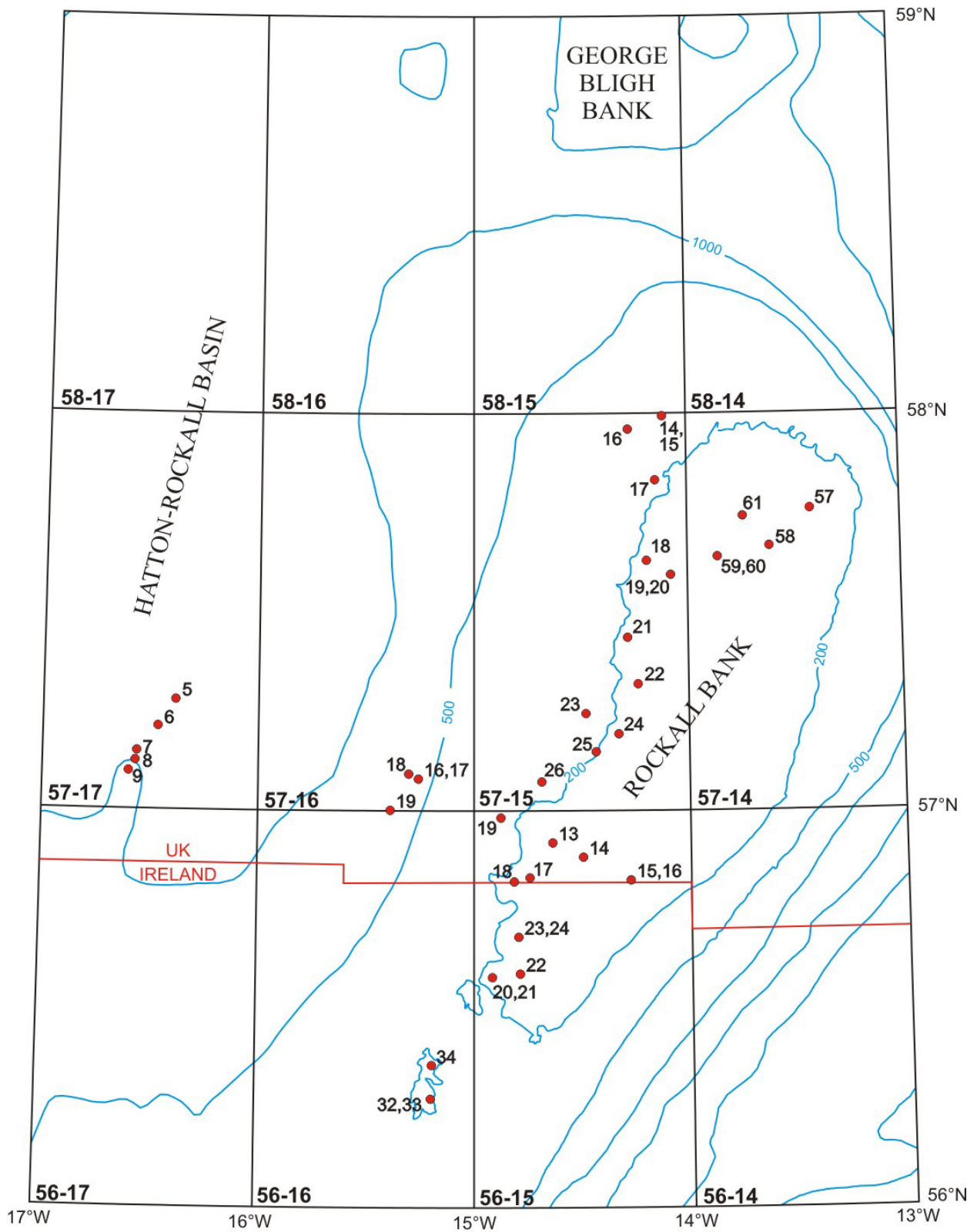


Fig 2c. Sample site map, Rockall Bank

Table 1 Correlation of original site numbers to official BGS sample numbers.

Original site number	BGS sample number	Original site number	BGS sample number
CM7	58-12/9	K130	57-15/21
JD1	56-09/385	K132	57-15/23
JD1	56-09/386	K133	57-15/24
JD2	56-09/387	K134	57-15/26
JD2	56-09/388	K136	56-15/15
JD3	56-09/383	K136	56-15/16
JD3	56-09/384	K137	56-15/14
JD4	56-08/924	K138	56-15/13
JD5	56-08/925	K140	56-15/19
JD5	56-08/926	K141	57-16/16
JD6	56-08/921	K141	57-16/17
JD7	56-08/920	K142	57-16/18
JD8	56-08/923	K143	57-17/9
JD9	57-09/533	K144	57-17/8
JD10	57-09/536	K145	57-17/6
JD10	57-09/537	K147	57-16/19
JD11	57-09/532	K148	57-15/16
JD12	57-09/531	K156	57-17/5
JD13	57-09/530	K158	57-12/41
JD15	57-09/534	K159	57-12/42
JD15	57-09/535	RH1	56-10/253
JD16	58-08/229	RH1	56-10/253
JD19	58-08/230	RH2	56-10/252
JD20	58-08/227	RH2	56-10/252
JD20	58-08/228	RH3	56-10/251
K46	57-14/58	RH3	56-10/251
K49	57-15/17	RH4	56-10/248
K109	57-17/7	RH4	56-10/249
K111	56-15/17	RH4	56-10/249
K112	56-15/18	RH5	56-10/250
K115	57-15/25	RH5	56-10/250
K116	57-15/22	RH6	56-10/254
K118	57-14/59	RH6	56-10/255
K118	57-14/60	S1	56-16/32
K119	57-14/61	S1	56-16/33
K121	57-14/57	S2	56-15/20
K123	57-15/14	S2	56-15/21
K123	57-15/15	S3	56-16/34
K125	57-15/18	S4	56-15/22
K127	57-15/19	S6	56-15/23
K127	57-15/20	S6	56-15/24

Two attempts at the same site (e.g. JD1) have the same original site numbers but different sample numbers.

If original site number and sample number are both repeated (e.g. RH1) then different equipment was used on successive attempts (see Table 2).

Table 2 Summary of site details.

Sample number	Kit	TD(m) Core (m)	Location	Lat/Long	WD (m)	Summary
56-08/920 JD7	DR	1.26 1.08	Hebrides Shelf	56° 58.96'N 07° 52.58W	73	Metamorphic basement
56-08/921 JD6	DR	0.90 0.78	Hebrides Shelf	56° 48.264'N 07° 52.284'W	82	Metamorphic basement
56-08/923 JD8	DR	1.52 ---	Hebrides Shelf	56° 37.470'N 07° 46.810'W	80	Gravel
56-08/924 JD4	DR	1.69 1.13	Hebrides Shelf	56° 16.368'N 07° 46.458'W	56	Mylonitic basement
56-08/925 JD5	DR	1.80 ---	Hebrides Shelf	56° 15.522'N 07° 58.188'W	93	Gravel
56-08/926 JD5	DR	2.10 ---	Hebrides Shelf	56° 15.52'N 07° 58.19'W	93	Gravel
56-09/383 JD3	DR	0.34 ---	Hebrides Shelf	56° 25.60'N 08° 09.05'W	74	Nil recovery
56-09/384 JD3	DR	1.80 1.27	Hebrides Shelf	56° 25.596'N 08° 09.048'W	74	Metamorphic basement
56-09/385 JD1	DR	1.33 0.20	Hebrides Shelf	56° 19.46'N 08° 09.15'W	101	Metamorphic basement
56-09/386 JD1	DR	1.71 1.18	Hebrides Shelf	56° 19.46'N 08° 09.15'W	101	Mylonitic basement
56-09/387 JD2	DR	0.50 0.13	Hebrides Shelf	56° 17.075'N 08° 13.699'W	114	Metamorphic basement
56-09/388 JD2	DR	0.83 0.21	Hebrides Shelf	56° 17.075'N 08° 13.699'W	114	Metamorphic basement
56-10/248 RH4	VE	2.43 ---	Donegal Fan (Irish waters)	56° 14.520'N 09° 13.953'W	657	No recovery
56-10/249 RH4	CS	4.33 4.33	Donegal Fan (Irish waters)	56° 14.53'N 09° 13.95'W	657	Dark grey mud
56-10/249 RH4	VE	4.20 4.20	Donegal Fan (Irish waters)	56° 14.53'N 09° 13.95'W	657	Dark grey mud
56-10/250 RH5	CS	3.84 3.84	Donegal Fan (Irish waters)	56° 14.98'N 09° 15.12'W	737	Dark green/grey mud
56-10/250 RH5	VE	4.36 4.36	Donegal Fan (Irish waters)	56° 14.98'N 09° 15.12'W	737	Dark green/grey mud
56-10/251 RH3	CS	2.79 2.79	Donegal Fan (Irish waters)	56° 14.98'N 09° 15.86'W	776	Dark grey/brown sandy mud
56-10/251 RH3	VE	4.00 4.00	Donegal Fan (Irish waters)	56° 14.98'N 09° 15.86'W	776	Dark grey/brown sandy mud
56-10/252 RH2	CS	3.38 3.38	Donegal Fan (Irish waters)	56° 16.03'N 09° 14.78'W	717	Dark grey/brown sandy mud
56-10/252 RH2	VE	4.48 4.48	Donegal Fan (Irish waters)	56° 16.03'N 09° 14.78'W	717	Dark grey/brown sandy mud
56-10/253 RH1	CS	0.10 0.10	Donegal Fan (Irish waters)	56° 16.07'N 09° 12.48'W	591	Sand (almost nil recovery)

56-10/253 RH1	VE	4.30 4.30	Donegal Fan (Irish waters)	56° 16.07'N 09° 12.48'W	591	Sand on mud
56-10/254 RH6	VE	4.39 4.39	Hebrides Slope	56° 22.15'N 09° 10.11'W	644	Sand on mud
56-10/255 RH6	VE	4.79 4.79	Hebrides Slope	56° 22.15'N 09° 10.11'W	644	Sand on mud
56-15/13 K138	DR	4.86 1.00	Rockall Bank	56° 55.266'N 14° 38.394'W	189	Sand and gravel
56-15/14 K137	DR	1.79 0.73	Rockall Bank	56° 53.010'N 14° 29.688'W	185	Gravel, core
56-15/15 K136	DR	3.90 0.26	Rockall Bank	56° 49.56'N 14° 16.47'W	186	Sand, gravel, basalt
56-15/16 K136	VE	0.62 0.02	Rockall Bank	56° 49.56'N 14° 16.47'W	186	Sand
56-15/17 K111	DR	2.20 ---	Rockall Bank	56° 49.932'N 14° 44.514'W	195	Gravel
56-15/18 K112	DR	4.52 4.21	Rockall Bank	56° 49.242'N 14° 49.002'W	182	Metamorphic basement
56-15/19 K140	DR	1.40 ---	Rockall Bank	56° 58.92'N 14° 52.50'W	238	Gravel
56-15/20 S2	DR	1.61 ---	Rockall Bank (Irish waters)	56° 34.90'N 14° 55.00'W	181	Gravel
56-15/21 S2	DR	1.13 ---	Rockall Bank (Irish waters)	56° 34.90'N 14° 55.00'W	181	Gravel
56-15/22 S4	DR	1.98 ---	Rockall Bank (Irish waters)	56° 35.400'N 14° 47.400'W	181	Gravel
56-15/23 S6	DR	1.35 ---	Rockall Bank (Irish waters)	56° 41.00'N 14° 47.70'W	182	Gravel
56-15/24 S6	DR	1.38 ---	Rockall Bank (Irish waters)	56° 40.994'N 14° 47.703'W	183	Gravel
56-16/32 S1	DR	2.15 ---	Rockall Bank (Irish waters)	56° 16.400'N 15° 11.850'W	178	Gravel
56-16/33 S1	DR	1.83 0.46	Rockall Bank (Irish waters)	56° 16.400'N 15° 11.850'W	178	Metamorphic basement
56-16/34 S3	DR	1.20 0.46	Rockall Bank (Irish waters)	56° 21.50'N 15° 11.60'W	187	Metamorphic basement
57-09/530 JD13	DR	3.06 0.67	Hebrides Shelf	57° 41.02'N 08° 20.43'W	118	Gravel on metamorphic basement
57-09/531 JD12	DR	3.90 ---	Hebrides Shelf	57° 31.284'N 08° 18.522'W	137	Sand on gravel
57-09/532 JD11	DR	1.91 0.57	Hebrides Shelf	57° 25.69'N 08° 17.62'W	118	Gravel and metamorphic basement
57-09/533 JD9	DR	2.56 0.48	Hebrides Shelf	57° 19.271'N 08° 24.991'W	129	Gravel
57-09/534 JD15	DR	1.33 0.09	Hebrides Shelf	57° 10.596'N 08° 02.652'W	99	Single metamorphic cobble only
57-09/535 JD15	DR	1.02 0.09	Hebrides Shelf	57° 10.602'N 08° 02.655'W	99	Single metamorphic cobble only
57-09/536 JD10	DR	0.50 0.23	Hebrides Shelf	57° 07.157'N 08° 05.489'W	120	Metamorphic basement

57-09/537 JD10	DR	2.90 2.49	Hebrides Shelf	57° 07.16'N 08° 05.49'W	118	Metamorphic basement
57-12/41 K158	DR	4.03 1.14	Anton Dohrn	57° 23.09'N 11° 12.84'W	667	Sand and limestone
57-12/42 K159	DR	1.78 ---	Anton Dohrn	57° 25.127'N 11° 18.174'W	745	Nil recovery
57-14/57 K121	DR	1.33 0.48	Rockall Bank	57° 45.481'N 13° 25.290'W	150	Gravel and 'basalt'
57-14/58 K46	DR	2.61 1.81	Rockall Bank	57° 39.858'N 13° 36.882'W	121	Gabbro
57-14/59 K118	DR	0.96 0.13	Rockall Bank	57° 38.34'N 13° 51.40'W	116	'Basalt'
57-14/60 K118	DR	1.03 0.31	Rockall Bank	57° 38.34'N 13° 51.40'W	116	'Basalt' cobbles
57-14/61 K119	DR	0.00 ---	Rockall Bank	57° 44.36'N 13° 44.25'W	128	Nil recovery
57-15/14 K123	DR	0.95 ---	Rockall Bank	57° 59.573'N 14° 06.792'W	250	Nil recovery
57-15/15 K123	DR	1.28 0.59	Rockall Bank	57° 59.57'N 14° 06.79'W	250	Trachyandesite
57-15/16 K148	DR	4.86 0.58	Rockall Bank	57° 57.66'N 14° 16.29'W	262	'Basalt' and gravel
57-15/17 K49	DR	1.39 ---	Rockall Bank	57° 49.883'N 14° 09.897'W	201	Gravel
57-15/18 K125	DR	1.25 ---	Rockall Bank	57° 37.752'N 14° 11.526'W	190	Gravel
57-15/19 K127	DR	1.01 ---	Rockall Bank	57° 35.586'N 14° 04.746'W	167	Gravel
57-15/20 K127	DR	1.30 ---	Rockall Bank	57° 35.586'N 14° 04.746'W	167	Gravel
57-15/21 K130	DR	1.30 ---	Rockall Bank	57° 26.105'N 14° 16.926'W	186	'Basalt' gravel
57-15/22 K116	DR	1.18 ---	Rockall Bank	57° 18.146'N 14° 14.075'W	179	'Basalt' gravel
57-15/23 K132	DR	1.33 ---	Rockall Bank	57° 14.706'N 14° 28.812'W	214	'Basalt' gravel
57-15/24 K133	DR	0.89 ---	Rockall Bank	57° 11.574'N 14° 19.620'W	183	'Basalt' gravel
57-15/25 K115	DR	1.48 ---	Rockall Bank	57° 08.916'N 14° 26.082'W	197	'Basalt' gravel
57-15/26 K134	DR	0.77 ---	Rockall Bank	57° 04.314'N 14° 41.255'W	219	Gravel
57-16/16 K141	DR	4.88 0.48	West flank of Rockall Bank	57° 04.836'N 15° 15.444'W	602	Soft chalk
57-16/17 K141	VE	3.48 2.52	West flank of Rockall Bank	57° 04.84'N 15° 15.44'W	602	Sand and mud
57-16/18 K142	VE	3.19 2.71	West flank of Rockall Bank	57° 05.55'N 15° 18.204'W	670	Sand
57-16/19 K147	VE	3.31 3.07	West flank of Rockall Bank	57° 00.053'N 15° 23.229'W	666	Calcareous mud/clay
57-17/5 K156	DR	4.64 4.40	Sandastre (Hitchen's Nob)	57° 16.602'N 16° 23.232'W	963	Chalk on volcanic breccia

57-17/6 K145	DR	4.88 3.10	Sandastre	57° 12.54'N 16° 28.02'W	891	Volcanic breccia
57-17/7 K109	DR	3.51 1.68	Sandastre	57° 08.80'N 16° 33.79'W	810	Tuffaceous limestones and siltstones
57-17/8 K144	DR	4.11 3.81	Sandastre	57° 07.32'N 16° 34.17'W	691	Limestone on sandy conglomerate
57-17/9 K143	DR	4.16 0.94	Sandastre	57° 05.694'N 16° 36.078'W	936	Conglomeratic limestone/sandstone
58-08/227 JD20	DR	0.38 0.04	Hebrides Shelf	58° 29.140'N 07° 23.648'W	66	Single metamorphic boulder
58-08/228 JD20	DR	1.32 0.98	Hebrides Shelf	58° 29.140'N 07° 23.648'W	66	Pegmatitic basement
58-08/229 JD16	DR	0.99 ---	Hebrides Shelf	58° 08.874'N 07° 57.738'W	105	Gravel
58-08/230 JD19	DR	2.04 1.33	Hebrides Shelf	58° 01.488'N 07° 53.625'W	64	Metamorphic basement
58-12/9 CM7	CS	3.35 3.35	Rockall Trough	58° 07.31'N 11° 16.458'W	1935	Soft clay

SAMPLE 56-08/920

SITE DETAILS

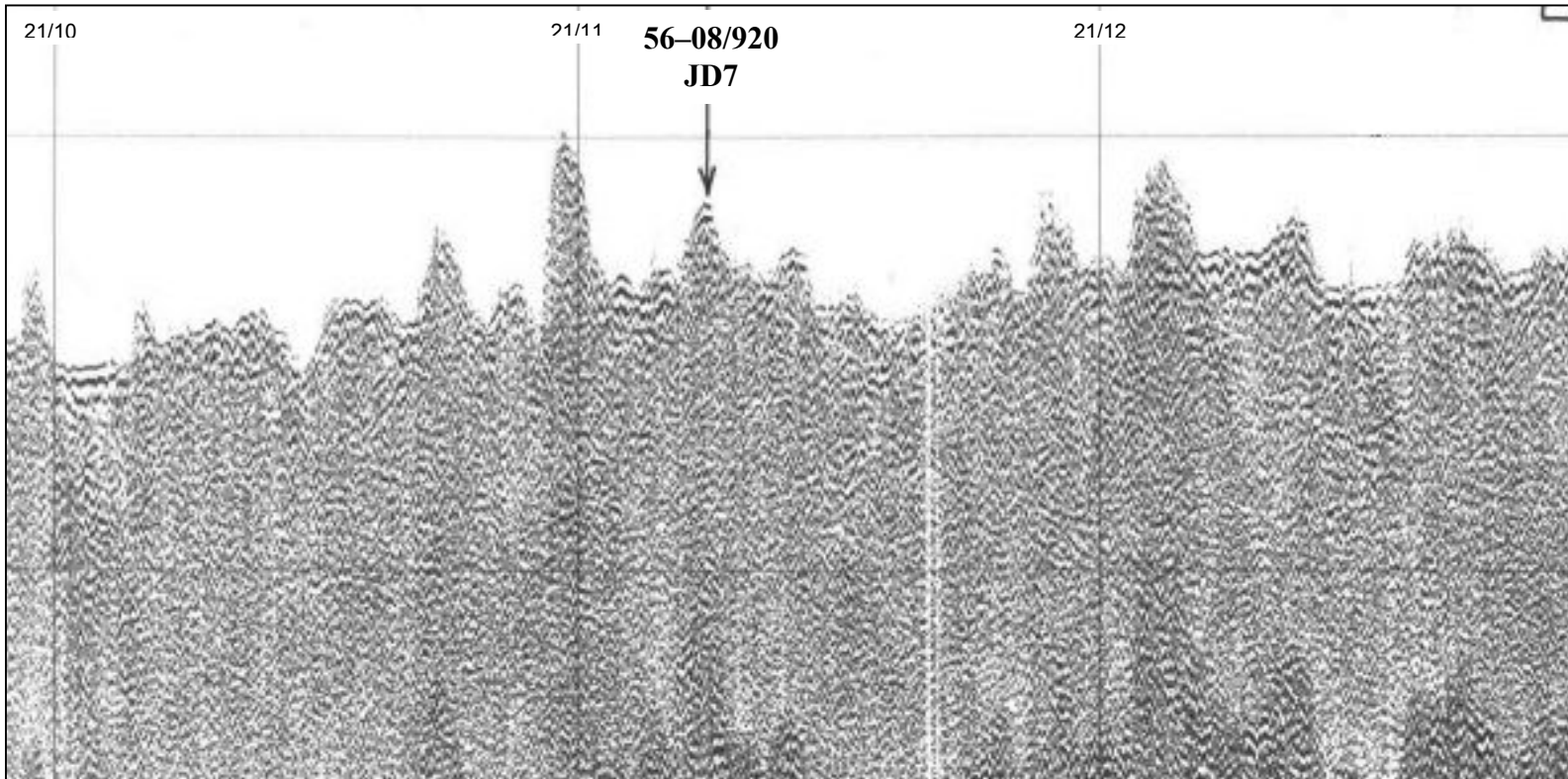
Date of drilling: 9th August 2001
Original site number: JD7
Latitude: 56° 58.96'N
Longitude: 07° 52.58W
Location: Hebrides Shelf
Line and fix number: 85/03-21 11.3
Equipment: BGS rockdrill
Core length: 1.08m
Lithology: Quartz-feldspathic gneiss
Age: ?Lewisian (Archaean)

SUMMARY

A single attempt recovered 1.26m of strongly banded and foliated biotite-hornblende gneiss.

W

E



LINE 85/03-21

SPARKER

BGS CORE NO: 56-08/920DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Outer Isles Platform	
Latitude	56° 58.96'N	Licence Block	134/1
Longitude	007° 52.58'W	BGS Plan No	JD7
Navigation	DGPS	Total Depth	1.26m (Rec. 1.08 m)
Map Area	Tiree	Water Depth	73m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	09/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
Lewisian	0	# d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d f # d # g d f # d d f # d # g d f # # d # g d f # d f # d # g d f # d d f # d # g d f # # d # g d f # d f # d # g d f # d							IGChem 0.51m TS 0.72m		BIOTITE HORNBLLENDE GNEISS Excellent, near complete recovery of biotite, hornblende gneiss. Medium grained, strongly banded and foliated. Foliation dipping at ~30 degrees from core vertical. Some alteration of mafic phases to chlorite. Fe-staining occurs near bottom of core (83 to 108 cm), particularly adjacent to 1-mm-wide quartz veins. Otherwise, quite fresh. Trace amounts of sulphides.
	1	# d # g d f # d d f # d # g d f # f # d # g d f # d								Top encrusted with biota, indicating exposure of bare rock on seafloor.	



PETROLOGY OF SAMPLE 56-08/920

Emrys Phillips

Registered number: N3704

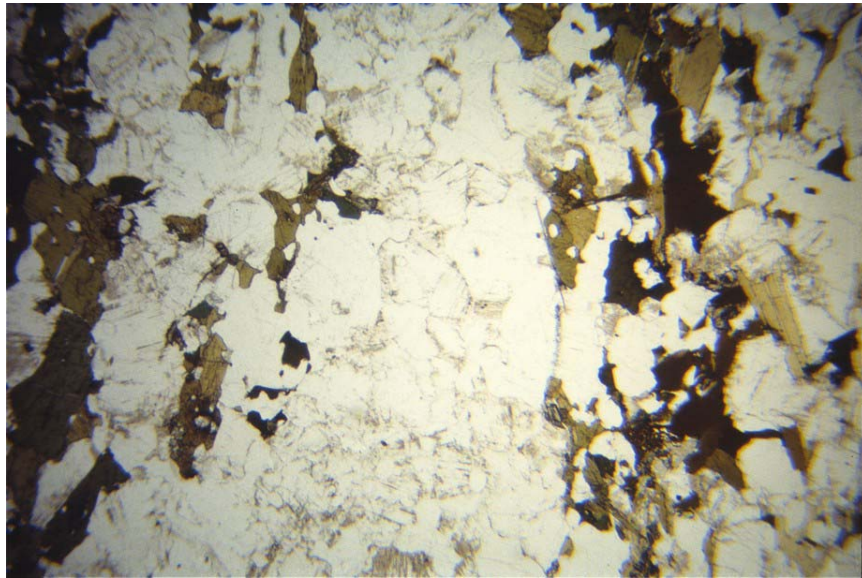
Thin section from 0.72-0.73m depth.

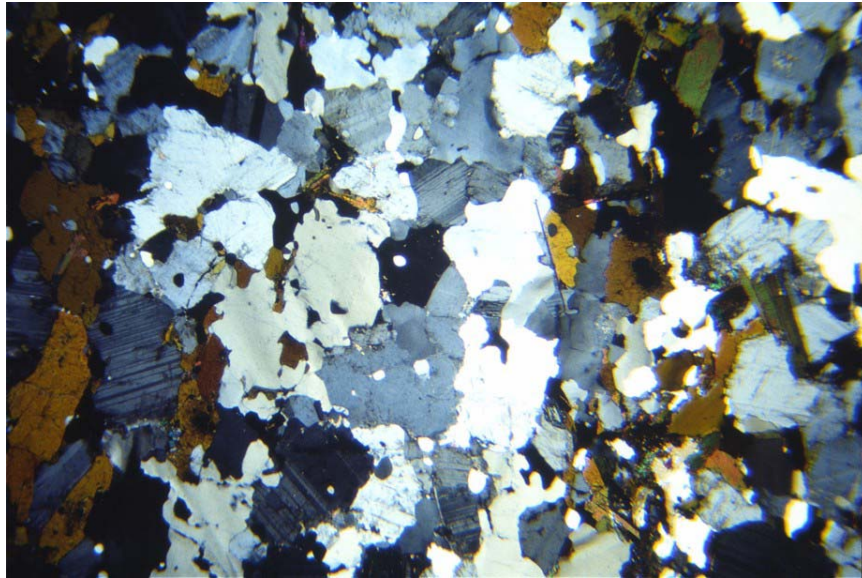
Rock Type: banded biotite and amphibole-bearing quartzofeldspathic gneiss

Mineralogy: major – plagioclase, quartz, biotite, amphibole
minor – clinozoisite/epidote, opaque minerals, titanite, K-feldspar, apatite
alteration – sericite, clay minerals, carbonate

Photomicrographs:

Photomicrographs of biotite and amphibole-bearing quartzofeldspathic gneiss (N3704), plane and crossed polarised light.





Description: This thin section is of a banded, weakly foliated, medium- to coarse-grained, inequigranular, anhedral granular amphibole and biotite-bearing quartzofeldspathic gneiss. The bulk of this high-grade (?upper amphibolite facies) metamorphic rock is composed of anhedral plagioclase and subordinate quartz. The compositional banding is defined by the variation in modal biotite and amphibole. A tectonic foliation which occurs parallel to the compositional banding is defined by the alignment of biotite and, to a lesser extent, amphibole.

Plagioclase forms twinned and untwinned, anhedral crystals (≤ 4.5 mm in length, typically 1.0 to 2.0 mm in size) which exhibit a slight dusty appearance in plane polarised light due to minor alteration to sericite, clay minerals and trace carbonate. Plagioclase may locally contain rounded inclusions of quartz. Although typically unstrained, plagioclase may locally possess an undulose extinction and may locally be enclosed within a rim of untwinned albite or K-feldspar. Quartz is slightly finer grained than plagioclase and forms anhedral crystals which possess a well developed undulose extinction, sub-grain textures and/or deformation bands. Occasional, large (5.0 to 6.0 mm in size) intergranular poikiloblastic or poikilitic quartz crystals containing inclusions of finer grained plagioclase have also been noted.

Biotite possesses a moderately developed pleochroism and ranges from yellow-brown to brown in colour. It forms anhedral flakes which may contain inclusions of apatite and titanite. Biotite occurs as clusters of several crystals as well as single, isolated flakes. Worm-like or symplectitic inclusions of quartz were also noted within biotite. Green to blue-green amphibole forms anhedral crystals which are spatially related to and may partially enclose finer grained biotite. Minor secondary epidote and anhedral titanite crystals are both associated with the ferromagnesian minerals. Apatite is a common accessory phase and forms anhedral, rounded crystals which range up to 0.3 mm in diameter.

GEOCHEMICAL DATA FOR SAMPLE 56-08/920

Sample name	Depth	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O _{3t}	Mn ₃ O ₄	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃	Cr ₂ O ₃	SrO	ZrO ₂	BaO	NiO	CuO	ZnO	PbO	LOI	Total	
	(metres)	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
56-08/920	0.51-0.67	60.57	0.55	14.25	7.90	0.17	4.06	6.42	3.92	0.98	0.05	<0.1	0.03	0.03	<0.02	0.02	0.01	<0.01	0.02	<0.01	0.81	99.79	

XRFs Data		Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Rb	Sr	Zr	Mo	Ag	Cd	Sn	Sb	Te	Ba	W	Tl	Pb	Bi
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
56-08/920	0.51-0.67	24	116	195	20	76	20	120	21	1	12	<1	<1	21	291	86	<1	<1	<1	5	<1	<1	108	<1	<1	10	2

ICP-MS Data		Y	Nb	Cs	La	Ce	Pr	Nd	Sm	Eu	Tb	Gd	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
56-08/920	0.51-0.67	19.3	10.0	0.2	32.2	76.8	9.33	36.4	6.80	1.04	0.73	5.33	3.94	0.76	2.02	0.30	1.83	0.27	2.6	0.8	5.7	0.26

SAMPLE 56-08/921

SITE DETAILS

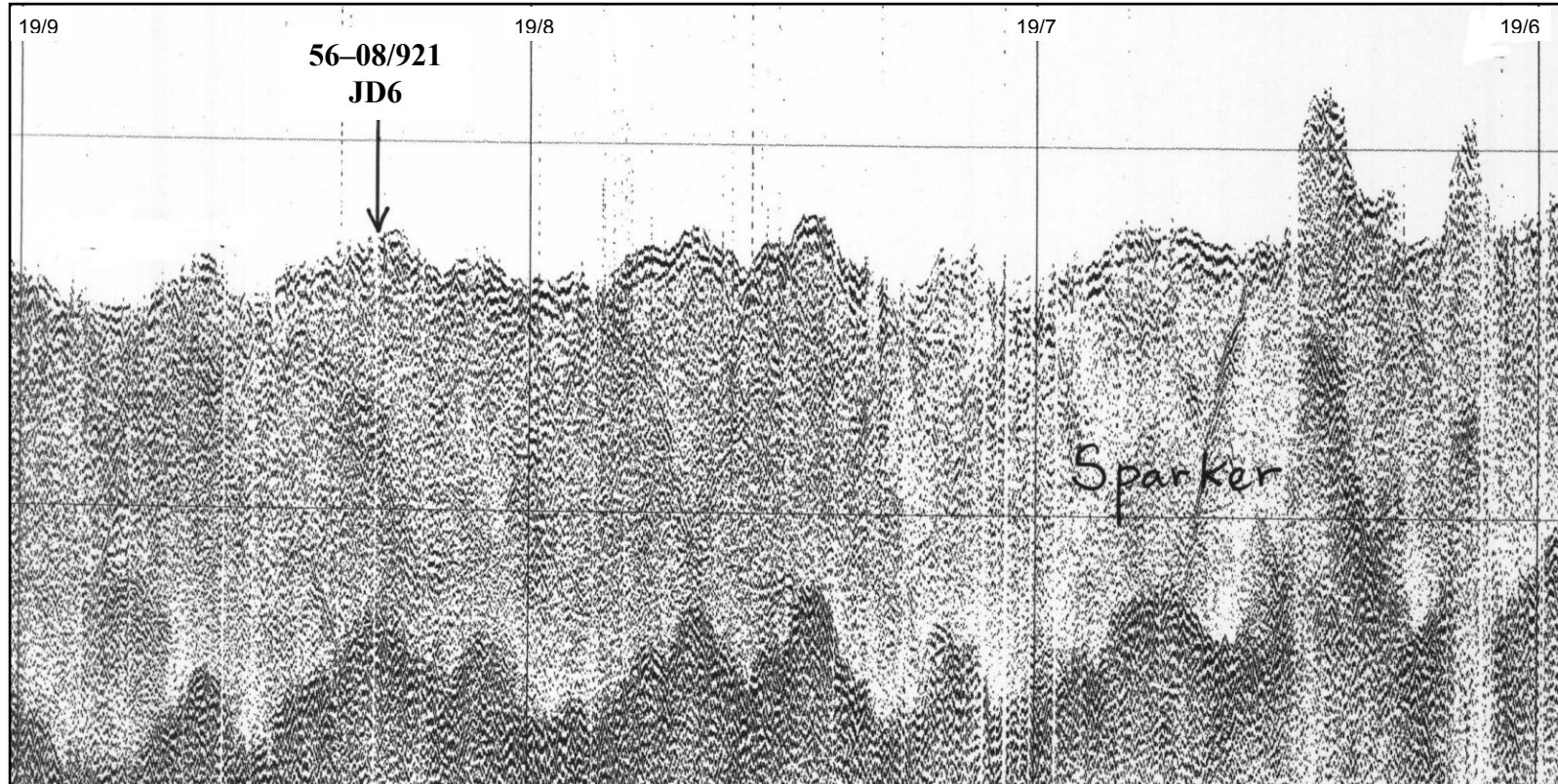
Date of drilling: 9th August 2001
Original site number: JD6
Latitude: 56° 48.264'N
Longitude: 07° 52.284'W
Location: Hebrides Shelf
Line and fix number: 85/03-19 8.3
Equipment: BGS rockdrill
Core length: 0.78m
Lithology: Quartzo-feldspathic gneiss
Age: ?Lewisian (Archaean)

SUMMARY

A single attempt recovered 0.78m of strongly banded and foliated biotite gneiss with little or no apparent amphibole.

W

E



LINE 85/03-19

SPARKER

BGS CORE NO: 56-08/921DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

Outer Isles Platform

Latitude	56° 48.264'N	Licence Block	134/6	Vessel	James Clark Ross
Longitude	007° 52.284'W	BGS Plan No	JD6	Station Keeping	DP
Navigation	DGPS	Total Depth	0.90m (Rec 0.78m)	Dates of Drilling	09/08/2001
Map Area	Tiree	Water Depth	82m	Geologists	Kempton & Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
Lewisian	0	# d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d							TS 0.50m TS 0.78m		<p>BIOTITE GNEISS WITH K-FELDSPAR PORPHYROCLASTS</p> <p>Biotite gneiss with variable grain size and modal mineralogy. Strongly foliated and banded. Differs from other gneisses recovered in having little or no amphibole. Also appears to contain large porphyroclasts of K-feldspar.</p> <p>Some biotite partially altered to chlorite. Sulfides occur toward the bottom of the section. Fe-staining occurs along steeply dipping fractures and around thin veins and along some grain boundaries. Fe staining complicates identification of K-feldspar in hand specimen, but larger pink crystals are almost certainly K-feldspar and not stained plagioclase.</p> <p>Top surface encrusted with biota indicating recovery from seabed.</p>
	1										
	2										
	3										
	4										
	5										
	6										



PETROLOGY OF SAMPLE 56-08/921

Emrys Phillips

Registered number: N3705

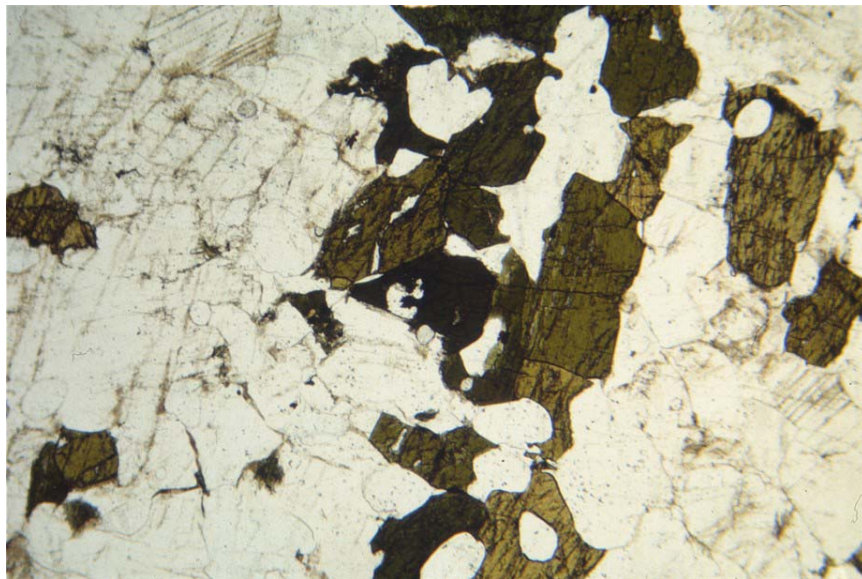
Thin section from 0.50m depth.

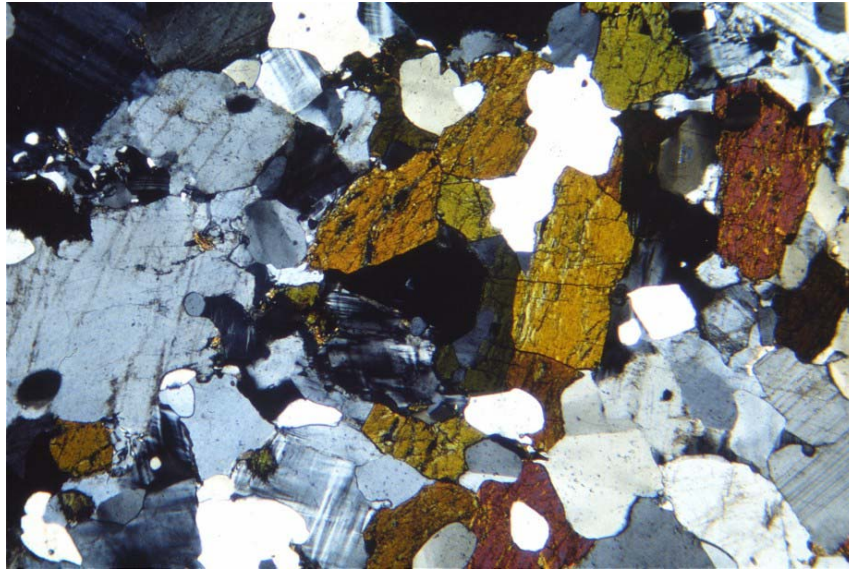
Rock Type: biotite-bearing quartzofeldspathic gneiss containing trace amounts of amphibole

Mineralogy: major – plagioclase, quartz, biotite, K-feldspar
minor – amphibole, opaque minerals, apatite
alteration – sericite, clay minerals

Photomicrographs:

Photomicrographs of a biotite-bearing quartzofeldspathic gneiss containing trace amphibole (N3705), plane and crossed polarised light.





Description: This thin section is of a medium- to coarse-grained, inequigranular, anhedral granular, banded, weakly foliated, amphibole and biotite bearing quartzofeldspathic gneiss. A compositional banding present within this high-grade (?upper amphibolite facies) metamorphic rock is defined by the variation in modal biotite and amphibole. Both ferromagnesian minerals are minor components within this gneiss. A weakly developed tectonic foliation is parallel to this compositional banding and defined by shape-aligned biotite flakes. Biotite forms anhedral, strongly pleochroic crystals (≤ 1.0 mm in length) which range from yellow-brown to dark brown in colour. Amphibole is an accessory phase and is restricted to one band within this gneissose rock. Amphibole forms clusters of several anhedral, equant to elongate crystals which range from green to dark blue-green in colour.

The bulk of the rock is mainly composed of plagioclase and quartz with K-feldspar typically being more common within the biotite-bearing bands. Plagioclase forms anhedral, twinned and untwinned crystals which exhibit a slight dusty appearance under plane polarised light. Intracrystalline deformation within plagioclase resulted in the variable development of an undulose to sweeping extinction. Plagioclase may locally contain rounded inclusions of quartz. Traces of myrmekite were noted forming rims upon plagioclase. Quartz is strained with an undulose extinction and variably developed deformation bands and sub-grain textures. It is slightly coarser grained than plagioclase and forms anhedral crystals which are weakly elongate parallel to the compositional banding and tectonic foliation. K-feldspar forms anhedral to irregular crystals which possess a shadowy extinction and diffuse microcline twins. K-feldspar is weakly perthitic and is locally being replaced by myrmekite.

PETROLOGY OF SAMPLE 56-08/921

Emrys Phillips

Registered number: N3706

Thin section from 0.78m depth.

Rock Type: weakly foliated quartzofeldspathic gneiss

Mineralogy: major – plagioclase, quartz, K-feldspar, biotite
minor – opaque minerals, muscovite, clinozoisite, zircon
alteration – sericite, clay minerals, carbonate, chlorite, opaque oxides, prehnite

Description: This thin section is of a coarse-grained, anhedral granular, inequigranular, weakly foliated, possibly granitic, quartzofeldspathic gneiss. The rock is mainly composed of anhedral plagioclase, quartz and K-feldspar with minor amounts of biotite. A weakly developed foliation is defined by lenticular to wispy looking aggregates of biotite. Biotite is yellow-brown to red-brown in colour and exhibits minor alteration to possible prehnite along the basal (001) cleavage. Biotite within the aggregates are variably shape aligned parallel to the foliation. Biotite may locally contain inclusions of zircon and possible allanite enclosed within dark pleochroic haloes.

The bulk of the rock is composed of feldspar and quartz. Plagioclase is the dominant feldspar and forms anhedral, twinned and untwinned crystals up to 1.0 to 2.0 mm in size. It may locally exhibit minor alteration to sericite, clay minerals and carbonate. Plagioclase may locally possess moderately developed or preserved crystal faces suggesting that the protolith of this gneiss was a granitic igneous rock. Plagioclase is locally rimmed by a clear rim of K-feldspar or albite. Myrmekite was also noted forming poorly developed rims upon plagioclase along plagioclase-K-feldspar grain contacts. The myrmekite appears to be replacing the adjacent K-feldspar. Plagioclase within this intergrowth is typically in optical continuity with the host feldspar crystal.

Quartz is coarser grained and apparently intergranular to plagioclase. It forms anhedral crystals up to *c.* 6.0 to 7.0 mm in length which are shape aligned parallel to the biotite fabric. Intracrystalline deformation within quartz resulted in the development of an undulose extinction, deformation bands and sub-grain textures. These large quartz crystals may contain inclusions of finer grained feldspar. K-feldspar is fresh and forms anhedral, weakly perthitic crystals which are intergranular to both plagioclase and quartz. K-feldspar possesses a distinctive shadow extinction and coarse microcline twins.

SAMPLE 56-08/923

SITE DETAILS

Date of drilling: 10th August 2001

Original site number: JD8

Latitude: 56° 37.470'N

Longitude: 07° 46.810'W

Location: Hebrides Shelf

Line and fix number: 85/04-48 5.0

Equipment: BGS rockdrill

Core length:

Lithology: Metamorphic gravel

Age:

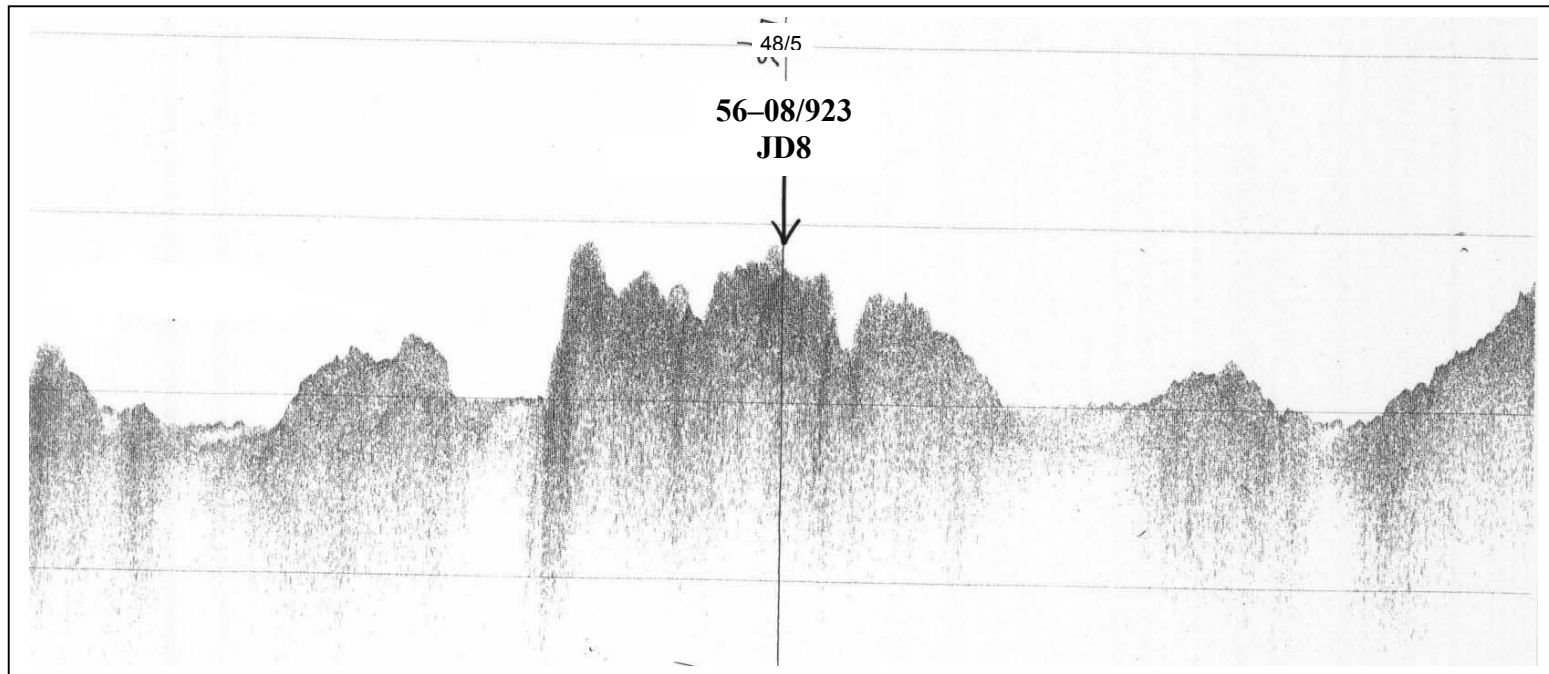
SUMMARY

(NB There was no sample recovered in 56-08/922).

Gravel was recovered at this location. The material comprises mainly rounded metamorphic rock fragments.

SW

NE



LINE 85/04-48

PINGER

BGS CORE NO: 56-08/923DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

Outer Isles Platform

Latitude	56° 37.4704'N	Licence Block	134/12	Vessel	James Clark Ross
Longitude	007° 46.8095'W	BGS Plan No	JD8	Station Keeping	DP
Navigation	DGPS	Total Depth	1.52m	Dates of Drilling	10/08/2001
Map Area	Tiree	Water Depth	80m	Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0									<p>SURFICIAL SEAFLOOR DEPOSIT (PREDOMINANTLY METAMORPHIC CLASTS)</p> <p>This site is located at a slight offset from 56-08/922DR, which had no recovery.</p> <p>Gravel: Recovered around 40 pebbles, 10-40 mm in diameter, plus a small amount of coarse sand. Pebbles predominantly subrounded metamorphic rock fragments including quartz, mafic mica-rich and felspar-rich foliated clasts, with fine grained basaltic(?) fragments.</p> <p>Sand: Coarse sand contains similar mix of lithologies, but more angular to subangular grains.</p>
	0.2									
	0.4									
	0.6									
	0.8									
	1.0									
	1.2									
	1.4									
	1.6									
	1.8									
	2.0									
	2.2									
	2.4									



SAMPLE 56-08/924

SITE DETAILS

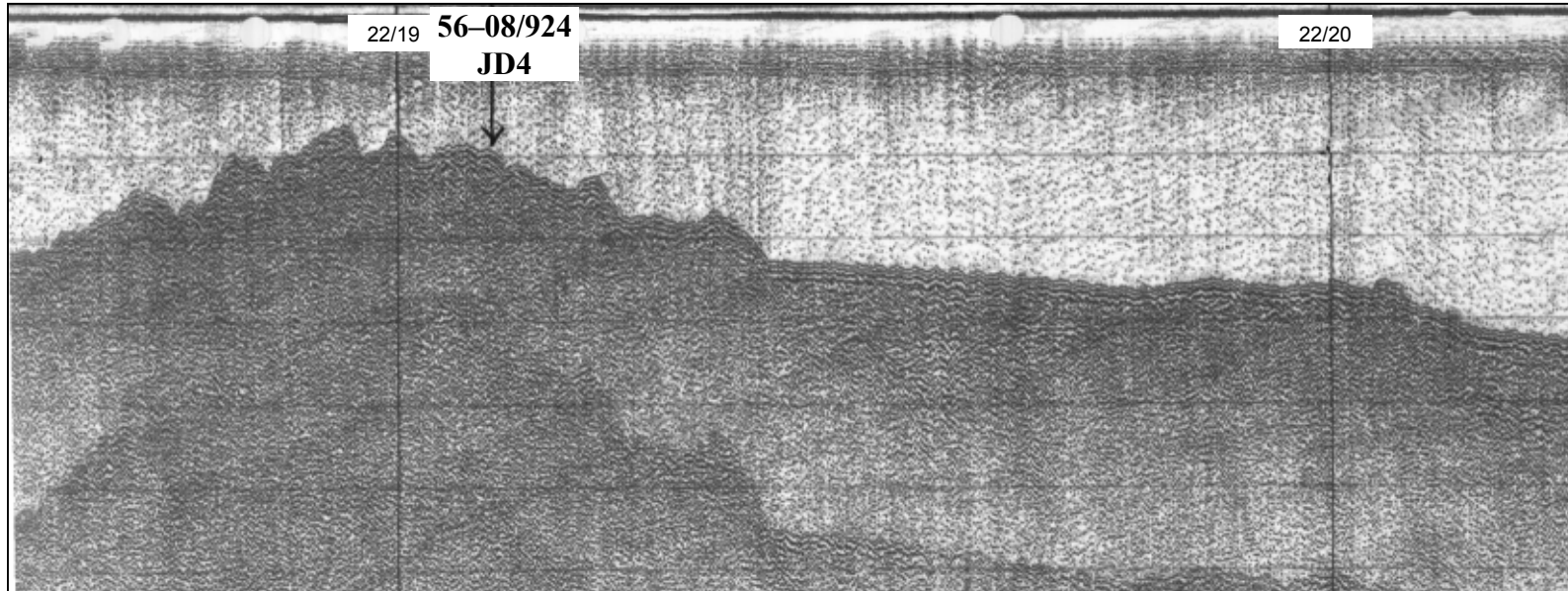
Date of drilling:	10th August 2001
Original site number:	JD4
Latitude:	56° 16.368'N
Longitude:	07° 46.458'W
Location:	Hebrides Shelf
Line and fix number:	70/05-22 19.1
Equipment:	BGS rockdrill
Core length:	1.13m
Lithology:	Protomylonitic monzonitic rock
Age:	?Lewisian (Archaean)

SUMMARY

The core comprises amphibolite (0.00-0.28m) overlying granitic gneiss (0.58-1.13m) with a transition zone between 0.28 and 0.58m.

SW

NE



LINE 70/05-22

SPARKER

BGS CORE NO: 56-08/924



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

Outer Isles Platform

Latitude	56° 16.368'N	Licence Block	134/22	Vessel	James Clark Ross
Longitude	007° 46.458'W	BGS Plan No	JD4	Station Keeping	DP
Navigation	DGPS	Total Depth	1.69m (Rec. 1.13 m)	Dates of Drilling	08/10/2001
Map Area	Tiree	Water Depth	56m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION	
Lewisian	0	# d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d									<p>AMPHIBOLITE - GRANITIC GNEISS CONTACT</p> <p>Nearly continuous recovery of contact between amphibolite and granitic gneiss. The amphibolite extends from the seafloor to a depth of 28 cm. Between 28 and 58 cm the amphibolite and gneiss are intimately interlayered, with bands less than 1 cm width. The bottom 55 cm are more homogeneous granitic gneiss; the bottom 28 cm of the gneiss are more altered (replacement of mafic phases by chlorite ± actinolite) than that above. The amphibolite and transitional interval are relatively unaltered. Foliation is at about 45 degrees to the core vertical. A fracture at ~85 cm is lined with Fe-stained amorphous silica; the fracture is oriented at ~45 degrees to the core vertical.</p> <p>Amphibolite is medium grained consists of ~70% amphibole and 30% feldspar + quartz. The gneiss is slightly coarser grained, pinkish in color and consists of K-feldspar, plagioclase, quartz and ~30% amphibole. There is also a pinkish yellow, euhedral to subhedral accessory phase that may be sphene.</p> <p>The top of the core is encrusted with serpulid worms and corals, indicating exposure of bare rock on the seafloor.</p>
	1	# d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d									
	2	# d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d									
	3	# d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d									
	4	# d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d									
	5	# d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d									
	6	# d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d # d # g d f # d d f # d # g d f # d									



PETROLOGY OF SAMPLE 56-08/924

Emrys Phillips

Registered number: N3707

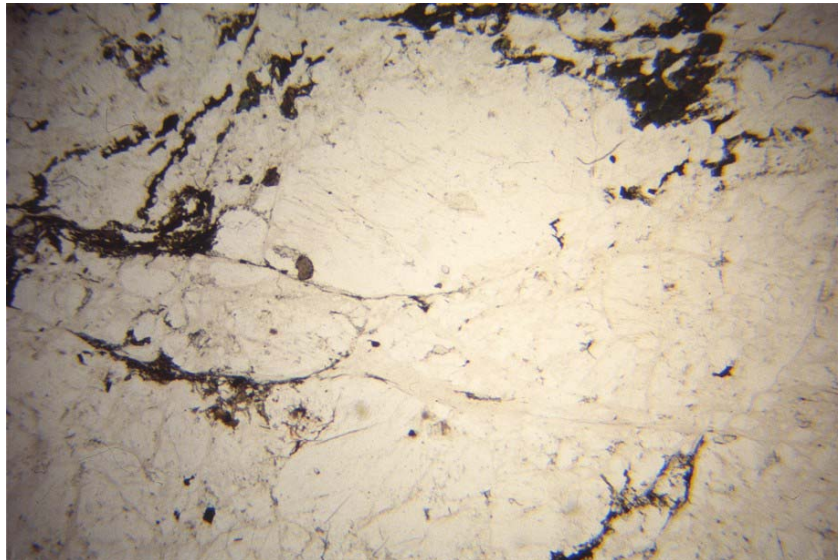
Thin section from 0.26-0.33m depth.

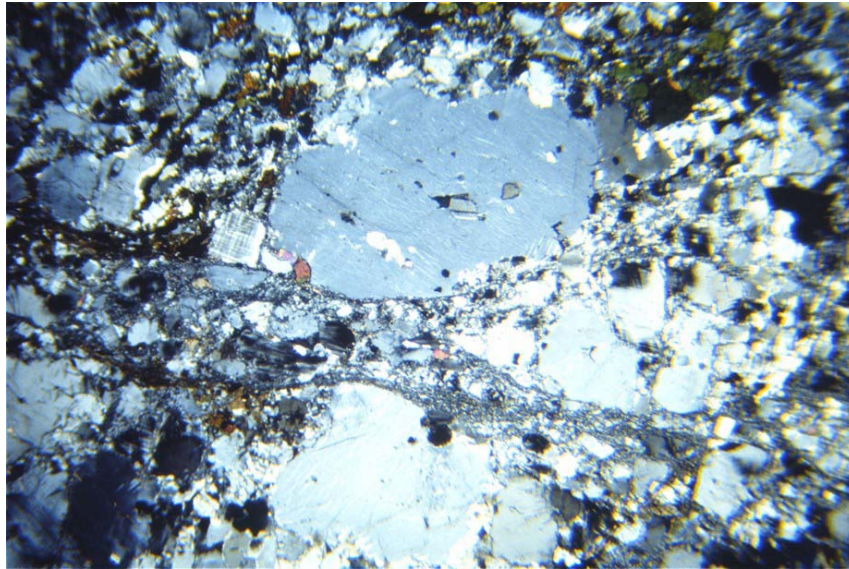
Rock Type: protomylonitic monzonitic rock

Mineralogy: major – K-feldspar, quartz, plagioclase, amphibole (1), amphibole (2), biotite
minor – opaque minerals, titanite, allanite, apatite
alteration – carbonate, clinozoisite

Photomicrographs:

Photomicrographs of a protomylonitic monzonitic rock (N3707), plane and crossed polarised light.





Description: This thin section is of a medium- to coarse-grained, highly deformed, banded, protomylonitic monzonitic/granitic rock. The rock is mainly composed of K-feldspar, plagioclase and quartz. A compositional banding is defined or preserved by the occurrence of amphibole and biotite. Accessory titanite and apatite are spatially related to the occurrence of these ferromagnesian minerals. The amphibole-bearing bands are finer grained than the remaining feldspathic part of this K-feldspar-rich rock. An early formed foliation which is defined by chains of amphibole and biotite, has been reactivated during a later phase of ductile deformation which resulted in mylonitisation of this broadly granitic rock. A weakly developed S-C or extensional crenulation cleavage (ECC) is defined by anastomosing bands of dynamically recrystallised quartz, feldspar and biotite. These anastomosing fabric also yield a sinistral sense of shear.

Two textural varieties of amphibole are present within this protomylonitic rock: (1) early brown-green amphibole; and (2) a later, green to blue green amphibole which appears to replacing and formed at the expense of type 1. The brown-green amphibole was noted forming anhedral lozenge-shaped crystals which are enclosed within or overgrown by beards or tails of biotite. In contrast to quartz and feldspar, amphibole has undergone more brittle/cataclastic deformation during mylonitisation. Both textural varieties of amphibole have undergone fracturing and disaggregation, with larger crystals locally being broken up into individual cleavage rhombs. Titanite is spatially related to amphibole and clearly overgrows the mylonitic foliation.

K-feldspar is fresh and possesses a distinctive shadowy extinction and diffuse microcline twins. K-feldspar is also perthitic and forms rounded to elliptical porphyroclasts which range up to 4.0 mm in length. These porphyroclasts possess irregular serrated grain boundaries due to dynamic recrystallisation and new grain growth being focused along the grain margins. Quartz is strained with a well developed undulose extinction, deformation bands and sub-grain textures. The feldspar porphyroclasts are wrapped by a moderately well developed mylonitic foliation. This fabric is defined by narrow bands or zones of very fine-grained to cryptocrystalline, dynamically recrystallised quartz and feldspar. Relict, eye-shaped quartz and feldspar crystals are wrapped by and variably aligned parallel to this mylonitic foliation. Dynamic recrystallisation has also effected biotite to forms elongate needle-like crystals and very fine-grained irregular to ragged-looking flakes. The rock is also deformed by several narrow shear bands which occur oblique to the mainly mylonitic foliation. These shear bands are characterised by narrow zones of intense grain reduction and yield an apparent sinistral (top to left) sense of shear in this plane of section.

Minor amounts of vein perthite have been recognised associated with the most intensely deformed parts of the thin section. It is possible that this exsolution is strain induced and

associated with ductile deformation and mylonitisation. Traces of secondary carbonate are also present replacing the cryptocrystalline quartzofeldspathic mosaic within the mylonitic foliation. Trace amounts of post-kinematic clinozoisite are also present.

SAMPLE 56-08/925

SITE DETAILS

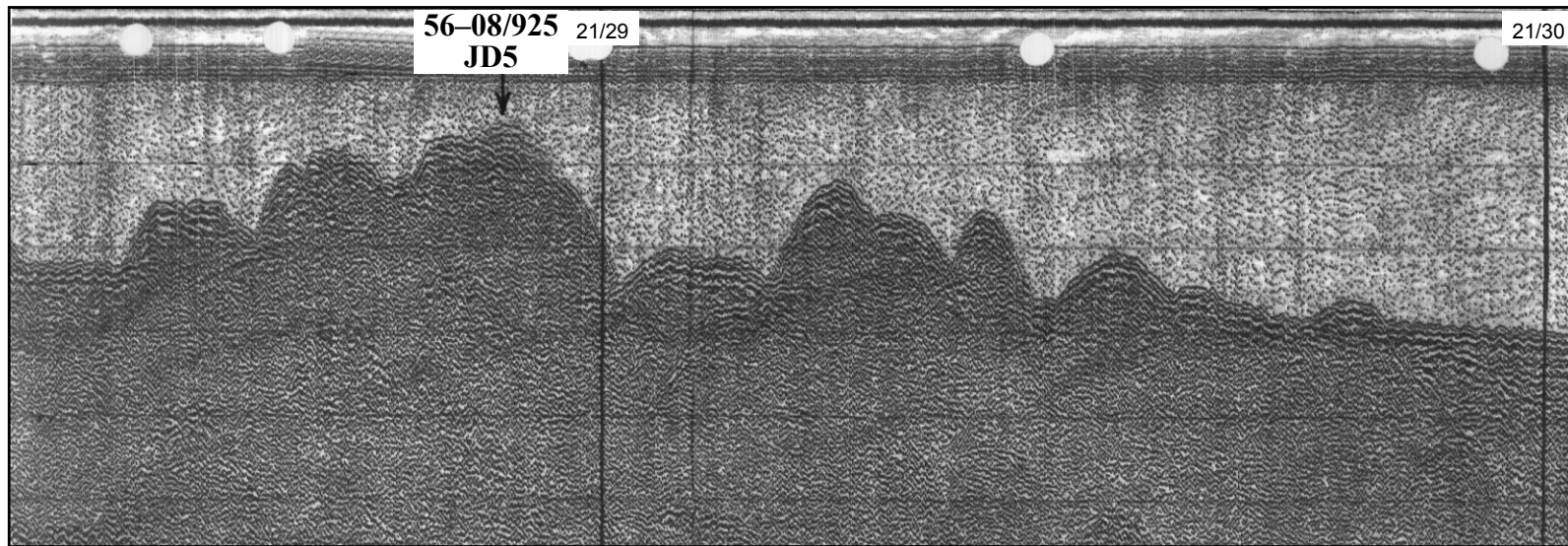
Date of drilling: 10th August 2001
Original site number: JD5
Latitude: 56° 15.522'N
Longitude: 07° 58.188'W
Location: Hebrides Shelf
Line and fix number: 70/05-21 28.9
Equipment: BGS rockdrill
Core length:
Lithology: Gravel
Age:

SUMMARY

Gravel was recovered at this location. The material comprises mainly rounded metamorphic rock fragments.

SW

NE



LINE 70/05-21

SPARKER

BGS CORE NO: 56-08/925DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

Outer Isles Platform

Latitude	56° 15.522'N	Licence Block	134/21	Vessel	James Clark Ross
Longitude	007° 58.188'W	BGS Plan No	JD5	Station Keeping	DP
Navigation	DGPS	Total Depth	1.80m	Dates of Drilling	10/08/2001
Map Area	Tiree	Water Depth	93m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
Unknown	0	[Mixed Lithology]									<p>SURFICIAL SEAFLOOR DEPOSIT (MIXED LITHOLOGY)</p> <p>Recovered material consists of pebbles (up to 4.5 cm in diameter) of assorted metamorphic lithologies, predominantly gneiss. Also included are basalt (zeolitised), red sandstone, mollusc shells and fragments of coral. Numerous clasts are encrusted with biota (serpulid worms and coral).</p>
	1										
	2										
	3										
	4										
	5										
	6										



SAMPLE 56-08/926

SITE DETAILS

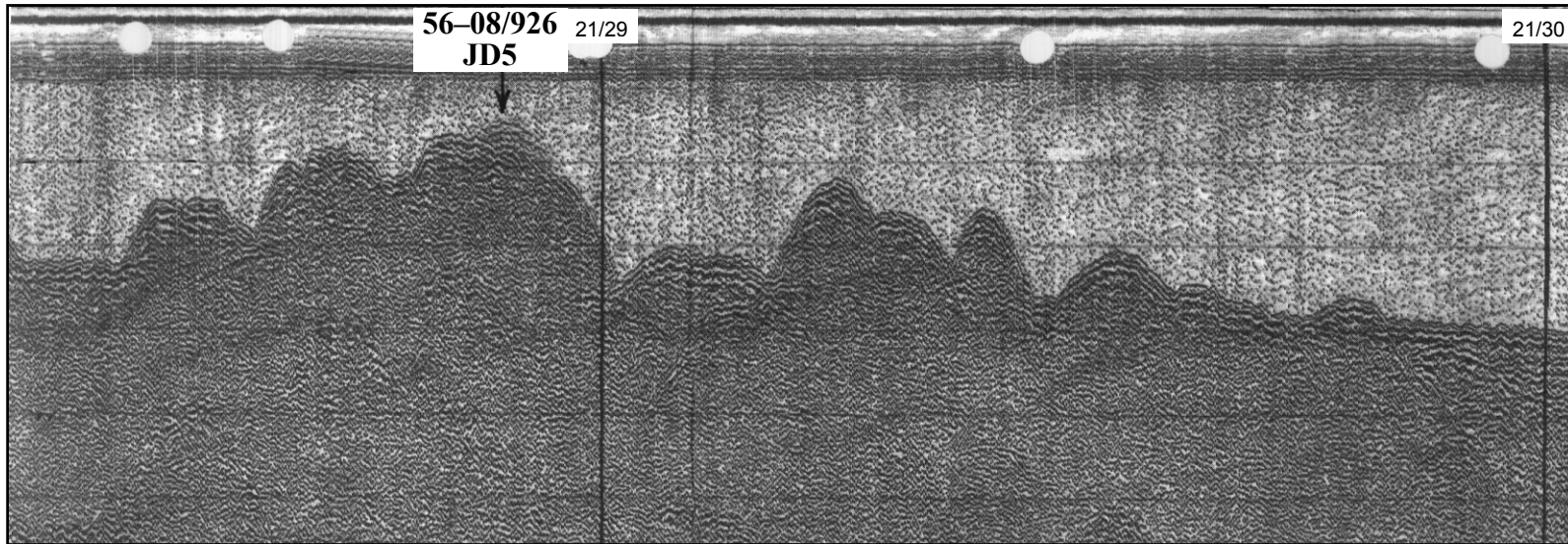
Date of drilling: 10th August 2001
Original site number: JD5
Latitude: 56° 15.52'N
Longitude: 07° 58.19'W
Location: Hebrides Shelf
Line and fix number: 70/05-21 28.9
Equipment: BGS rockdrill
Core length:
Lithology: Gravel
Age:

SUMMARY

This was a second attempt at JD5. Gravel was again recovered but less than on the previous attempt.

SW

NE



LINE 70/05-21

SPARKER

BGS CORE NO: 56-08/926DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Outer Isles Platform

Latitude 56° 15.52'N

Licence Block 134/21

Vessel James Clark Ross

Longitude 007° 58.19'W

BGS Plan No JD5

Station Keeping DP

Navigation DGPS

Total Depth 2.10m

Dates of Drilling 10/08/2001

Map Area Tiree

Water Depth 93m

Geologists P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
Unknown	0	[Mixed Lithology]									<p>SURFICIAL SEAFLOOR DEPOSIT (MIXED LITHOLOGY)</p> <p>Consists of 7 pebbles and 1 bivalve shell. Pebbles up to 5.5 cm across. Lithologies similar to previous site (56-08/925).</p>
	0.1										
	0.2										
	0.3										
	0.4										
	0.5										
	0.6										
	0.7										
	0.8										
	0.9										
	1.0										
	1.1										
	1.2										

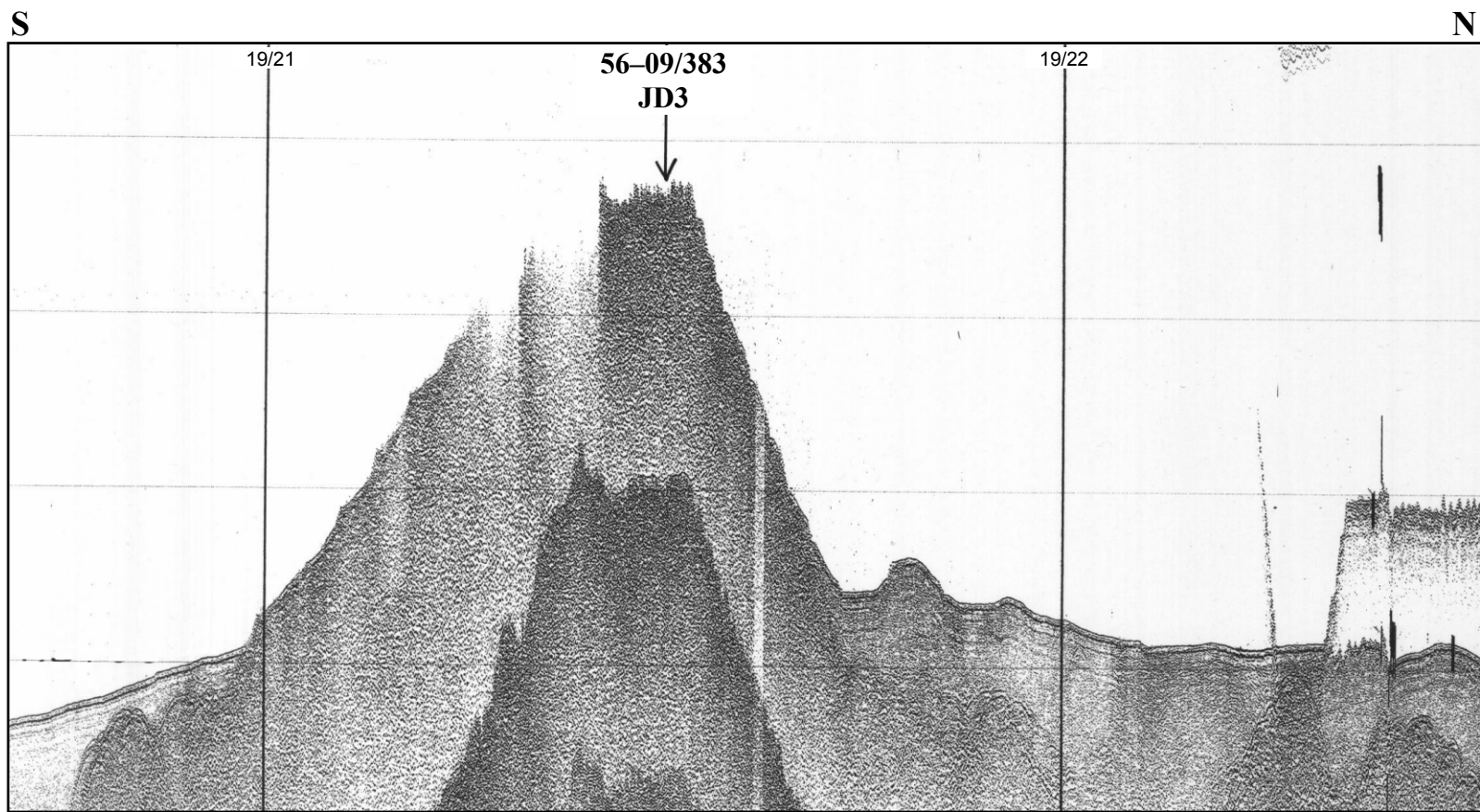
SAMPLE 56-09/383

SITE DETAILS

Date of drilling: 10th August 2001
Original site number: JD3
Latitude: 56° 25.60'N
Longitude: 08° 09.05'W
Location: Hebrides Shelf
Line and fix number: 85/06-19 21.5
Equipment: BGS rockdrill
Core length:
Lithology:
Age:

SUMMARY

No recovery.



LINE 85/06-19

BOOMER

BGS CORE NO: 56-09/383DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Outer Isles Platform

Latitude 56° 25.60'N

Licence Block 133/20

Vessel James Clark Ross

Longitude 008° 09.05'W

BGS Plan No JD3

Station Keeping DP

Navigation DGPS

Total Depth 0.34m

Dates of Drilling 10/08/2001

Map Area Peach

Water Depth 74m

Geologists R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
	0										NO RECOVERY
	1										
	2										
	3										
	4										
	5										
	6										

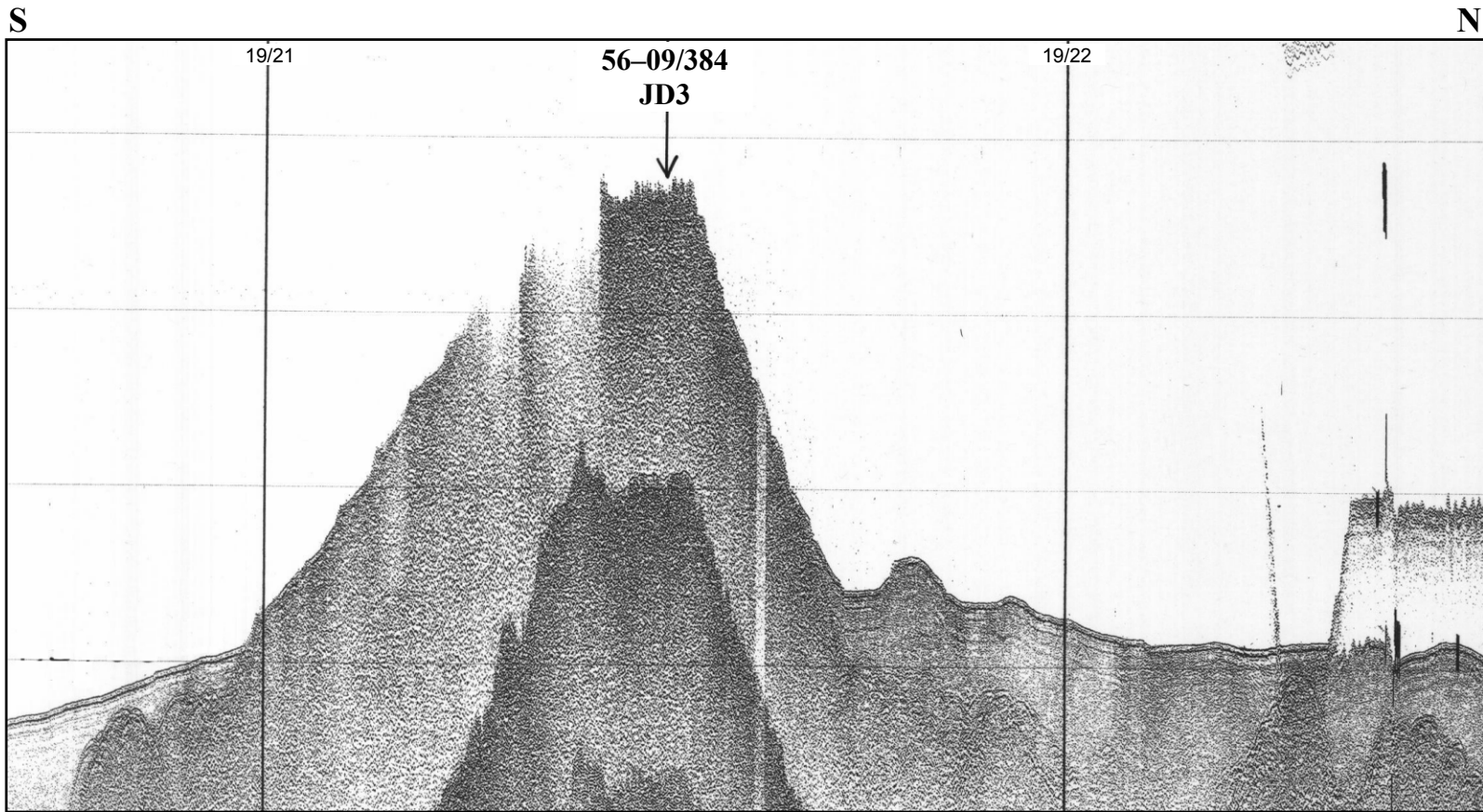
SAMPLE 56-09/384

SITE DETAILS

Date of drilling:	10th August 2001
Original site number:	JD3
Latitude:	56° 25.596'N
Longitude:	08° 09.048'W
Location:	Hebrides Shelf
Line and fix number:	85/06-19 21.5
Equipment:	BGS rockdrill
Core length:	1.27m
Lithology:	Amphibolite
Age:	?Lewisian (Archaean)

SUMMARY

This was a second attempt at JD3. A core of amphibolite was recovered.



LINE 85/06-19

BOOMER

BGS CORE NO: 56-09/384 DR



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Stanton Bank

Latitude 56° 25.596'N **Licence Block** 133/20 **Vessel** James Clark Ross
Longitude 008° 09.048'W **BGS Plan No** JD3 **Station Keeping** DP
Navigation DGPS **Total Depth** 1.8m (Rec 1.27m) **Dates of Drilling** 10/08/2001
Map Area Peach **Water Depth** 74m **Geologists** R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Lewisian	0	# d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d						10Chem 0.44m		AMPHIBOLITE Encrusted seabed with diverse fauna, including brittle stars, serpulid worms etc. Metabasic rock: Amphibolite, fine crystals amphibole, feldspar, biotite, pyrite, quartz, greenish mineral (epidote?). Some quartz veining, thick (1 cm) irregular folded vein at 0.37 m, subhorizontal, contrasting with steeply dipping fractures, veins and foliation. 1.13-1.26 m: thin very steeply dipping vein of greenish soft, fibrous/bladed crystals, some local effervescence with HCl.
								TS 0.99m		



PETROLOGY OF SAMPLE 56-09/384

Emrys Phillips

Registered number: N3708

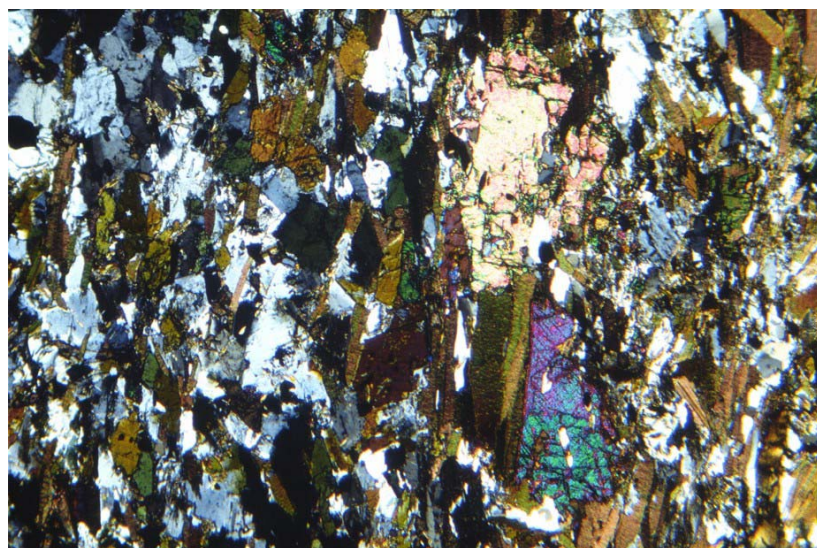
Thin section from 0.99m depth.

Rock Type: schistose epidote-biotite-amphibolite

Mineralogy: major –biotite, amphibole, plagioclase, quartz, epidote
minor – opaque minerals, titanite, apatite, zircon
alteration –sericite, clay minerals

Photomicrographs:

Photomicrographs of a schistose epidote-biotite-amphibolite (N3708), plane and crossed polarised light.



Description: This thin section is of a medium-grained, foliated, inequigranular, epidote-bearing, schistose biotite-amphibolite. A well developed domainal schistosity is defined by alternating biotite-rich and amphibole-bearing domains. The biotite-rich lithons are slightly coarser grained and composed of anhedral to ragged-looking, shape-aligned biotite flakes with subordinate plagioclase and minor quartz. Biotite is strongly pleochroic and ranges from yellow-brown to dark brown in colour. The foliation within the biotite-rich domains is overgrown by post-kinematic, anhedral epidote porphyroblasts. Nucleation and growth of epidote clearly post-dated the imposition of the schistosity. Epidote is weakly pleochroic and ranges from pale yellow to colourless.

The adjacent amphibole domains are composed of amphibole, plagioclase, biotite, quartz and epidote. Small anhedral titanite crystals (accessory phase) are common within these amphibole-rich domains, with titanite also locally forming irregular rims upon opaque minerals. Anhedral to irregular amphibole is moderately to strongly pleochroic and ranges from blue-green to yellow-green in colour. Elongate amphibole crystals may be shape aligned parallel to the biotite fabric. Biotite within the amphibole domains is finer grained than that in the adjacent biotite lithons. Biotite within these more feldspathic domains is shape aligned parallel to the main foliation. A second, weakly developed anastomosing foliation, also defined by biotite, is preserved within the amphibole domains. This asymmetrical foliation yields a possible dextral (top to right) sense of shear in this plane of section.

The remainder of the rock is composed of anhedral to ragged-looking plagioclase with fine-grained intergranular biotite and amphibole. Plagioclase varies from twinned to untwinned and possesses an undulose extinction. Plagioclase may contain rod-shaped inclusion of apatite as well as ragged looking biotite flakes. Minor to accessory quartz is strained with a variably developed undulose extinction. Both plagioclase and amphibole are locally being replaced by epidote. Recrystallisation associated with epidote growth appears to have resulted in the ragged appearance of many of the biotite flakes. Possible zircon inclusions, with associated pleochroic haloes, have been recorded within biotite.

GEOCHEMICAL DATA FOR SAMPLE 56-09/384

Sample name	Depth	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃ t	Mn ₃ O ₄	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃	Cr ₂ O ₃	SrO	ZrO ₂	BaO	NiO	CuO	ZnO	PbO	LOI	Total	
	(metres)	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
56-09/384	0.44-0.64	47.30	2.13	15.85	13.38	0.22	5.12	7.29	3.88	2.40	0.57	0.2	0.01	0.08	<0.02	0.10	0.01	<0.01	0.02	<0.01	1.08	99.64	

XRFS Data		Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Rb	Sr	Zr	Mo	Ag	Cd	Sn	Sb	Te	Ba	W	Tl	Pb	Bi
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
56-09/384	0.44-0.64	19	186	52	44	66	33	172	21	2	1	<1	<1	102	661	119	<1	1	<1	3	<1	<1	817	<1	<1	11	2

ICP-MS Data		Y	Nb	Cs	La	Ce	Pr	Nd	Sm	Eu	Tb	Gd	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
56-09/384	0.44-0.64	23.3	12.5	1.5	21.9	50.2	6.66	29.8	6.00	1.86	0.82	5.63	4.66	0.93	2.51	0.35	2.18	0.33	3.1	1.4	0.7	0.48

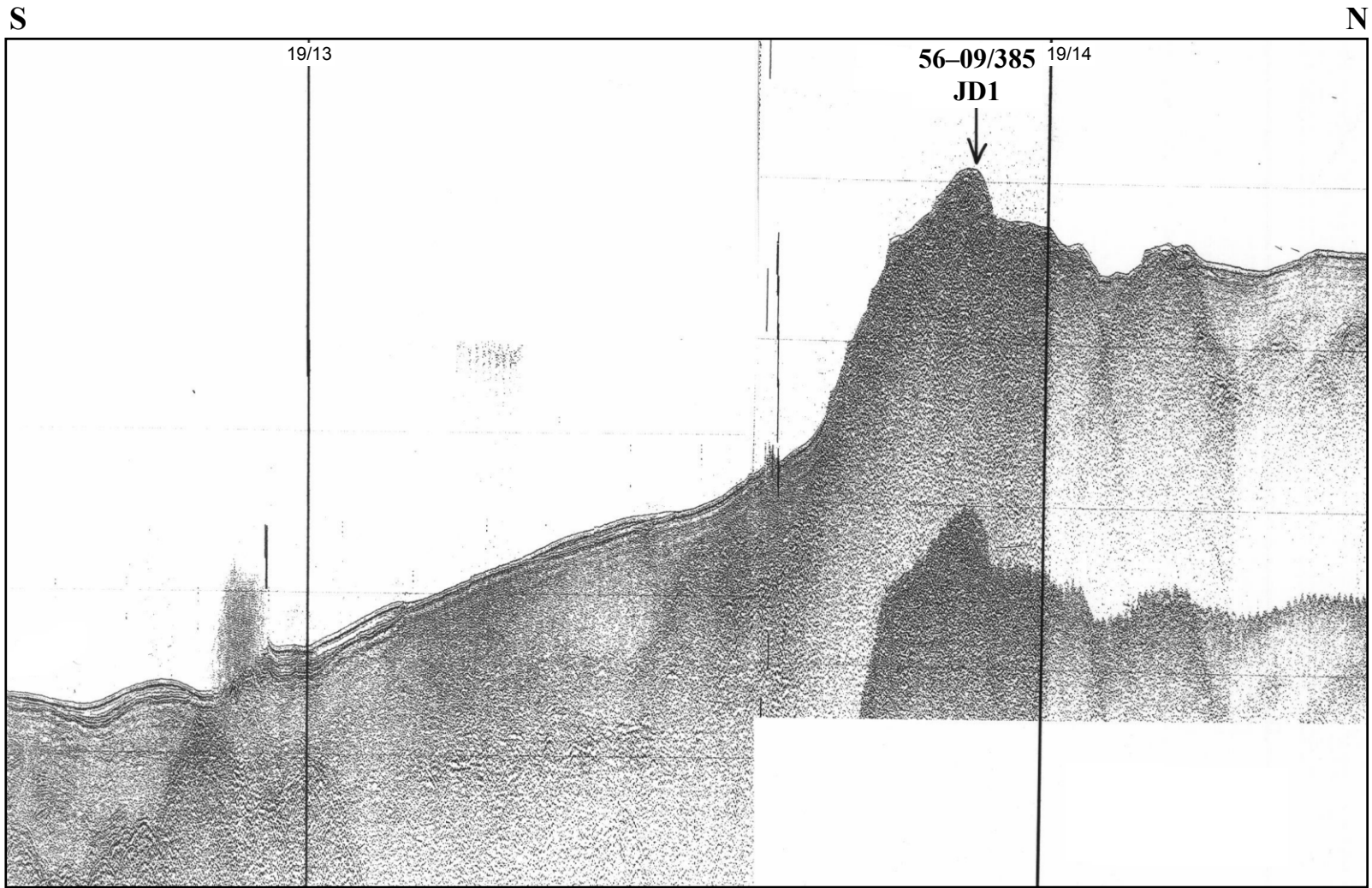
SAMPLE 56-09/385

SITE DETAILS

Date of drilling: 10th August 2001
Original site number: JD1
Latitude: 56° 19.46'N
Longitude: 08° 09.15'W
Location: Hebrides Shelf
Line and fix number: 85/06-19 13.9
Equipment: BGS rockdrill
Core length: 0.20m
Lithology: Gneiss
Age: ?Lewisian (Archaean)

SUMMARY

Four short lengths of granitic gneiss were recovered, one shattered into pieces.



LINE 85/06-19

BOOMER

BGS CORE NO: 56-09/385DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Outer Isles Platform

Latitude 56° 19.46'N

Licence Block 133/25

Vessel James Clark Ross

Longitude 008° 09.15'W

BGS Plan No JD1

Station Keeping DP

Navigation DGPS

Total Depth 1.33m (Rec. 0.2m)

Dates of Drilling 10/08/2001

Map Area Peach

Water Depth 101m

Geologists P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
	0	# d # g d f # d d f # d # g d f # # d # g d f # d									GRANITIC BIOTITE GNEISS
	1										<p>Pink to black granitic biotite gneiss, consists of large partially recrystallised K-feldspar porphyroclasts (up to 2 cm maximum dimension), separated by bands of medium grained plagioclase + quartz + biotite. Recovered samples show minimal alteration. Foliation appears chaotic in Piece 1 (0-6 cm), but is oriented at ~ 60 degrees to core vertical at the bottom (15-20 cm). Piece 1 (0-6 cm) has an old vertical fracture surface on one side. The top of this piece and the old fracture surface are encrusted with assorted biota, indicated that bare rock is exposed on the seafloor at this site.</p>
	2										
	3										
	4										
	5										
	6										



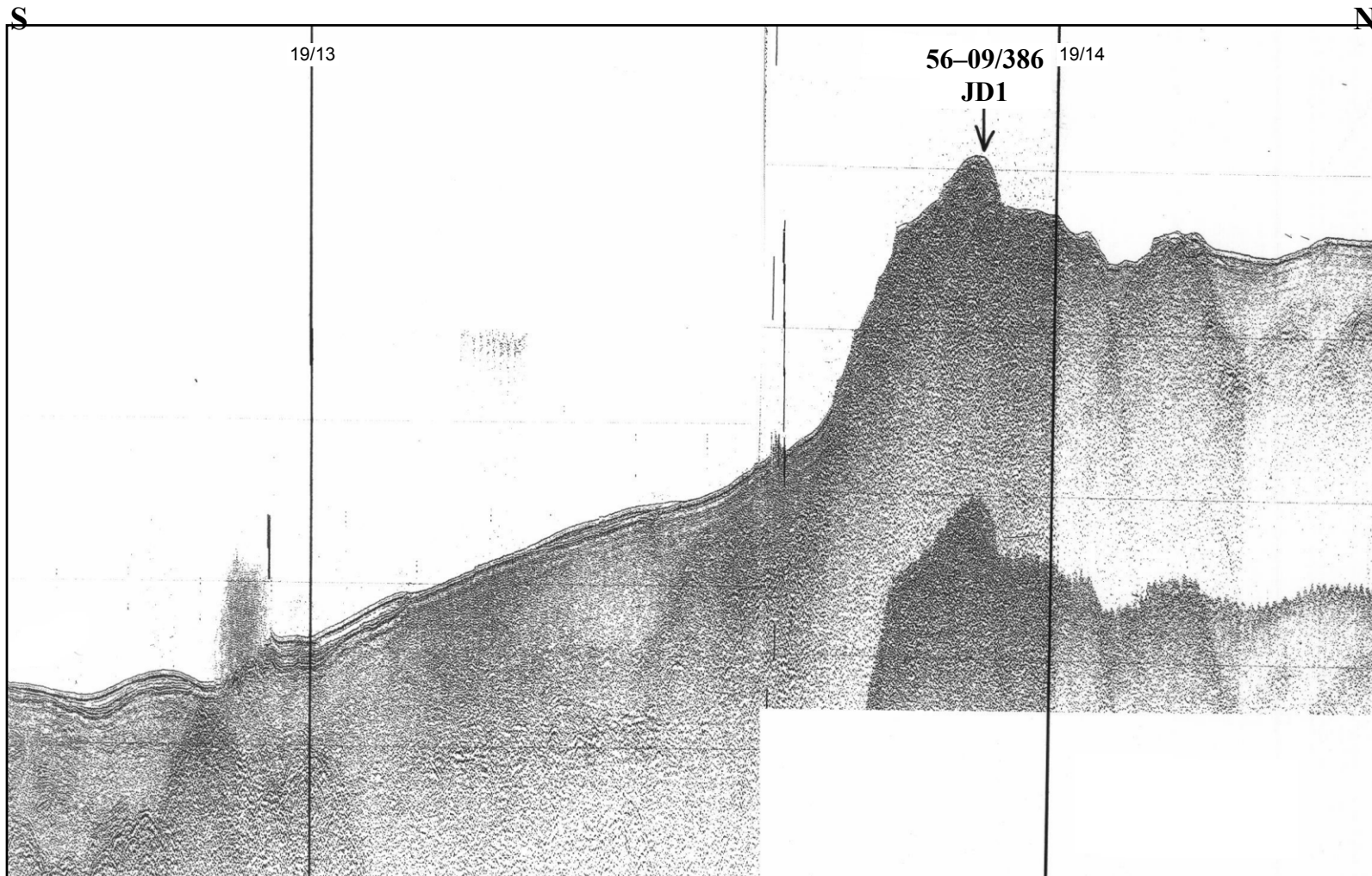
SAMPLE 56-09/386

SITE DETAILS

Date of drilling:	10th August 2001
Original site number:	JD1
Latitude:	56° 19.46'N
Longitude:	08° 09.15'W
Location:	Hebrides Shelf
Line and fix number:	85/06-19 13.9
Equipment:	BGS rockdrill
Core length:	1.18m
Lithology:	Protomylonitic granodioritic or monzodioritic rock
Age:	?Lewisian (Archaean)

SUMMARY

This was a second attempt at JD1 and recovered 1.18m of igneous/meta-igneous rock.



LINE 85/06-19

BOOMER

BGS CORE NO: 56-09/386DR



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Stanton Banks

Latitude 56° 19.46' N **Licence Block** 133/25 **Vessel** James Clark Ross
Longitude 008° 09.15' W **BGS Plan No** JD1 **Station Keeping** DP
Navigation DGPS **Total Depth** 1.71m (Rec 1.18 m) **Dates of Drilling** 10/08/2001
Map Area Peach **Water Depth** 101m **Geologists** R Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Lewisian	0	# d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f #								GRANITIC GNEISS Many large pinkish feldspars up to 5cm long, with finer biotite, quartz and feldspars forming a moderate-weak foliation with shallow dip. Seabed encrusted with organisms indicating absence of sediment cover.
	1	# d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # f # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f #						TS 1.1m		



PETROLOGY OF SAMPLE 56-09/386

Emrys Phillips

Registered number: N3709

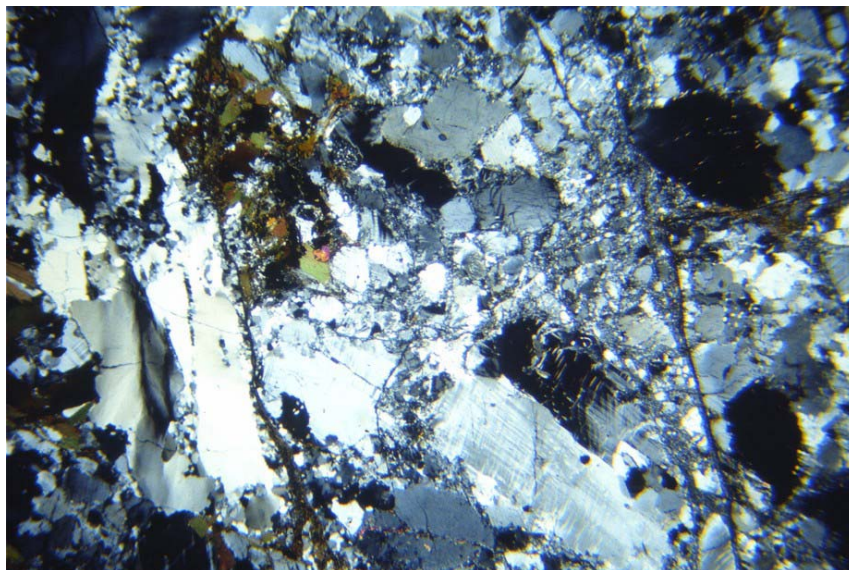
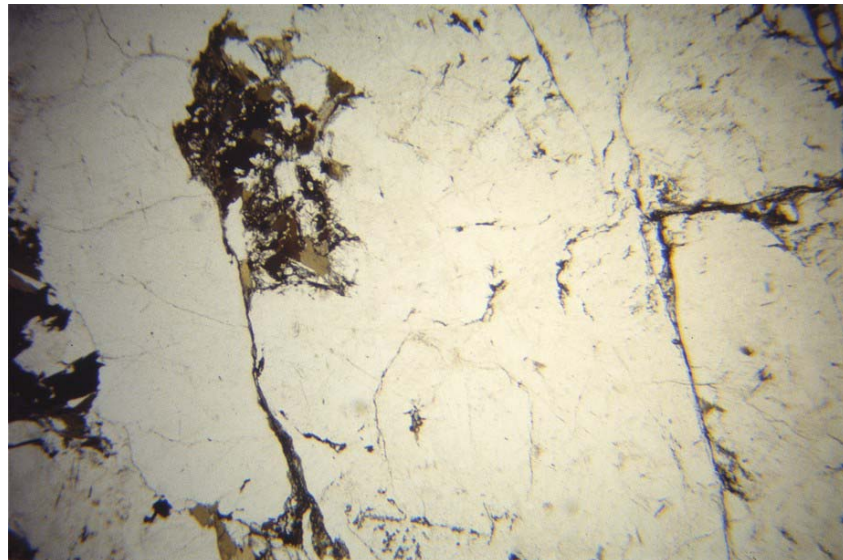
Thin section from 1.11-1.18m depth.

Rock Type: amphibole-bearing protomylonitic granodioritic or monzodioritic rock

Mineralogy: major – plagioclase, quartz, K-feldspar, biotite
minor – amphibole, opaque minerals, titanite, epidote, apatite, zircon
alteration – chlorite

Photomicrographs:

Photomicrographs of a amphibole-bearing protomylonitic granodiorite or monzodioritic rock (N3709), plane and crossed polarised light.



Description: This thin section is of a highly deformed, very coarse-grained, inequigranular, amphibole-bearing, protomylonitic granodioritic to monzodioritic rock. The protolith was a very coarse-grained feldspar porphyritic granitic rock with megacrysts of both plagioclase and K-feldspar. Ductile deformation resulting in mylonitisation was partitioned into the groundmass and resulted in dynamic recrystallisation of this highly deformed igneous/meta-igneous rock.

Quartz forms large, 4.0 to 5.0 mm long, relict crystals which possess a well developed undulose extinction and deformation bands, with sub-grains and new grains being concentrated along increasingly serrated grain boundaries. These large porphyroclasts are also cut by bands of quartz new grains, with a number of the larger crystals having been completely replaced by an interlocking mosaic of unstrained to weakly strained quartz crystals. Plagioclase and K-feldspar were more resistant to deformation with intracrystalline deformation largely being restricted to the development of an undulose extinction. Plagioclase forms twinned, anhedral to occasionally subhedral porphyroclasts. In contrast to plagioclase, K-feldspar shows a higher degree of deformation and forms irregular crystals which possess a well developed shadowy extinction and irregular to serrated grain boundaries; the latter are surrounded by a mosaic of unstrained new grains. K-feldspar is locally perthitic and possesses coarse microcline twins. Poorly developed quartz pressure shadows have been noted developed upon some feldspar porphyroclasts.

The mylonitic fabric is defined by narrow, wispy zones of intense dynamic recrystallisation which are composed of very fine-grained to cryptocrystalline quartz, feldspar and granular biotite. This mylonitic fabric is locally overgrown by late, post-kinematic epidote, opaque minerals and titanite. Titanite forms anhedral crystals and was also noted forming irregular rims upon opaque minerals. Epidote is typically associated with the breakdown of biotite. Annealing of the mylonitic fabric, probably accompanying epidote growth, has resulted in a slight increase in the grain size. The very fine grained high strain zones which define the mylonitic fabric may, therefore, represent the later stages of deformation.

The matrix of this protomylonitic rock is composed of fine-grained (≤ 0.3 mm in size), variably strained quartz and feldspar. Plagioclase within the matrix may contain rounded to bleb-like inclusions of quartz resulting in a crude myrmekitic intergrowth. K-feldspar is locally being replaced by irregular patches of coarse myrmekitic intergrowth. These patches are composed of single plagioclase crystals which contain wormy to bleb-like quartz inclusions. Lenticular aggregates or clusters of biotite are variably deformed by the mylonitic foliation to form wispy-looking foliae. Biotite is green-brown in colour and forms anhedral plates and flakes which range up to 1.4 mm in length. It may contain inclusions of apatite and zircon; the latter enclosed with dark pleochroic haloes. Accessory titanite is spatially related to biotite. Blue-green amphibole is an accessory phase and is partially replaced by biotite.

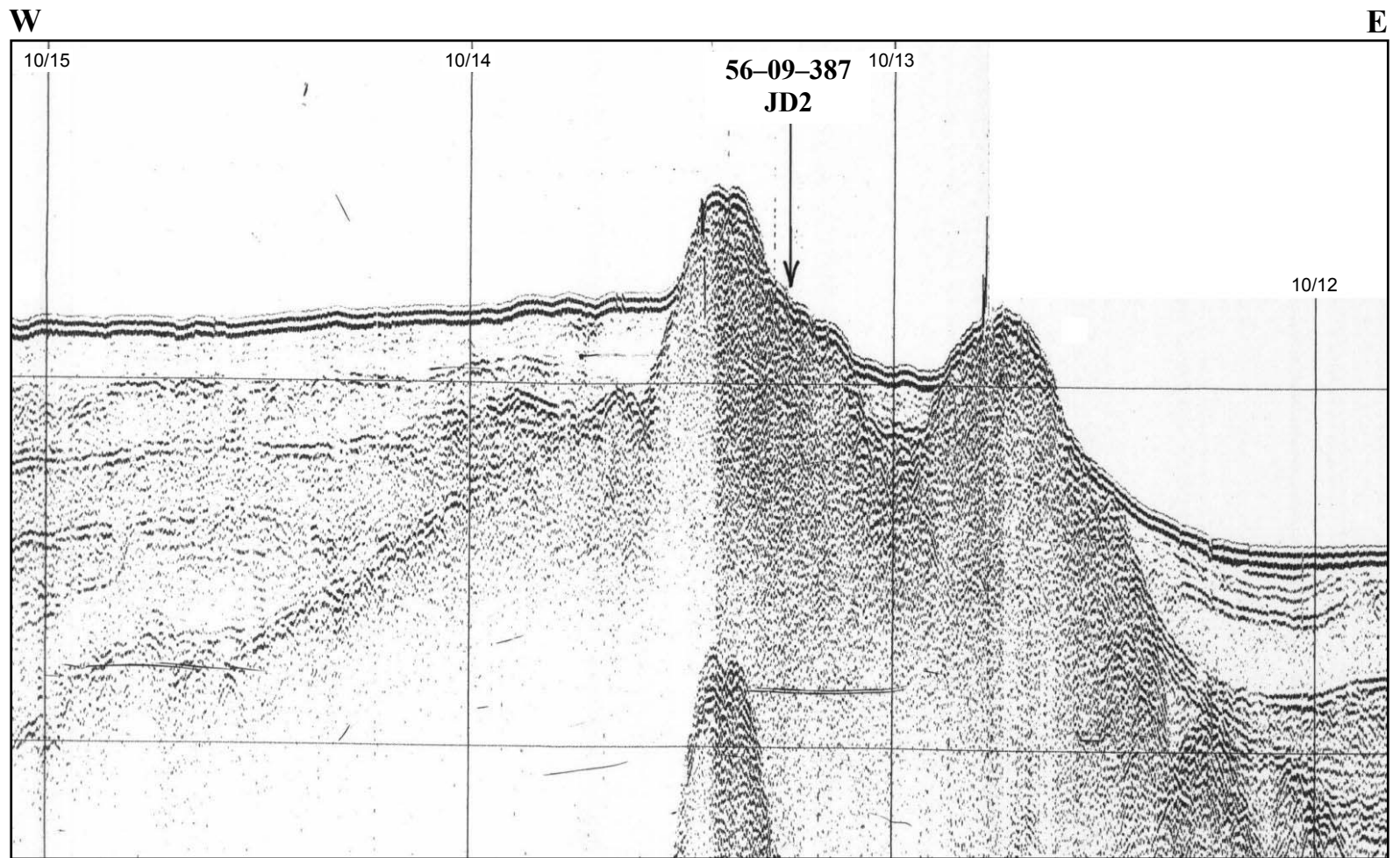
SAMPLE 56-09/387

SITE DETAILS

Date of drilling:	11th August 2001
Original site number:	JD2
Latitude:	56° 17.075'N
Longitude:	08° 13.699'W
Location:	Hebrides Shelf
Line and fix number:	85/06-10 13.25
Equipment:	BGS rockdrill
Core length:	0.13m
Lithology:	Gneiss
Age:	?Lewisian (Archaean)

SUMMARY

A single length of quartz-biotite-feldspar gneiss was recovered.



LINE 85/06-10

SPARKER

BGS CORE NO: 56-09/387DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Stanton Banks

Latitude	56° 17.0748' N	Licence Block	133/24	Vessel	James Clark Ross
Longitude	008° 13.6995' W	BGS Plan No	JD2	Station Keeping	DP
Navigation	DGPS	Total Depth	0.5m (Rec 0.13m)	Dates of Drilling	11/8/2001
Map Area	Peach	Water Depth	114m	Geologists	R Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Levisian	0	# d # g d f # d d # d # g d f #								GNEISS Quartz, biotite, feldspar, variable crystal size, with areas of finer more mafic (biotite) material and areas of pinkish K-feldspar rich rock. Foliation not pronounced and irregular. One thin quartz vein cross-cutting foliation, and dipping at around 45 degrees. Seabed encrusted with variable assemblage, including coral and serpulid worms.
	0.1									
	0.2									
	0.3									
	0.4									
	0.5									
	0.6									
	0.7									
	0.8									
	0.9									
	1.0									
	1.1									
	1.2									



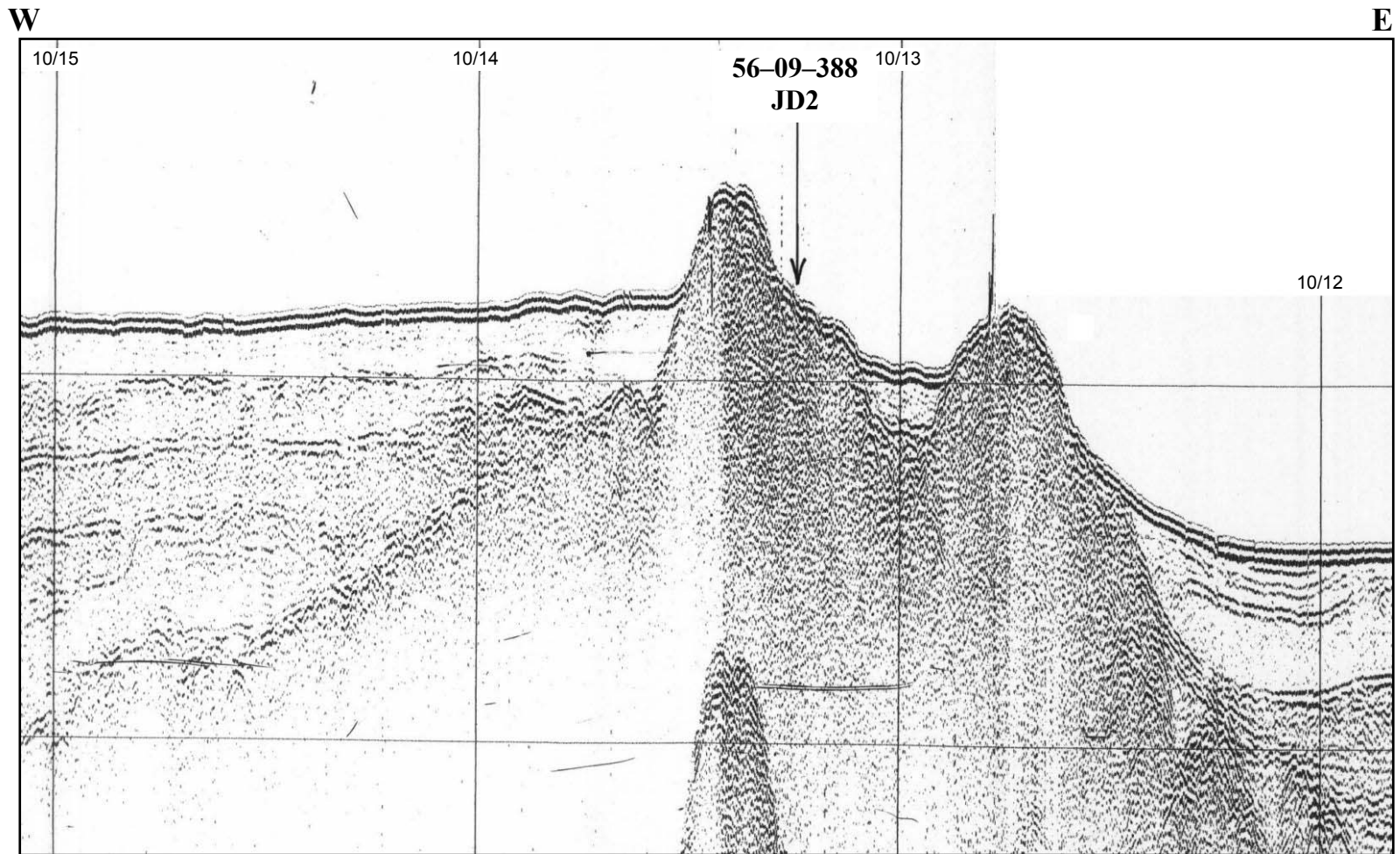
SAMPLE 56-09/388

SITE DETAILS

Date of drilling: 11th August 2001
Original site number: JD2
Latitude: 56° 17.075'N
Longitude: 08° 13.699'W
Location: Hebrides Shelf
Line and fix number: 85/06-10 13.25
Equipment: BGS rockdrill
Core length: 0.21m
Lithology: Quartzo-feldspathic gneiss
Age: ?Lewisian (Archaean)

SUMMARY

This was the second attempt at JD2. A dark quartz-biotite gneiss was recovered.



LINE 85/06-10

SPARKER

BGS CORE NO: 56-09/388DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Stanton Bank

Latitude	56° 17.0748' N	Licence Block	133/24	Vessel	James Clark Ross
Longitude	008° 13.6995' W	BGS Plan No	JD2	Station Keeping	DP
Navigation	DGPS	Total Depth	0.83m (Rec 0.21m)	Dates of Drilling	11/08/2001
Map Area	Peach	Water Depth	114m	Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Lewisian	0	# d # g d f # d d f # d # g d f # # d # g d f # d	0 50					TS 0.17m IGChem 0.18m		<p>BIOTITE GNEISS</p> <p>Gneiss, quartz-biotite, very dark, high percentage of mafic minerals, trace pyrite. Percentage mafics decreases towards base of core, and crystal size increases up to circa 1 cm.</p> <p>Encrusted seabed at top of core, ?bryozoan.</p>
	1									
	2									
	3									
	4									
	5									
	6									



PETROLOGY OF SAMPLE 56-09/388

Emrys Phillips

Registered number: N3710

Thin section from 0.17m depth.

Rock Type: amphibole-bearing quartzofeldspathic gneiss

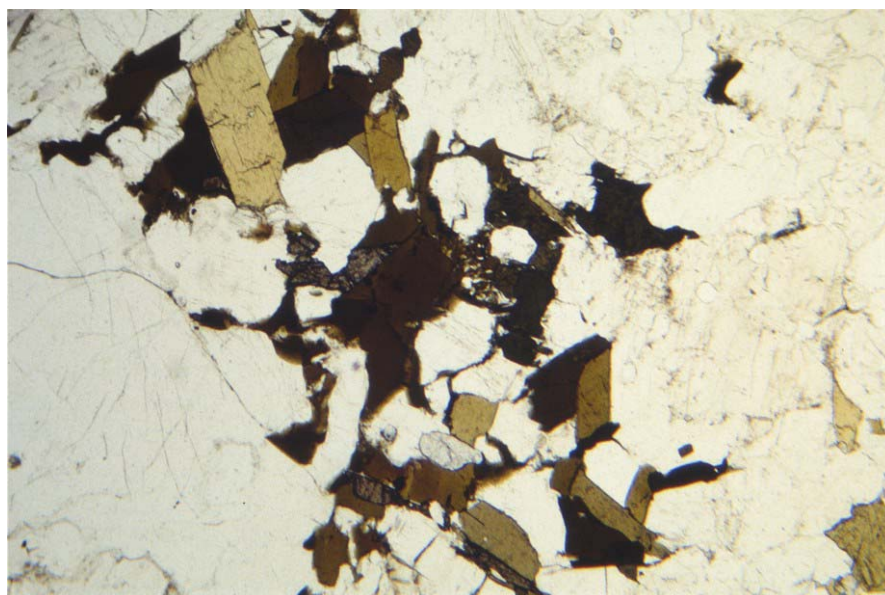
Mineralogy: major – plagioclase, quartz, amphibole, biotite, K-feldspar

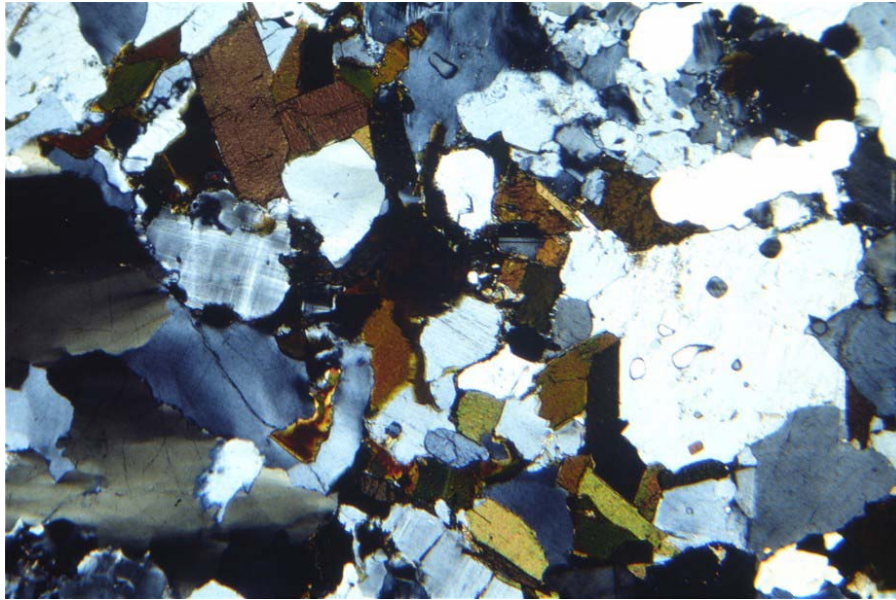
minor – opaque minerals, titanite, allanite, apatite, zircon

alteration – sericite, clay minerals, carbonate

Photomicrographs:

Photomicrographs of a amphibole-bearing quartzofeldspathic gneiss (N3710), plane and crossed polarised light.





Description: This thin section is of a medium- to coarse-grained, inequigranular, anhedral granular, massive, amphibole-bearing quartzofeldspathic gneiss. The protolith to this broadly dioritic in composition gneissose metamorphic rock is uncertain. This high-grade metamorphic rock is mainly composed of anhedral plagioclase and quartz. Plagioclase forms twinned and untwinned crystals which possess a slight dusty appearance under plane polarised light. Plagioclase may locally contain small rounded inclusions of quartz. Rare, crudely lath-shaped crystals of plagioclase are also present suggesting that this rock may have originally been igneous in origin (speculative). Quartz is strained and possesses a variably developed undulose extinction, deformation bands and sub-grain textures. Quartz locally forms elongate crystals which range up to 3.0 to 3.5 mm in size and may define a crude foliation or banding.

Amphibole and biotite are patchily distributed within this gneiss with the central area of the thin section being more granitic in composition. Amphibole possesses a moderately developed pleochroism and ranges from green, through yellow-green to blue-green in colour. It forms clusters or chains of anhedral crystals and is spatially related to biotite. Biotite forms finer grained, anhedral to ragged looking flakes. It is yellow-brown to dark brown in colour with a moderate to well developed pleochroism. Rare rounded to worm-like inclusions of quartz and/or feldspar have been noted within biotite resulting in a crude symplectitic intergrowth. Rounded, anhedral apatite is a common accessory phase and typically occurs associated with amphibole. Traces of secondary carbonate have been recorded associated with, or enclosed within biotite.

K-feldspar is patchily distributed and occurs associated with irregular patches of coarse- to fine-grained myrmekite and/or micrographic intergrowth. K-feldspar forms anhedral crystals which possess a shadowy extinction and coarse to diffuse microcline twins. Myrmekite forms irregular rims upon plagioclase which replace the adjacent K-feldspar. Feldspar within the myrmekite intergrowth is in optical continuity with the host plagioclase. It is possible that K-feldspar and myrmekite may be related to very localised partial melting.

GEOCHEMICAL DATA FOR SAMPLE 56-09/388

Sample name	Depth	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O _{3t}	Mn ₃ O ₄	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃	Cr ₂ O ₃	SrO	ZrO ₂	BaO	NiO	CuO	ZrO	PbO	LOI	Total	
	(metres)	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
56-09/388	0.18-0.21	65.05	0.32	16.30	3.74	0.08	1.36	3.52	4.48	3.21	0.18	<0.1	0.01	0.07	<0.02	0.25	<0.01	<0.01	<0.01	<0.01	0.52	99.09	

XRF Data		Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Rb	Sr	Zr	Mo	Ag	Cd	Sn	Sb	Te	Ba	W	Tl	Pb	Bi
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
56-09/388	0.18-0.21	7	49	32	7	8	18	58	16	<1	1	<1	<1	47	611	104	<1	<1	1	3	2	<1	2030	<1	<1	7	1

ICP-MS Data		Y	Nb	Cs	La	Ce	Pr	Nd	Sm	Eu	Tb	Gd	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
56-09/388	0.18-0.21	7.5	2.7	0.1	37.1	70.3	7.20	25.2	3.47	0.88	0.31	2.32	1.58	0.30	0.79	0.10	0.64	0.09	2.6	<0.5	2.9	0.34

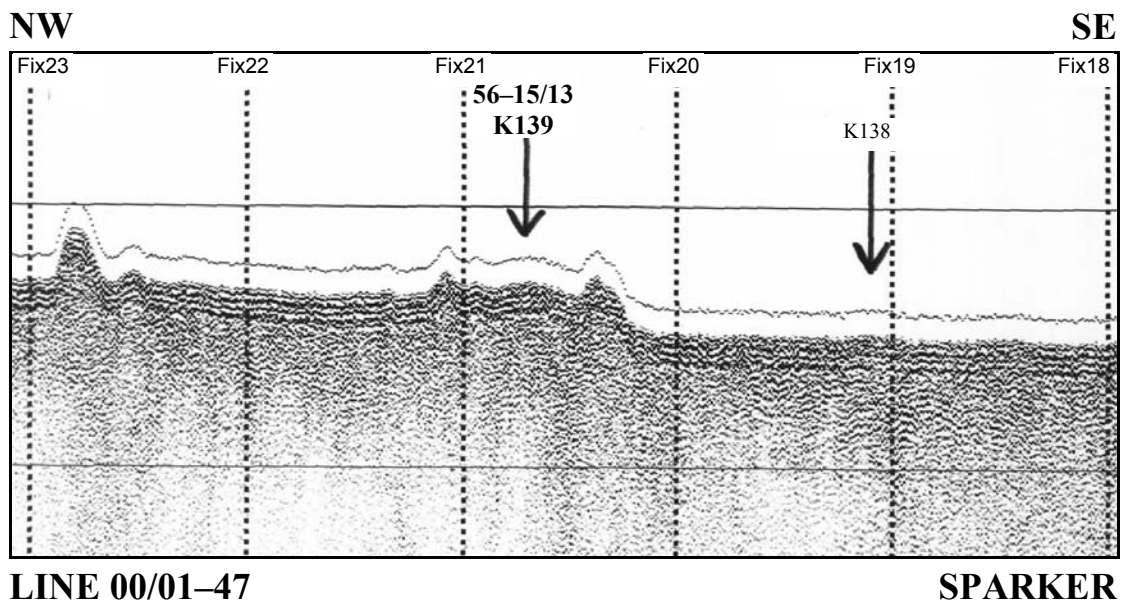
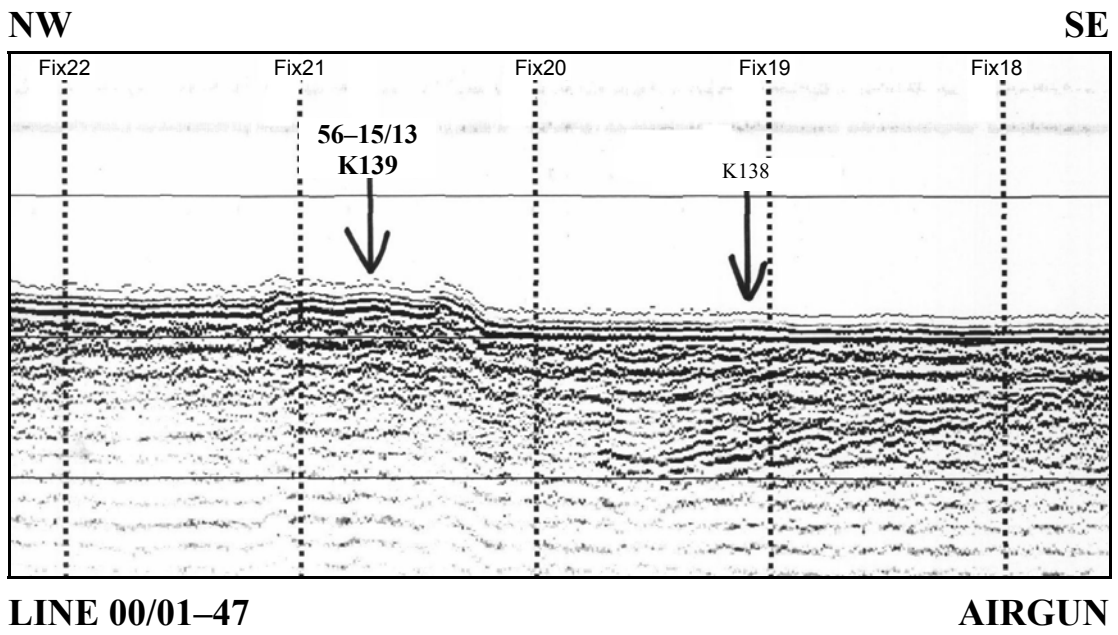
SAMPLE 56-15/13

SITE DETAILS

Date of drilling: 16th August 2001
Original site number: K138
Latitude: 56° 55.266'N
Longitude: 14° 38.394'W
Location: Rockall Bank
Line and fix number: 00/01-47 19.1
Equipment: BGS rockdrill
Core length: 1.00m
Lithology: Sand and gravel
Age:

SUMMARY

This site was aimed at dipping reflectors which are truncated at the sea bed (see seismic panel). It was hoped to prove whether these represented early Tertiary or possibly older (?Mesozoic) sediments. A solid core was not achieved at this site and the nature and age of the bedrock here remains unknown.



BGS CORE NO: 56-15/13DR

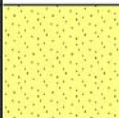



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude	56° 55.266' N	Licence Block	127/2	Vessel	James Clark Ross
Longitude	14° 38.394' W	BGS Plan No	K138	Station Keeping	DP
Navigation	DGPS	Total Depth	4.86m (Rec 1.00m)	Dates of Drilling	16/08/2001
Map Area		Water Depth	189m	Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										<p>SAND AND GRAVEL</p> <p>Recovery of 1 m of sediment graded in the core barrel from fine sand at the top to pebbles at the base, with a large semi-drilled cobble stuck in the core catcher. Irregular drilling pattern and the occurrence of encrusting organisms (dead) on several pebbles suggests sorting whilst drilling/recovery. Log here is based on recovered sample.</p> <p>0-0.16 m Fine sand, poorly sorted, muddy, quartz, shell fragments and a range of coloured minerals and dark lithic fragments.</p> <p>0.16-0.46 m Medium - coarse sand, similar to finer material, but coarser fraction is predominantly angular-rounded shell fragments.</p> <p>0.46-0.72 m Coarse - very coarse sand, many shell fragments, including bivalves, forams, bryozoa. Finer material includes quartz and assorted lithic fragments and minerals.</p> <p>0.72 -1.00 m Gravel, angular - subangular, pebbles < 3 cm diameter, predominantly foliated metamorphic rocks, with variable amounts of quartz, feldspar and mafic minerals At the base is a 5 cm cobble (partially drilled) of feldspathic (pink) gneiss.</p>
	1										
	2										
	3										
	4										
	5										
	6										



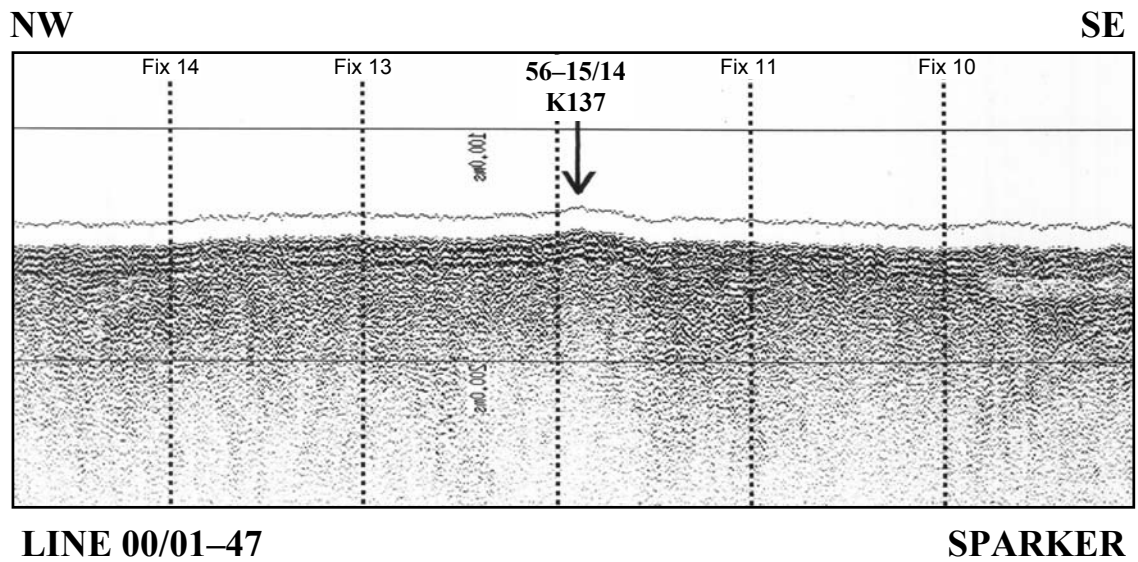
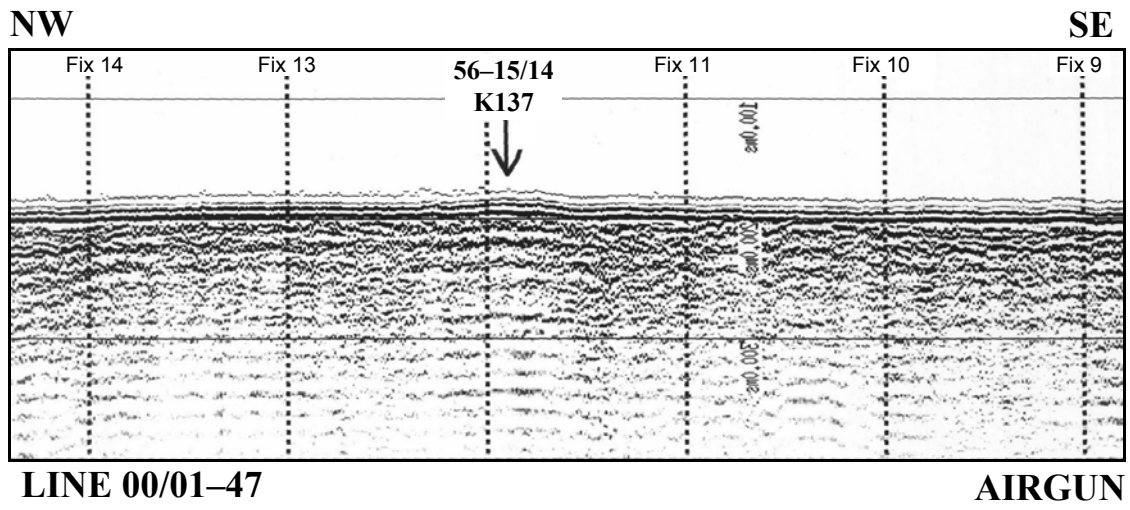
SAMPLE 56-15/14

SITE DETAILS

Date of drilling: 16th August 2001
Original site number: K137
Latitude: 56° 53.010'N
Longitude: 14° 29.688'W
Location: Rockall Bank
Line and fix number: 00/01-47 11.9
Equipment: BGS rockdrill
Core length: 0.73m
Lithology: Gravel and core
Age:

SUMMARY

Basaltic and gneissic pebbles were recovered together with some highly weathered ?basalt fragments.



BGS CORE NO: 56-15/14DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

Rockall Bank

Latitude	56° 53.010' N	Licence Block	127/3	Vessel	James Clark Ross
Longitude	14° 29.688' W	BGS Plan No	K137	Station Keeping	DP
Navigation	DGPS	Total Depth	1.79m (Rec 0.73m)	Dates of Drilling	16/08/2001
Map Area		Water Depth	185m	Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0	[Patterned area]									<p>SURFICIAL SEABED SEDIMENTS (MIXED IGNEOUS AND METAMORPHIC PEBBLES)</p> <p>Pebbles, up to 5cm in diameter, predominantly subrounded, some subangular. Primarily two lithologies within the pebbles; a) basaltic (the majority of pebbles), dark grey when wet, but drying to white/grey with laths of ?feldspar. Many of the mafic minerals are biotite intergrown with an Fe-oxide. These pebbles are either intrusive or metamorphic in origin: b) pink, medium-grained granitic gneiss with many feldspars.</p> <p>The upper part of the sample is washed clean, but the lower part is held together with a grey mud with shell fragments.</p> <p>Some pebbles are encrusted with calcitic biogenic material.</p> <p>The basal two mafic pieces of core were trapped in the core catcher, and may be part of a boulder or possibly bedrock.</p>
	1										
	2										
	3										
	4										
	5										
	6										



SAMPLE 56-15/15

SITE DETAILS

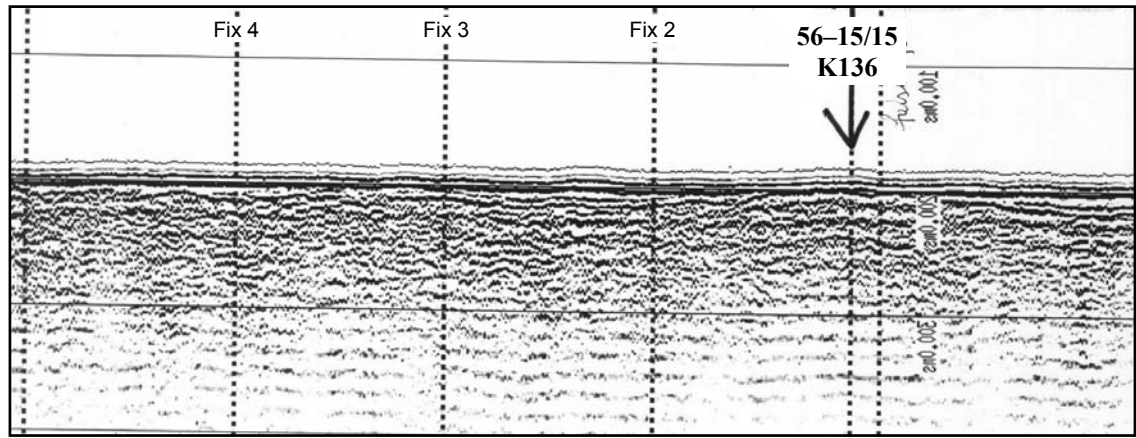
Date of drilling: 16th August 2001
Original site number: K136
Latitude: 56° 49.56'N
Longitude: 14° 16.47'W
Location: Rockall Bank
Line and fix number: 00/01-47 1.0
Equipment: BGS rockdrill
Core length: 0.26m
Lithology: Sand, gravel and alkali basalt
Age: ?

SUMMARY

The basal material comprises a 6cm long, altered 'basalt' core.

NW

SE



LINE 00/01-47

AIRGUN

BGS CORE NO: 56-15/15DR

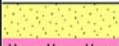


British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude	56° 49.56'N	Licence Block	127/9	Vessel	James Clark Ross
Longitude	014° 16.47'W	BGS Plan No	K136	Station Keeping	DP
Navigation	DGPS	Total Depth	3.9m (Rec. 0.26m)	Dates of Drilling	16/08/2001
Map Area		Water Depth	186m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0	 M M M						TS 0.20m IGChem 0.22m		<p>SURFICIAL SEAFLOOR DEPOSIT (MIXED LITHOLOGY)</p> <p>Recovered material consists of ~20 cm of greenish black (2.5/10GY) sand, gravel, 2 pebbles and one cored piece of dark grey, aphyric basalt at the base.</p> <p>The basalt core is 6 cm long and encrusted with worm tubes on the top surface. It probably contained groundmass olivine (<1mm in size), which is now totally replaced by a dark reddish brown secondary mineral. Rare spherical vesicles (<1mm) are filled with a greenish blue zeolite mineral. Otherwise, the rock appears quite fresh.</p> <p>One pebble is a polycrystalline lump of calcite containing black (basaltic?) sand grains; it is 3 cm in maximum dimension. The other pebble is a grey to dark red metamorphic clast, probably a granitic gneiss (3.5 cm maximum dimension).</p> <p>The sand also contains sand to gravel size shell fragments.</p>
	1									
	2									
	3									
	4									
	5									
	6									



PETROLOGY OF SAMPLE 56-15/15

Emrys Phillips

Registered number: N3746

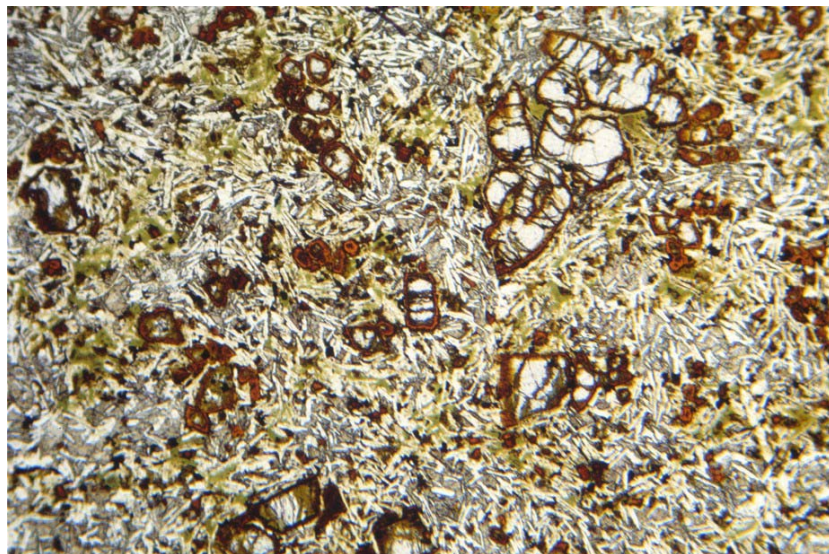
Thin section from 0.20m depth.

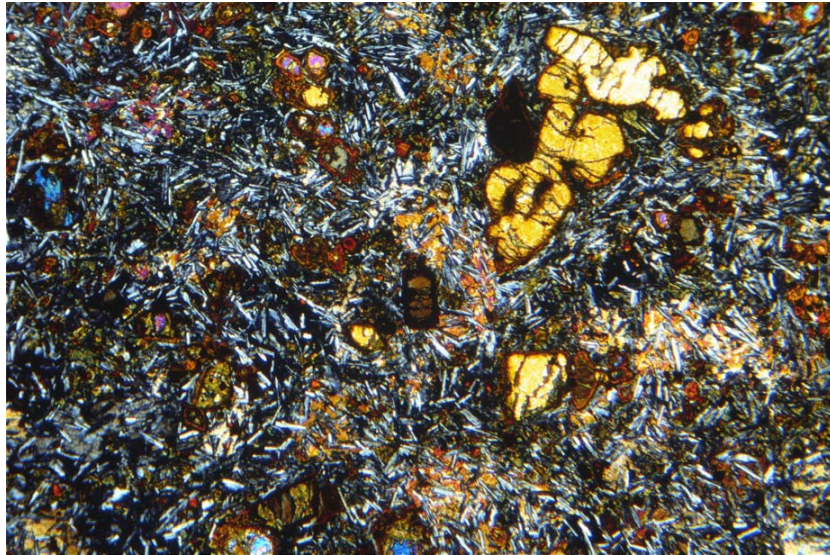
Rock Type: olivine microporphyritic alkali basalt which possesses a distinctive ophimottled texture

Mineralogy: major – plagioclase, Ti-augite, olivine
minor – opaque minerals
alteration – chlorite, bowlingite, iddingsite, sericite, opaque oxides, clay minerals, carbonate

Photomicrographs:

Photomicrographs of olivine microporphyritic alkali basalt (N3746), plane and crossed polarised light.





Description: This thin section is of a moderately altered, fine- to very fine-grained, hypocrySTALLINE, inequigrANular, micropORPHYritic alkali basalt. Rounded to embayed, partially resorbed microphenocrysts are mainly composed of olivine. Partial resorption of these early formed olivine crystals suggests that there was a change in pressure-temperature conditions and/or composition of the melt during crystallisation. Rare plagioclase microphenocrysts are also present within this basalt. Olivine is colourless and forms anhedral to irregular, fractured crystals which are variably altered to, or pseudomorphed by iddingsite, bowlingite and chlorite. However, minor fresh olivine is present. The pseudomorphs after olivine comprise an outer rim of iddingsite enclosing a core of very fine-grained to cryptocrystalline, locally mesh-textured chlorite and/or bowlingite. Iddingsite rims were also noted developed upon fresh olivine microphenocrysts and appear to represent the first stage of the replacement of this ferromagnesian mineral phase.

The groundmass is mainly composed of fine-grained, randomly orientated to locally aligned plagioclase laths. The alignment of plagioclase defines a patchily developed pilotaxitic fabric. Plagioclase forms anhedral twinned laths which occur as small clusters of crystals which are enclosed within interstitial ophitic to subophitic clinopyroxene. Plagioclase and pyroxene form an open framework or network with the remaining interstitial to intersertal areas being filled by cryptocrystalline chloritic material. Clinopyroxene is a pinky brown coloured Ti-augite and forms anhedral crystals which are up to *c.* 1.0 mm in length. The common occurrence of intergranular ophitic to subophitic clinopyroxene results in a locally well developed ophimottled texture to the groundmass. Rare amygdales are composed of cryptocrystalline bowlingite and/or chlorite. Minor to accessory olivine present within the groundmass has been completely replaced or pseudomorphed by bowlingite and iddingsite. Accessory opaque minerals are intergranular to plagioclase and may occur as inclusions within clinopyroxene. Traces of secondary carbonate have been noted replacing the chloritic pseudomorphs after olivine.

SAMPLE 56-15/16

SITE DETAILS

Date of drilling: 16th August 2001

Original site number: K136

Latitude: 56° 49.56'N

Longitude: 14° 16.47'W

Location: Rockall Bank

Line and fix number: 00/01-47 1.0

Equipment: BGS vibrocore

Core length: 0.02m

Lithology: Sand

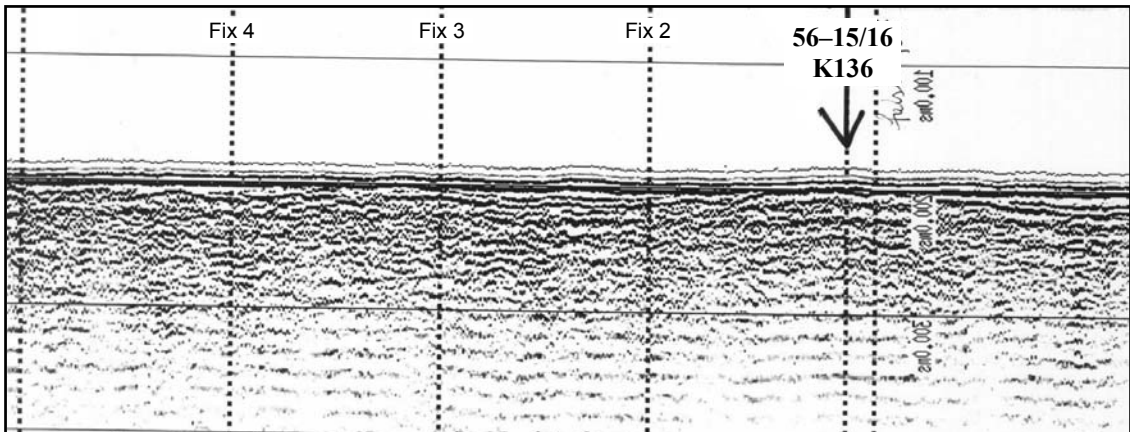
Age:

SUMMARY

Due to poor recovery at this site with the rockdrill, a second attempt was made with the vibrocore. Recovery was even worse.

NW

SE

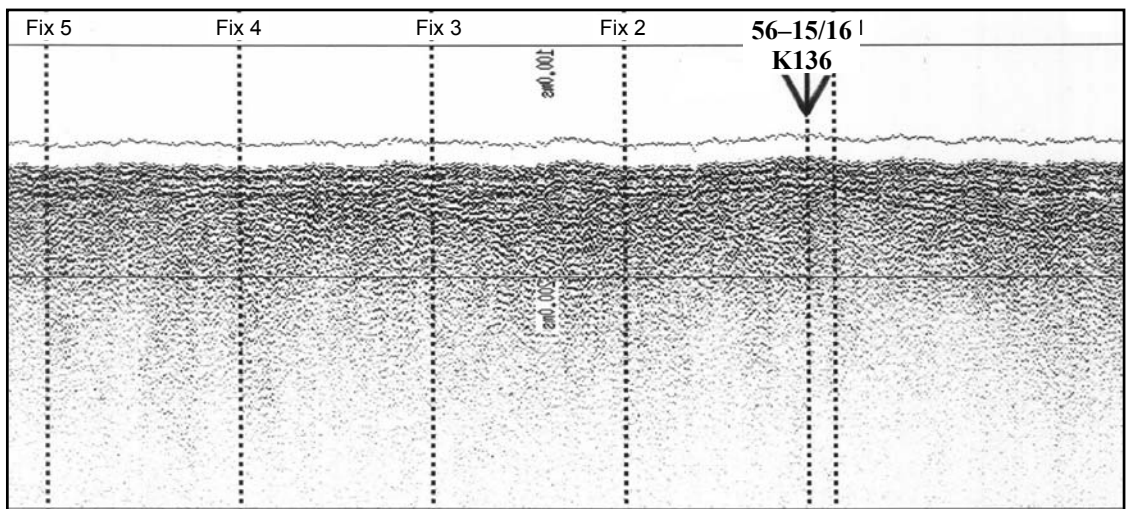


LINE 00/01-47

AIRGUN

NW

SE



LINE 00/01-47

SPARKER

BGS CORE NO: 56-15/16VE



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	56° 49.56'N	Licence Block	127/9
Longitude	014° 16.47'W	BGS Plan No	K136
Navigation	DGPS	Total Depth	0.62m (Rec. <2cm)
Map Area		Water Depth	186m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	08/16/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										DARK GREENISH GREY SAND
	1										Recovery using drilling rig at this site poor, so attempted a vibrocore. This recovered a very small amount of dark greenish grey sand and silt on the outside of the core liner. The sand consists of quartz, shell fragments and basalt.
	2										
	3										
	4										
	5										
	6										

SAMPLE 56-15/17

SITE DETAILS

Date of drilling: 16th August 2001

Original site number: K111

Latitude: 56° 49.932'N

Longitude: 14° 44.514'W

Location: Rockall Bank

Line and fix number: 00/01-40 159.4

Equipment: BGS rockdrill

Core length:

Lithology: Gravel

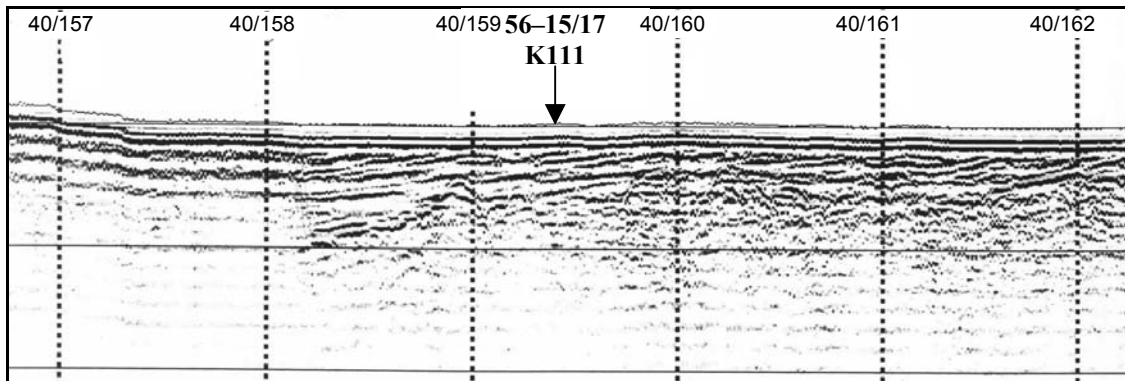
Age:

SUMMARY

This site was aimed at dipping reflectors which are truncated at the sea bed (see seismic panel). It was hoped to prove whether these represented early Tertiary or possibly older (?Mesozoic) sediments. Pebbles basalt, metamorphic basement and sandstone were recovered. The nature and age of the solid bedrock here remains unknown.

NW

SE

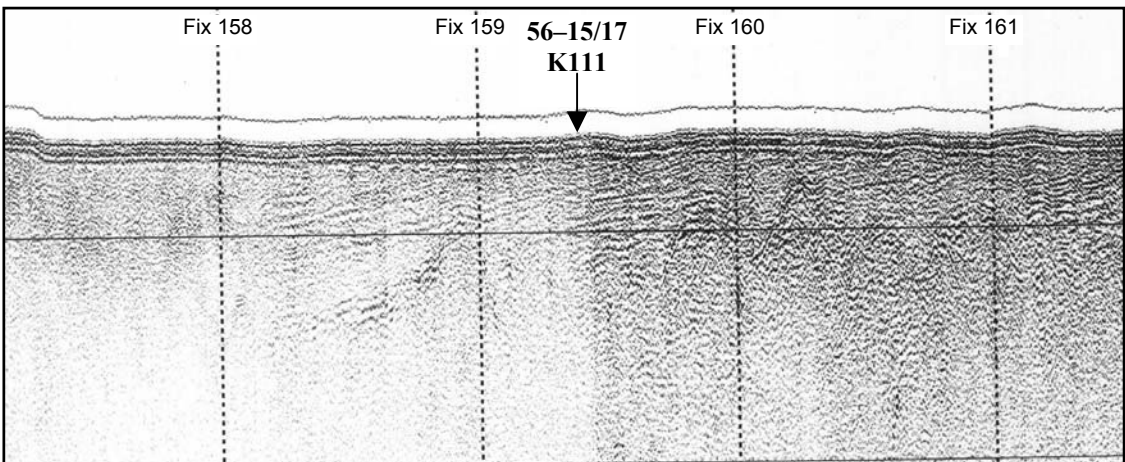


LINE 00/01-40

AIRGUN

NW

SE



LINE 00/01-40

SPARKER

BGS CORE NO: 56-15/17DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	56° 49.932'N	Licence Block	127/7
Longitude	014° 44.514'W	BGS Plan No	K111
Navigation	DGPS	Total Depth	2.20m (Rec. 0.22m)
Map Area		Water Depth	195m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	16/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0	# d # g d f # d								<p>SURFICIAL SEAFLOOR DEPOSIT (PREDOMINANTLY METAMORPHIC CLASTS)</p> <p>Recovered material consists of a collection of 9 pebbles and 2 cobbles in a poorly sorted sand that includes various shell fragments and tests, Fe-stained quartz (?), mica and basalt grains</p> <p>The pebbles include an altered aphyric basalt (groundmass olivine oxidised to orange Fe-oxyhydroxides), a granite or granitic gneiss, sandstone, biotite gneiss with large (1.5cm) feldspar-porphyroclasts, a hornblende + plagioclase + quartz rock (difficult to tell whether it's igneous or metamorphic), and a clast of carbonate-cemented sand in which the sand grains include basalt, a bottle green mineral and a brown mineral (both of which look clear and pristine). Several of the pebbles are encrusted with biota.</p> <p>The cobbles include one feldspar + quartz + Fe-oxide(?) gneiss and a mica schist. The mica schist has cored outer surfaces. The gneiss has one side that has been cored and is partially encrusted with coral on one side.</p>
	1									
	2									
	3									
	4									
	5									
	6									

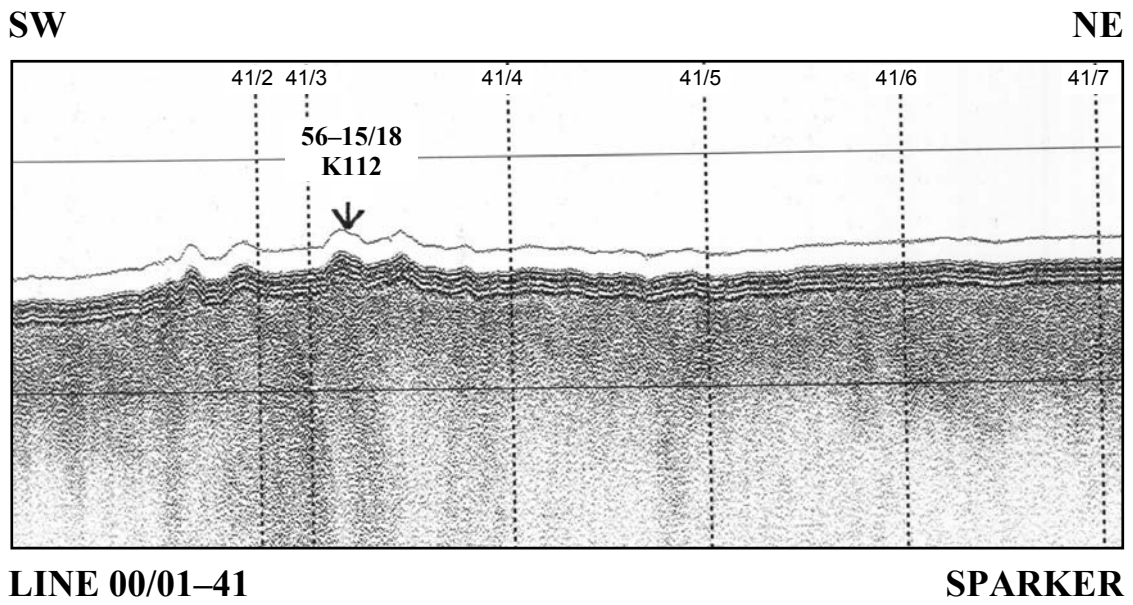
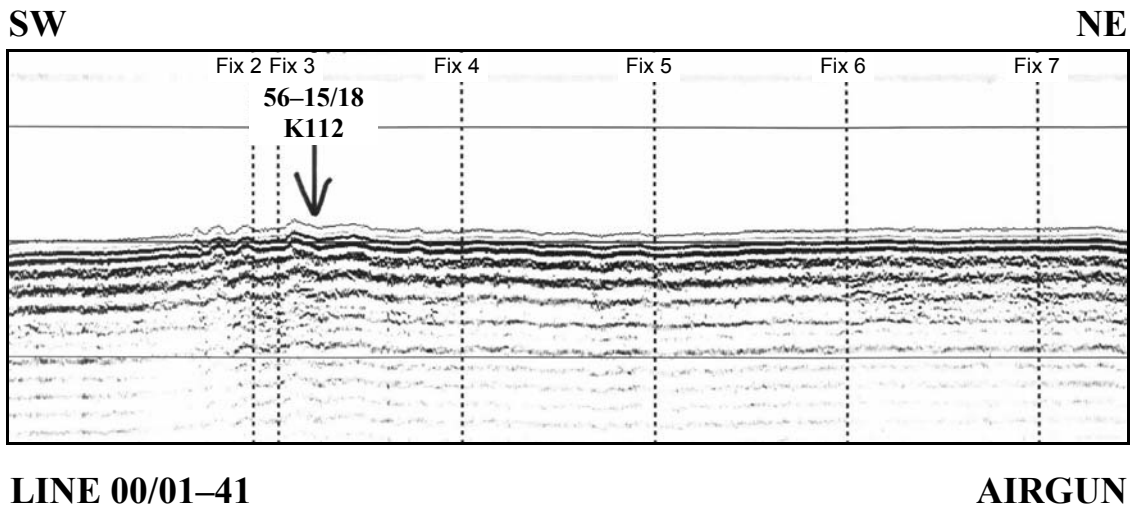
SAMPLE 56-15/18

SITE DETAILS

Date of drilling:	16th August 2001
Original site number:	K112
Latitude:	56° 49.242'N
Longitude:	14° 49.002'W
Location:	Rockall Bank
Line and fix number:	00/01-41 3.2
Equipment:	BGS rockdrill
Core length:	4.21m
Lithology:	Tonalitic gneiss
Age:	?Early Proterozoic

SUMMARY

Excellent recovery of a medium and coarse grained quartz-feldspar-hornblende-biotite gneiss.



PETROLOGY OF SAMPLE 56-15/18

Emrys Phillips

Registered number: N3711

Thin section from 1.65m depth.

Rock Type: hornblende-bearing, tonalitic two-pyroxene gneiss (granulite facies)

Mineralogy: major – plagioclase, quartz, clinopyroxene, orthopyroxene, K-feldspar, hornblende
minor – opaque minerals, apatite, rutile, biotite, zircon
alteration – sericite, clay minerals

Description: This thin section is of a medium- to coarse-grained, inequigranular, anhedral granoblastic, hornblende-bearing, two-pyroxene tonalitic gneiss. The presence of both clinopyroxene and orthopyroxene within the mineral assemblage of this gneiss indicates that it has undergone granulite facies metamorphism. A weak compositional banding or gneissose foliation is defined by elongate stringers or aggregates of pyroxene, opaque minerals and hornblende. The bulk of this high-grade metamorphic rock is composed of anhedral plagioclase with minor quartz and K-feldspar. Plagioclase is fresh and forms twinned and untwinned anhedral crystals which exhibit very little alteration to sericitic white mica along fractures. Plagioclase is locally antiperthitic and may also show signs of intracrystalline deformation and possess a sweeping to undulose extinction. The antiperthitic plagioclase (parent) crystals contain square to rod-shaped lamellae of K-feldspar (daughter phase). Traces of myrmekite are also present, occurring along inter plagioclase-K-feldspar and quartz-K-feldspar grain boundaries. The feldspar within the myrmekite is locally composed of a single crystals and may be in optical continuity with the host plagioclase crystal.

Quartz forms anhedral strained crystals with intracrystalline deformation resulting in the variable development of an undulose extinction and sub-grain textures. Quartz may locally contain small rod-shaped, faceted zircon crystals, the latter may also be present included within feldspar. K-feldspar possesses a distinctive shadowy extinction and forms anhedral to irregular crystals which are typically untwinned, but may locally possess poorly developed, diffuse microcline twins. K-feldspar may be weakly perthitic. Quartz, plagioclase and, to a lesser extent, K-feldspar show a weak preferred shape alignment parallel to the gneissose banding.

Clinopyroxene is green-grey in colour and forms anhedral fractured crystals which exhibit very minor alteration to a turbid brown-green assemblage along fractures. Pyroxene may locally contain inclusions of opaque minerals and apatite. These minor to accessory phases are closely spatially related to the ferromagnesian minerals. Opaques may locally form partial rims upon clinopyroxene. Orthopyroxene is pale brown-grey in colour and weakly pleochroic (pale brown to green). It is clearly distinguished from the spatially related clinopyroxene by its straight extinction and slightly lower birefringence colours. The finer grained clinopyroxene may be locally partially included within slightly larger orthopyroxene crystals, indicating that orthopyroxene growth occurred later than, or continued after clinopyroxene had ceased. Hornblende is dark green to green-brown in colour with the larger crystals, up to 2.0 mm in size, containing inclusions of opaque and apatite. Apatite forms anhedral to subhedral equant to rod-shaped crystals.

PETROLOGY OF SAMPLE 56-15/18

Emrys Phillips

Registered number: N3712

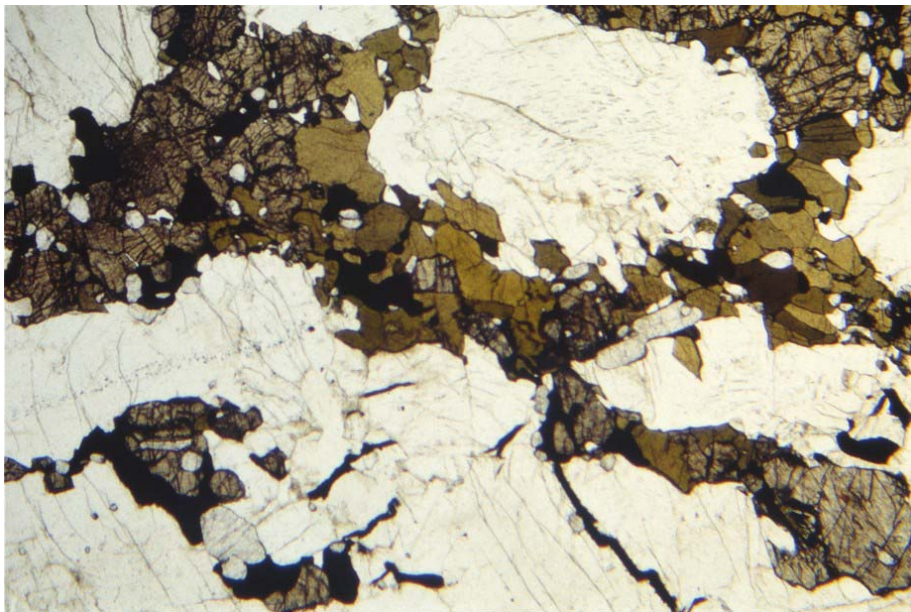
Thin section from 4.00m depth.

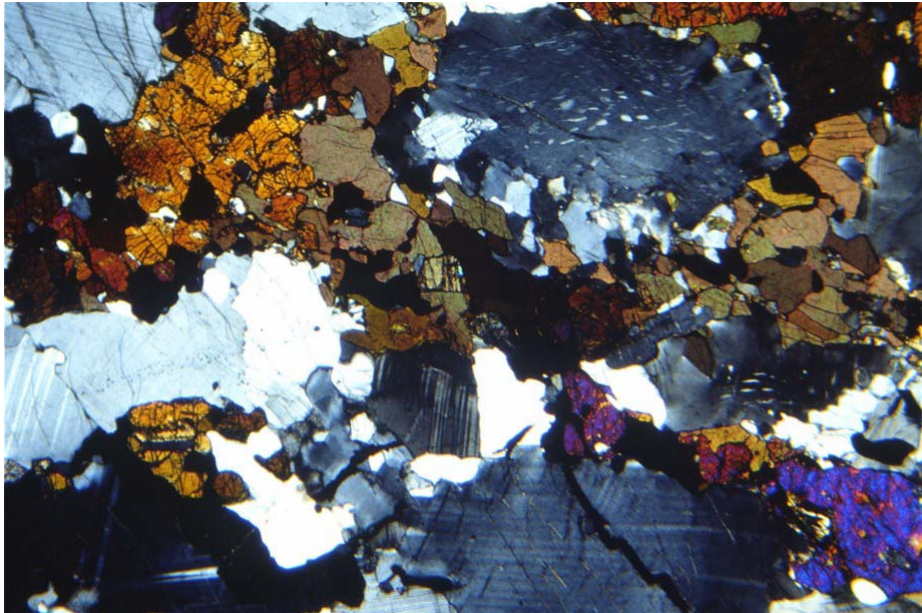
Rock Type: hornblende-bearing, two-pyroxene tonalitic gneiss

Mineralogy: major – plagioclase, quartz, orthopyroxene, clinopyroxene, amphibole, K-feldspar
minor – opaque minerals, apatite, biotite
alteration – sericite, white mica

Photomicrographs:

Photomicrographs of a hornblende-bearing two-pyroxene tonalitic gneiss (N3712 b), plane and crossed polarised light.





Description: This thin section is of a coarse-grained, inequigranular, weakly foliated, hornblende-bearing, two-pyroxene tonalitic gneiss. The foliation within this high-grade (granulite facies) metamorphic rock is defined by stringers or chains of granular pyroxene and associated hornblende. The bulk of the rock is composed of plagioclase and quartz. Plagioclase is fresh and forms anhedral, twinned and untwinned crystals (0.3 up to 2.0 mm in size) which possess a sweeping to undulose extinction. Plagioclase may locally exhibit a weak preferred shape alignment parallel to the gneissose foliation. Weakly antiperthitic plagioclase crystals contain small, elongate lamellae of K-feldspar. Quartz is strained with an undulose extinction and variably developed sub-grain textures and deformation bands.

Orthopyroxene is pale brown to pale green in colour and forms anhedral crystals which possess a weakly developed pleochroism. Orthopyroxene is the dominant ferromagnesian mineral and is distinguished from clinopyroxene by its straight extinction. Clinopyroxene is typically pale green in colour and non-pleochroic. Both pyroxene and contain fine-grained inclusions of opaque minerals and apatite. Hornblende is associated with pyroxene, forming a granular looking rim around both orthopyroxene and clinopyroxene. Hornblende is green to green-brown in colour and forms anhedral crystals with a moderately developed pleochroism.

Apatite and opaque minerals are common accessory phases. Minor to trace amounts of weakly perthitic K-feldspar have also been recorded. K-feldspar possesses a shadowy extinction and variably developed microcline twins.

GEOCHEMICAL DATA FOR SAMPLE 56-15/18

Sample name	Depth (metres)	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃ t	Mn ₃ O ₄	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃	Cr ₂ O ₃	SrO	ZrO ₂	BaO	NiO	CuO	ZnO	PbO	LOI	Total					
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%			
56-15/18	1.65-1.70	56.29	1.16	18.67	7.76	0.14	1.47	5.56	4.24	3.26	0.45	<0.1	<0.01	0.08	<0.02	0.26	<0.01	<0.01	0.02	<0.01	-0.04	99.32					
56-15/18	3.02-3.36	54.98	1.34	18.34	9.09	0.17	1.71	6.01	4.31	2.53	0.55	<0.1	<0.01	0.07	<0.02	0.19	<0.01	<0.01	0.02	<0.01	0.06	99.37					
XRFS Data		Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Rb	Sr	Zr	Mo	Ag	Cd	Sn	Sb	Te	Ba	W	Tl	Pb	Bi
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
56-15/18	1.65-1.70	16	40	17	8	5	16	127	24	2	<1	<1	<1	58	630	98	<1	<1	1	2	<1	<1	2138	<1	<1	15	2
56-15/18	3.02-3.36	20	45	22	10	5	19	152	25	1	<1	<1	<1	49	592	103	<1	<1	1	2	<1	<1	1523	<1	<1	11	2
ICP-MS Data		Y	Nb	Cs	La	Ce	Pr	Nd	Sm	Eu	Tb	Gd	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U					
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg				
56-15/18	1.65-1.70	24.8	13.3	0.4	31.7	69.0	8.50	36.5	6.93	3.19	0.86	6.22	4.95	0.99	2.75	0.37	2.41	0.38	2.3	0.6	1.0	0.52					
56-15/18	3.02-3.36	32.1	16.0	0.5	36.9	85.7	10.68	46.0	8.97	3.29	1.12	7.96	6.45	1.28	3.49	0.48	3.04	0.46	2.5	0.8	1.6	0.80					

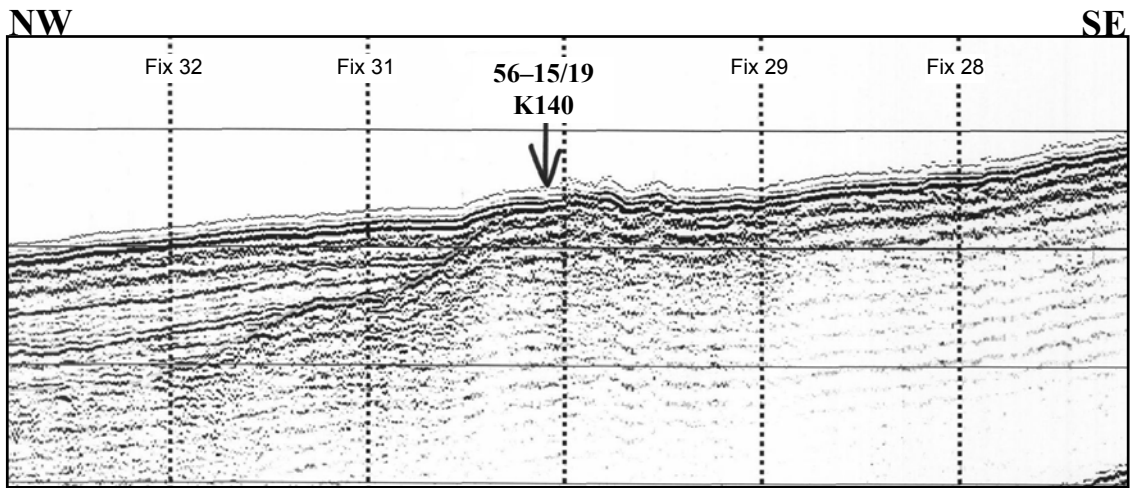
SAMPLE 56-15/19

SITE DETAILS

Date of drilling: 16th August 2001
Original site number: K140
Latitude: 56° 58.92'N
Longitude: 14° 52.50'W
Location: Rockall Bank
Line and fix number: 00/01-47 30.1
Equipment: BGS rockdrill
Core length:
Lithology: Gravel
Age:

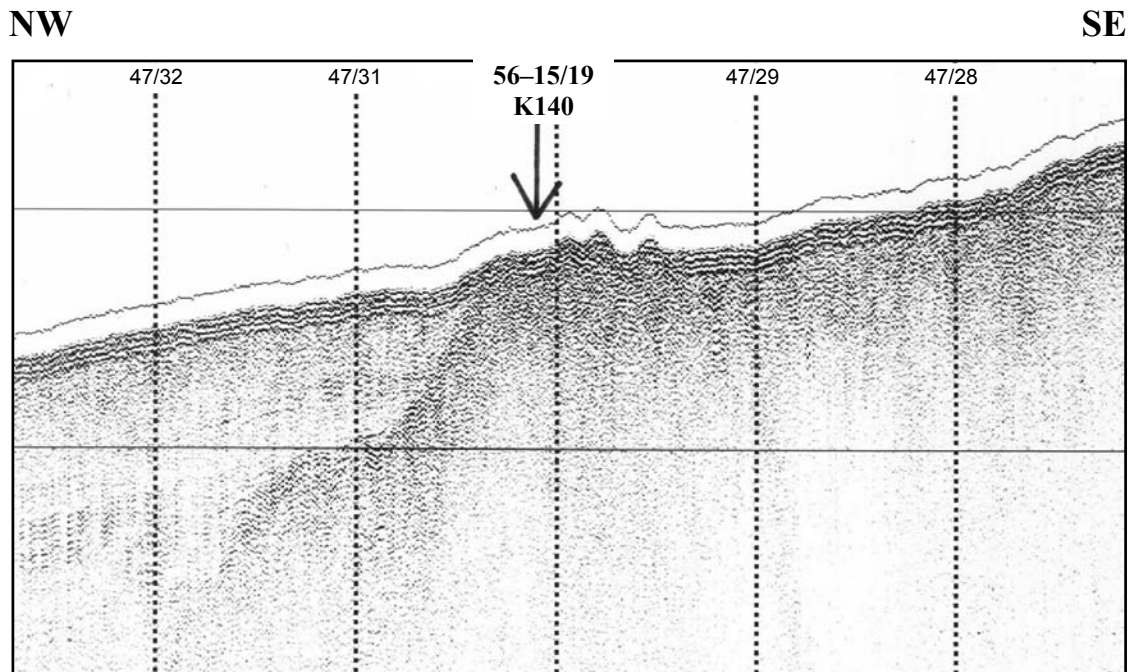
SUMMARY

The gravel comprises mainly metamorphic rock fragments of two distinct lithologies.



LINE 00/01-47

AIRGUN



LINE 00/01-47

SPARKER

BGS CORE NO: 56-15/19DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	56° 58.92' N	Licence Block	127/1
Longitude	14° 52.50'W	BGS Plan No	K140
Navigation	DGPS	Total Depth	1.4m (Rec 0.4m)
Map Area		Water Depth	238m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	16/08/2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0									<p>SURFICIAL SEABED SEDIMENTS (METAMORPHIC ROCK FRAGMENTS)</p> <p>Pebbles, 1-6 cm in diameter, most grains very angular, some subrounded, although most of the very angular grains occur in the lower part of the sample, and may have been fractured during drilling.</p> <p>There are two distinct lithologies. At the top, the pebbles are dark grey-white, medium to coarse grained and consist of feldspar, quartz and mafic minerals, including biotite; some clasts show distinct foliation, but others are more equant with no obvious metamorphic fabric. In the lower part of the core, there are more pebbles of a pink, coarsely crystalline granitic feldspathic gneiss.</p>
	1									
	2									
	3									
	4									
	5									
	6									



SAMPLE 56-15/20

SITE DETAILS

Date of drilling:	18th August 2001
Original site number:	S2
Latitude:	56° 34.90'N
Longitude:	14° 55.00'W
Location:	Rockall Bank (Irish waters)
Line and fix number:	Site chosen on Admiralty Chart C.6091
Equipment:	BGS rockdrill
Core length:	
Lithology:	Gravel
Age:	

SUMMARY

Drill recovered gravel of at least two different metamorphic lithologies.


BGS CORE NO: 56-15/20DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		S. Rockall Bank	
Latitude	56° 34.90'N	Licence Block	Irish Quadrant 78
Longitude	014° 55.0'W	BGS Plan No	S2
Navigation	DGPS	Total Depth	1.61m
Map Area		Water Depth	181m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	18/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
	0										<p>SURFICIAL SEAFLOOR DEPOSIT (METAMORPHIC CLASTS)</p> <p>Recovered material consists of 27 pebbles ranging from 1.5 to 5 cm in maximum dimension; the latter has cored outer surfaces. All other have weathered subangular outer surfaces. Some have small patches of light grey, silty mud adhering to the outer surfaces.</p> <p>There are at least two different metamorphic lithologies present (possibly more, but difficult to tell from small size and weathered outer surfaces). The dominant lithology is coarse grained, hornblende ± biotite gneiss. Mafic phases make up ~30% of the mode and the rocks have a strong foliation. The rest of the clasts appear to be similar to the fine grained biotite gneiss recovered at Site 56-16/34DR. These rocks appear dark grey and show no apparent foliation.</p>
	1										
	2										
	3										
	4										
	5										
	6										

SAMPLE 56-15/21

SITE DETAILS

Date of drilling:	18th August 2001
Original site number:	S2
Latitude:	56° 34.90'N
Longitude:	14° 55.00'W
Location:	Rockall Bank (Irish waters)
Line and fix number:	Site chosen on Admiralty Chart C.6091
Equipment:	BGS rockdrill
Core length:	
Lithology:	Gravel
Age:	

SUMMARY

This was the second attempt at this site. More gravel of metamorphic lithology was recovered.

BGS CORE NO: 56-15/21DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	56° 34.90' N	Licence Block	Irish Quadrant 78
Longitude	14° 55.00' W	BGS Plan No	S2
Navigation	DGPS	Total Depth	1.13m
Map Area		Water Depth	181m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	18/06/2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										<p>SURFICIAL SEABED SEDIMENTS (METAMORPHIC ROCK FRAGMENTS)</p> <p>Recovered 19 metamorphic rock pebbles, angular to subangular, between 2-5 cm in diameter. Pebbles are medium-grained feldspathic foliated gneiss with quartz, biotite, ?hornblende, and some Fe oxide alteration. A few are cut by thin quartz veins. Several are pink and very feldspathic whereas others are quartz-rich, with others more mafic and darker grey.</p>
	1										
	2										
	3										
	4										
	5										
	6										

SAMPLE 56-15/22

SITE DETAILS

Date of drilling:	19th August 2001
Original site number:	S4
Latitude:	56° 35.400'N
Longitude:	14° 37.400'W
Location:	Rockall Bank (Irish waters)
Line and fix number:	Site chosen on Admiralty Chart C.6091
Equipment:	BGS rockdrill
Core length:	
Lithology:	Gravel
Age:	

SUMMARY

Metamorphic gravel recovered.

BGS CORE NO: 56-15/22DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	56° 35.4002' N	Licence Block	Irish Quadrant 78
Longitude	14° 47.4003' W	BGS Plan No	S4
Navigation	DGPS	Total Depth	1.98m
Map Area		Water Depth	181m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	19.08.2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
	0										<p>SURFICIAL SEABED SEDIMENTS (METAMORPHIC ROCK PEBBLES)</p> <p>Recovered 30 pebbles, 1-5 cm in diameter, subangular-subrounded, mainly dark grey to greenish grey, quartz-feldspar-biotite-?amphibole gneiss. One small pebble of very mafic rock - ?amphibolite.</p> <p>Many pebbles encrusted with biota, including serpulid worm casts and bryozoa.</p>
	1										
	2										
	3										
	4										
	5										
	6										

SAMPLE 56-15/23

SITE DETAILS

Date of drilling: 19th August 2001

Original site number: S6

Latitude: 56° 41.00'N

Longitude: 14° 47.70'W

Location: Rockall Bank (Irish waters)

Line and fix number: Site chosen on Admiralty chart C.6091

Equipment: BGS rockdrill

Core length:

Lithology: Gravel

Age:

SUMMARY

Metamorphic gravel was recovered.

BGS CORE NO: 56-15/23DR



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude 56° 41.00' N **Licence Block** Irish Quadrant 78 **Vessel** James Clark Ross
Longitude 14° 47.7' W **BGS Plan No** S6 **Station Keeping** DP
Navigation DGPS **Total Depth** 1.35m **Dates of Drilling** 19.08.2001
Map Area **Water Depth** 182m **Geologists** R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										<p>SURFICIAL SEABED SEDIMENTS (METAMORPHIC PEBBLES)</p> <p>Recovered 23 metamorphic rock pebbles, most very dark grey, greenish-grey, few more feldspathic and pink, subangular to subrounded, 1.5-5 cm diameter. Most pebbles medium-coarse grained, foliated, quartz, feldspar, with fine mafic minerals, generally biotite and ?amphiboles. One grey pebble is finer grained with no obvious foliation.</p> <p>Some pebbles encrusted with calcareous biota.</p>
	1										
	2										
	3										
	4										
	5										
	6										

SAMPLE 56-15/24

SITE DETAILS

Date of drilling:	19th August 2001
Original site number:	S6
Latitude:	56° 40.994'N
Longitude:	14° 47.703'W
Location:	Rockall Bank (Irish waters)
Line and fix number:	Site chosen on Admiralty chart C.6091
Equipment:	BGS rockdrill
Core length:	
Lithology:	Gravel
Age:	

SUMMARY

This was the second attempt at this site after the ship had been moved a few metres. Metamorphic gravel was recovered.

BGS CORE NO: 56-15/24DR



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	56° 40.994' N	Licence Block	Irish Quadrant 78
Longitude	14° 47.703' W	BGS Plan No	S6
Navigation	DGPS	Total Depth	1.38m
Map Area		Water Depth	183m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	19.08.2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										<p>SURFICIAL SEABED SEDIMENTS (METAMORPHIC PEBBLES)</p> <p>Recovered 12 dark grey metamorphic rock fragments, subangular to subrounded, quartz, feldspar, mafic minerals (including biotite and amphibole), which are partially altered.</p> <p>Some pebbles encrusted with calcite faunal remains.</p> <p>This borehole is a repeat of 56-15/23DR, following a 10 m ship move. Recovered pebbles are of the same lithology as the dark grey pebbles in the first hole.</p>
	1										
	2										
	3										
	4										
	5										
	6										

SAMPLE 56-16/32

SITE DETAILS

Date of drilling: 18th August 2001

Original site number: S1

Latitude: 56° 16.400'N

Longitude: 15° 11.850 'W

Location: Rockall Bank (Irish waters)

Line and fix number: Site chosen on Admiralty chart C.6091

Equipment: BGS rockdrill

Core length:

Lithology: Gravel

Age:

SUMMARY

Recovered material comprises three pebbles of metamorphic basement.

BGS CORE NO: 56-16/32DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		S. Rockall Bank	
Latitude	56° 16.3997'N	Licence Block	Irish Quadrant 79
Longitude	015° 11.8495'W	BGS Plan No	S1
Navigation	DGPS	Total Depth	2.15m
Map Area		Water Depth	178m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	18/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0	# d # g d f # d d f # d # g d f #								<p>FELDSPATHIC BIOTITE HORNBLLENDE GNEISS</p> <p>Recovered material consists of 2 pebbles and 1 cobble size clast of metamorphic basement. The pebbles are both ~4 cm in size; the cobble is 7.5 cm long and one side has a cored surface. The other side was originally fractured and exposed at the seafloor, as it is encrusted with a serpulid worm tube. The pebbles are also encrusted with biota and have weathered outer surfaces.</p> <p>The rocks are medium to coarse grained, feldspar and quartz rich. Mafic phases make up less than ~20% of the rock. The feldspar and quartz crystals are apparently larger than the mafic phases (although partially recrystallised to smaller subgrains). Biotite is present as small equant to elongate patches; amphibole is probably also present, but not positively identified. The cobble changed character about half way along its length. The felsic minerals in the top half are a pale buff colour on average and the mafic mineral content is ~20% (probably biotite + amphibole). The colour of the lower half is grey; the mafic phases are less abundant (~5%) and appear to be predominantly biotite. Fe oxides and sulphides present in trace amounts throughout. The two pebbles are most similar to the top half of the cobble (i.e. the more mafic rich variety).</p>
	1									
	2									
	3									
	4									
	5									
	6									

SAMPLE 56-16/33

SITE DETAILS

Date of drilling:	18th August 2001
Original site number:	S1
Latitude:	56° 16.400'N
Longitude:	15° 11.850 'W
Location:	Rockall Bank (Irish waters)
Line and fix number:	Site chosen on Admiralty chart C.6091
Equipment:	BGS rockdrill
Core length:	0.46m (includes some pebbles)
Lithology:	Metamorphic basement
Age:	?Early Proterozoic

SUMMARY

This was the second attempt at this site. The core comprises predominantly dark grey, fine-grained, foliated biotite gneiss.


BGS CORE NO: 56-16/33DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		S. Rockall Bank	
Latitude	56° 16.40	Licence Block	Irish Quadrant 79
Longitude	015° 11.85'W	BGS Plan No	S1
Navigation	DGPS	Total Depth	1.83m
Map Area		Water Depth	178m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	18/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
	0										<p>BIOTITE ± HORNBLENDE GNEISS</p> <p>Recovered material consists of 31 cm of cored biotite + hornblende gneiss overlain by 15 cm of pebbles (1-4 cm in size) of metamorphic origin, similar in lithology to the rocks recovered at 56-16/32DR (also includes 1 mollusc shell). Several pebbles are encrusted with seafloor biota.</p> <p>The cored gneiss is predominantly fine-grained (crystal sizes <~1 mm) biotite gneiss. Biotite makes up between 30-40% of the rock, with the rest being feldspar and quartz. The rock shows a clear foliation (defined by preferred orientation of mica) and banding (defined by 1-2 cm thick intervals of coarser grained crystals, up to 1cm). The banding has an orientation of ~30° to core vertical. Amphibole is present in the bottom 5-10 cm of the core, but does not appear to be present higher up.</p>
	1										
	2										
	3										
	4										
	5										
	6										

SAMPLE 56-16/34

SITE DETAILS

Date of drilling:	18th August 2001
Original site number:	S3
Latitude:	56° 21.50'N
Longitude:	15° 11.60'W
Location:	Rockall Bank (Irish waters)
Line and fix number:	Site chosen on Admiralty chart C.6091
Equipment:	BGS rockdrill
Core length:	0.46m
Lithology:	Metamorphic basement
Age:	?Early Proterozoic

SUMMARY


A dark biotite, partly garnetiferous gneiss was recovered.

BGS CORE NO: 56-16/34DR



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		S. Rockall Bank	
Latitude	56° 21.5'N	Licence Block	Irish Quadrant 79
Longitude	015° 11.6'W	BGS Plan No	S3
Navigation	DGPS	Total Depth	1.20m (Rec. 0.46m)
Map Area		Water Depth	187m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	18/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										<p>BIOTITE ± GARNET GNEISS</p> <p>0.00-0.02 m: Calcite cemented, dark olive green sandy mud with a pebble of biotite gneiss. Sand grains include quartz, garnet, metamorphic rock fragments, unidentified bioclasts.</p> <p>0.02-0.22 m: Pebble to cobble size clasts of biotite ± garnet gneiss. Some pebbles with weathered surfaces, some with partially cored surfaces. About 2/3 of the pebbles resemble the biotite ± garnet gneiss below; the rest resemble the coarse grained biotite gneiss pebbles from Sites 56-16/33DR and 56-16/32DR.</p> <p>0.22-0.46 m: Two pieces of cored gneiss (now highly fractured) separated by some gravel size chips from the same lithology. Both pieces preserve a relatively sharp contact between two lithologies. One is a fine grained biotite gneiss. There is no obvious foliation in this lithology; it may contain garnet, but this is difficult to tell because of the fine grain size. The other lithology is coarse grained biotite + garnet gneiss. The garnets are very pale pink, generally equant, subhedral to anhedral, and range up to 4 mm in size. The first contact is preserved between 0.22-0.27 m; the second between 0.38-0.46 m. The banding generated by the change in grain size is oriented at ~25-30° to the core vertical. The orientation of the lower contact is less clear because of fracturing, but also appears to be ~30°. It is difficult to tell the interval over which the banding occurs because of the degree of fracturing of the recovered material. However, it appears that we have recovered the sequence: fine grained gneiss - garnet biotite gneiss - fine grained gneiss - garnet biotite gneiss, with each layer of the order of 5 cm in thickness. The lower core piece is crosscut by very thin chlorite (?) veins that are nearly perpendicular to the orientation of the contact between fine and coarse grained gneiss.</p> <p>Note: Core was not sampled to preserve texture for shore based studies.</p>
	1										
	2										
	3										
	4										
	5										
	6										

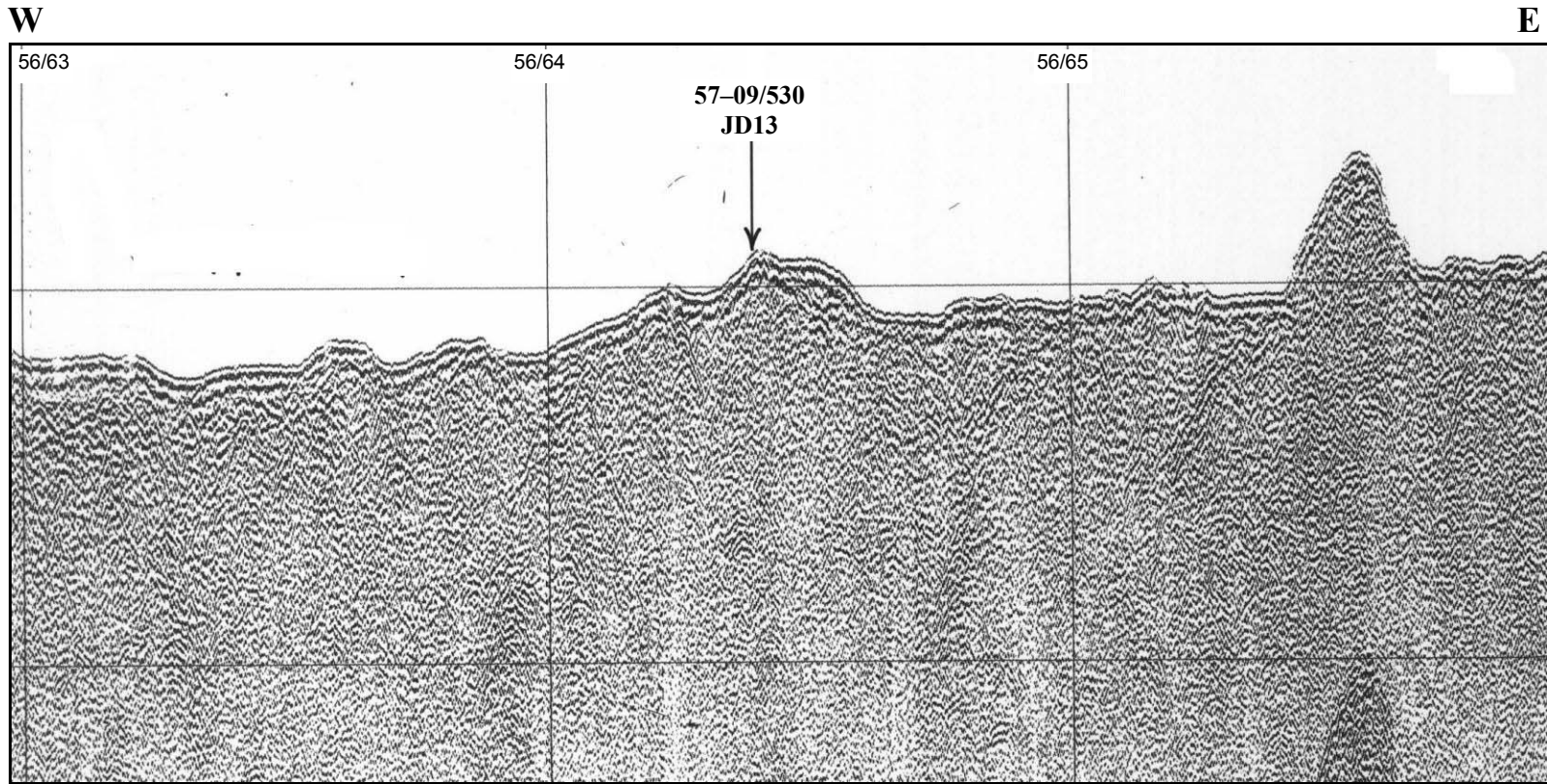
SAMPLE 57-09/530

SITE DETAILS

Date of drilling:	8th August 2001
Original site number:	JD13
Latitude:	57° 41.02'N
Longitude:	8° 20.43'W
Location:	Hebrides Shelf
Line and fix number:	84/06-54 64.4
Equipment:	BGS rockdrill
Core length:	0.67m
Lithology:	Gravel on metamorphic basement
Age:	?Lewisian (Archaean)

SUMMARY

Actual core is just under 20cm in length and comprises biotite-hornblende gneiss and ?diorite.



LINE 84/06-54

SPARKER

BGS CORE NO: 57-09/530DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Outer Isles Platform

Latitude	57° 41.02'N	Licence Block	143/9	Vessel	James Clark Ross
Longitude	008° 20.43'w	BGS Plan No	JD13	Station Keeping	DP
Navigation	DGPS	Total Depth	3.06m (Rec. 0.67m)	Dates of Drilling	08/08/2001
Map Area	St Kilda	Water Depth	118m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
Unknown	0										<p>SURFICIAL DEPOSIT ON SEAFLOOR (MIXED LITHOLOGY)</p> <p>Sedimentary deposit of mixed lithologies including hornblende biotite gneiss, hornblende-biotite diorite (to tonalite?), vesicular, olivine phyric basalt, conglomerate of metamorphic clasts and red metamorphosed quartzite(?).</p> <p>Most clasts are smaller than the diameter of the core, so no stratigraphic significance can be associated with their location in the core. Exceptions include piece 1 at the top, the olivine basalt in the middle and the biotite-hornblende diorite at the bottom.</p> <p>The largest clast (16 cm long) is the vesicular olivine phyric basalt. Vesicles, up to 1 cm in maximum dimension, are filled with a white zeolite. Olivines, up to 2 mm in size, are ~50% altered to chlorite and/or serpentine. Otherwise, the sample is relatively unaltered.</p> <p>Biotite-hornblende gneiss is medium grained, consists of 25-50% mafic minerals. Ranges in color from reddish to grey. Some alteration of micas to chlorite and some Fe-staining of felsic minerals, but otherwise quite fresh.</p> <p>Biotite-hornblende diorite is medium grained and fresh.</p> <p>Some clasts coated in pale brown, silty ooze, probably indicative of material originally infilling between the pebbles, cobbles and boulders of this deposit.</p>
	1										
	2										
	3										
	4										
	5										
	6										



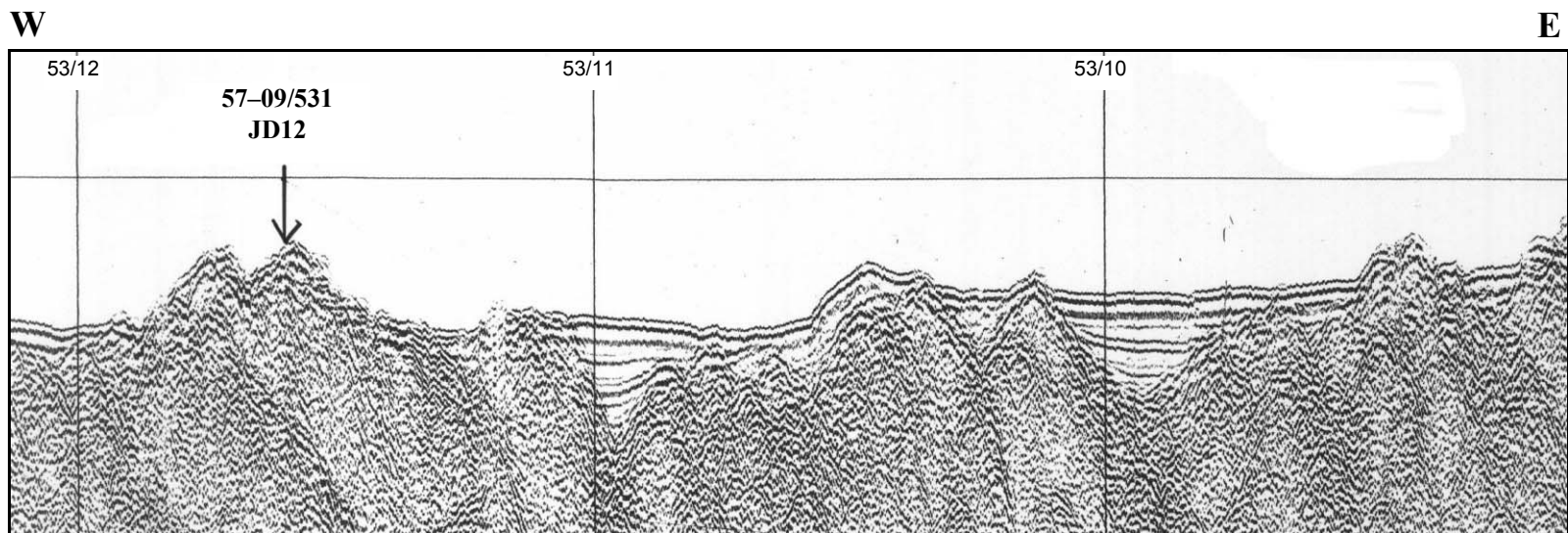
SAMPLE 57-09/531

SITE DETAILS

Date of drilling: 8th August 2001
Original site number: JD12
Latitude: 57° 31.284'N
Longitude: 8° 18.522'W
Location: Hebrides Shelf
Line and fix number: 84/06-53 11.6
Equipment: BGS rockdrill
Core length:
Lithology: Sand on gravel
Age:

SUMMARY

The gravel comprises mixed metamorphic lithologies.



LINE 84/06-53

SPARKER

BGS CORE NO: 57-09/531DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Outer Isles Platform

Latitude	57° 31.284'N	Licence Block	143/14	Vessel	James Clark Ross
Longitude	008° 18.522'W	BGS Plan No	JD12	Station Keeping	DP
Navigation	DGPS	Total Depth	3.9m	Dates of Drilling	08/08/2001
Map Area	St Kilda	Water Depth	137m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
Unknown	0										<p>SURFICIAL DEPOSIT ON SEAFLOOR (PREDOMINANTLY METAMORPHIC)</p> <p>Recovery includes ~20 cm of unconsolidated, poorly sorted black sand overlying ~40 cm of pebble to cobble size clasts of metamorphic origin. The black sand contains some shell fragments.</p> <p>Most clasts are some variety of biotite ± hornblende gneiss. Colour varies from pinkish to grey. Modal mineralogy varies significantly, even in the same piece. One clasts (~2 cm diam.) has bounding surfaces consisting of >50% biotite, whereas the interior of the piece consists of >90% quartz + feldspar. Other lithologies include 1 small pebble of hornblende schist and the largest clast (7 cm long) which is a garnet, biotite schist (medium grained and encrusted on one side with worm tubes). Minerals in most clasts are remarkably fresh.</p> <p>Silty clay adheres to the outer surfaces of some clasts, suggesting that at least some fine grained material originally filled the interstices between the clasts.</p>
	1										
	2										
	3										
	4										
	5										
	6										



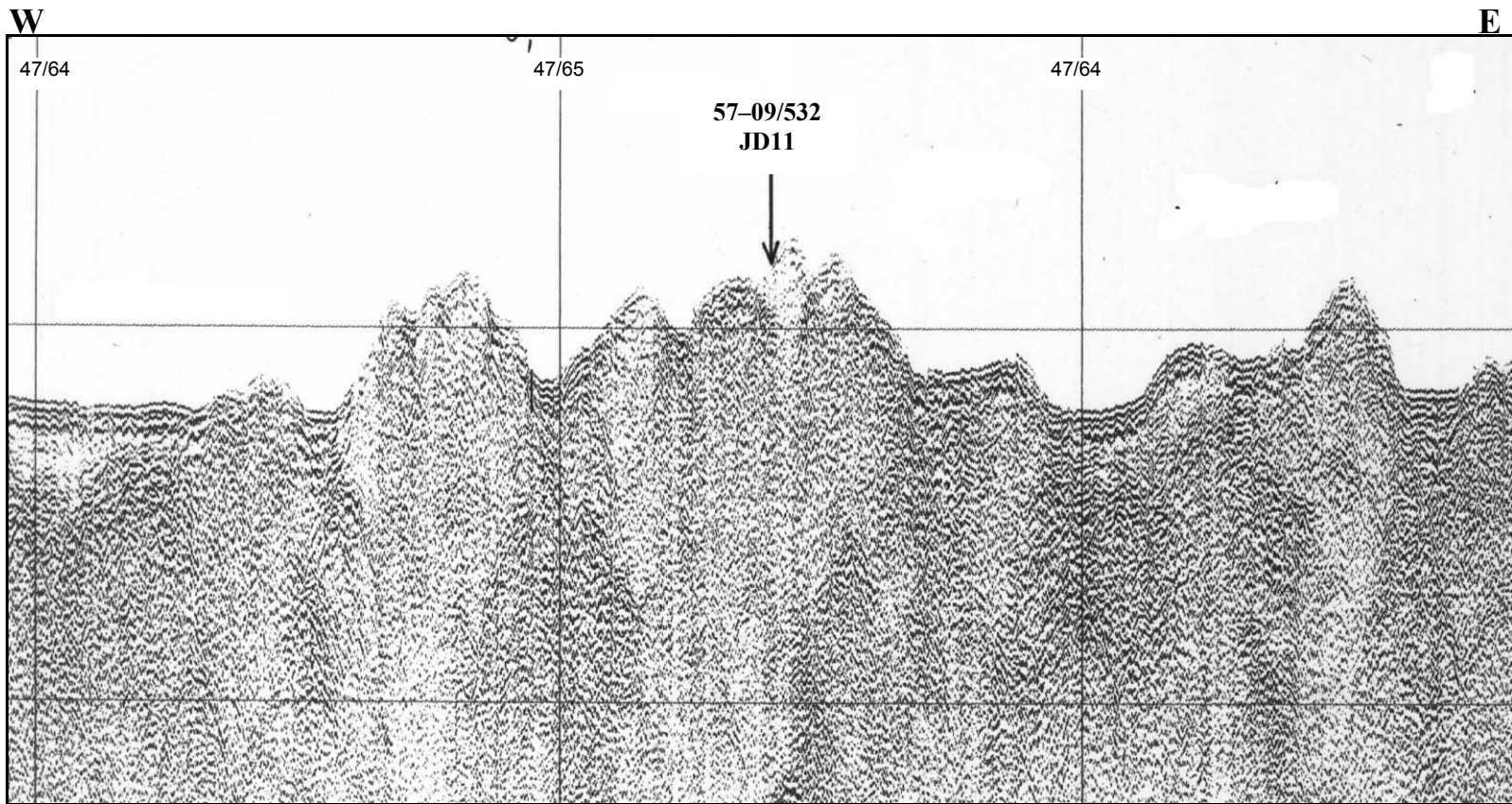
SAMPLE 57-09/532

SITE DETAILS

Date of drilling:	8th August 2001
Original site number:	JD11
Latitude:	57° 25.69'N
Longitude:	8° 17.62'W
Location:	Hebrides Shelf
Line and fix number:	84/06-47 65.4
Equipment:	BGS rockdrill
Core length:	0.57m
Lithology:	Gravel and metamorphic basement
Age:	?Lewisian (Archaean)

SUMMARY

The recovered material comprises large pebbles and short cored lengths which may be from sea-bed boulders. Lithologies are mainly biotite gneiss with or without hornblende.



LINE 84/06-47

SPARKER

BGS CORE NO: 57-09/532DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Outer Isles Platform	
Latitude	57° 25.69'N	Licence Block	143/19
Longitude	008° 17.62'W	BGS Plan No	JD11
Navigation	DGPS	Total Depth	1.91m (Rec. 0.57m)
Map Area	St. Kilda	Water Depth	118m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	08/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
Unknown	0										<p>SURFICIAL DEPOSIT ON SEAFLOOR (PREDOMINANTLY METAMORPHIC)</p> <p>Deposit of mixed lithologies, dominated by biotite ± garnet gneiss (>90%). One large clast (10.5 cm long) at top of hole is a fine grained hornblende-bearing, mafic igneous rock (hornblende diabase?). The piece is relatively fresh, although a fracture surface on one side is encrusted with worm casts and other biota.</p> <p>The biotite gneiss is medium grained and grey in colour in most cases. At least one piece contains garnet. One clast shows a contact between dark grey/ black biotite gneiss (~4cm long) and a more granitic gneiss (~2cm long). Poorly sorted, grey, clayey-silt containing sand and gravel fragments adheres to one side of this clast. The sediment also contains some shell fragments.</p> <p>Second clast from the bottom is predominantly a very coarse grained (pegmatitic?) gneiss, most of which consists of feldspar + quartz, but the bottom of this clast is biotite-rich (partially altered to chlorite). The clast is ~6 cm long.</p> <p>The last piece in the core is a well foliated, medium grained biotite gneiss, dark grey in color; the piece is ~10 cm long. The top of this piece was damaged during removal from the core catcher.</p> <p>Although the age of the deposit is not known, most of the metamorphic clasts are probably Lewisian.</p>
	1										
	2										
	3										
	4										
	5										
	6										



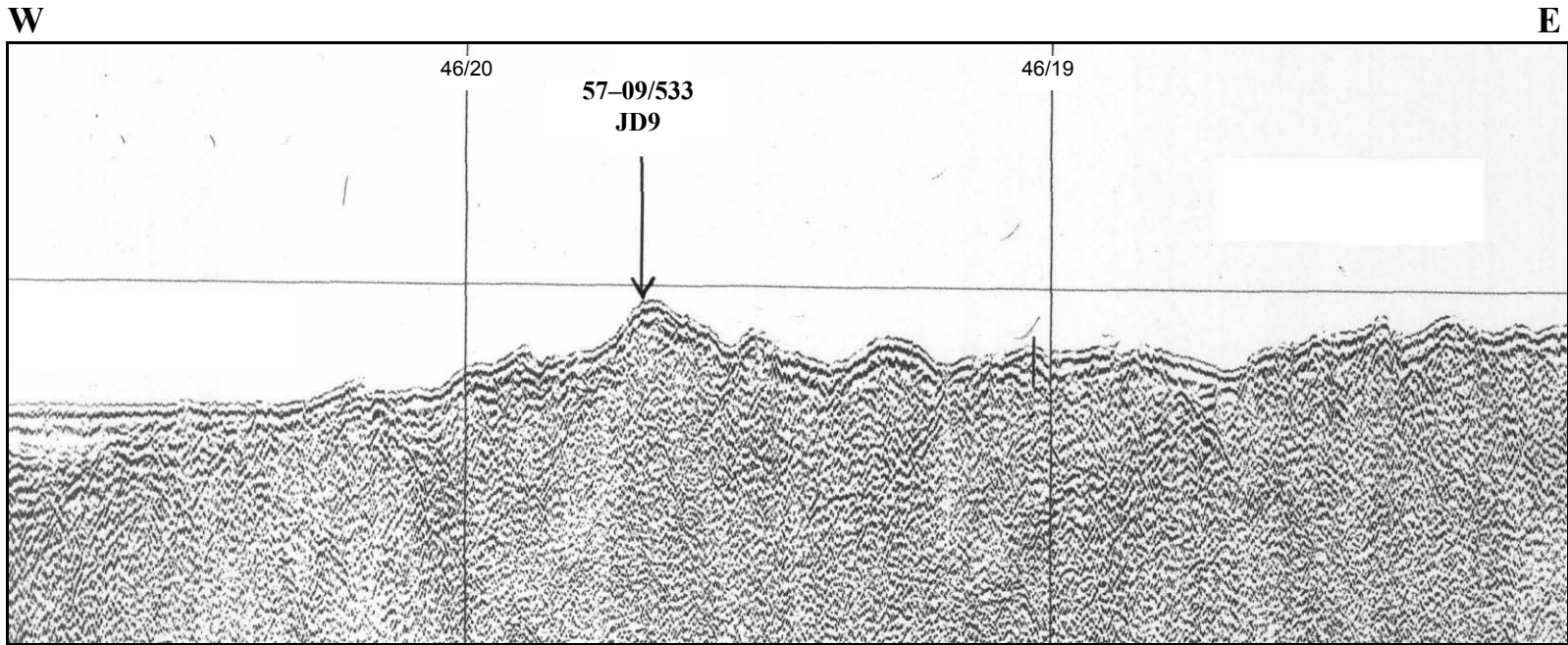
SAMPLE 57-09/533

SITE DETAILS

Date of drilling:	9th August 2001
Original site number:	JD9
Latitude:	57° 19.271'N
Longitude:	8° 24.991'W
Location:	Hebrides Shelf
Line and fix number:	84/06-46 19.7
Equipment:	BGS rockdrill
Core length:	0.48m
Lithology:	Gravel
Age:	?Lewisian (Archaean)

SUMMARY

The recovered material comprises gravel and short cored lengths of metamorphic basement gneiss which may be from sea-bed boulders or the bedrock.



LINE 84/06-46

SPARKER

BGS CORE NO: 57-09/533DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Outer Isles Platform	
Latitude	57° 19.2705' N	Licence Block	143/23
Longitude	008° 24.9912' W	BGS Plan No	JD9
Navigation	DGPS	Total Depth	2.56m (Rec. 0.48m)
Map Area	St Kilda	Water Depth	129m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	09/08/2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
unknown	0										<p>SURFICIAL SEAFLOOR DEPOSIT (METAMORPHIC ROCK CLASTS)</p> <p>Recovered 48 cm of clay, pebbles and upper part of bedrock or large boulder/cobble.</p> <p>Upper 20 cm: mud, soft, silty, olive-grey (5Y 4/2).</p> <p>20-30 cm: pebbles and rock fragments, angular to sub-rounded, 2 mm - 20 mm diameter, predominantly metamorphic rock fragments, quartz-biotite gneiss.</p> <p>30-38 cm: mud, soft, olive-grey (5Y 4/2), becoming darker towards base, some pebbles.</p> <p>38-43 cm: mud, much darker, black (5Y 2.5/1).</p> <p>43-48cm: Gneiss, quartz, biotite, may be part of boulder or bedrock</p> <p>Gneiss at base of sample probably from 2.51-2.56m depths of overlying sediments is uncertain.</p>
	1										
	2										
	3										
	4										
	5										
	6										



SAMPLE 57-09/534

SITE DETAILS

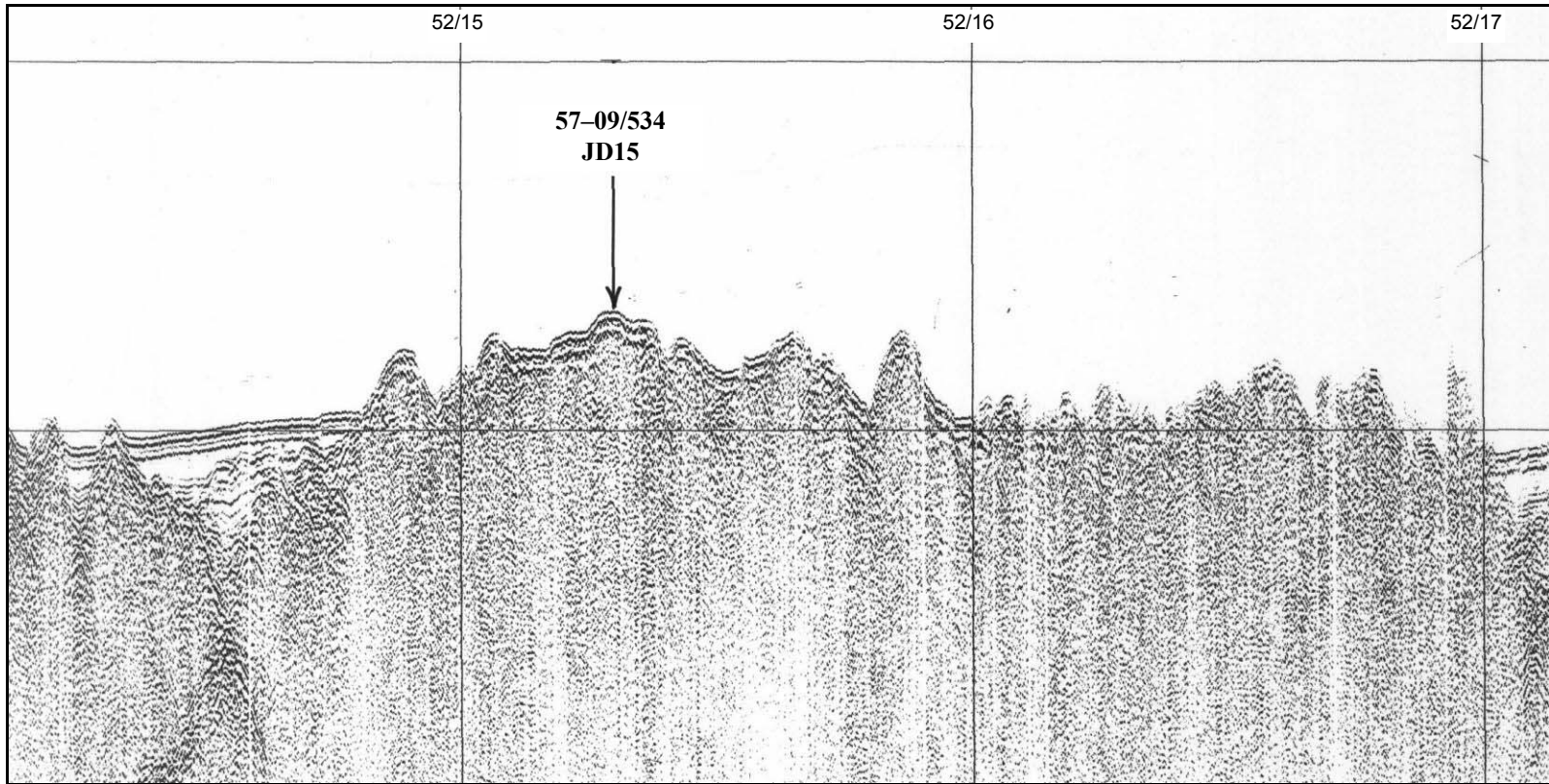
Date of drilling: 9th August 2001
Original site number: JD15
Latitude: 57° 10.596'N
Longitude: 8° 02.652'W
Location: Hebrides Shelf
Line and fix number: 84/06-52 15.3
Equipment: BGS rockdrill
Core length:
Lithology: Quartzo-feldspathic gneiss
Age:

SUMMARY

Only a single metamorphic cobble was recovered.

S

N



LINE 84/06-52

SPARKER

BGS CORE NO: 57-09/534DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Outer Isles Platform

Latitude 57° 10.596'N

Licence Block 143/25

Vessel James Clark Ross

Longitude 008° 02.652'W

BGS Plan No JD15

Station Keeping DP

Navigation DGPS

Total Depth 1.33m (Rec. 0.09m)

Dates of Drilling 09/08/2001

Map Area St Kilda

Water Depth 99m

Geologists R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
Lewisian	0	# d # g d f # d							Ts 0.05m		BIOTITE GNEISS Gneiss, pale grey, quartz-biotite, biotite <2 mm in length. Only one 9 cm (?) boulder recovered.
	0.1										
	0.2										
	0.3										
	0.4										
	0.5										
	0.6										
	0.7										
	0.8										
	0.9										
	1.0										
	1.1										
	1.2										

PETROLOGY OF SAMPLE 57-09/534

Emrys Phillips

Registered number: N3713

Thin section from 0.05m depth.

Rock Type: quartzofeldspathic gneiss

Mineralogy: major – plagioclase, quartz, K-feldspar, biotite
minor – clinozoisite/epidote, opaque minerals, titanite, allanite, apatite, zircon/monazite
alteration – chlorite, sericite, clay minerals

Description: This thin section is of a medium- to coarse-grained, inequigranular, anhedral granular, weakly foliated quartzofeldspathic gneiss (comparable to samples N3713 (b) and N3714). This high-grade (?upper amphibolite facies) metamorphic rock is mainly composed of anhedral plagioclase and quartz with subordinate K-feldspar. Plagioclase forms twinned and untwinned crystals which possess a slight dusty appearance under polarised light due to minor secondary alteration. Plagioclase may locally contain small, rounded inclusions of quartz. Quartz is strained to unstrained with a variably developed undulose extinction, deformation bands and sub-grained textures. Unstrained quartz tends to form rounded crystals (?recrystallised new grains). K-feldspar appears to be intergranular to plagioclase and possesses a distinctive shadowy extinction and coarse microcline twins. K-feldspar is also weakly perthitic and appear to be associated with the rounded quartz crystals.

A weak tectonic foliation present within the gneiss is defined by variably shape-aligned biotite flakes. Biotite is green-brown to dark brown and forms anhedral crystals which possess a well developed pleochroism. Minor chloritic alteration of biotite has also been noted. Secondary epidote/clinozoisite is typically associated with biotite and was locally observed replacing plagioclase. Epidote also forms irregular rims upon rare allanite crystals. Apatite is a common accessory phase and forms anhedral rounded crystals up to 0.2 mm in diameter. Rare, possible zircon/monazite crystals were noted included within biotite.

SAMPLE 57-09/535

SITE DETAILS

Date of drilling: 9th August 2001

Original site number: JD15

Latitude: 57° 10.602'N

Longitude: 8° 02.655'W

Location: Hebrides Shelf

Line and fix number: 84/06-52 15.3

Equipment: BGS rockdrill

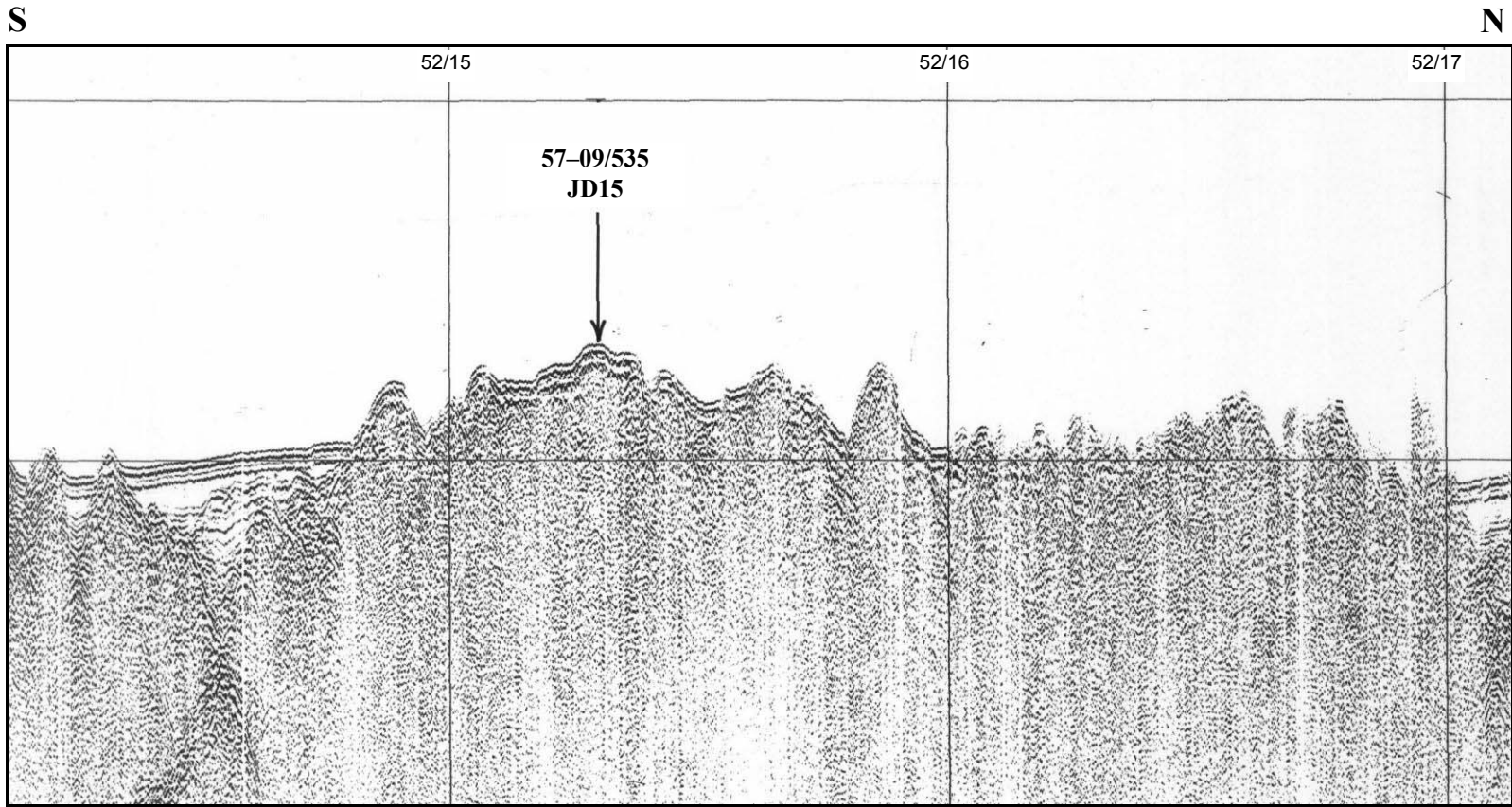
Core length:

Lithology: Quartzo-feldspathic gneiss

Age:

SUMMARY

This was the second attempt at JD15. Again, only a single metamorphic cobble was recovered.



LINE 84/06-52

SPARKER

BGS CORE NO: 57-09/535DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

Outer Isles Platform

Latitude	57° 10.602'N	Licence Block	143/25	Vessel	James Clark Ross
Longitude	008° 02.655'W	BGS Plan No	JD15	Station Keeping	DP
Navigation	DGPS	Total Depth	1.02m (Rec. 0.09m)	Dates of Drilling	09/08/2001
Map Area	St Kilda	Water Depth	99m	Geologists	R.Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Lewisian	0	f # d # g d f # d						TS 0.05m		BIOTITE GNEISS Gneiss, grey, quartz-biotite, pink feldspars, recovered only one 9 cm cobble. This site is 10 m on a heading 340 degrees from 57-09/534.
	0.1									
	0.2									
	0.3									
	0.4									
	0.5									
	0.6									
	0.7									
	0.8									
	0.9									
	1.0									
	1.1									
	1.2									

PETROLOGY OF SAMPLE 57-09/535

Emrys Phillips

Registered number: N3714

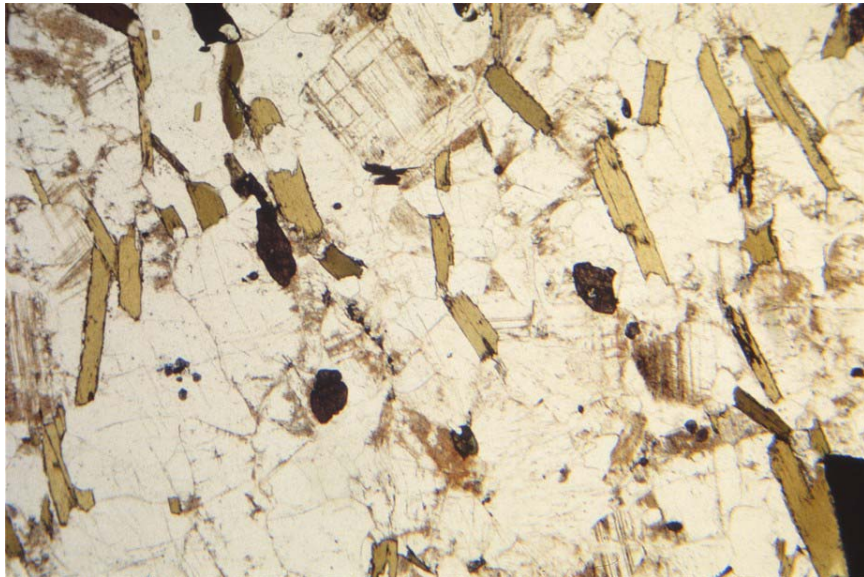
Thin section from 0.05m depth.

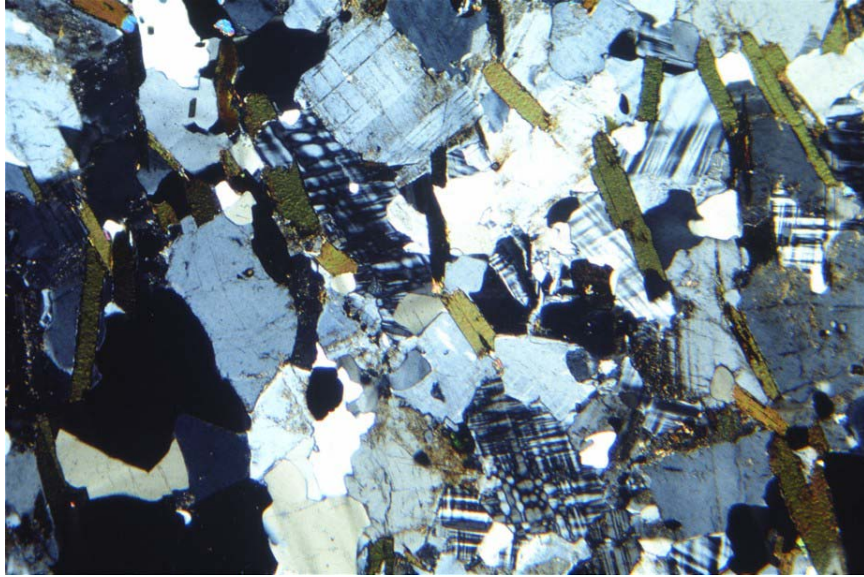
Rock Type: quartzofeldspathic gneiss

Mineralogy: major – K-feldspar, quartz, plagioclase, biotite
minor – titanite, opaque minerals, apatite, allanite, muscovite,
clinozoisite, zircon, ?monazite
alteration – chlorite, sericite, clay minerals, carbonate

Photomicrographs:

Photomicrographs of a quartzofeldspathic gneiss (N3714), plane and crossed polarised light.





Description: This thin section is of a medium- to coarse-grained (average grain size 0.6 to 0.8 mm), inequigranular, weakly to moderately foliated quartzofeldspathic gneiss. This high-grade (?upper amphibolite facies) metamorphic rock is mainly composed of anhedral K-feldspar, quartz and plagioclase. A crude compositional banding present within the rock is defined by the variation in modal K-feldspar. K-feldspar is fresh and possesses distinctive coarse to locally diffuse microcline twins. Traces of myrmekite have been noted replacing K-feldspar, with K-feldspar also containing rounded to bleb-like inclusions of quartz. K-feldspar is weakly perthitic and may be variably shape-aligned parallel to the tectonic fabric. This homogeneous (no obvious segregation or mica-rich domains) foliation is mainly defined by aligned biotite flakes. Biotite is green-brown in colour with a well developed pleochroism and forms anhedral flakes up to 2.0 mm in length (typically ≤ 1.0 mm).

Plagioclase possesses a slight dusty appearance under plane polarised light due to minor alteration to sericite and/or clay minerals. This alteration is mainly focused along cleavage and/or twin composition planes. Plagioclase occurs as both twinned and untwinned crystals which may possess a weakly developed zonation. Titanite and apatite are common minor to accessory phases. Quartz is strained with intracrystalline deformation resulting in a well developed undulose extinction, deformation bands and sub-grain textures. Titanite forms anhedral to weakly subhedral rounded to lozenge-shaped crystals which may be shape aligned-parallel to the biotite fabric. Titanite was also noted forming irregular rims upon opaque minerals. Muscovite is an accessory phase within this gneissose rock and forms small ragged flakes which are associated with clinozoisite. Clinozoisite locally forms irregular rims upon altered allanite crystals. Small faceted ?zircon crystals have been noted included within feldspar.

The protolith of this high-grade metamorphic rock is uncertain and may have been either granodioritic igneous rock or a feldspathic sandstone.

SAMPLE 57-09/536

SITE DETAILS

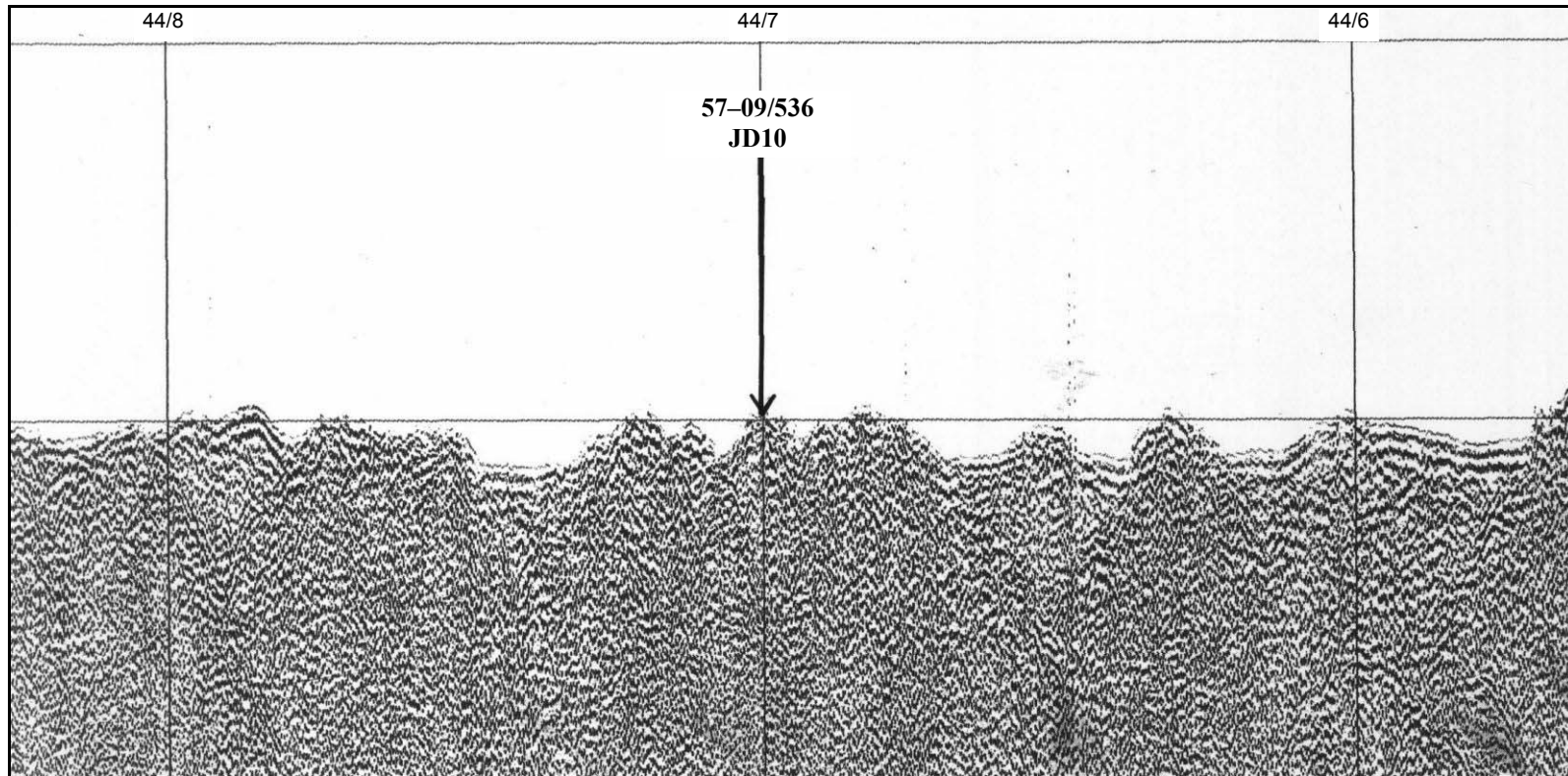
Date of drilling:	9th August 2001
Original site number:	JD10
Latitude:	57° 07.157'N
Longitude:	8° 05.489'W
Location:	Hebrides Shelf
Line and fix number:	84/06-44 7.0
Equipment:	BGS rockdrill
Core length:	0.23m
Lithology:	Hornblende-biotite gneissose rock
Age:	?Lewisian (Archaean)

SUMMARY

A strongly-foliated dark grey and white quartz-biotite gneiss was recovered.

W

E



LINE 84/06-44

SPARKER

BGS CORE NO: 57-09/536DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Outer Isles Platform

Latitude 57° 07.1567'N

Licence Block 143/30

Vessel James Clark Ross

Longitude 008° 05.4892'W

BGS Plan No JD10

Station Keeping DP

Navigation DGPS

Total Depth 0.50m (Rec. 0.23m)

Dates of Drilling 09/08/2001

Map Area St Kilda

Water Depth 120m

Geologists R.Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
	0	# d # g d f # d d f # d # g d f # f # d # g d f # d							Ts 0.05m		BIOTITE HORNBLLENDE GNEISS Quartz-biotite gneiss, dark grey, large amounts of biotite and amphiboles. Strong foliated texture. Trace quantities of pyrite, some alteration (breakdown) of biotite to brown mineral.
	1										
	2										
	3										
	4										
	5										
	6										



PETROLOGY OF SAMPLE 57-09/536

Emrys Phillips

Registered number: N3715

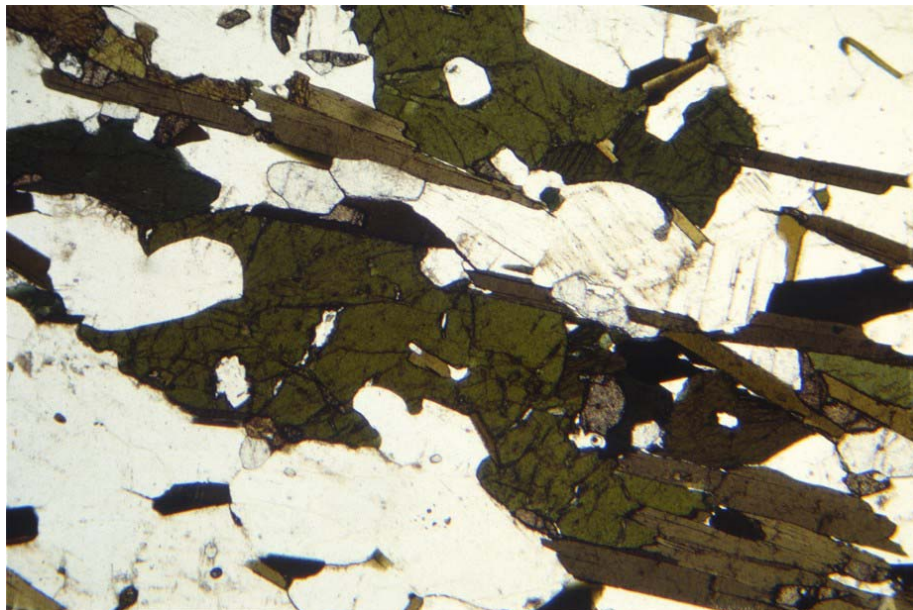
Thin section from 0.05-0.07m depth.

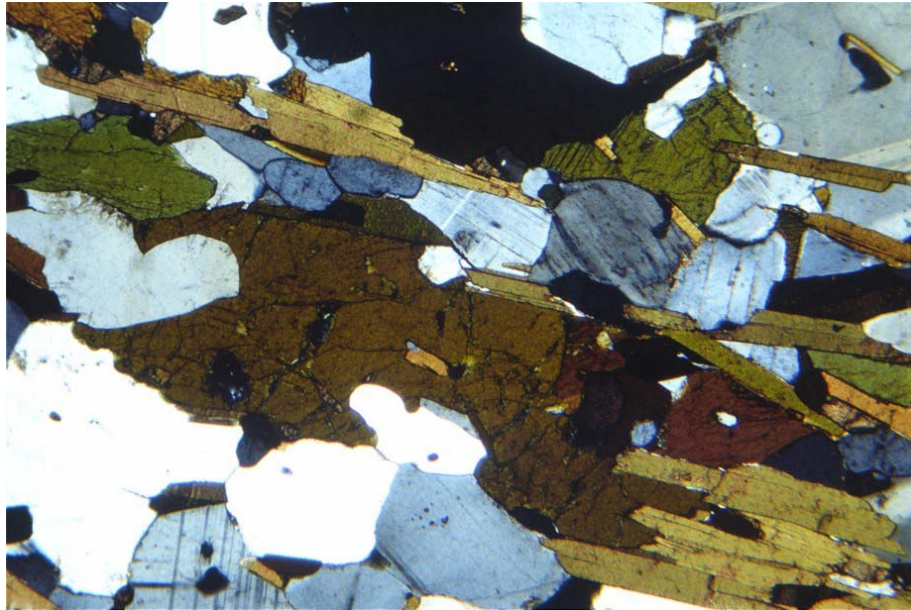
Rock Type: banded, hornblende-biotite gneissose rock

Mineralogy: major – plagioclase, biotite, amphibole, quartz, K-feldspar
minor – opaque minerals, titanite, allanite
alteration – clinozoisite/epidote

Photomicrographs:

Photomicrographs of a hornblende-biotite gneissose rock (N3715), plane and crossed polarised light.





Description: This thin section is of a medium- to coarse-grained, inequigranular, moderately foliated, hornblende-biotite-bearing quartzofeldspathic gneiss. A compositional banding present within this high-grade (?upper amphibolite facies) metamorphic rock is defined by the variation in modal biotite and hornblende. A tectonic fabric is developed parallel to this banding and is defined by shape-aligned biotite flakes and, to a lesser extent, plagioclase and amphibole. Biotite is the dominant ferromagnesian mineral and forms anhedral to weakly subhedral flakes. It possesses a strong pleochroism, ranging from green-brown to dark brown in colour. Biotite locally contains inclusions of titanite and apatite.

Hornblende is associated with biotite and locally overgrown finer-grained biotite crystals. Hornblende is strongly pleochroic (olivine green to blue green to very dark green) and forms anhedral crystals which may contain small inclusions of apatite and titanite. Both apatite and titanite are common accessory phases within this gneiss.

The remainder of the rock is composed of anhedral granoblastic plagioclase with subordinate amounts of quartz and trace K-feldspar. Plagioclase is weakly antiperthitic and forms twinned crystals which exhibit very little or no alteration. K-feldspar possesses a distinctive sweeping undulose extinction and diffuse, coarse microcline twins. Quartz is intergranular to plagioclase, biotite and amphibole and forms strained anhedral crystals which possess an undulose extinction.

SAMPLE 57-09/537

SITE DETAILS

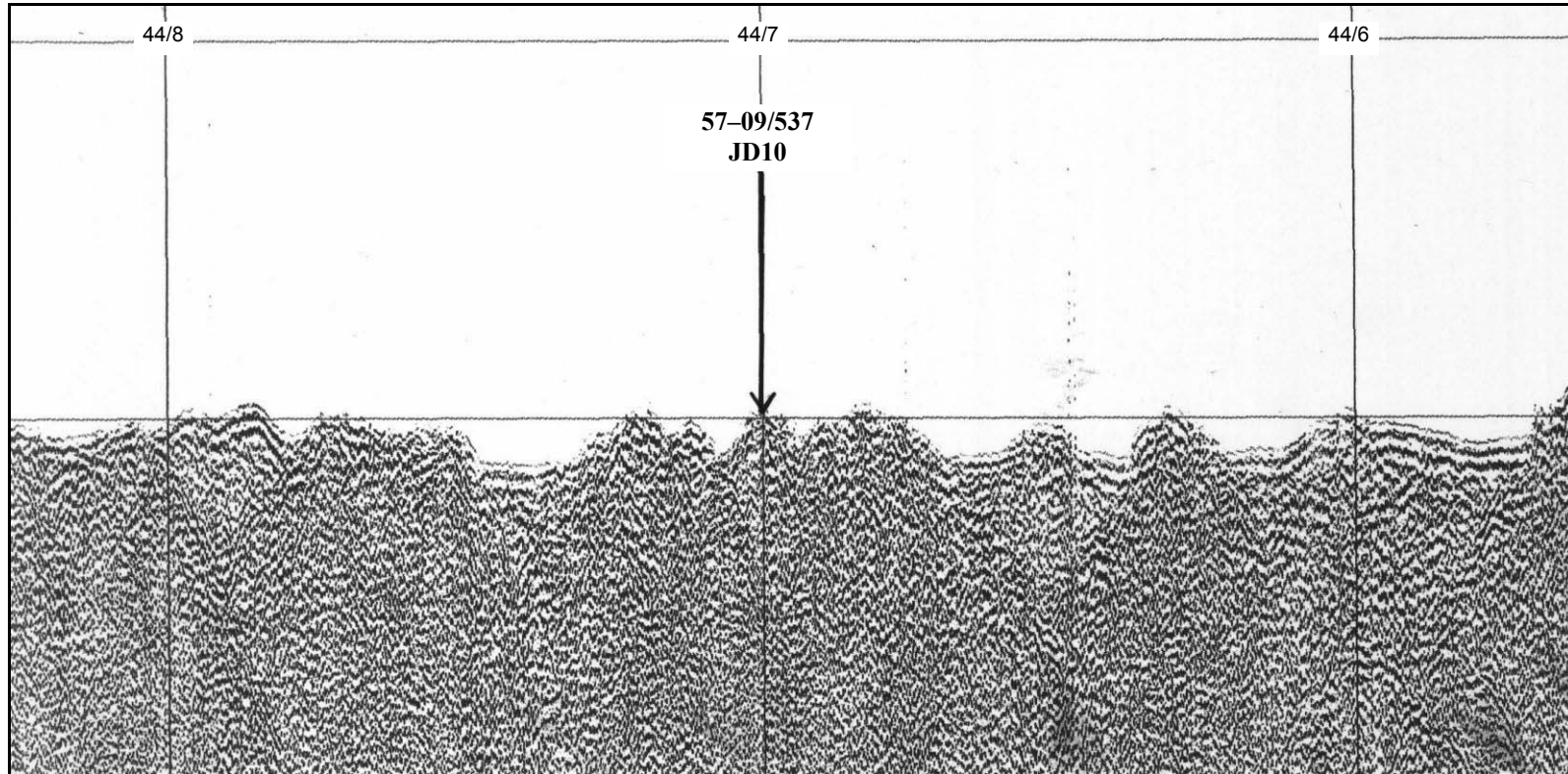
Date of drilling:	9th August 2001
Original site number:	JD10
Latitude:	57° 07.16'N
Longitude:	8° 05.49'W
Location:	Hebrides Shelf
Line and fix number:	84/06-44 7.0
Equipment:	BGS rockdrill
Core length:	2.49m
Lithology:	Amphibolite and quartzo-feldspathic gneiss
Age:	?Lewisian (Archaean)

SUMMARY

Excellent recovery of dark grey biotite-hornblende gneiss with paler-coloured quartz-rich bands overlying 6cm of pink granitic gneiss just above TD. The core is strongly foliated, exhibits complex minor folds at certain intervals and is very fresh throughout.

W

E



LINE 84/06-44

SPARKER



PETROLOGY OF SAMPLE 57-09/537

Emrys Phillips

Registered number: N3716

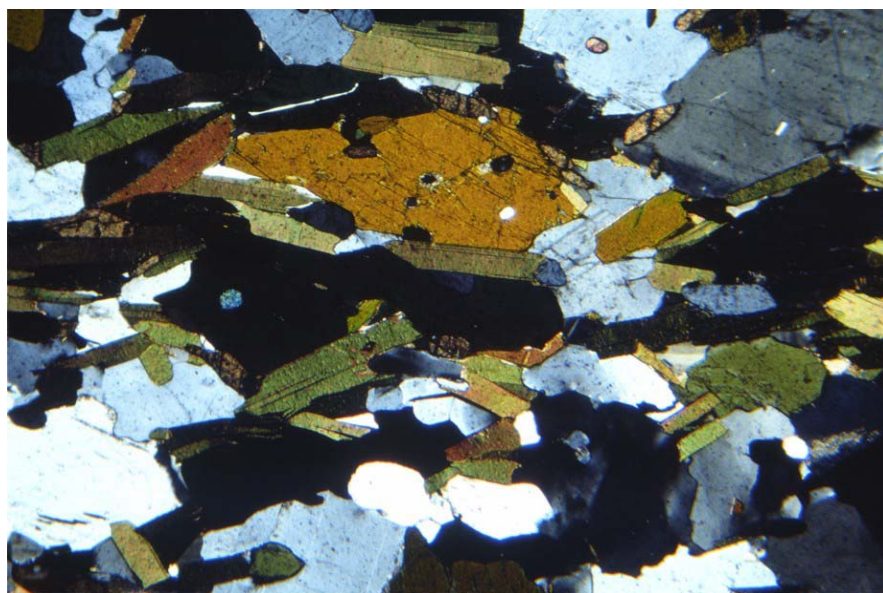
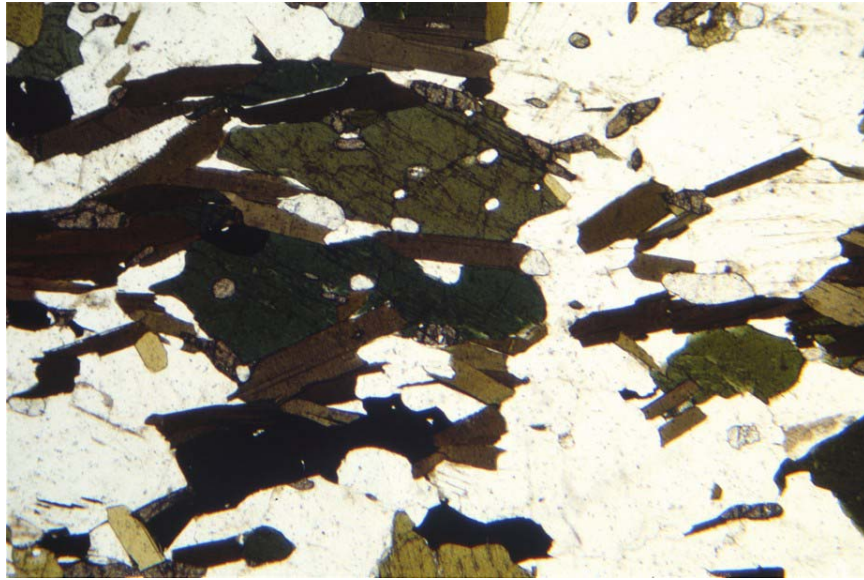
Thin section from 0.83-0.89m depth.

Rock Type: schistose biotite-amphibolite

Mineralogy: major – plagioclase, biotite, amphibole, quartz, K-feldspar
minor – opaque minerals, titanite, allanite, apatite
alteration – chlorite, sericite, clay minerals, clinozoisite/epidote

Photomicrographs:

Photomicrographs of a schistose biotite-amphibolite (N3716), plane and crossed polarised light.



Description: This thin section is of a medium- to coarse-grained, inequigranular, anhedral granular, well foliated biotite-amphibolite. A well developed homogenous tectonic foliation is defined by shape-aligned biotite and subordinate amphibole. Biotite forms anhedral to weakly

subhedral, yellow-brown to dark brown flakes which possess a moderate to well developed pleochroism. Amphibole is blue-green to yellow-green in colour and forms anhedral crystals which possess a weak to moderate pleochroism.

The remainder of this high-grade (?upper amphibolite facies) metamorphic rock is composed of plagioclase and minor quartz. Plagioclase is fresh and forms twinned and untwinned crystals which are locally antiperthitic. Plagioclase may also exhibit a weak preferred shape alignment parallel to the biotite dominated foliation. Rare to trace K-feldspar possesses a distinctive shadowy extinction and poorly developed microcline twins. Quartz forms anhedral strained crystals which possess a well developed undulose extinction, deformation bands and sub-grain textures.

Apatite and titanite are common accessory phases and are both spatially related to, and may be included within biotite and amphibole. Apatite forms anhedral to rounded crystals which range up to 0.3 mm in size. Titanite forms anhedral, rounded, irregular to weakly lozenge-shaped crystals which may be aligned parallel to the biotite fabric. Anhedral crystals of opaque minerals range up to 0.8 to 1.0 mm in size. Rare allanite crystals enclosed within a rim of later clinozoisite/epidote have also been recorded.

PETROLOGY OF SAMPLE 57-09/537

Emrys Phillips

Registered number: N3717

Thin section from 0.83-0.89m depth.

Rock Type: Interbanded schistose biotite-amphibolite and quartzofeldspathic gneiss

Mineralogy: **amphibolite:** major – plagioclase, biotite, amphibole, quartz, K-feldspar
minor – opaque minerals, titanite, allanite, apatite
alteration – chlorite, sericite, clay minerals, clinozoisite/epidote, carbonate
quartzofeldspathic gneiss: major – plagioclase, quartz, K-feldspar,
biotite
minor – opaque minerals, titanite, amphibole, apatite, clinozoisite/epidote
alteration – chlorite, sericite, clay minerals,

Description: This thin section is of a interbanded medium- to coarse-grained biotite-amphibolite (comparable to sample N3716) and quartzofeldspathic gneiss (comparable to N3714). The boundary between these two lithologies is sharp and marked by the disappearance of biotite and amphibole, and increase in modal K-feldspar.

The biotite-amphibolite possesses a well developed, homogenous tectonic foliation which is defined by shape-aligned biotite and, to a lesser extent, amphibole crystals. This tectonic foliation occurs parallel to the compositional banding. Biotite is yellow-brown to dark brown in colour and forms anhedral to weakly subhedral flakes (up to 2.0 mm in length) which possess a strong pleochroism. Amphibole is green to blue-green in colour and forms anhedral crystals. The remainder of this high-grade metamorphic rock (upper amphibolite facies) is composed of plagioclase with minor amounts of K-feldspar and quartz. Quartz is strained with a variably developed undulose extinction and sub-grained textures. Plagioclase forms anhedral, twinned and untwinned crystals. K-feldspar is distinguished by a distinctive shadowy extinction and the presence of weakly developed, diffuse microcline twins. Traces of myrmekite were also noted replacing K-feldspar. Titanite and apatite are common accessory phases with the latter locally forming larger rounded crystals up to 0.4 mm in diameter. Titanite forms anhedral, fractured weakly lozenge shaped crystals which are shape aligned parallel to the biotite fabric. Large (up to 1.7 mm in length), anhedral to weakly subhedral opaque crystals are shape aligned parallel to the biotite fabric.

The adjacent quartzofeldspathic gneiss is a medium- to coarse-grained, anhedral granular rock. The protolith of this high-grade metamorphic rock is uncertain and may have been either a granitic igneous rock or feldspathic sandstone. This gneiss is mainly composed of an anhedral assemblage of plagioclase, K-feldspar and quartz. Plagioclase forms twinned and untwinned anhedral crystals which possess a slight dusty appearance under plane polarised light due to minor secondary alteration. Plagioclase is also antiperthitic and may contain coarse lamellae of microcline. K-feldspar is weakly perthitic and possesses a shadowy extinction. K-feldspar appears to be coarser grained and slightly more abundant adjacent to the boundary with the biotite-amphibolite band. Traces of epidote are present. Quartz forms anhedral strained crystals with a variably developed undulose extinction. However, quartz was also noted forming rounded, unstrained crystals (?recrystallised). Minor biotite present within this

quartzofeldspathic gneiss is shape aligned and defines a weakly developed foliation, parallel to the compositional banding and fabric present within the adjacent biotite-amphibolite.

PETROLOGY OF SAMPLE 57-09/537

Emrys Phillips

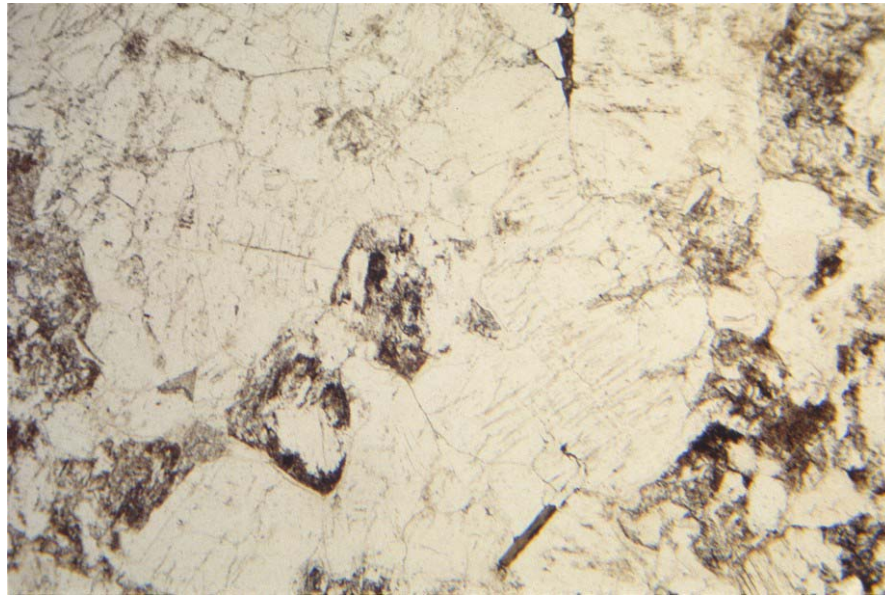
Registered number: N3718
Thin section from 2.46m depth.

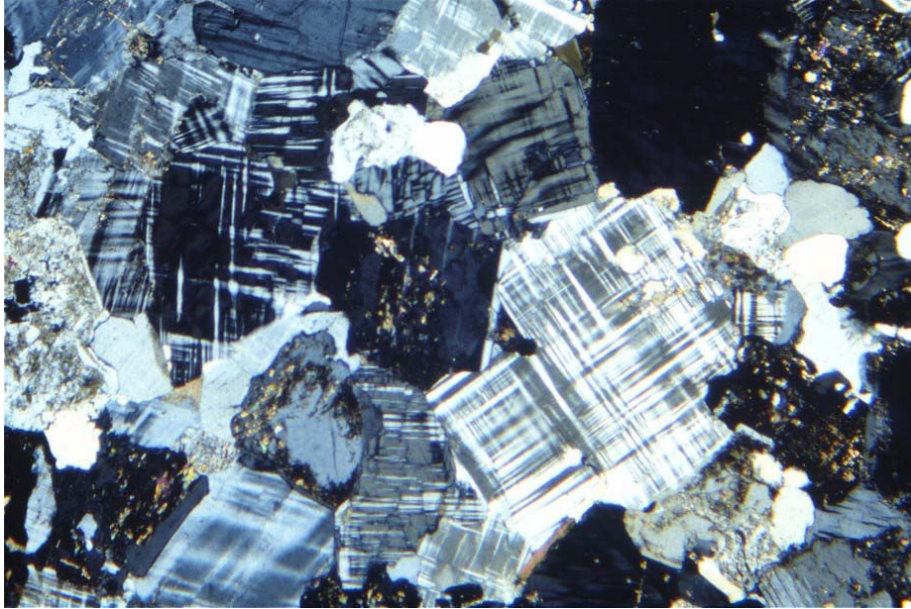
Rock Type: monzonitic granite vein/band cutting amphibole-biotite-bearing quartzofeldspathic gneiss

Mineralogy: **monzonite:** major – K-feldspar, quartz, plagioclase, biotite
minor – opaque minerals, muscovite, clinozoisite, zircon
alteration – sericite, carbonate, chlorite, opaque oxides
gneiss: major – plagioclase, K-feldspar, quartz, biotite, amphibole
minor – opaque minerals, clinozoisite, apatite, titanite
alteration – sericite, clay minerals

Photomicrographs:

Photomicrographs of a monzonitic granite vein (N3718 c), plane and crossed polarised light.





Description: This thin section is of a monzonitic granite vein or band cutting an amphibole and biotite-bearing quartzofeldspathic rock; the latter is lithologically similar to samples N3705 and 3704.

The monzonitic vein or band is composed medium- to coarse-grained, anhedral granular, weakly banded, recrystallised/metamorphosed granite. The rock is mainly composed of K-feldspar and quartz with subordinate amounts of plagioclase. The banding is defined by elongate ribbons of quartz and a slight variation in the modal proportion of K-feldspar. K-feldspar is the dominant mineral phase and forms anhedral, locally perthitic crystals which possess distinctive coarse microcline twins.

Quartz and plagioclase are apparently intergranular to K-feldspar. Plagioclase forms anhedral, weakly zoned, twinned and untwinned crystals which exhibit preferential alteration of their cores to sericite and carbonate (\pm muscovite). Alteration results in a slight dusty appearance of plagioclase under plane polarised light. Plagioclase may locally possess moderately developed or preserved crystal faces and may be rimmed by albite. Quartz forms anhedral crystals within which intracrystalline deformation has resulted in the development of an undulose extinction, sub-grain textures and/or deformation bands. Rounded quartz grains are typically unstrained and may represent new grains.

The contact between the monzonite and the adjacent amphibole- and biotite-bearing quartzofeldspathic gneiss is sharp. The monzonite vein clearly cross cuts a moderately developed biotite foliation. The amphibole- and biotite-bearing gneiss appear to be broadly dioritic to granodioritic in composition and is mainly composed of plagioclase, quartz and K-feldspar with minor shape aligned biotite. Plagioclase is the dominant feldspar and forms anhedral crystals which possess a slight dusty appearance under plane polarised light due to minor sericitic alteration. K-feldspar is fresh and forms anhedral, weakly perthitic crystals which possess well developed microcline twins. Small patches of finer grained quartz, K-feldspar and, in some cases myrmekite occur intergranular to plagioclase and coarse grained K-feldspar. The myrmekite appears to be replacing the adjacent coarser grained K-feldspar and is composed of single crystals of plagioclase contain worm-like inclusions of quartz.

Yellow-brown to green-brown biotite forms anhedral to weakly subhedral crystals which possess a moderately developed pleochroism. Opaque minerals, titanite and apatite are common accessory phases and are typically associated with biotite. Titanite forms anhedral to weakly subhedral elongate to lozenge-shaped crystals which are locally overgrown by, or included

within biotite. Minor amounts of brown-green to blue-green, moderately pleochroic amphibole are present forming anhedral crystals which may partially include or overgrown biotite and titanite.

SAMPLE 57-12/41

SITE DETAILS

Date of drilling:	12th August 2001
Original site number:	K158
Latitude:	57° 23.09'N
Longitude:	11° 12.84'W
Location:	Anton Dohrn
Line and fix number:	92/01-44 78.0
Equipment:	BGS rockdrill
Core length:	1.14m
Lithology:	Sand and partially dolomitised limestone
Age:	Pleistocene (NN21)

SUMMARY

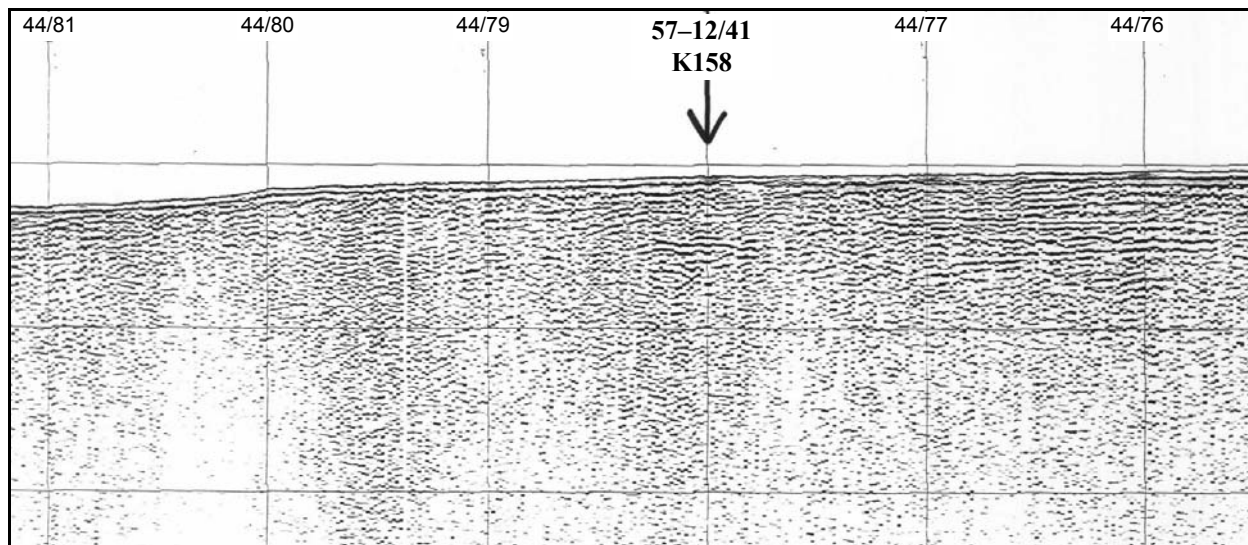
The sand is partially biogenic and lithic and in origin. The limestone reacts variably with HCl. Burrows and hardgrounds are present in the core.

The cyclicity of carbonate deposition and hardground formation suggests a punctuated sedimentary record in which non-deposition and erosion might be significant.

From nannofossil data, a Pleistocene age (NN21) age is suggested for the upper part of the core. The lower part may range back to the earliest Pleistocene (NN19). Foraminiferal analysis suggests a Pleistocene age

NW

SE

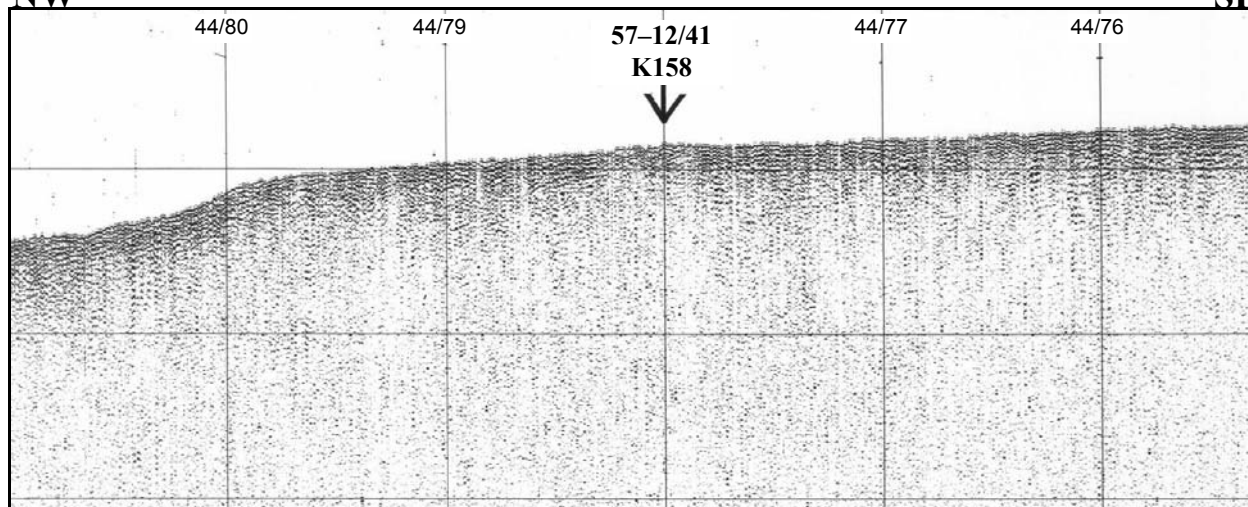


LINE 92/01-44

AIRGUN

NW

SE



LINE 92/01-44

SPARKER

BGS CORE NO: 57-12/41DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

Anton Dohrn

Latitude	57° 23.09'N	Licence Block	140/19	Vessel	James Clark Ross
Longitude	011° 12.84'W	BGS Plan No	K158	Station Keeping	DP
Navigation	DGPS	Total Depth	4.03m (Rec. 1.14m)	Dates of Drilling	12/08/2001
Map Area	Anton Dohrn	Water Depth	667m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION		
Unknown	0							MPal 0.00m		<p>BIOTURBATED, PARTIALLY DOLOMITISED CALCARENITE</p> <p>0.00-0.12 m: Very poorly sorted, uncemented sediment, consisting of yellowish brown, sandy clay (10Y 5/4); sand size particles are biogenic in origin; lithic clasts up to 2 cm across include metamorphic (Quartz-mafic minerals), basalt and limestone.</p> <p>0.12-0.37 m: Limestone, partially dolomitized and ?silicified biogenic deposit consisting of light brown matrix that is heavily bioturbated, particularly at the top. Burrows highlighted by dark, reddish black colour due to the presence of Mn-Fe oxyhydroxides. This forms a 4cm manganese crust at the top of the core. Note that one burrow, appears to be approximately 4 cm wide and 11 cm long. Shell fragments (generally less than 1cm across) are common, as well as numerous other types of unidentified bioclasts. A vug lined with euhedral quartz crystals occurs between 0.26-0.28 m.</p> <p>0.37-0.59 m: An irregular boundary (~5-10 mm wide and roughly horizontal), occurs at 0.37 m and is defined by a concentration of Mn-Fe oxyhydroxides - ?hardground. Below this boundary the deposit is similar in appearance to the material between 0.25 and 0.35 m, although slightly more yellow in colour (10YR 7/6). Below 0.42m, porosity increases (i.e. cementation decreases), with a reduction in reaction with HCl suggesting a greater percentage dolomitisation. This persists down to 0.59 m.</p> <p>0.59-0.72 m: Another dark horizon occurs at 0.59 m. It is ~15 mm wide, roughly horizontal in orientation. The deposit below this is partially cemented, but reacts with HCl. The degree of cementation decreases with depth. Colour is still yellow, but dulled by abundant, minute flecks of Mn-Fe oxyhydroxides.</p> <p>0.72-0.95 m: In this interval, the deposit is virtually uncemented and friable, breaking down into sand-size particles of biogenic origin, including many forams and rounded unidentified bioclastic fragments.</p> <p>0.95-1.14 m: The degree of cementation increases, but porosity is still high—a poorly cemented calcarenite. Between 0.97-1.00 m there is a darkening of the core suggesting partial formation of another manganese crust.</p>		
									MPal 0.01m			
											MPal 0.76m	
											MPal 0.76m	
			1									
			2									
			3									
			4									
			5									
			6									



FORAMINIFERA OF SAMPLE 57-12/41

Ian Wilkinson

The planktonic assemblage recovered from the sample at 0.00-0.10m (MPA50844), being dominated by sinistral *N. pachyderma* and frequent *Globigerina bulloides* and *Globorotalia inflata*, is characteristic of the Subarctic faunal province (in the sense of BÉ, 1977) of the Pleistocene to Recent. The abundance of sinistrally coiled *N. pachyderma* suggests Spring water temperatures below 7.2°C and at the latitude of the bore site its incoming is characteristic of the base of the Pleistocene (i.e. c.1.8Ma). Benthonic foraminifera are generally rare or very rare, but there are no species that have been derived from the inner shelf. *Cibicides lobatulus*, *Paromalina crassa*, *Oridorsalis umbonata* and *Planularia ariminensis* are often found on the continental slope of north western Europe (MURRAY, 1991). *Planularia ariminensis* for example is particularly found in water depths between about 300 and 500m although it has been recorded down to c.800m. *Paromalina crassa* is generally found in water depths in excess of about 600m. It is found living in the Porcupine Seabight between 800 and 950m and between 880 and 1400m in the Western Approaches where it appears to be associated with the Mediterranean Water mass.

The sample from a depth of 0.76-0.88m (MPA50845) yielded only very rare, poorly preserved foraminifera. Although no biostratigraphical or palaeoenvironmental conclusions can be made, those taxa found (listed above) are the same as those for the overlying sample.

NANNOFOSSILS OF SAMPLE 57-12/41

Jackie Lees

Two samples were taken for analysis from this short core.

0.00-0.05m

0.76-0.88m

Both samples were productive, and preservation was moderately good. *E. huxleyi* was present at the top of the core, along with a varied selection of geophyrocapsids, indicating NN21 (latest Pleistocene to Early Holocene). This was accompanied by reworked Neogene through Late Cretaceous taxa. The presence of *H. inversa* but absence of *E. huxleyi* at 0.76-0.88m suggests lowest NN19 (earliest Pleistocene). Reworking of Neogene through Late Cretaceous is evident in this sample.

SEDIMENTOLOGY OF SAMPLE 57-12/41

Alick Leslie

The core contains 1.14m of carbonate, comprising a topmost 0.12m of unconsolidated bioclastic sand overlying 1.02m carbonate of variable bioclastic content showing some dark 'hardground' horizons. There is no biostratigraphic information.

0.00 – 0.12m

The top part of the core comprises foraminiferal sand containing some pebbles of metamorphic and igneous lithology. The sand fraction is predominantly composed of forams and is well sorted. The pebbles appear to occur throughout the sand.

0.12 – 0.60m

Dense, micritic limestone containing shelly bioclasts and lithic fragments and a small quantity of quartz. The succession consists of two cycles topped by dark material, with a boundary at 0.37m.

The top of the upper cycle is a dark brown to black band 40mm thick with an irregular surface possibly affected by bioturbation. The carbonate is cemented by a micritic matrix and contains both intact shells and rounded fragments of what appear to be orange - brown, weathered igneous rocks. The pebbles are up to 60mm in length. Cementation is assumed to be fine-grained calcium carbonate, however the brittle fracture of the core suggests that there may be some silica disseminated through the carbonate, or possibly dolomite.

The lower cycle is topped by a dark band 8mm in thickness, below which is a bioclastic sand comprising fragments and intact specimens of shells and other biogenic material. Clasts of brown, weathered igneous material are present near the top of this cycle.

0.60 – 1.14m (TD)

Bioclastic limestone with variable cementation, topped by a dark band. The dark band is 9 – 18mm in thickness, and immediately underlying this are fragments of a similar dark material within a bioclastic matrix. The majority of this succession is a bioclastic sand – some shells are intact – with variable amounts of cementation. The cementation does not appear to be related to the top surface.

At this location, surficial sand overlies a carbonate consisting of several cycles of deposition topped by dark material. This dark material is interpreted to be a Manganese-rich crust, formed during prolonged exposure at the sea bed. The upper cycle appears to be more lithified, the lower is predominantly composed of bioclastic material. The cyclicity of carbonate deposition and hardground formation suggests a punctuated sedimentary record in which non-deposition and erosion might be significant.

Borehole 90/15,15A (drilled in 1990 on Anton Dohrn) proved roughly 5m of bioclastic material of mid-Miocene age overlying 3.5m of Palaeocene to Eocene limestone from the top of Anton Dohrn (Stoker et al. 1993). The Palaeogene limestone contains hardgrounds and may be a correlative of the succession recovered in 57-12/41. Bioclastic analysis is required to confirm the age of the carbonates.

SAMPLE 57-12/42

SITE DETAILS

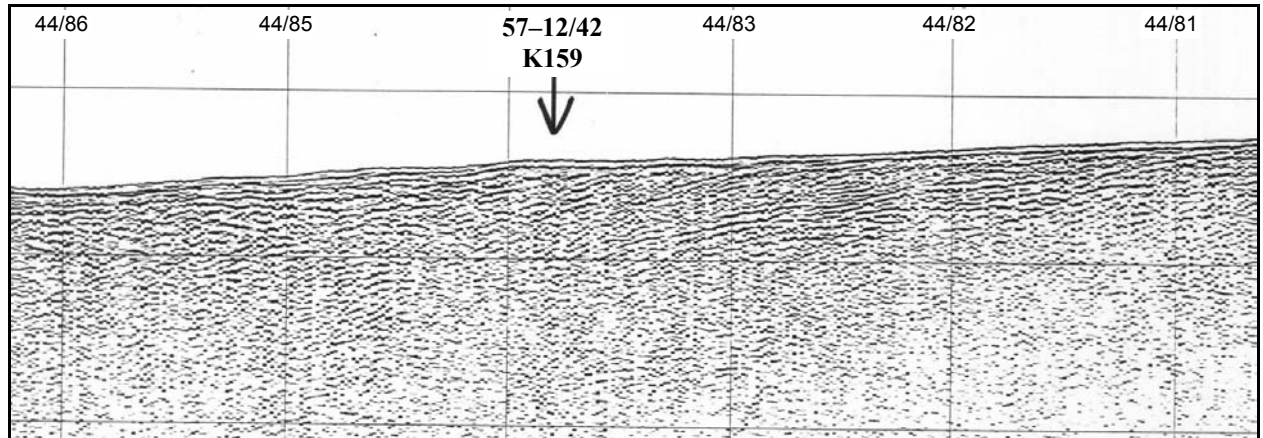
Date of drilling: 12th August 2001
Original site number: K159
Latitude: 57° 25.127'N
Longitude: 11° 18.174'W
Location: Anton Dohrn
Line and fix number: 92/01-44 83.8
Equipment: BGS rockdrill
Core length: 0.00m
Lithology:
Age:

SUMMARY

Nil recovery.

NW

SE

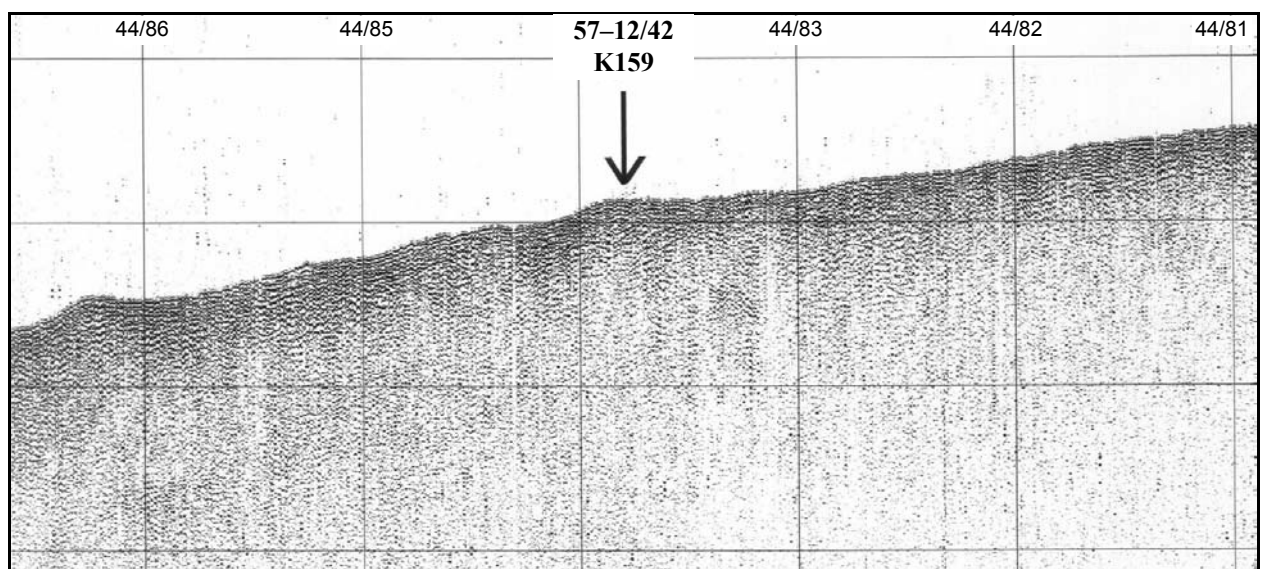


LINE 92/01-44

AIRGUN

NW

SE



LINE 92/01-44

SPARKER

BGS CORE NO: 57-12/42DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Anton Dohrn

Latitude 57° 25.1272'N **Licence Block** 140/19 **Vessel** James Clark Ross

Longitude 011° 18.1737'W **BGS Plan No** K159 **Station Keeping** DP

Navigation DGPS **Total Depth** 1.78m **Dates of Drilling** 12/08/2001

Map Area Anton Dohrn **Water Depth** 745m **Geologists** P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										NO RECOVERY
	1										
	2										
	3										
	4										
	5										
	6										

SAMPLE 57-14/57

SITE DETAILS

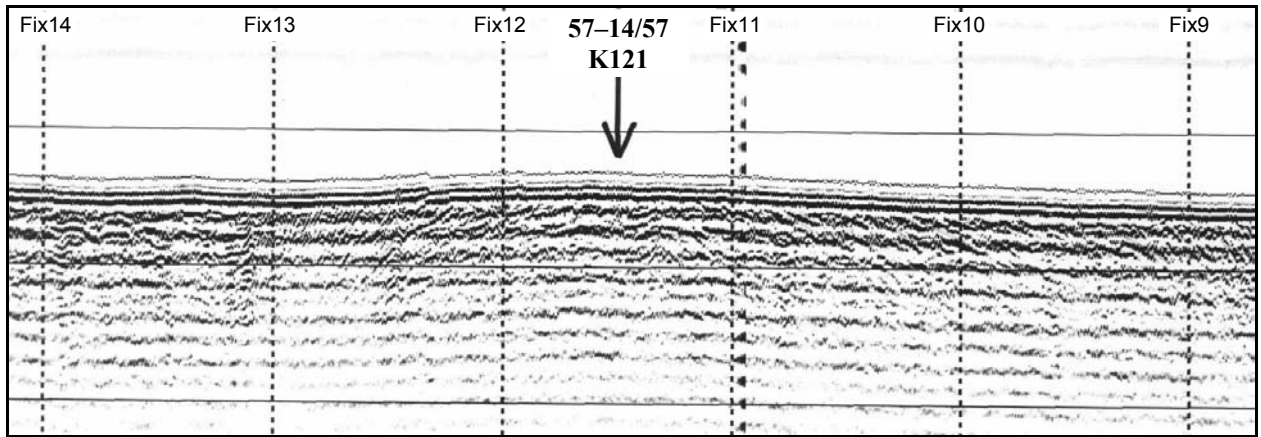
Date of drilling:	13th August 2001
Original site number:	K121
Latitude:	57° 45.481'N
Longitude:	13° 25.290'W
Location:	Rockall Bank
Line and fix number:	00/01-42 11.5
Equipment:	BGS rockdrill
Core length:	0.48m
Lithology:	Gravel and 'alkali basalt'
Age:	?Early Tertiary

SUMMARY

Recovered material comprises pebbles and short cored lengths but these are likely to come from loose boulders on the sea bed. Apart from the top pebble, which is oxidised to a dark reddish brown colour, the material appears to be dark grey aphyric basalt.

NW

SE

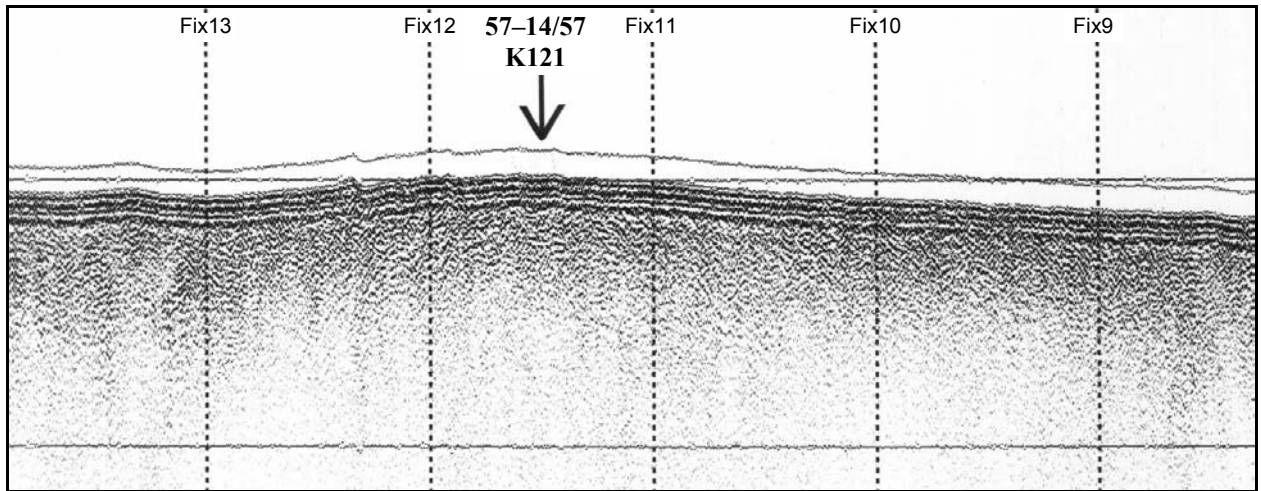


LINE 00/01-42

AIRGUN

NW

SE



LINE 00/01-42

SPARKER

BGS CORE NO: 57-14/57 DR



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude	57° 45.4805'N	Licence Block	138/8	Vessel	James Clark Ross
Longitude	013° 25.2902'W	BGS Plan No	K121	Station Keeping	DP
Navigation	DGPS	Total Depth	1.33m (Rec. 0.48m)	Dates of Drilling	13/08/2001
Map Area	Rockall Island	Water Depth	150m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0							TS 0.38m IGChem 0.42m		<p>SURFICIAL DEPOSIT ON SEABED (DARK GREY APHYRIC BASALT)</p> <p>Section consists of a collection of 15 pebbles and 2 cobbles. Pebbles range from 2-6 cm in size and are weathered on all surfaces. Two cobbles are large enough to have some cored outer surfaces, but still have weathered surfaces retained. The largest cobble (14cm long) has encrusting coral on one side (the apparent bottom). The top pebble of the core is oxidised to a dark reddish brown and encrusted by assorted biota on all sides.</p> <p>The lithology of the pebbles is predominantly dark grey, aphyric basalt. A pale blue, slightly translucent mineral, probably a zeolite replacing plagioclase, is present on the outer surfaces of some pieces, suggesting alteration of groundmass. Small patches, up to 1 cm in size, which appear to have a greater concentration of felsic minerals, may either be an artifact of alteration or an indication of assimilation of some crustal material. Interior of cut pieces appear quite fresh, plagioclase rich (i.e. this is probably an evolved rock) although the mafic phases appear to be altered to Fe-oxyhydroxides.</p>
	1									
	2									
	3									
	4									
	5									
	6									



PETROLOGY OF SAMPLE 57-14/57

Emrys Phillips

Registered number: N3747

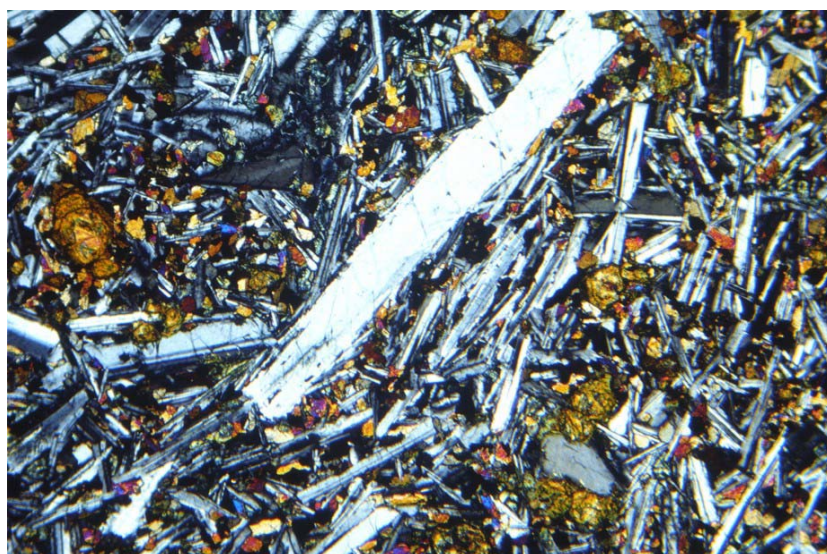
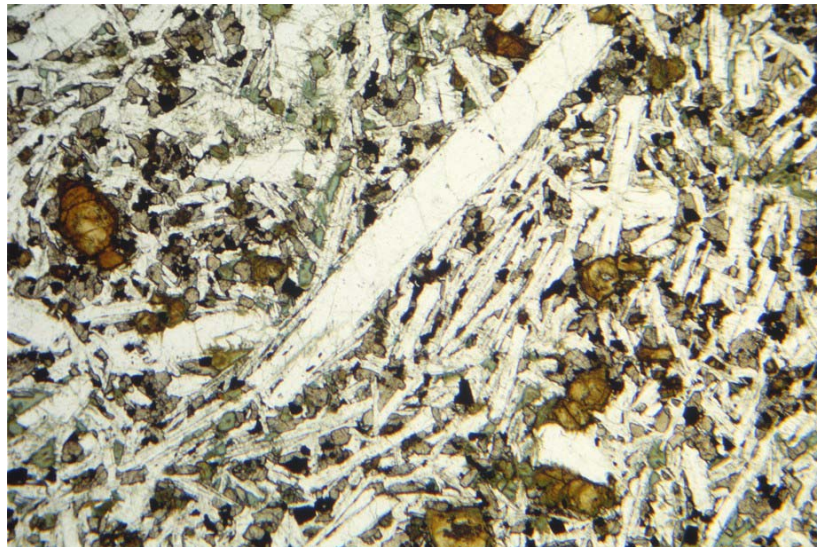
Thin section from 0.38m depth.

Rock Type: weakly pilotaxitic olivine-plagioclase microporphyritic alkali basalt

Mineralogy: major – plagioclase, clinopyroxene, olivine
minor – opaque minerals, apatite
alteration – chlorite, bowlingite, iddingsite

Photomicrographs:

Photomicrographs of an olivine-plagioclase porphyritic alkali basalt (N3747), plane and crossed polarised light.



Description: This thin section is of a fine- to medium-grained, inequigranular, hypocrystalline, microporphyritic to weakly macroporphyritic alkali basalt which possesses a weakly developed pilotaxitic fabric. The phenocrysts are mainly composed of plagioclase with pseudomorphs after

finer-grained olivine. Plagioclase forms twinned, anhedral lath-shaped crystals which possess a variably developed zonation. Feldspar phenocrysts range up to 3.5 to 4.0 mm in length, but are typically much finer grained (≤ 1.5 mm). Plagioclase phenocrysts are variably aligned parallel to and partially define a weakly developed pilotaxitic fabric. The finer grained plagioclase phenocrysts grade into the groundmass resulting in a crude seriate texture. The larger plagioclase phenocrysts may contain small inclusions of opaque minerals, clinopyroxene and rare olivine. Anhedral, rounded to irregular olivine microphenocrysts are completely pseudomorphed by a green to honey yellow-brown cryptocrystalline assemblage of chlorite, bowlingite and iddingsite.

The groundmass is mainly composed of variably aligned plagioclase laths and interstitial, granular clinopyroxene. The remaining interstitial to intersertal areas are filled by cryptocrystalline chlorite; possibly replacing original glass. Minor olivine present within the groundmass has largely been replaced by chlorite, bowlingite and iddingsite. However, traces of relict olivine have been noted. Clinopyroxene is brown-grey in colour and forms anhedral, granular crystals. Accessory apatite forms elongate needle-shaped crystals which are typically included within plagioclase.

SAMPLE 57-14/58

SITE DETAILS

Date of drilling:	13th August 2001
Original site number:	K46
Latitude:	57° 39.858'N
Longitude:	13° 36.882'W
Location:	Rockall Bank
Line and fix number:	00/01-1 8.8
Equipment:	BGS rockdrill
Core length:	1.81m
Lithology:	Weakly altered/metamorphosed gabbro
Age:	?

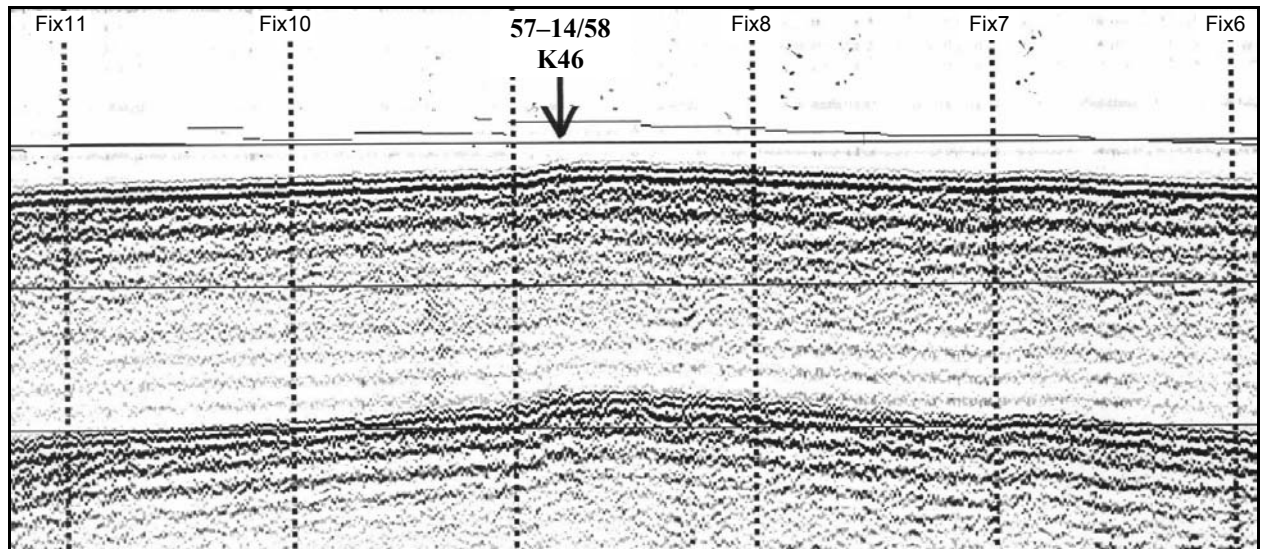
SUMMARY

This site is approximately 9km NNE of Rockall Island. There was excellent recovery of solid core although shipboard inspection could not conclude whether the rock was igneous or metamorphic (or metamorphosed igneous).

Subsequent thin section analysis suggests the rock is gabbroic with primary mineralogy being clinopyroxene and plagioclase (altered to chlorite and epidote).

NW

SE

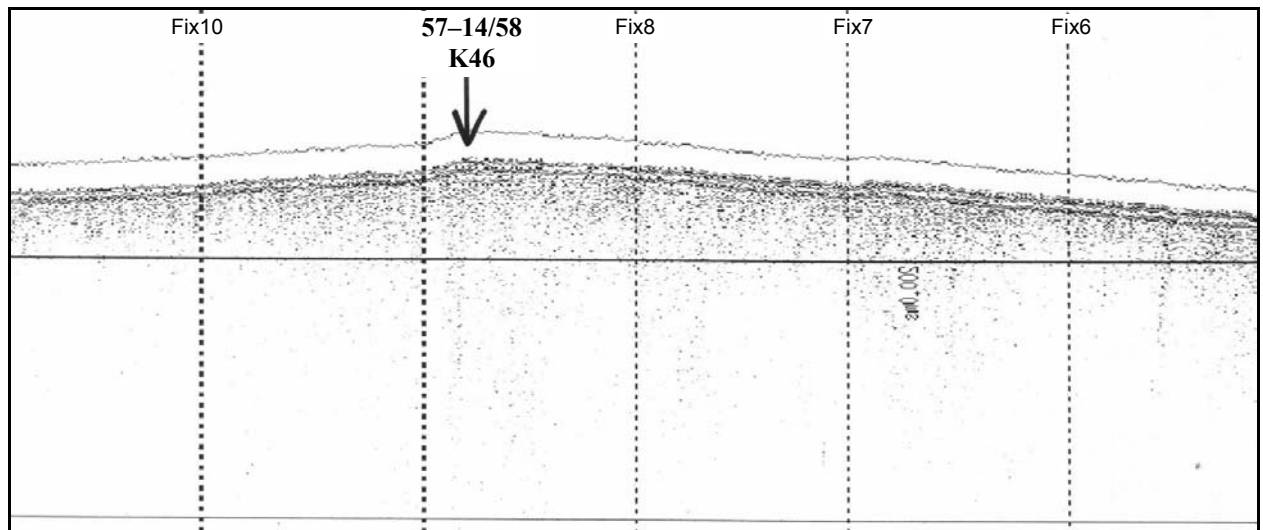


LINE 00/01-1

AIRGUN

NW

SE



LINE 00/01-1

SPARKER



PETROLOGY OF SAMPLE 57-14/58

Emrys Phillips

Registered number: N3719

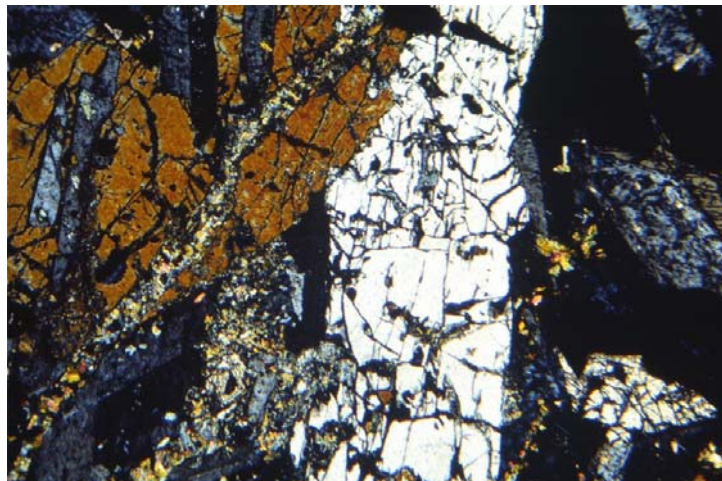
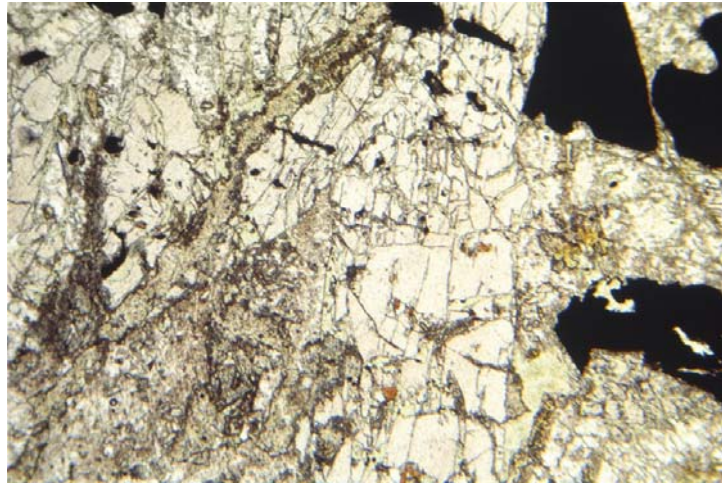
Thin section from 0.79-0.83m depth.

Rock Type: weakly altered/metamorphosed gabbro

Mineralogy: major – plagioclase, clinopyroxene
minor – opaque minerals, apatite, amphibole, biotite
alteration – epidote, clinozoisite, carbonate, quartz, chlorite, sericite, opaque oxides, clay minerals, titanite, leucoxene

Photomicrographs:

Photomicrographs of altered gabbro (N3719), plane and crossed polarised light.



Description: This thin section is of a coarse- to very coarse-grained (average grain size 2.0 to 3.0 mm), inequigranular, anhedral granular, weakly foliated to massive, holocrystalline gabbro. The rock is mainly composed of anhedral to very weakly subhedral, elongate to lath-shaped plagioclase crystals (1.0 to 2.5 mm in length). Plagioclase forms a relatively dense crystal framework of locally shape-aligned crystals which are linked by later irregular feldspar (also

plagioclase) overgrowths. It is twinned and forms simply zoned crystals which are variably replaced by anhedral to skeletal, poikiloblastic epidote (\pm carbonate, white mica and chlorite). Clinzoisite is colourless to pale yellow with a variably developed anomalous blue interference colour. Plagioclase may also exhibit a dusty appearance in plane polarised light due to minor alteration to sericitic white mica and/or clay minerals. The interstitial areas to this primocryst framework are mainly filled by coarse-grained, anhedral, pale brown clinopyroxene. Pyroxene is sub-ophitic and forms elongate crystals which range up to 6.0 mm in length.

Rod-like to irregular opaque minerals occur intergranular to plagioclase and are included within and, therefore, pre-date the crystallisation of pyroxene. These primary opaque minerals are variably altered to leucoxene and may be rimmed by titanite. Minor interstitial apatite and plagioclase are also present within this gabbro. The remaining interstitial to intersertal areas are filled by very fine-grained to cryptocrystalline chlorite (\pm carbonate) and fine-grained, granular clinzoisite. Traces of possible red-brown piedmontite have also been recognised forming rims upon some of the opaque minerals. Accessory red-brown biotite and amphibole (possibly ?kaersutite) are present within this gabbroic rock and are included within clinopyroxene. Trace to rare chalcedonic to cryptocrystalline quartz occurs as fine, radial fibrous crystals. Chloritic (\pm epidote) alteration has largely focused upon the interstitial areas/phases.

GEOCHEMICAL DATA FOR SAMPLE 57-14/58

Sample name	Depth	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃ t	Mn ₃ O ₄	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃	Cr ₂ O ₃	SrO	ZrO ₂	BaO	NiO	CuO	ZnO	PbO	LOI	Total	
	(metres)	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
57-14/58	0.43-0.78	46.77	4.47	15.72	12.35	0.22	3.80	9.06	4.15	0.78	0.36	<0.1	<0.01	0.06	0.02	0.06	<0.01	<0.01	0.01	<0.01	1.68	99.51	

XRFS Data		Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Rb	Sr	Zr	Mo	Ag	Cd	Sn	Sb	Te	Ba	W	Tl	Pb	Bi	
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
57-14/58	0.43-0.78	34	209	28	26	3	16	92	22	2	<1	<1	<1	17	528	172	<1	<1	<1	2	1	<1	464	<1	<1	3	2	

ICP-MS Data		Y	Nb	Cs	La	Ce	Pr	Nd	Sm	Eu	Tb	Gd	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U	
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
57-14/58	0.43-0.78	34.4	7.9	0.2	11.6	31.8	4.87	24.7	6.67	2.47	1.13	7.51	7.00	1.39	3.73	0.53	3.21	0.50	4.9	0.6	0.9	0.35	

SAMPLE 57-14/59

SITE DETAILS

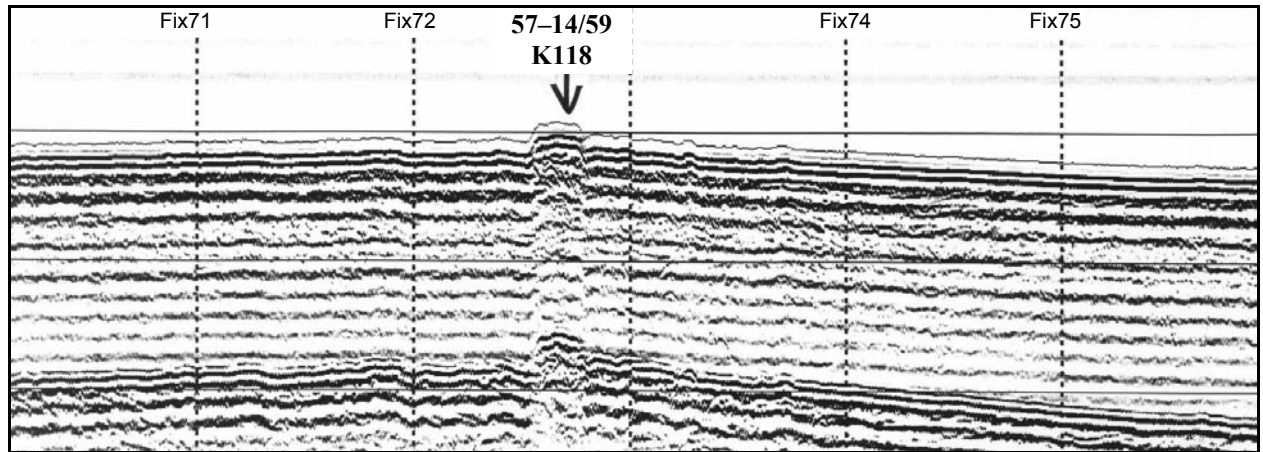
Date of drilling: 13th August 2001
Original site number: K118
Latitude: 57° 33.34'N
Longitude: 13° 51.40'W
Location: Rockall Bank
Line and fix number: 00/01-41 72.7
Equipment: BGS rockdrill
Core length: 0.13m
Lithology: Alkali basalt
Age: ?Early Tertiary

SUMMARY

A very short length of fine-grained, dark grey basaltic rock was recovered, possibly from a boulder.

SW

NE

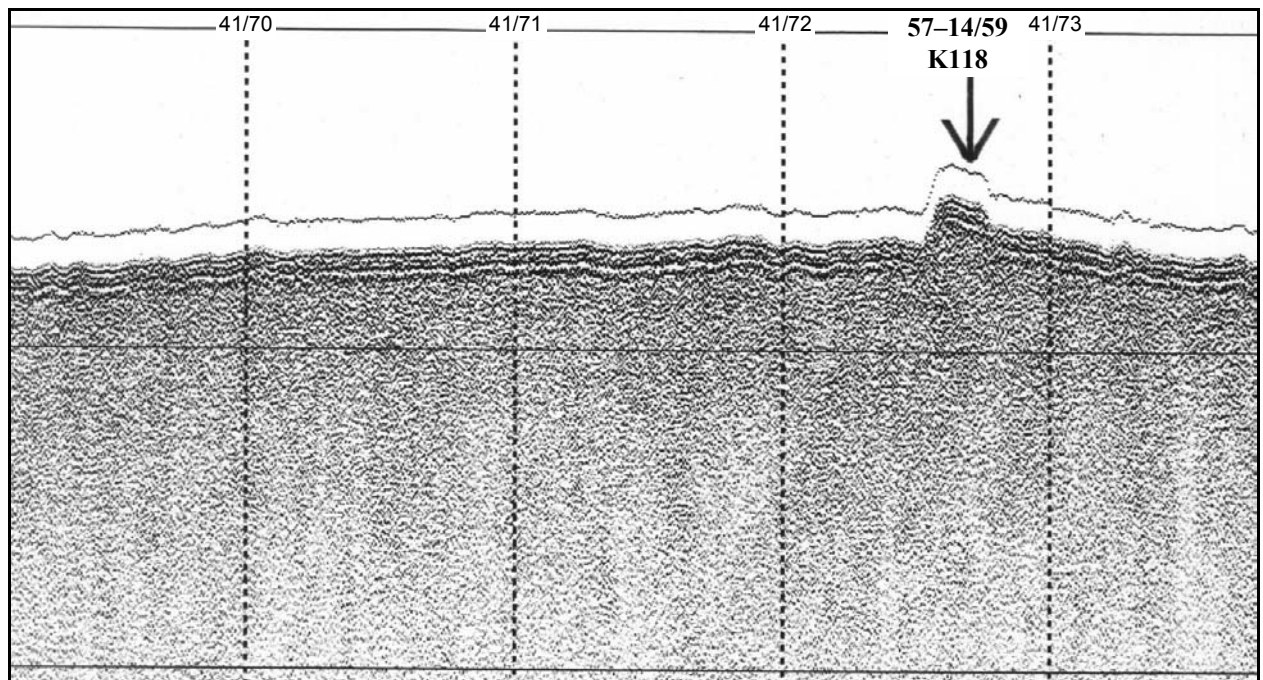


LINE 00/01-41

AIRGUN

SW

NE



LINE 00/01-41

SPARKER

BGS CORE NO: 57-14/59DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude	57° 38.34'N	Licence Block	138/11	Vessel	James Clark Ross
Longitude	13° 51.40'W	BGS Plan No	K118	Station Keeping	DP
Navigation	DGPS	Total Depth	0.96m (Rec. 0.13m)	Dates of Drilling	13/08/2001
Map Area	Rockall Island	Water Depth	116m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0	M M M M	0 50					IGChem 0.02m TS 0.05m		<p>SPARSELY PLAGIOCLASE PHYRIC BASALT</p> <p>Dark grey, fine grained, sparsely plagioclase phyric basalt. Plagioclase laths up to 1.2 cm in size; constitute less than 2% of the mode. Most contain melt inclusions.</p> <p>At 0.07-0.13 m, 1-mm-wide calcite veins, lined with chlorite, crosscut the core with a subvertical orientation.</p>
	1									
	2									
	3									
	4									
	5									
	6									



PETROLOGY OF SAMPLE 57-14/59

Emrys Phillips

Registered number: N3748

Thin section from 0.05m depth.

Rock Type: plagioclase macroporphyritic alkali basalt

Mineralogy: major – plagioclase, Ti-augite
minor – opaque minerals
alteration – chlorite, bowlingite, sericite, opaque oxides, clay minerals, carbonate, amphibole, epidote, titanite, leucoxene

Description: This thin section is of a fine-grained, hypocrystalline, inequigranular, macroporphyritic, massive, anhedral granular alkali basalt which contains pale pink-brown Ti-augite. The phenocrysts are mainly composed of randomly orientated, euhedral to subhedral plagioclase laths which range up to 5.5 to 6.0 mm in size. These plagioclase phenocrysts occur as single crystals and as clusters of several slightly finer grains microphenocrysts. Plagioclase is twinned and forms elongate to prismatic crystals which show minor alteration to chlorite and/or sericitic white mica along fractures. The larger crystals may also possess a distinct sieve textured core which contains very small, rounded to worm-like inclusions of altered glass. Plagioclase may possess a dusty appearance under plane polarised light due to secondary alteration to clay minerals. Rare chlorite (\pm opaque oxide) pseudomorphs after possible olivine microphenocrysts (≤ 1.0 mm in diameter) were also recorded within this alkali basalt.

The anhedral granular groundmass to this basalt is composed of an open crystal framework of plagioclase laths with interstitial, locally sub-ophitic Ti-augite granular opaque minerals and feldspar. Augite forms anhedral, elongate to granular looking crystals which exhibit minor alteration to pale green chlorite along fractures. The remaining interstitial areas are composed of a very fine-grained to cryptocrystalline assemblage of chlorite, bowlingite and serpentine. These secondary minerals are probably mainly replacing original interstitial to intersertal glass. However, occasional pseudomorphs after olivine are also present within the groundmass. Primary opaque minerals form anhedral to subhedral equant to rods-shaped crystals which may exhibit alteration to leucoxene and/or titanite. Traces of possible secondary actinolitic amphibole and epidote have also been noted associated with the alteration/hydration of primary ferromagnesian minerals.

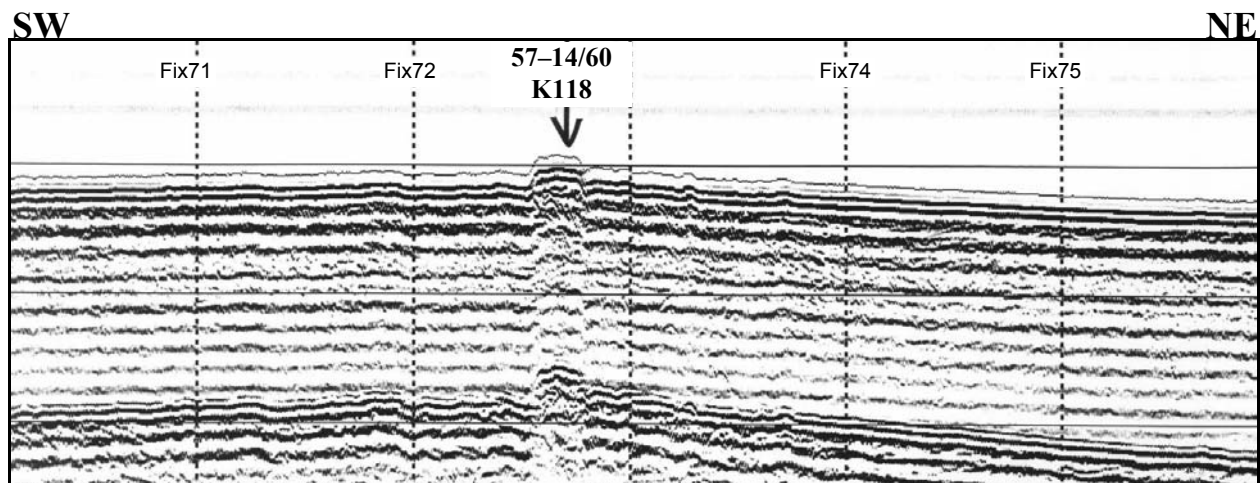
SAMPLE 57-14/60

SITE DETAILS

Date of drilling: 13th August 2001
Original site number: K118
Latitude: 57° 33.34'N
Longitude: 13° 51.40'W
Location: Rockall Bank
Line and fix number: 00/01-41 72.7
Equipment: BGS rockdrill
Core length: 0.31m
Lithology: Basalt cobbles
Age: ?Early Tertiary

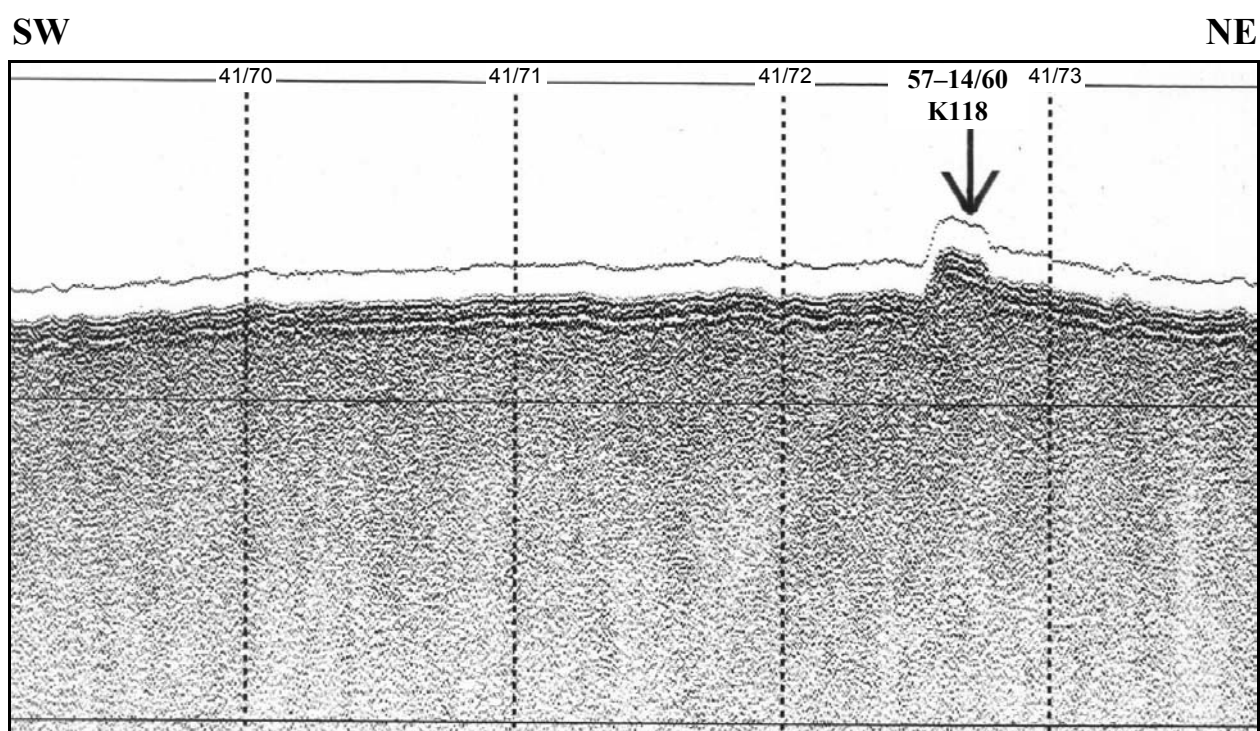
SUMMARY

This was the second attempt at this site. Recovery was little better, comprising cobbles and very short 5cm long core lengths of plagioclase-phyric basalt.



LINE 00/01-41

AIRGUN



LINE 00/01-41

SPARKER

BGS CORE NO: 57-14/60DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	57° 38.34'N	Licence Block	138/11
Longitude	013° 51.40'W	BGS Plan No	K118
Navigation	DGPS	Total Depth	1.03m (Rec. 0.31m)
Map Area	Rockall Island	Water Depth	116m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	13/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0	M M M M M M M M M M M M								<p>SPARSELY PLAGIOCLASE PHYRIC BASALT</p> <p>Recovery consists of a number of pebble-size fragments from 0.00 to 0.15 m, plus 3 cored pieces ~5 cm long each. The outer surfaces of these pieces were badly scored by the drill bit.</p> <p>Lithologically, the rocks are dark grey, fine grained sparsely plagioclase phyric basalt identical to that recovered at 57-14/59DR. Plagioclase phenocrysts, less than 2% of the mode, range up to 1.5 cm in length.</p> <p>Calcite partially coats the surfaces of fractures (i.e. pieces now broken along those fractures).</p>
	1									
	2									
	3									
	4									
	5									
	6									



SAMPLE 57-14/61

SITE DETAILS

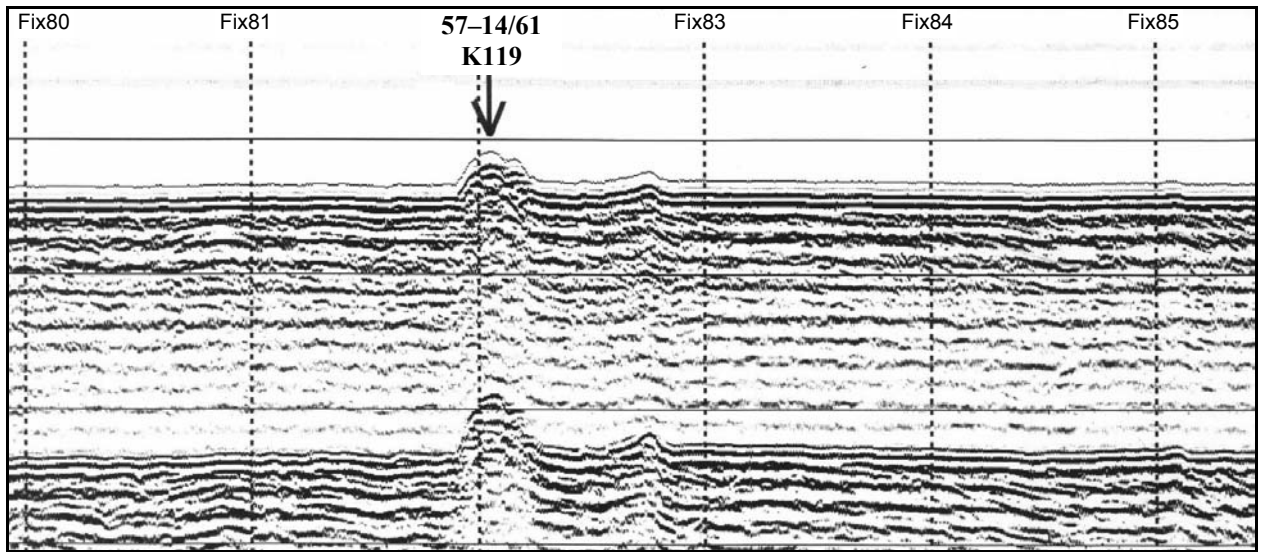
Date of drilling: 13th August 2001
Original site number: K119
Latitude: 57° 44.36'N
Longitude: 13° 44.25'W
Location: Rockall Bank
Line and fix number: 00/01-41 82.05
Equipment: BGS rockdrill
Core length: 0.00m
Lithology:
Age:

SUMMARY

Nil recovery.

SW

NE

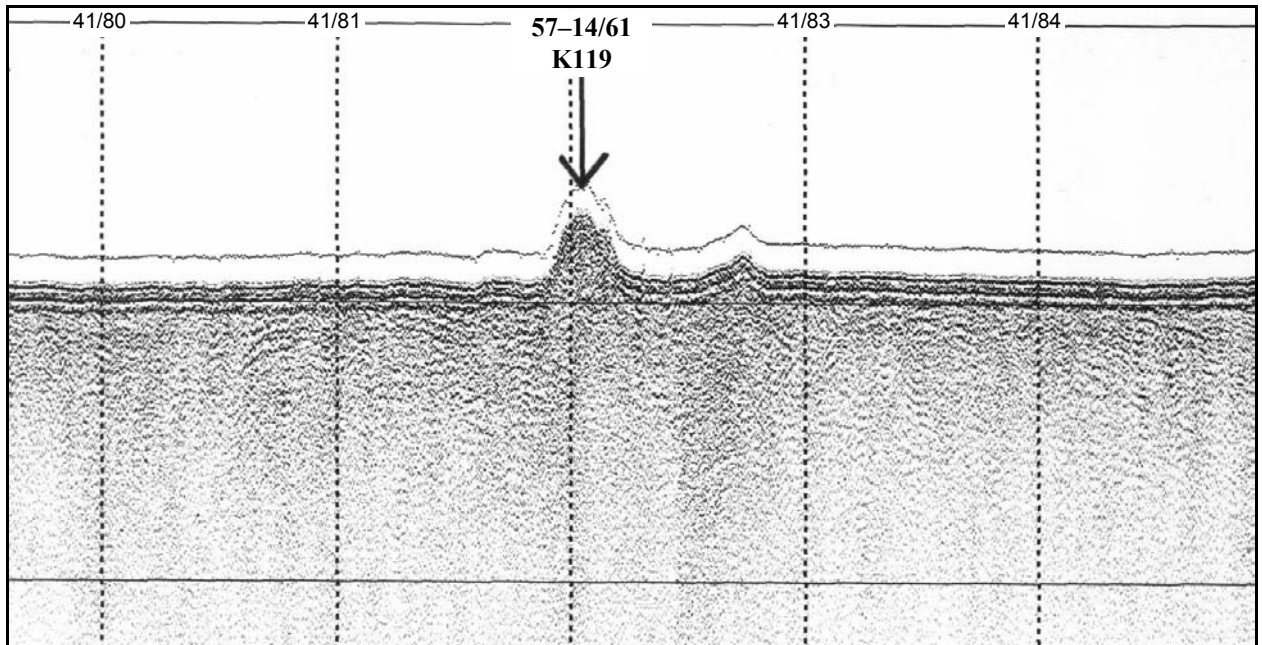


LINE 00/01-41

AIRGUN

SW

NE



LINE 00/01-41

SPARKER

BGS CORE NO: 57-14/61DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

Rockall Bank

Latitude	57° 44.36'N	Licence Block	138/7	Vessel	James Clark Ross
Longitude	013° 44.25'W	BGS Plan No	K119	Station Keeping	DP
Navigation	DGPS	Total Depth	0m	Dates of Drilling	13/08/2001
Map Area	Rockall Island	Water Depth	128m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0									NO RECOVERY
	1									
	2									
	3									
	4									
	5									
	6									

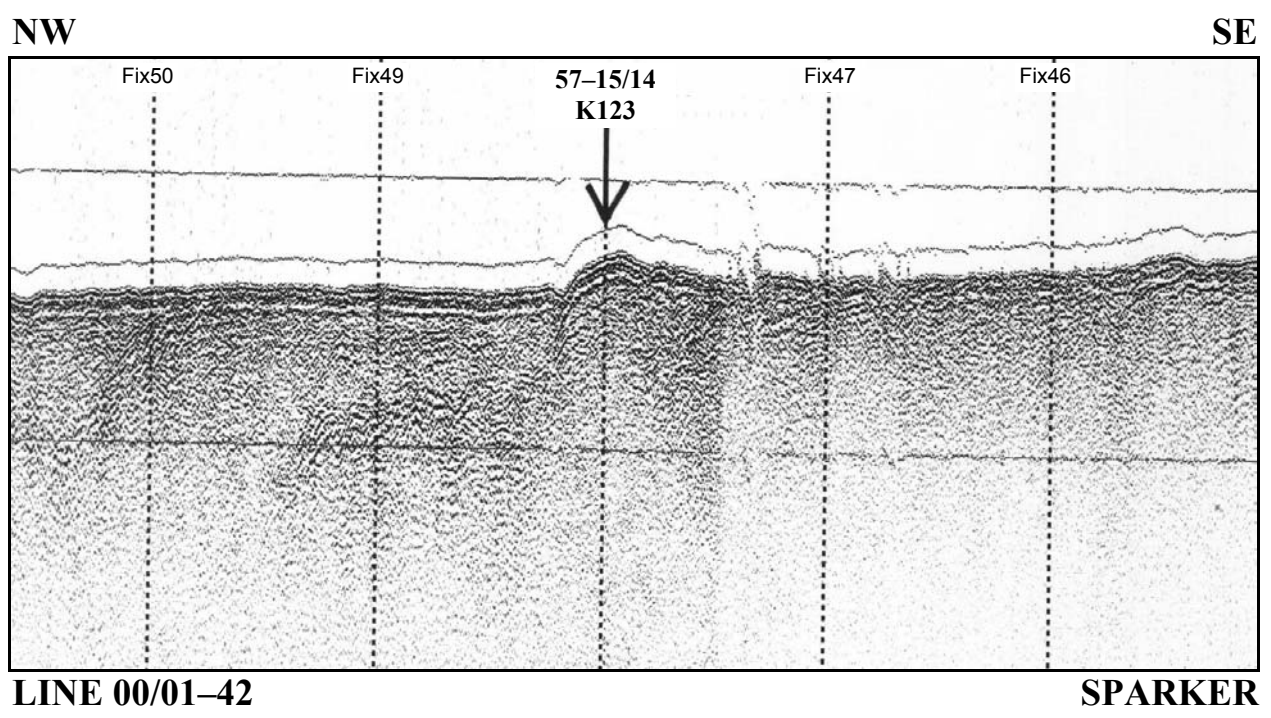
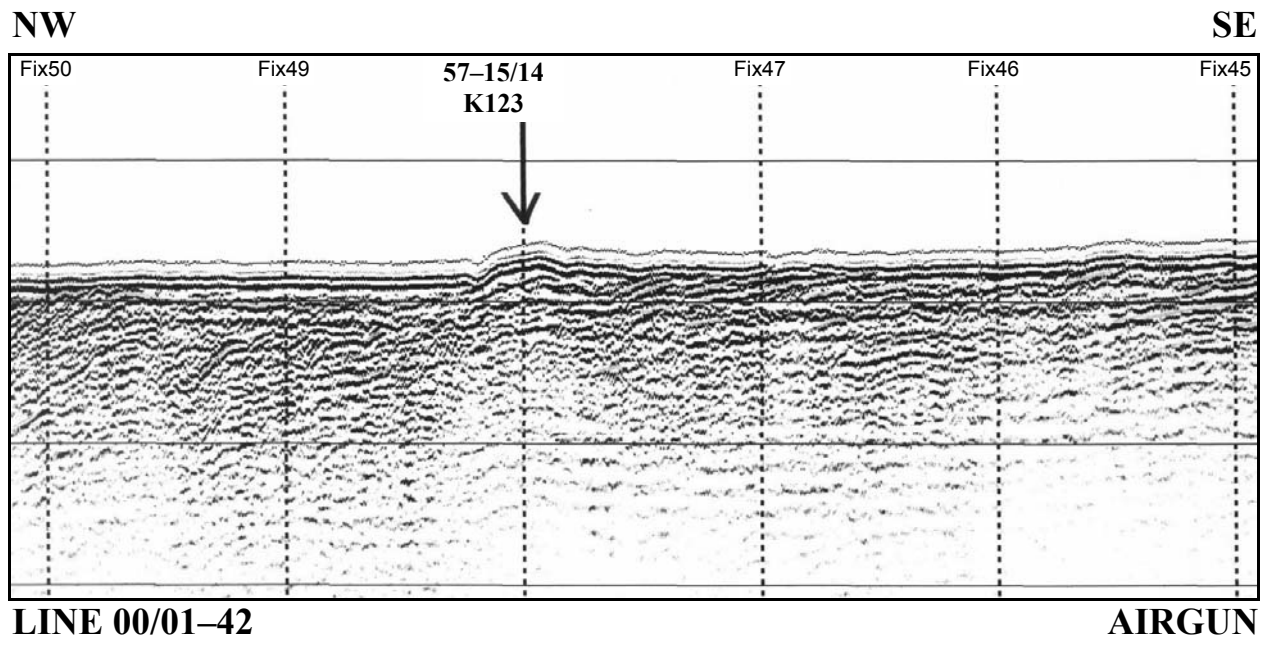
SAMPLE 57-15/14

SITE DETAILS

Date of drilling: 14th August 2001
Original site number: K123
Latitude: 57° 59.573'N
Longitude: 14° 06.792'W
Location: Rockall Bank
Line and fix number: 00/01-42 48.0
Equipment: BGS rockdrill
Core length: 0.00m
Lithology:
Age:

SUMMARY

Nil recovery.



BGS CORE NO: 57-15/14DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude	57° 59.573'N	Licence Block	137/5	Vessel	James Clark Ross
Longitude	014° 06.792'W	BGS Plan No	K123	Station Keeping	DP
Navigation	DGPS	Total Depth	0.95m (Rec. 0m)	Dates of Drilling	14/08/2001
Map Area		Water Depth	250m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										NO RECOVERY
	1										
	2										
	3										
	4										
	5										
	6										

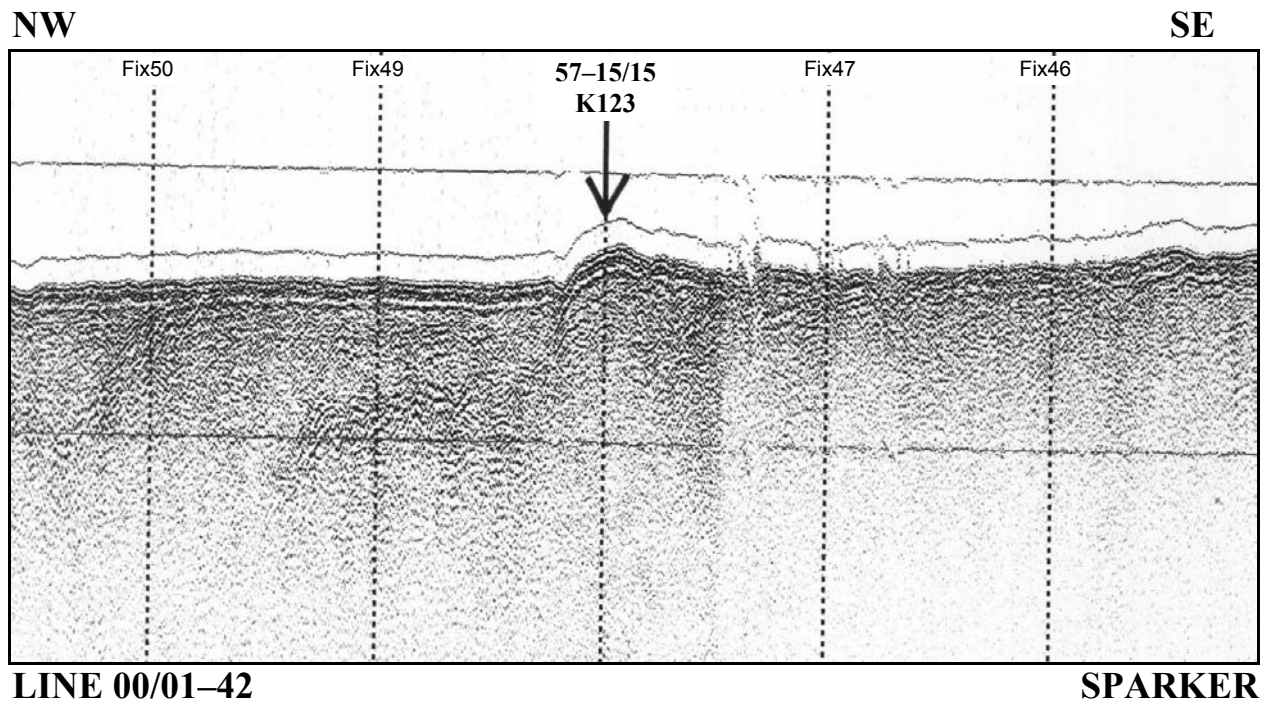
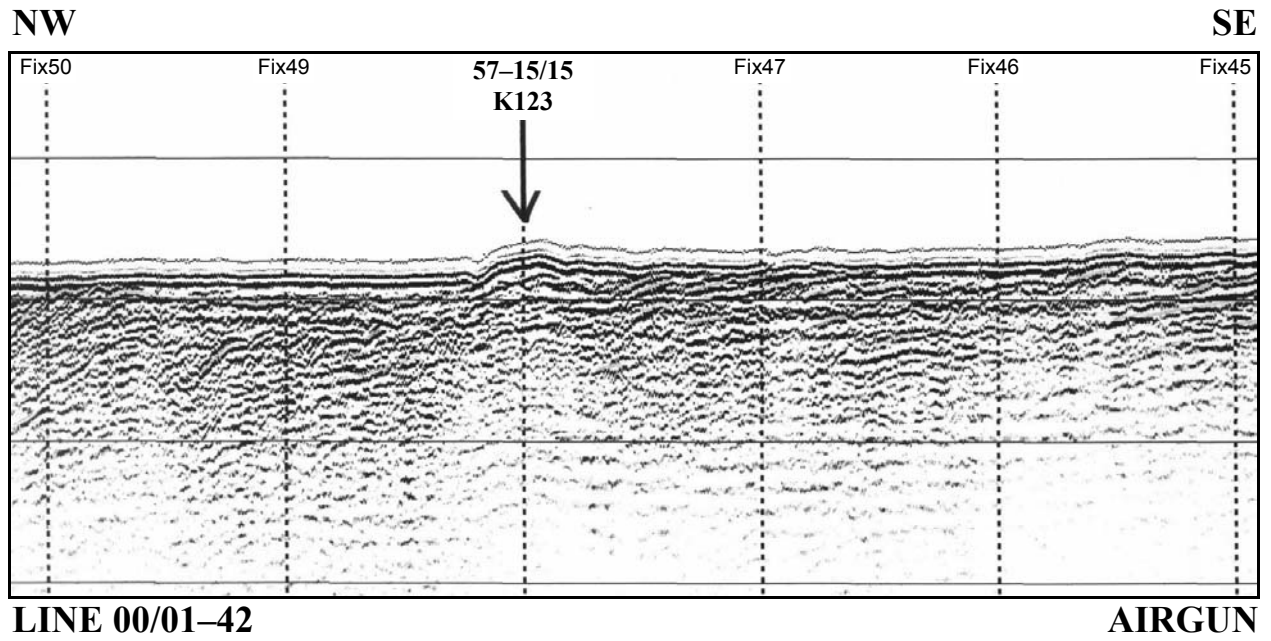
SAMPLE 57-15/15

SITE DETAILS

Date of drilling:	14th August 2001
Original site number:	K123
Latitude:	57° 59.57'N
Longitude:	14° 06.79'W
Location:	Rockall Bank
Line and fix number:	00/01-42 48.0
Equipment:	BGS rockdrill
Core length:	0.59m
Lithology:	Trachyandesite
Age:	?Early Tertiary

SUMMARY

This was the second attempt at this site. Fine-grained, dark grey aphyric trachyandesite was recovered notable for its non-weathered appearance.



BGS CORE NO: 57-15/15DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude	57° 59.57'N	Licence Block	137/5	Vessel	James Clark Ross
Longitude	014° 06.79'W	BGS Plan No	K123	Station Keeping	DP
Navigation	DGPS	Total Depth	1.28m (Rec. 0.59m)	Dates of Drilling	14/08/2001
Map Area		Water Depth	250m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0	M M M M M M M M M M M M M M M M M M M M						IGChem 0.19m TS 0.24m		APHYRIC BASALT Section consists of dark grey, fine grained aphyric basalt.
	1									0.00-0.10 m: rounded basaltic pebbles with slightly altered outer surfaces. Top most pebble in core has a thin film of buff coloured, sandy mud; the basalt clast looks slightly oxidised and appears to contain some zeolites (pale blue, translucent mineral) in vesicles/small pockets.
	2									0.10-0.28 m: Cored piece of basalt, now fractured, but probably during drilling, not before, i.e. no evidence of veins or secondary minerals on fracture surfaces. Basalt quite fresh.
	3									0.28-0.34 m: fractured fragments of fresh basalt.
	4									0.34-0.48 m: Cored piece containing some diffuse veins (~1 mm wide) of chlorite + Fe oxyhydroxides.
	5									0.48-0.59 m: fractured fragments of fresh basalt.
	6									



PETROLOGY OF SAMPLE 57-15/15

Emrys Phillips

Registered number: N3749

Thin section from 0.24m depth.

Rock Type: pilotaxitic, fine-grained trachyandesite

Mineralogy: major – feldspar, amphibole
minor – opaque minerals, apatite
alteration – opaque oxides, zeolite

Description: This thin section is of a very fine-grained, pilotaxitic, feldspathic, anhedral granular, hypocrySTALLINE to holocrystalline, inequigranular, aphyric trachyandesitic rock. This rock is mainly composed of closely packed variably shape aligned, anhedral plagioclase laths with the remaining interstitial to intersertal spaces filled by feldspar and zeolite. The zeolite is dusty yellow in colour and forms fine, fibrous crystals. Amphibole forms anhedral, granular crystals which are fractured and may locally possess a weak pleochroism. Opaque minerals present are enclosed within a halo of hematitic stain.

SAMPLE 57-15/16

SITE DETAILS

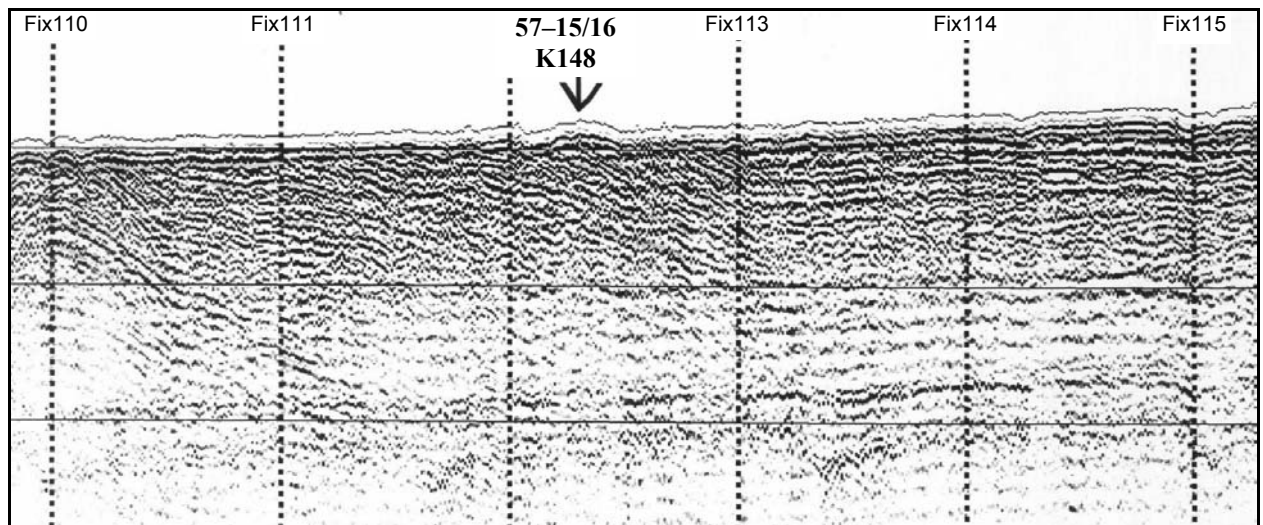
Date of drilling: 14th August 2001
Original site number: K148
Latitude: 57° 57.66'N
Longitude: 14° 16.29'W
Location: Rockall Bank
Line and fix number: 00/01-51 112.3
Equipment: BGS rockdrill
Core length: 0.58m
Lithology: Basalt and gravel
Age:

SUMMARY

Most of the recovered material comprises basaltic pebbles. There is also a short cored length of basalt but none of the material is likely to be *in situ*.

SW

NE

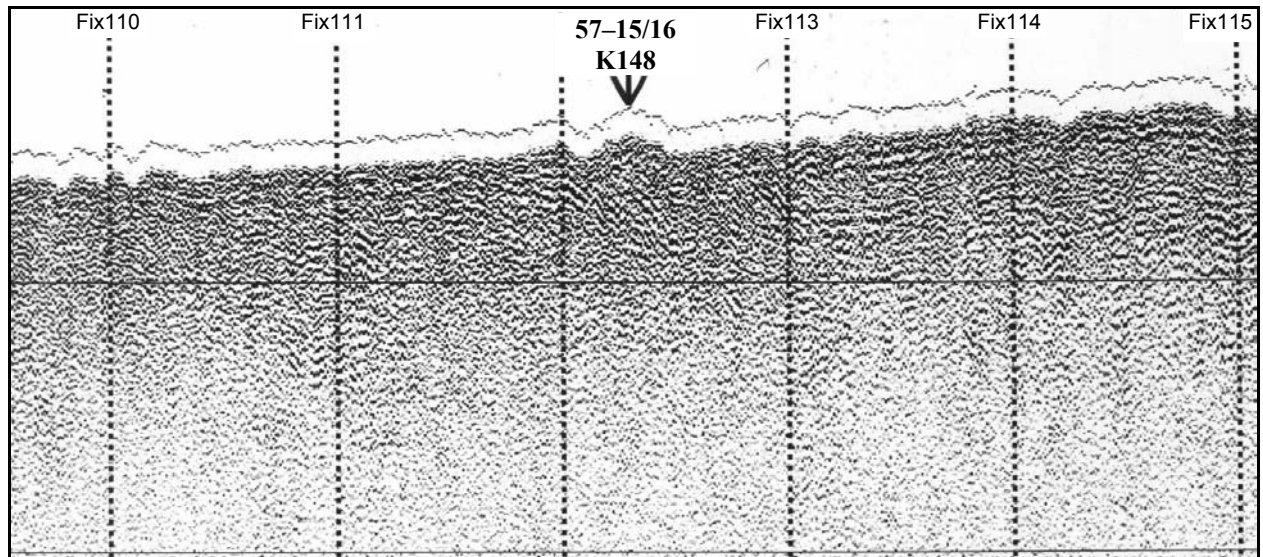


LINE 00/01-51

AIRGUN

SW

NE



LINE 00/01-51

SPARKER

BGS CORE NO: 57-15/16DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position	Rockall Bank		
Latitude	57° 57.66'N	Licence Block	137/4
Longitude	014° 16.29'W	BGS Plan No	K148
Navigation	DGPS	Total Depth	4.86m (Rec. 0.58m)
Map Area		Water Depth	262m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	14/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0									<p>SURFICIAL SEAFLOOR DEPOSIT (PREDOMINANTLY BASALTIC CLASTS)</p> <p>Recovered material appears to be a talus deposit consisting predominantly of basalt clasts.</p> <p>0.00-0.24 m: Pebbles 0.24-0.33 m: Aphyric basalt 0.33-0.58 m: Pebbles</p> <p>Most pebbles range from 1-3 cm in size; 2 are larger at 6 and 10 cm in maximum dimension; both of these have at least partial cored outer surfaces. Similar to 57-15/15DR, the top pebble in the core appears to be oxidised and has pale blue mineral (zeolites) filling small cavities. Below this, the basaltic fragments tend to be less altered.</p> <p>Some surfaces are coated with a sandy, grey mud; the sand particles range from white to black. The white grains are probably quartz, although there is some carbonate in the sediment.</p> <p>At least two basaltic pebbles have botryoidal quartz filling cavities. Two pebbles are small (<1 cm) fragments of a red metamorphic rock; 2 (<1 cm) are biotite gneiss; 2 slightly larger clasts (~2 cm) are altered metamorphic clasts and 2 look like either diabase or an intermediate plutonic igneous rock.</p> <p>There appears to be more than one generation of basalt present, although it's hard to be sure from the small, weathered pebbles. One (including the cored piece) is similar to the grey, fine grained, aphyric basalt of 57-15/15DR. Note that the cored piece of aphyric basalt is crosscut by several diffuse chlorite veins oriented at a high angle to the core vertical. The other "basalt" type seems to have more plagioclase and may be slightly more evolved.</p> <p>Assorted biota present on the outer surfaces of some pieces.</p>
	1									
	2									
	3									
	4									
	5									
	6									

SAMPLE 57-15/17

SITE DETAILS

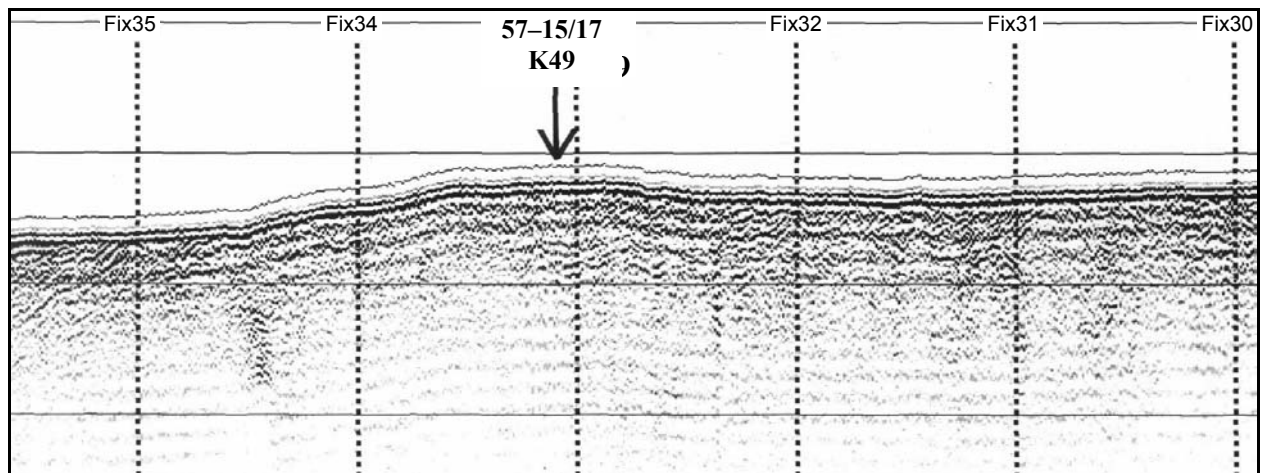
Date of drilling: 15th August 2001
Original site number: K49
Latitude: 57° 49.883'N
Longitude: 14° 9.897'W
Location: Rockall Bank
Line and fix number: 00/01-1 33.1
Equipment: BGS rockdrill
Core length: 0.1m
Lithology: Gravel
Age:

SUMMARY

Only five small pebbles were recovered, four of basaltic aspect, the fifth metamorphic.

NW

SE

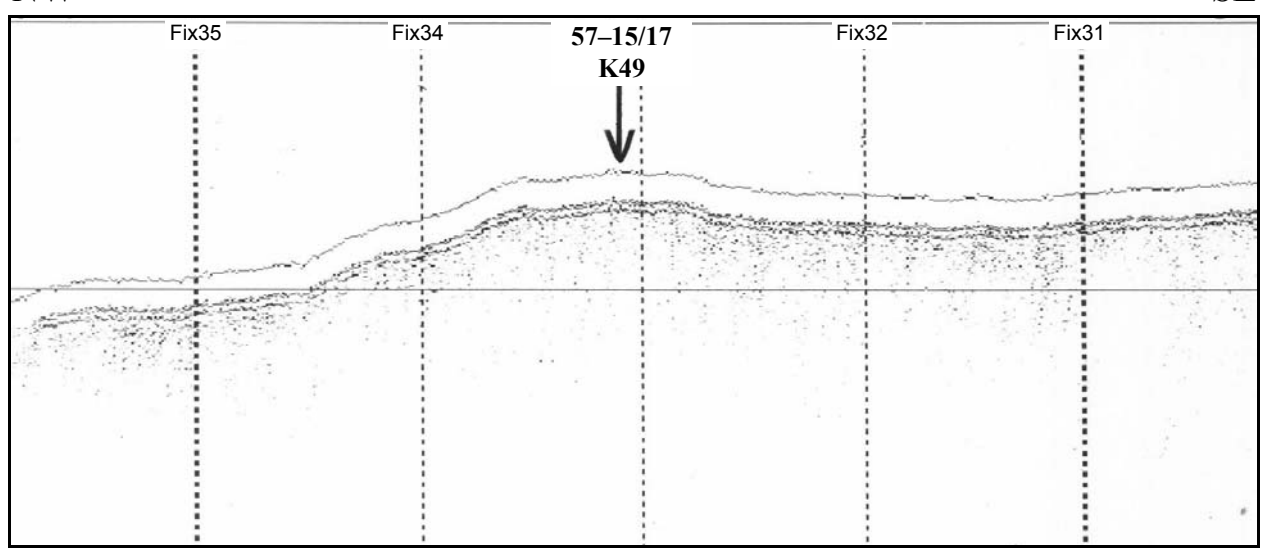


LINE 00/01-1

AIRGUN

NW

SE



LINE 00/01-1

SPARKER

BGS CORE NO: 57-15/17DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	57° 49.883' N	Licence Block	137/10
Longitude	14° 9.897 'W	BGS Plan No	K49
Navigation	DGPS	Total Depth	1.39m
Map Area		Water Depth	201m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	15/08/2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0									<p>SURFICIAL SEAFLOOR DEPOSIT (PREDOMINANTLY BASALT CLASTS)</p> <p>Recovered only five pebbles (2-5 cm in diameter) stuck in the bottom of the barrel.</p> <p>Most pebbles are fine grained aphyric basalts with some alteration and thin calcite veining in one pebble. Some encrusting organisms.</p> <p>One small pebble is coarser grained with quartz, feldspar and mafic minerals. There is some foliation suggesting a metamorphic basement origin.</p> <p>Drilling record suggests pebbles etc to TD.</p>
	1									
	2									
	3									
	4									
	5									
	6									

SAMPLE 57-15/18

SITE DETAILS

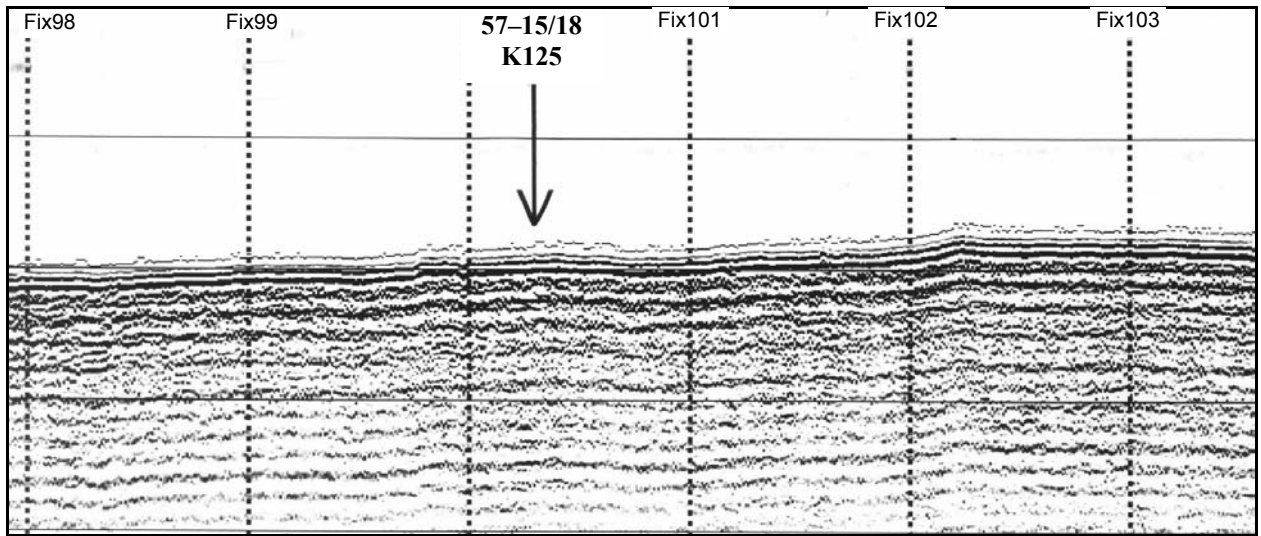
Date of drilling: 15th August 2001
Original site number: K125
Latitude: 57° 37.752'N
Longitude: 14° 11.526'W
Location: Rockall Bank
Line and fix number: 00/01-43 100.3
Equipment: BGS rockdrill
Core length:
Lithology: Gravel
Age:

SUMMARY

Numerous pebbles were recovered, most of basaltic aspect but some metamorphic.

NW

SE

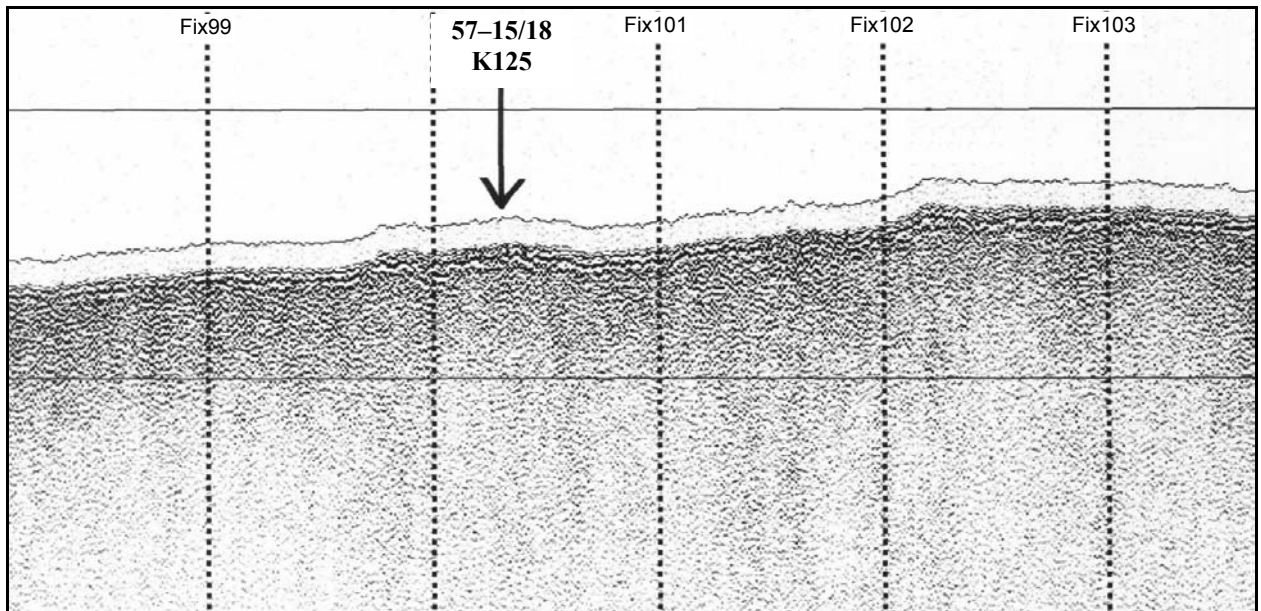


LINE 00/01-43

AIRGUN

NW

SE



LINE 00/01-43

SPARKER

BGS CORE NO: 57/15-18DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	57° 37.752' N	Licence Block	137/15
Longitude	14° 11.526' W	BGS Plan No	K125
Navigation	DGPS	Total Depth	1.25
Map Area		Water Depth	190m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	15.08.2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0	[Patterned area]								<p>SURFICIAL SEAFLOOR DEPOSIT</p> <p>Pebbles, circa 50 recovered, angular to subrounded, equant, 0.5-4 cm diameter.</p> <p>Pebbles are predominantly dark greenish-grey, aphyric and coarser grained basaltic rocks. Many are weathered brown with iron oxides.</p> <p>Several pebbles are brown and appear to include metamorphic, quartz-rich pebbles. The basal pebble is larger than the others and is a very feldspathic metamorphic rock, with quartz, fine mafic minerals and pyrite. Weak foliation and very pale coloured.</p> <p>Many of the pebbles are encrusted with biota, including serpulid worms.</p>
	1									
	2									
	3									
	4									
	5									
	6									

SAMPLE 57-15/19

SITE DETAILS

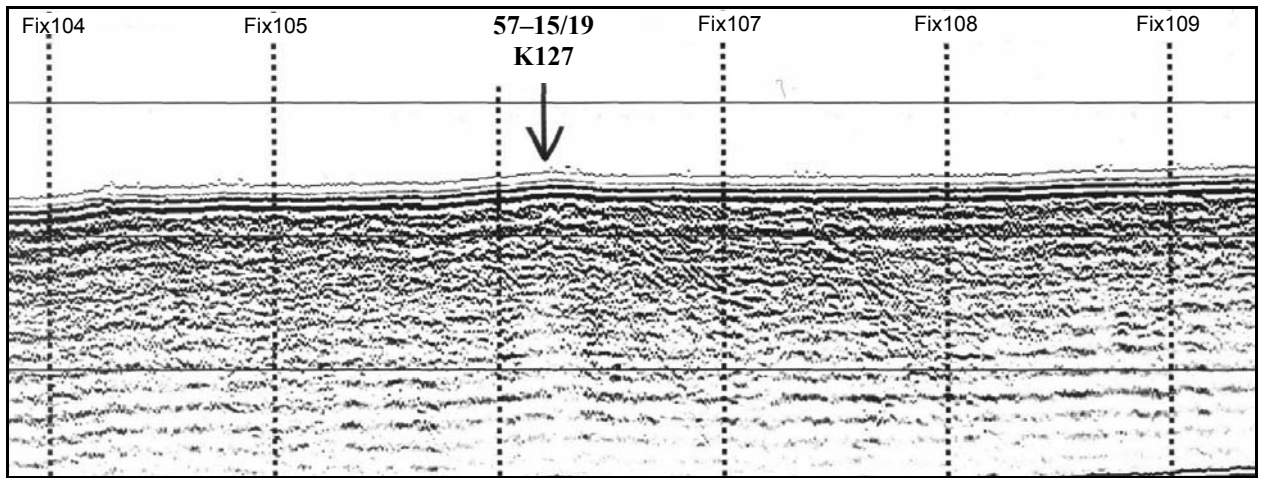
Date of drilling: 15th August 2001
Original site number: K127
Latitude: 57° 35.586'N
Longitude: 14° 4.746'W
Location: Rockall Bank
Line and fix number: 00/01-43 106.2
Equipment: BGS rockdrill
Core length:
Lithology: Gravel
Age:

SUMMARY

Approximately 20 pebbles were recovered, most comprising fine-grained, dark grey basalts.

NW

SE

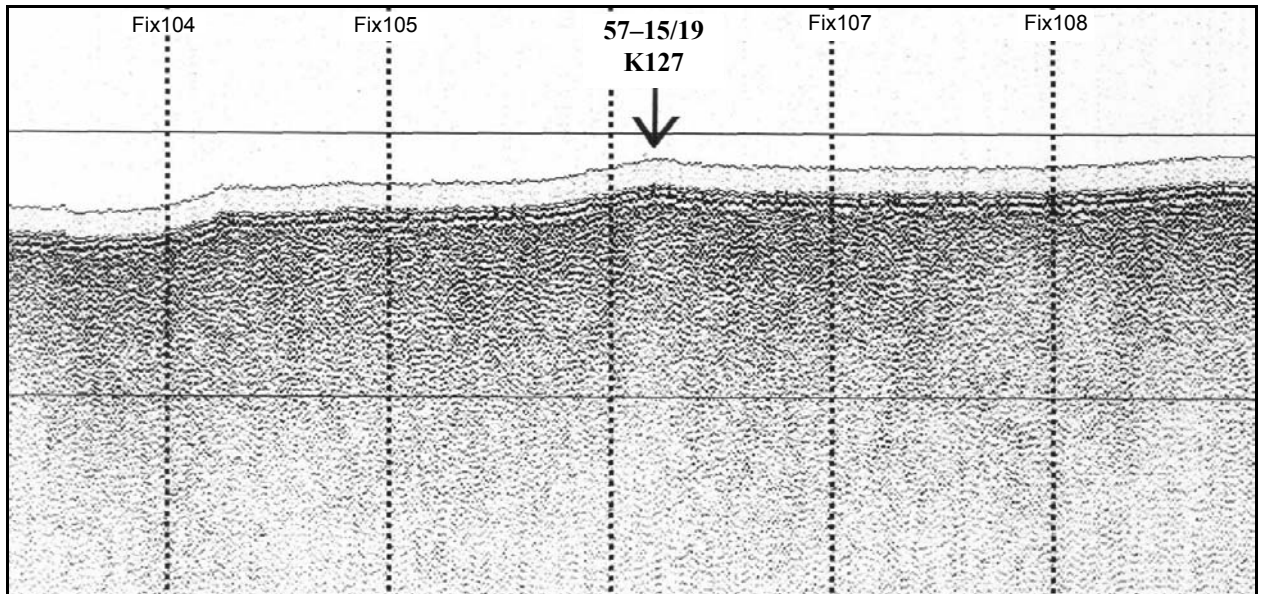


LINE 00/01-43

AIRGUN

NW

SE



LINE 00/01-43

SPARKER

BGS CORE NO: 57/15-19DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	57° 35.586' N	Licence Block	137/15
Longitude	14° 4.746' W	BGS Plan No	K127
Navigation	DGPS	Total Depth	1.01
Map Area		Water Depth	167
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	15.08.2001
		Geologists	R. Gatliff

AGE	DEPTH (M)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0	[Patterned area]									<p>SURFICIAL SEAFLOOR DEPOSIT</p> <p>Pebbles, recovered approx 20 pebbles, subangular to subrounded, 1-4 cm in diameter. Most pebbles very dark, fine grained, basaltic rocks, with feldspar laths and some larger mafic crystals. One pebble is well rounded and greener than the other pebbles. There are two fragments of a very weathered brown-grey rock, which contains more quartz.</p> <p>The largest pebble is much coarser crystalline, with quartz, feldspar and a mafic mineral. This is probably granitic in composition. Foliation is not clear; this pebble was not at the base of the sample.</p> <p>Several pebbles are encrusted with calcite from fauna living at the seabed.</p>
	1										
	2										
	3										
	4										
	5										
	6										

SAMPLE 57-15/20

SITE DETAILS

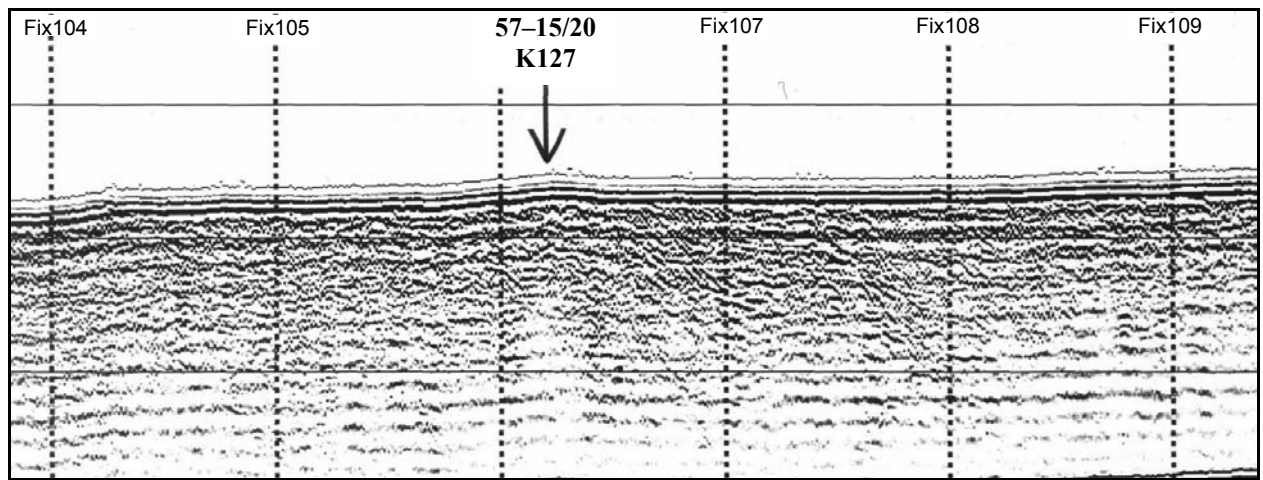
Date of drilling: 15th August 2001
Original site number: K127
Latitude: 57° 35.586'N
Longitude: 14° 4.746'W
Location: Rockall Bank
Line and fix number: 00/01-43 106.2
Equipment: BGS rockdrill
Core length:
Lithology: Gravel
Age:

SUMMARY

This was the second attempt at this site. Eighteen basaltic pebbles were recovered.

NW

SE

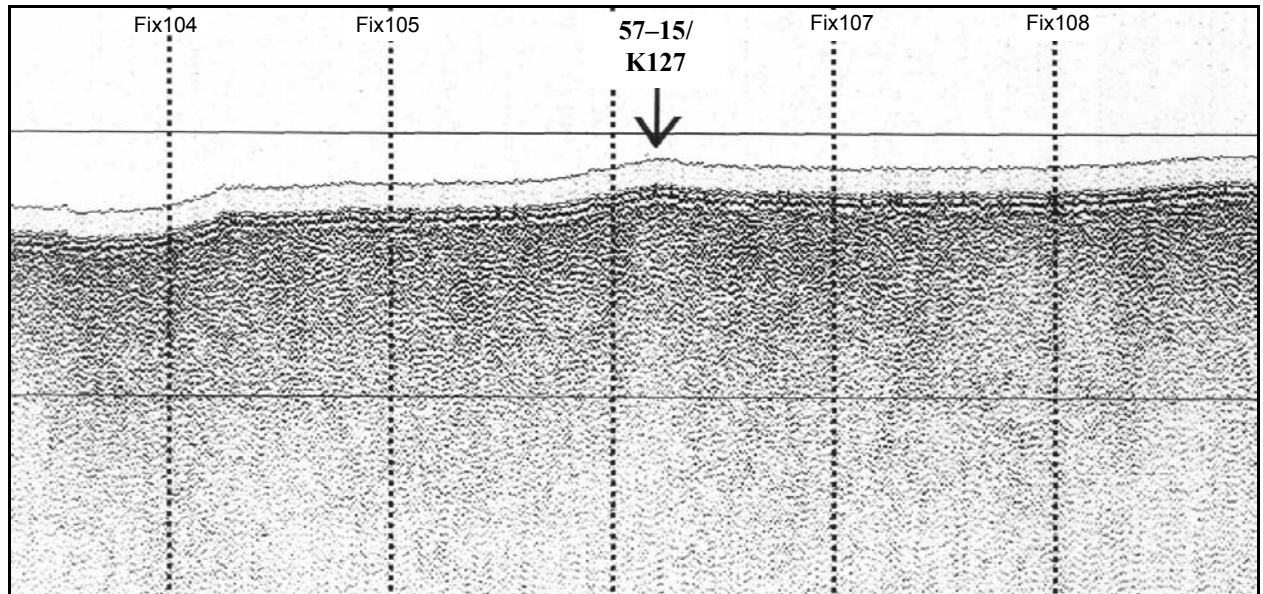


LINE 00/01-43

AIRGUN

NW

SE



LINE 00/01-43

SPARKER

BGS CORE NO: 57-15/20DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude 57° 35.586' N

Licence Block 137/15

Vessel James Clark Ross

Longitude 14° 04.746' W

BGS Plan No K127

Station Keeping DP

Navigation DGPS

Total Depth 1.3 m

Dates of Drilling 15/08/2001

Map Area

Water Depth 167m

Geologists R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	m/s 50							
	0										<p>SURFICIAL SEAFLOOR DEPOSIT (MAINLY BASALT CLASTS)</p> <p>Recovered 18 pebbles, mainly subangular, with 9 pebbles larger than one cm and smaller than 4 cm, and another 9 smaller pebbles. Most are dark, fine grained, basaltic with significant weathering, with yellow-orange and reddish Fe-oxide mineralisation. Two of the smaller fragments are bioclastic fragments.</p> <p>Many grains show evidence of encrusting organisms.</p> <p>The seabed photograph showed pebbles protruding through a relatively flat coating of finer sediment, none of which was recovered.</p>
	1										
	2										
	3										
	4										
	5										
	6										



SAMPLE 57-15/21

SITE DETAILS

Date of drilling: 15th August 2001

Original site number: K130

Latitude: 57° 26.105'N

Longitude: 14° 16.926'W

Location: Rockall Bank

Line and fix number: 00/01-44 25.4

Equipment: BGS rockdrill

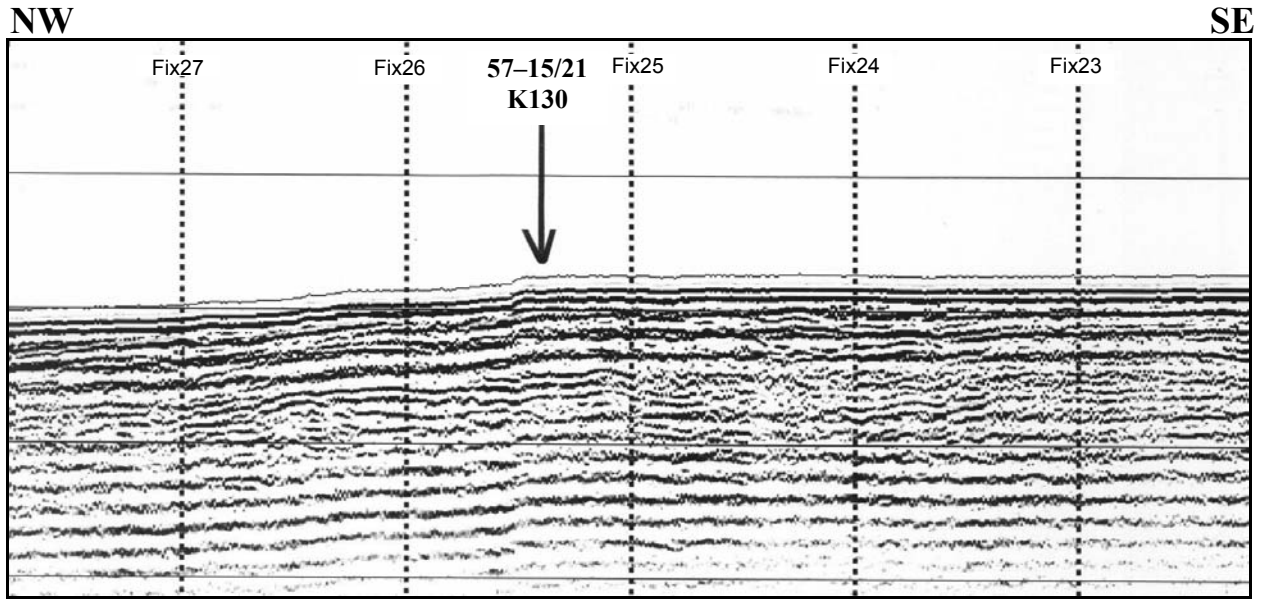
Core length:

Lithology: Basalt gravel

Age:

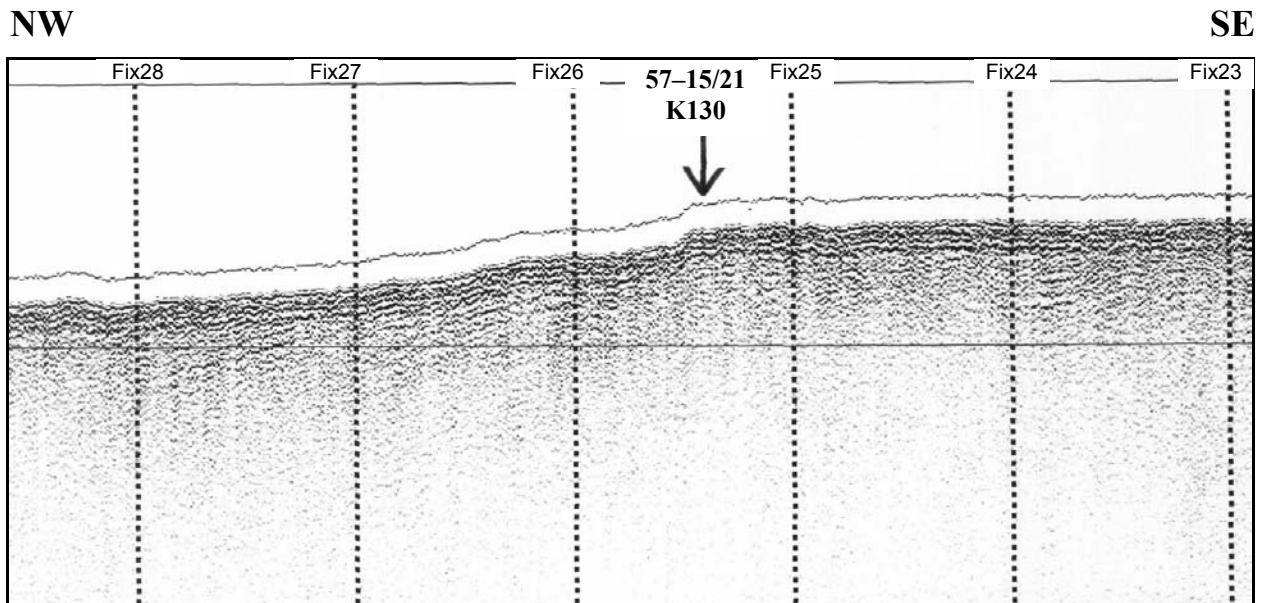
SUMMARY

Recovered material consists of pebbles and cobbles of aphyric basalt.



LINE 00/01-44

AIRGUN



LINE 00/01-44

SPARKER

BGS CORE NO: 57-15/21DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude 57° 26.105'N
Longitude 014° 16.926'W
Navigation DGPS
Map Area

Licence Block 137/19
BGS Plan No K130
Total Depth 1.30m
Water Depth 186m

Vessel James Clark Ross
Station Keeping DP
Dates of Drilling 15/08/2001
Geologists P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0									<p>SURFICIAL SEAFLOOR DEPOSIT (PREDOMINANTLY BASALT CLASTS)</p> <p>Recovered material consists predominantly of pebbles and cobbles of aphyric basalt.</p> <p>0.00-0.17 m: two aphyric basalt clasts with partially cored outer surfaces. The basalt is fine grained and shows partial alteration to chlorite ± zeolites in diffuse patches rather than veins.</p> <p>0.17-0.50 m: assorted basaltic pebbles, most <3m in size; three range from 4-6 cm.</p> <p>A grey sandy mud is found adhering to some clasts. Lithic sand particles range from white (quartz) to black (basalt); a few are red (metamorphics?).</p>
	1									
	2									
	3									
	4									
	5									
	6									

SAMPLE 57-15/22

SITE DETAILS

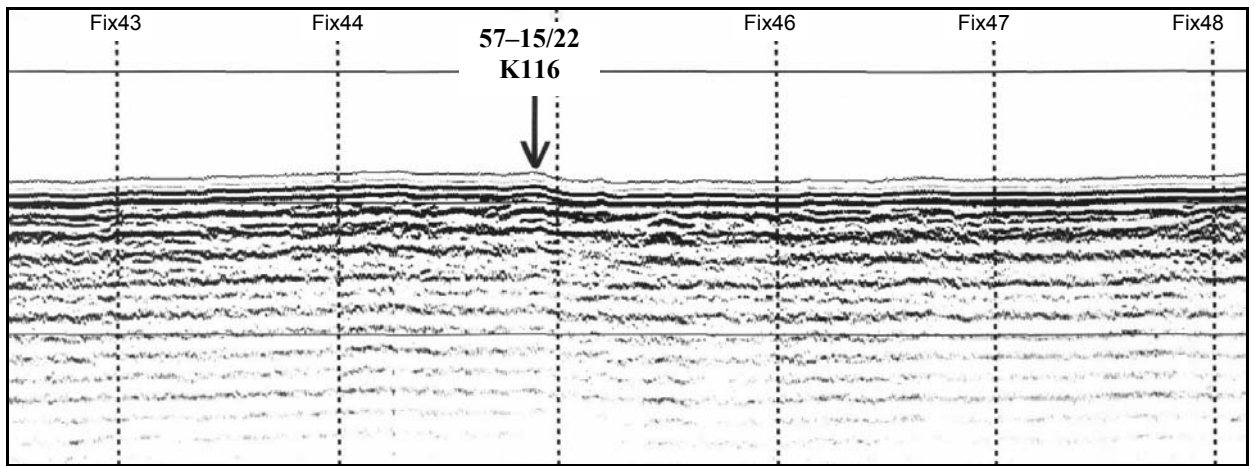
Date of drilling: 15th August 2001
Original site number: K116
Latitude: 57° 18.146'N
Longitude: 14° 14.075'W
Location: Rockall Bank
Line and fix number: 00/01-41 44.9
Equipment: BGS rockdrill
Core length:
Lithology: Basalt gravel
Age:

SUMMARY

Recovered material consists of pebbles and cobbles of fine-grained, dark grey, aphyric basalt.

SW

NE

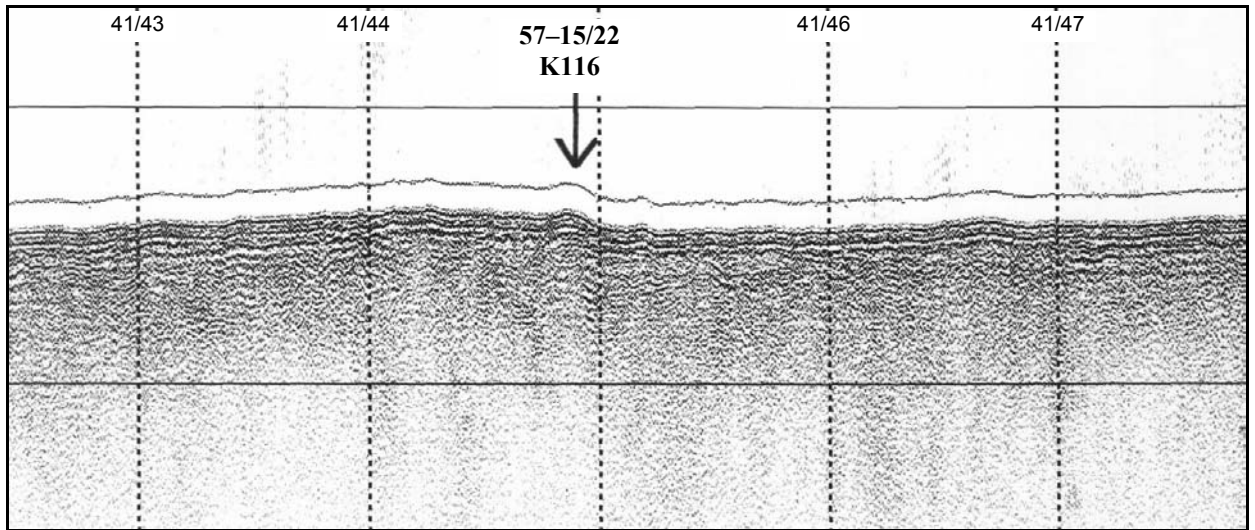


LINE 00/01-41

AIRGUN

SW

NE



LINE 00/01-41

SPARKER

BGS CORE NO: 57-15/22DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

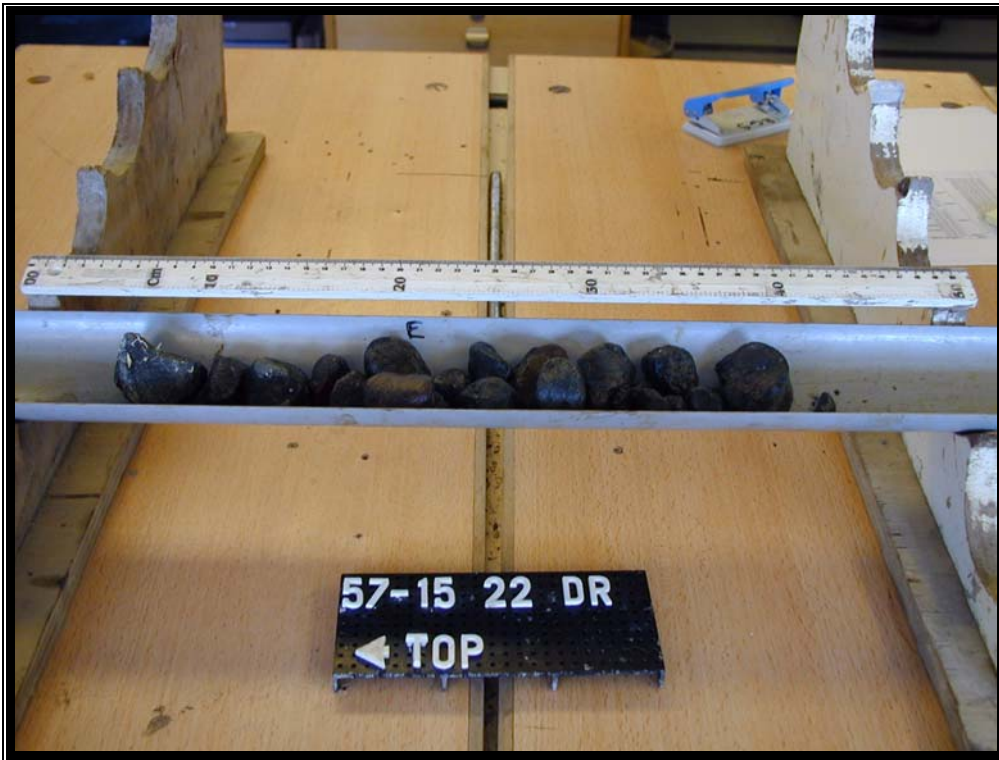
Approximate Position Rockall Bank

Latitude 57° 18.1463'N
Longitude 014° 14.0754'W
Navigation DGPS
Map Area

Licence Block 137/24
BGS Plan No K116
Total Depth 1.18m
Water Depth 179m

Vessel James Clark Ross
Station Keeping DP
Dates of Drilling 15/08/2001
Geologists P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
Unknown	0	[Pattern]									<p>SURFICIAL SEAFLOOR DEPOSIT (BASALTIC PEBBLES)</p> <p>Recovery consists of 21 pebbles, <5 cm in maximum dimension. All are fine grained, dark grey, aphyric basalt. There may be more than one basalt type present, but it's hard to tell from the weathered surfaces. At least one pebble has a distinctly different reddish alteration surface with some pale blue zeolites (i.e. maybe an older generation of basalt). A thin film of sandy mud, grey in colour, coats portions of some clasts.</p> <p>Top piece of core encrusted with bryozoans.</p>
	1										
	2										
	3										
	4										
	5										
	6										



SAMPLE 57-15/23

SITE DETAILS

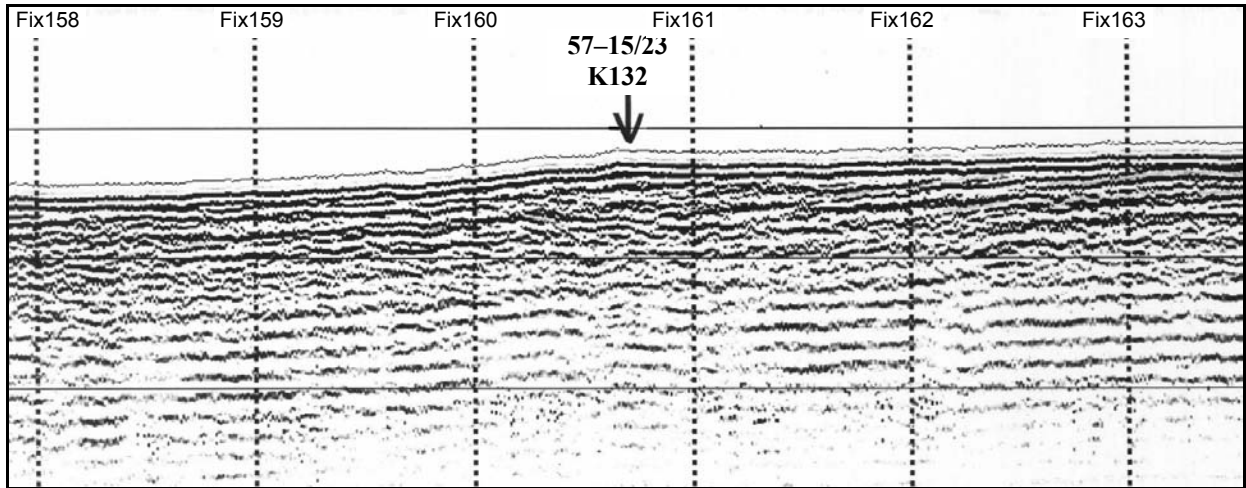
Date of drilling: 15th August 2001
Original site number: K132
Latitude: 57° 14.706'N
Longitude: 14° 28.812'W
Location: Rockall Bank
Line and fix number: 00/01-45 160.7
Equipment: BGS rockdrill
Core length:
Lithology: Alkali basalt
Age:

SUMMARY

Recovered material consists of fine-grained, dark grey, aphyric basalt pebbles.

NW

SE

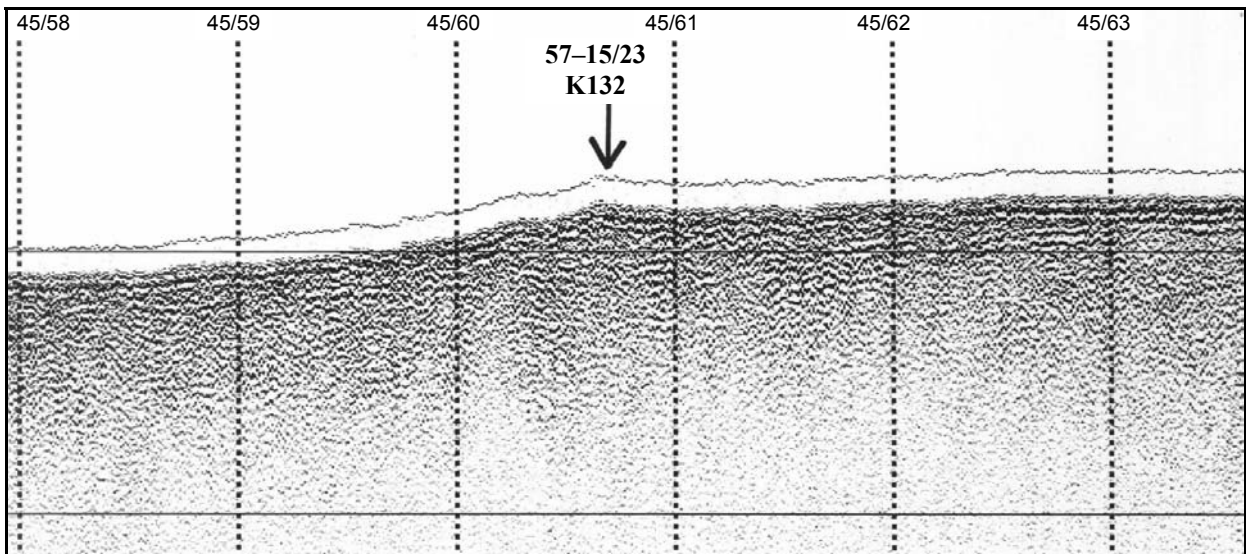


LINE 00/01-45

AIRGUN

NW

SE



LINE 00/01-45

SPARKER

BGS CORE NO: 57-15/23DR



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Rockall Bank

Latitude	57° 14.706'N	Licence Block	137/23	Vessel	James Clark Ross
Longitude	014° 28.812'W	BGS Plan No	K132	Station Keeping	DP
Navigation	DGPS	Total Depth	1.33m	Dates of Drilling	15/08/2001
Map Area		Water Depth	214m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0							TS 0.30m		<p>SURFICIAL SEAFLOOR DEPOSIT (BASALTIC CLASTS)</p> <p>Recovered material is predominantly pebble size clasts of fine grained, aphyric basalt, similar to previously recovered cores.</p> <p>Cobble sized clast at 0.30-0.36 m sampled for thin section and geochemistry. On cut surface the rock has a mottled appearance, which may indicate pervasive replacement of groundmass by chlorite. The surface shows the trace of a very thin chlorite vein oriented approximately parallel to core vertical.</p> <p>0.00-0.05 m is an unidentified lithology, consisting of ~40% brick red, Fe oxyhydroxides, plus ~10% calcite and ~50% of a colourless mineral, appears to show cleavage (doesn't fizz); could be a zeolite(?). The rock may be a highly altered scoria.</p>
	1									
	2									
	3									
	4									
	5									
	6									



PETROLOGY OF SAMPLE 57-15/23

Emrys Phillips

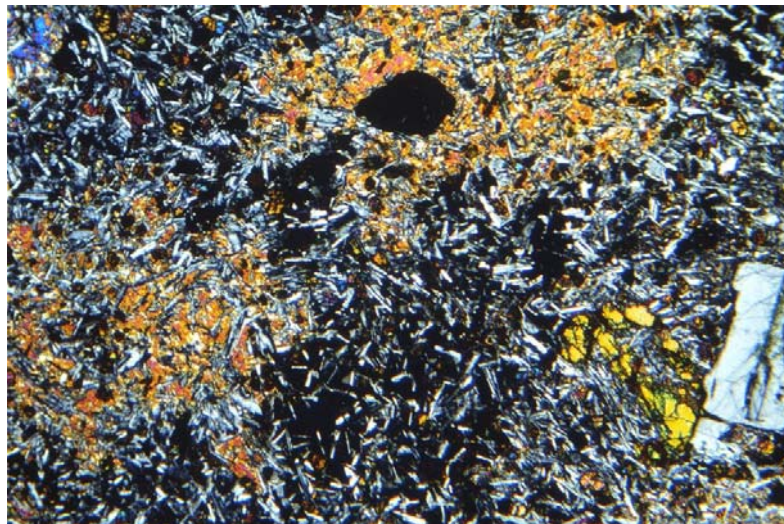
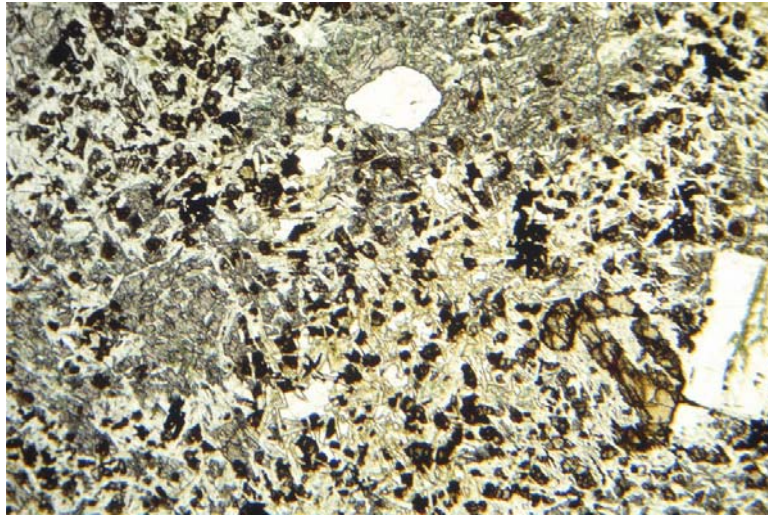
Registered number: N3750
Thin section from 0.30m depth.

Rock Type: ophimottled alkali basalt

Mineralogy: major – plagioclase, clinopyroxene, olivine, analcime
minor – opaque minerals
alteration – chlorite, bowlingite, iddingsite

Photomicrographs:

Photomicrographs of an ophimottled alkali basalt (N3750), plane and crossed polarised light.



Description: This thin section is of a fine- to very fine-grained, holocrystalline to weakly hypocrySTALLINE, inequigranular, weakly altered, aphyric alkali basalt which possesses a distinctive ophimottled texture. This texture comprises numerous small plagioclase laths included within coarser grained, 1.0 to 3.0 mm in size, anhedral intergranular clinopyroxene crystals. Ophitic, sieve-textured clinopyroxene also contains inclusions of opaque minerals and olivine. Clinopyroxene is pale brown in colour and may locally exhibit minor alteration to

chlorite. Olivine, however, mainly occurs within the areas of the basalt which lack clinopyroxene. These pyroxene free areas form an irregular network composed of plagioclase and subordinate olivine. Plagioclase forms small anhedral, twinned laths which may locally possess a weakly developed zonation.

Olivine forms small rounded crystals which are variably altered to chlorite, bowlingite and iddingsite. Although altered relict olivine is common within this basalt. The remaining interstitial to intersertal areas are mainly composed of analcime, chlorite and trace amounts of fine grained granular pyroxene. Analcime is colourless and isotropic under crossed polarised light and may exhibit alteration to chlorite. Small spots or aggregates of interstitial opaques are also present.

SAMPLE 57-15/24

SITE DETAILS

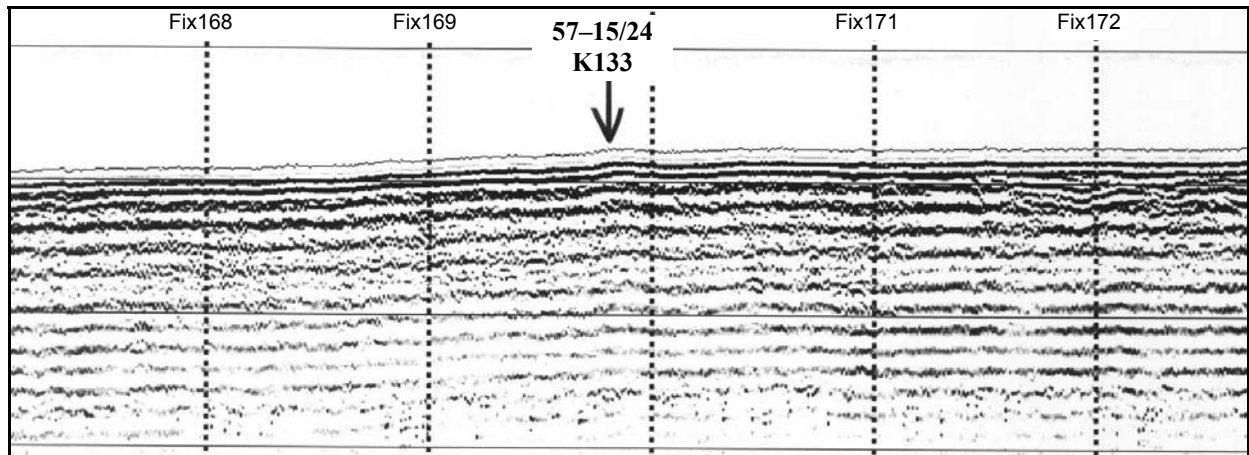
Date of drilling: 15th August 2001
Original site number: K133
Latitude: 57° 11.574'N
Longitude: 14° 19.620'W
Location: Rockall Bank
Line and fix number: 00/01-45 169.8
Equipment: BGS rockdrill
Core length:
Lithology: Basalt gravel
Age:

SUMMARY

Recovered material consists of fine-grained, dark grey, aphyric basalt pebbles.

NW

SE

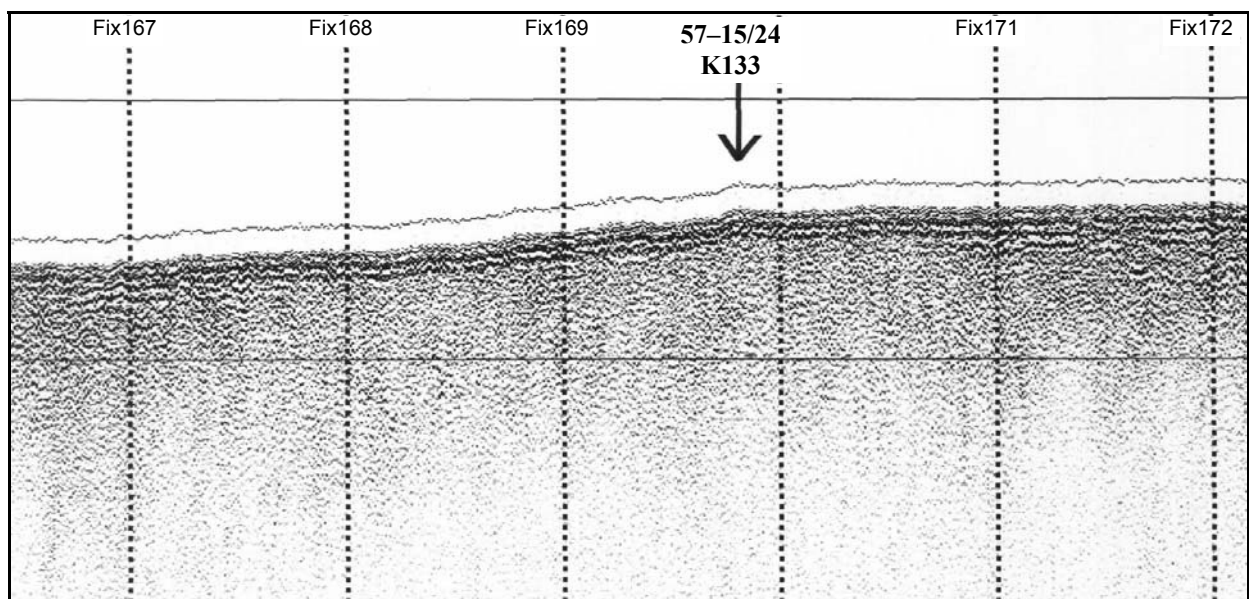


LINE 00/01-45

AIRGUN

NW

SE



LINE 00/01-45

SPARKER

BGS CORE NO: 57-15/24DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	57° 11.574'N	Licence Block	137/24
Longitude	014° 19.620'W	BGS Plan No	K133
Navigation	DGPS	Total Depth	0.89m
Map Area		Water Depth	183m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	15/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Unknown	0									<p>SURFICIAL SEAFLOOR DEPOSIT (BASALTIC CLASTS)</p> <p>Recovered material consists of pebbles of fine grained, aphyric basalt, similar to that recovered at previous sites. The pebbles have weathered outer surfaces and are subangular. Most have thin coatings of buff coloured, sandy mud, and most are less than 2 cm in diameter. Two larger clasts, one with a cored outer surface and one without, are 6 and 5 cm, respectively.</p>
	1									
	2									
	3									
	4									
	5									
	6									

SAMPLE 57-15/25

SITE DETAILS

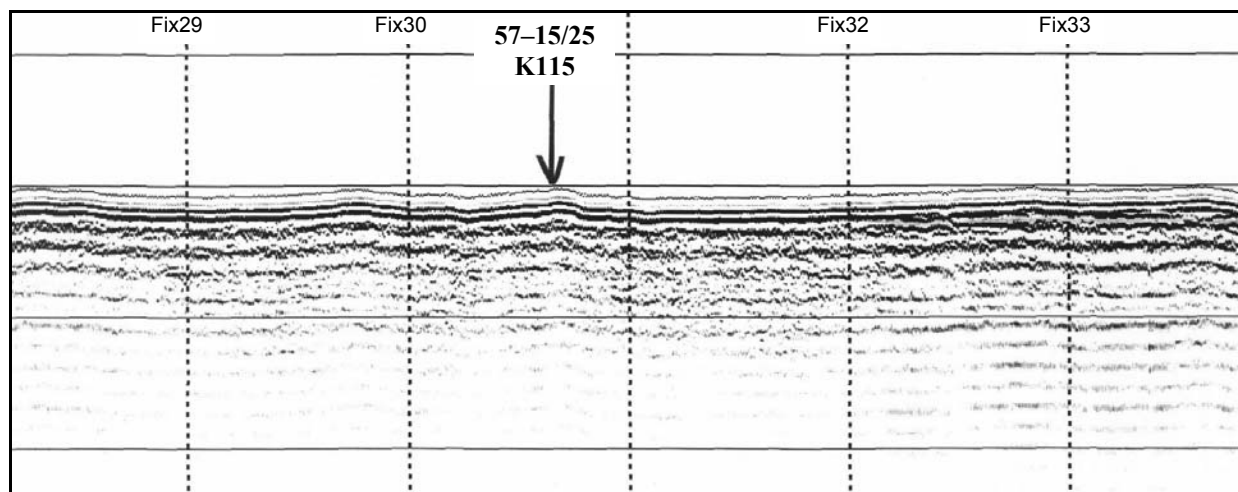
Date of drilling: 15th August 2001
Original site number: K115
Latitude: 57° 8.916'N
Longitude: 14° 26.082'W
Location: Rockall Bank
Line and fix number: 00/01-41 30.65
Equipment: BGS rockdrill
Core length:
Lithology: Basalt gravel
Age:

SUMMARY

Recovered material consists mainly of fine-grained, dark grey, basalt pebbles but there is also a single gneissic pebble of quartz-feldspar-mafics composition.

SW

NE

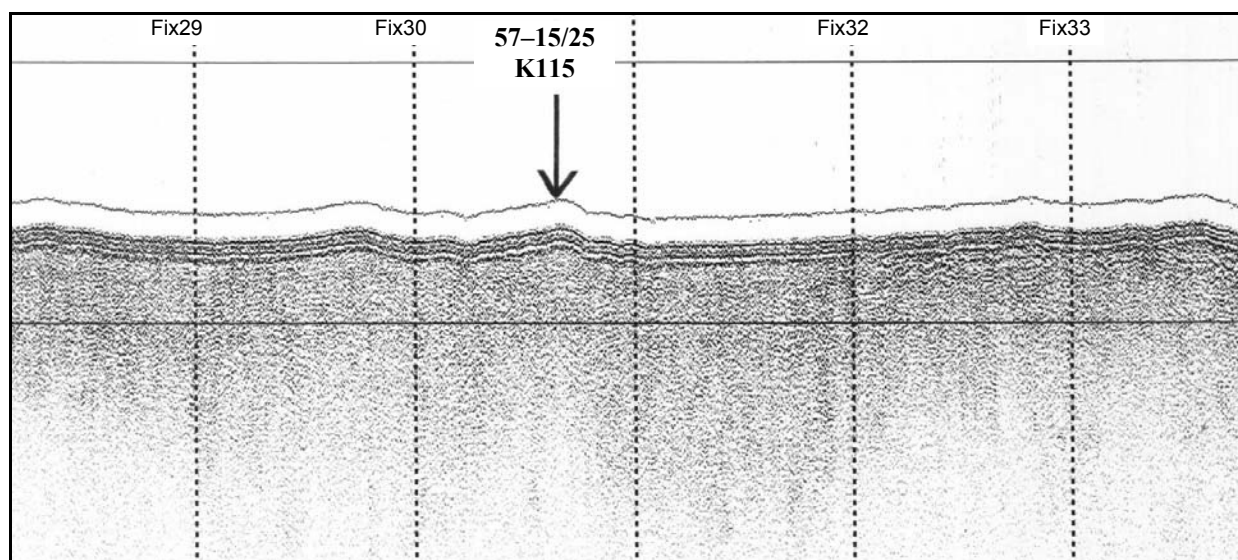


LINE 00/00-41

AIRGUN

SW

NE



LINE 00/00-41

SPARKER

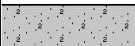
BGS CORE NO: 57-15/25DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	57° 08.9164' N	Licence Block	137/28
Longitude	14° 26.0815' W	BGS Plan No	K115
Navigation	DGPS	Total Depth	1.48m
Map Area		Water Depth	197m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	15/08/2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0									<p>SURFICIAL SEAFLOOR DEPOSIT (BASALTIC CLASTS)</p> <p>Pebbles, subrounded-subangular, most <2 cm diameter, some coarse sand, nearly all black, fine-grained basalts.</p> <p>The largest pebble was stuck in the bit and drilled - 6 cm long - basalt as above with one ?zeolite (green) filled vug.</p> <p>There is one pebble of a quartz-feldspar-mafic minerals granitic gneiss composition.</p> <p>Several pebbles are encrusted with biota.</p>
	1									
	2									
	3									
	4									
	5									
	6									

SAMPLE 57-15/26

SITE DETAILS

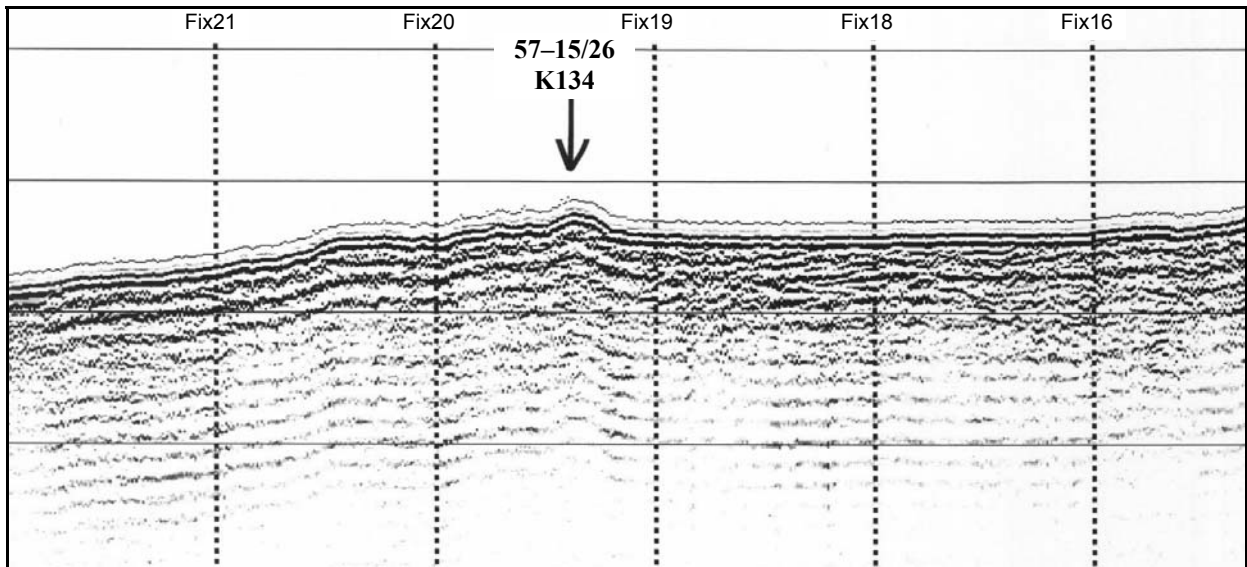
Date of drilling: 16th August 2001
Original site number: K134
Latitude: 57° 4.314'N
Longitude: 14° 41.255'W
Location: Rockall Bank
Line and fix number: 00/01-46 19.4
Equipment: BGS rockdrill
Core length:
Lithology: Gravel
Age:

SUMMARY

Recovered material comprises five pebbles, mainly of metamorphic aspect.

NW

SE

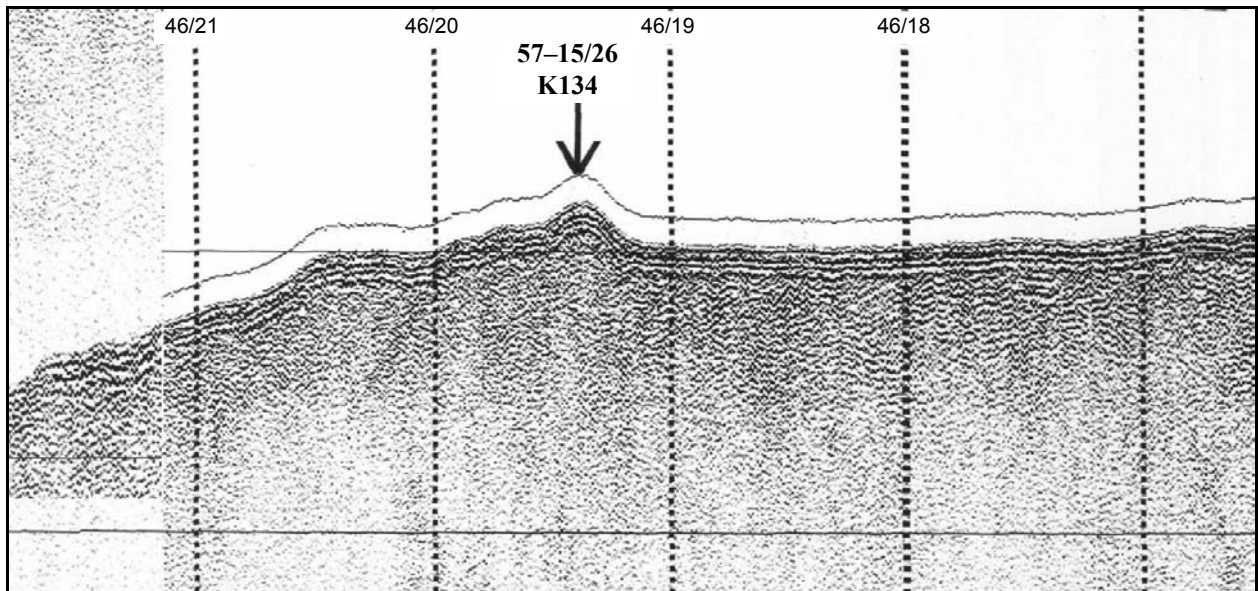


LINE 00/01-46

AIRGUN

NW

SE



LINE 00/01-46

SPARKER

BGS CORE NO: 57-15/26DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Rockall Bank	
Latitude	57° 04.3141' N	Licence Block	137/27
Longitude	14° 41.2551' W	BGS Plan No	K134
Navigation	DGPS	Total Depth	0.77m
Map Area		Water Depth	219m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	16/08/2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0									<p>SURFICIAL SEABED SEDIMENT (METAMORPHIC BASEMENT PEBBLES)</p> <p>Recovered only five angular to subangular pebbles ranging in size from 1.5 to 5.0 cm diameter. Pebble 1 is a pink and grey feldspathic gneiss. The other pebbles are dark grey with greenish and white patches and are also ?metamorphic gneissic basement. Foliation is not clear and could be intrusive igneous in origin. Minerals include quartz, feldspar, mafic minerals, weathered ?amphiboles and chlorite.</p> <p>Pebbles show evidence of encrusting biota.</p>
	1									
	2									
	3									
	4									
	5									
	6									

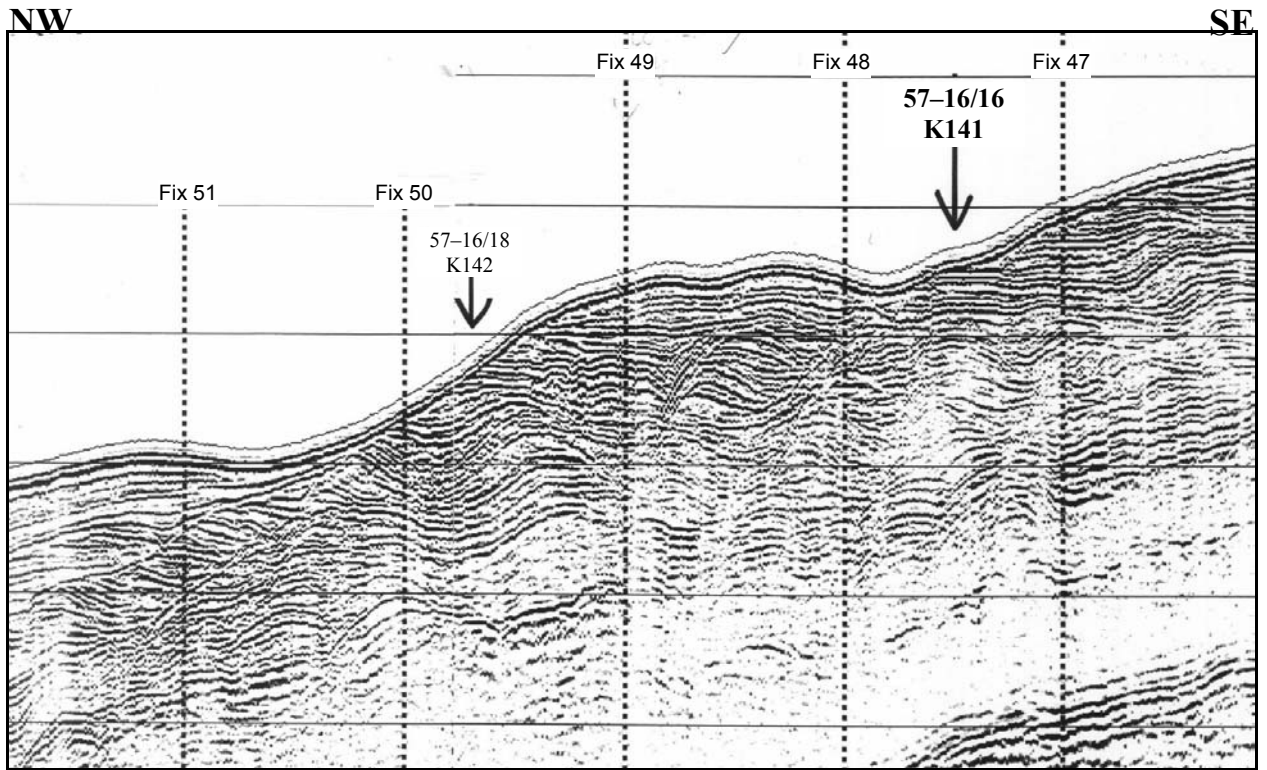
SAMPLE 57-16/16

SITE DETAILS

Date of drilling: 17th August 2001
Original site number: K141
Latitude: 57° 4.836'N
Longitude: 15° 15.444'W
Location: West flank of Rockall Bank
Line and fix number: 00/01-47 47.5
Equipment: BGS rockdrill
Core length: 0.48m
Lithology: Chalk
Age: Mid Miocene to Quaternary

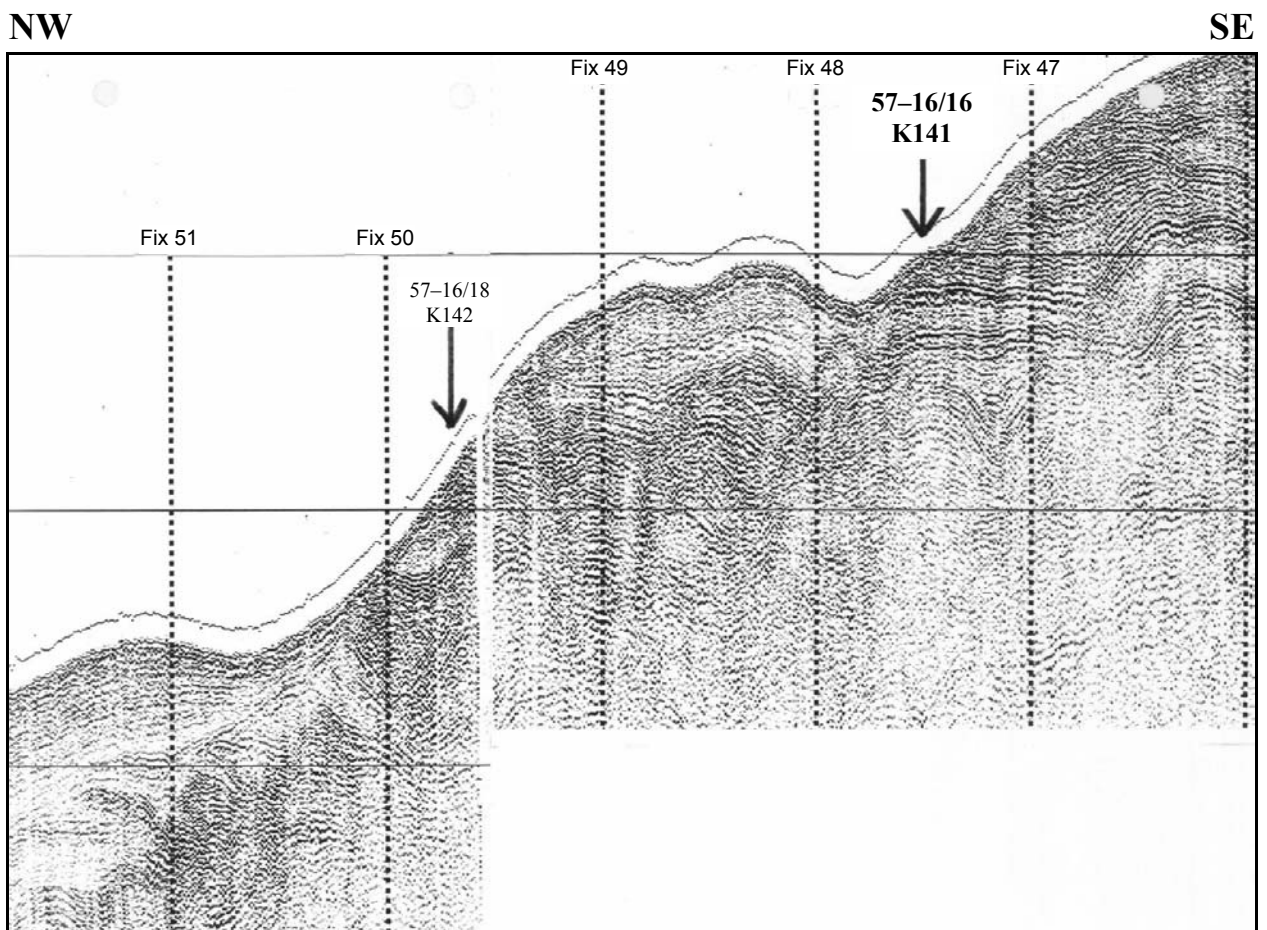
SUMMARY

The sample comprises a soft white chalk paste overlying more solid chalk micrite. Two pebbles were also recovered. The age is not well constrained. The site was re-drilled as 57-16/17 using the vibrocorer.



LINE 00/01-47

AIRGUN



LINE 00/01-47

SPARKER

BGS CORE NO: 57-16/16DR



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position West Rockall Bank

Latitude	57° 04.836' N	Licence Block	349/29	Vessel	James Clark Ross
Longitude	15° 15.444; W	BGS Plan No	K141	Station Keeping	DP
Navigation	DGPS	Total Depth	4.88m (Rec 0.48m)	Dates of Drilling	17/08/2001
Map Area		Water Depth	602m	Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										<p>CHALK</p> <p>0- 0.30 m: CHALK, soft paste, white (10YR 8/2), scattered mafic fragments, upper part of core barrel filled with "soup" . Contains scattered lithic fragments (basalt), up to 2 mm in diameter near base, but most < 0.25 mm. May be contamination during drilling.</p> <p>0.30- 0.39 m Gravel, two pebbles recovered, may originally have been above the chalk paste. One pebble (6 cm diameter) is a rounded, but fractured (? during drilling) aphyric basalt. The other is a brown quartzite, angular, with encrusting bryozoa, suggesting seafloor deposit at some time.</p> <p>0.39-0.48 m Chalk (micrite), white (colour as above), firm, cored, scattered forams, no basaltic fragments.</p> <p>SEE ALSO 57-16/17VE drilled at the same location.</p>
	1										
	2										
	3										
	4										
	5										
	6										



PALYNOLOGY OF SAMPLE 57-16/16

Jim Riding

Two samples were taken for analysis from this short core.

0.20-0.23m (cream clay)

0.44-0.48m (white mudstone)

The sample at 0.44m-0.48m is extremely organic-lean; only sufficient residue was produced for a single microscope slide. It proved virtually barren of palynomorphs. The residue comprised abundant resistant mineral grains with rare wood fragments and occasional plant tissue. A single indeterminate pollen grain was observed. No age assessment is therefore possible. The uppermost sample at 0.20m-0.23m also proved organically-lean. Mineral grains also were common, with subordinate wood and plant tissue. Low numbers (c. 10) of palynomorphs were observed. These comprise ?*Achomospaera andalousiensis*, bisaccate pollen, an indeterminate dinoflagellate cyst, small spherical pollen, *Spiniferites* sp. and triporate pollen. This assemblage is indicative of the Neogene (Mid Miocene) to Quaternary.

There is no evidence of reworking.

SEDIMENTOLOGY OF SAMPLE 57-16/16

Alick Leslie

This core contains 0.35m of unconsolidated chalk underlain by two large pebbles (basalt and quartzite). The basal 0.09m of core is a consolidated chalk.

The upper chalk unit is water rich and very soft. Forams are abundant and the fine-grained carbonate material is probably a nannoplankton ooze. Clasts of black basalt are uncommon, on average 1mm in diameter, angular to sub-angular. There is no sedimentary structure, possibly as a result of liquefaction during drilling. The two pebbles of basalt and quartzite appear to underlie the soft chalk. It is probable that the quartzite pebble was at some time at sea bed as it is encrusted by a bryozoan. It is possible that both pebbles originally overlay the soft chalk and were displaced during the drilling process.

The consolidated chalk is very similar in colour and biota to the overlying soft material but contains fewer basalt clasts. There is no structure visible within the sample.

Biostratigraphy (dinoflagellates) suggests an age between mid Miocene and Quaternary (Riding 2001).

See also discussion under 57-16/19.

SAMPLE 57-16/17

SITE DETAILS

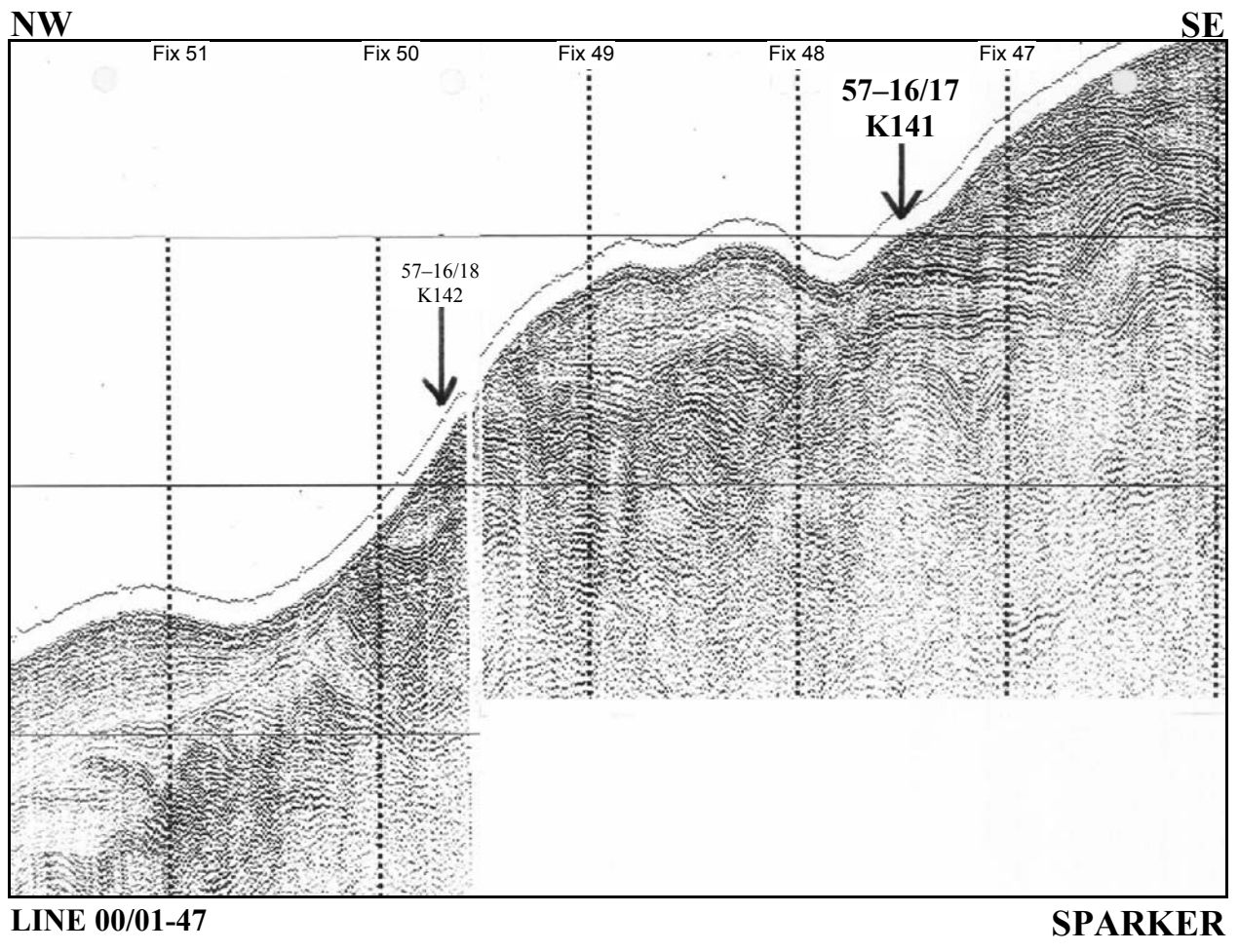
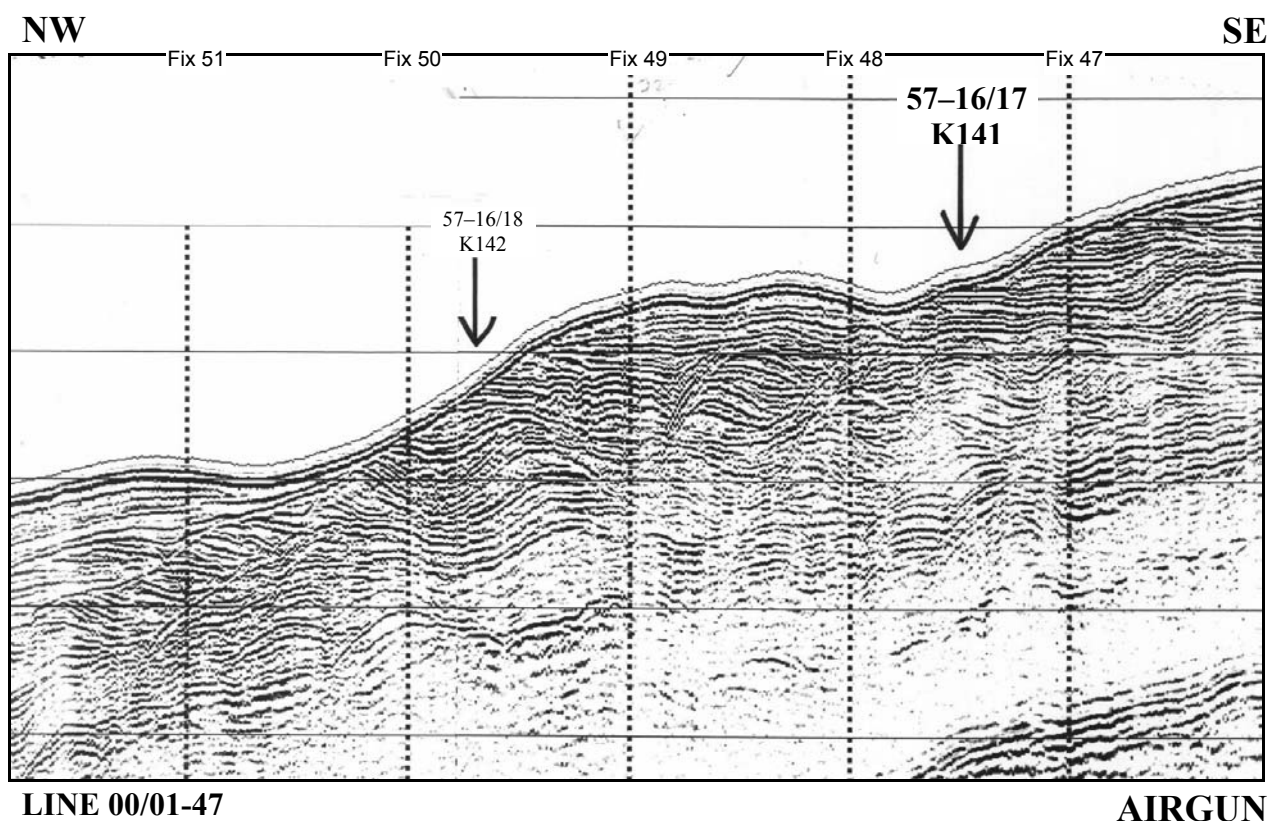
Date of drilling:	17th August 2001
Original site number:	K141
Latitude:	57° 4.84'N
Longitude:	15° 15.44'W
Location:	West flank of Rockall Bank
Line and fix number:	00/01-47 47.5
Equipment:	BGS vibrocore
Core length:	2.52m
Lithology:	Muddy sand and silt.
Age:	Mid-Late Pleistocene or Holocene (palynology) No older than Late Miocene (forams) Late Pleistocene-early Holocene (NN21) (nannofossils)

SUMMARY

This was the second attempt at this site. Together with 57-16/18, the aim was to sample the interval between two regionally significant unconformities in the area – presumed to be the equivalent of C10 (Early Pliocene) and C30 (Late Eocene) of the Rockall Trough.

The results of the micropalaeontology are not absolutely definitive. The palynological preparations yielded very sparse associations. Forams are more common. The rare presence of *Uvigerina venusta saxonica*, which is apparently confined to the Late Miocene, suggests this is the age of the cored material. However it was only recovered from the highest sampled interval (0.51-0.53m). The possibility exists that the lower core is older (although the whole core appears to be from a single succession) or that *Uvigerina venusta saxonica* has been reworked from the Late Miocene into younger sediment. The nannofossils yielded only Pleistocene ages.

The conclusion is that this short core did not penetrate through the thin Pleistocene-Holocene veneer and that microfossils older than this have been reworked.



BGS CORE NO: 57-16/17VE



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		West Rockall Bank	
Latitude	57° 04.84' N	Licence Block	349/29
Longitude	15° 15.44' W	BGS Plan No	K141
Navigation	DGPS	Total Depth	3.48m (Rec 2.52m)
Map Area		Water Depth	602m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	17/08/2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0							Paly 0.20m Paly 0.44m MPal 0.51m Paly 0.53m MPal 0.56m MPal 0.94m	Grey Light grey	SAND AND MUD Muddy sand, mainly foraminiferal, variegated in colour from cream, pale grey, grey, brown, mottled in places. Locally silty clay and white carbonate sandy muds. Scattered pebbles.
	1							Paly 0.96m MPal 1.38m MPal 1.40m Paly 1.40m		0- 0.11 m Foram sand, fine, predominantly round shells, plus a variety of other allochems, including echinoid spines, bivalves etc, with scattered lithic clasts (basaltic, metamorphic minerals, quartz etc). Core is cohesive with a pale muddy matrix. 0.11-0.15 m Mud, sandy silty, similar lithology to above but with much higher clay content.
	2							Paly 1.98m MPal 2.01m MPal 2.40m MPal 2.42m Paly 2.42m		0.15-0.95 m Foraminiferal sand, similar to above. Entire bivalve at 0.26 m, White, micritic 0.4-0.41 m. 0.95-1.05 m Mud, sandy, silty, similar lithology to above but with more clay.
	3									1.37-1.38 m Mud, sandy, as above. 1.38-1.95 m Sand, as above.
	4									1.95-2.04 m Sand, with many bivalve shells, very pale colour. 1.05-1.37 m Foraminiferal sand as above, white micritic 1.05-1.12 m. 2.04-2.52 m Foraminiferal sand, as above, with scattered pebbles, including sub-angular medium grained mafic rock with ?quartz and a rounded pebble of aphyric basalt near the base of the core.
	5									
	6									

PALYNOLOGY OF SAMPLE 57-16/17

Jim Riding

Five samples were taken for analysis from this short core.

0.53-0.56m (light brown clay)

0.96-1.00m (light brown clay)

1.40-1.45m (sandy, light brown clay)

1.98-2.01m (sandy, light brown clay)

2.42-2.45m (sandy, grey clay)

All five samples proved to be extremely organic-lean. They yielded sparse kerogen and palynomorph associations. Resistant mineral grains proved common to abundant and wood fragments are also present, often in relatively high proportions. Palynomorphs proved rare; typically around 10 specimens per microscope slide. The palynofloras comprise sparse pollen grains and dinoflagellate cysts. Miospores observed include undifferentiated bisaccate pollen, *Chenopodium*, small spherical pollen grains and triporate pollen. This flora is not biostratigraphically significant, however the absence of Palaeogene forms strongly suggests the Neogene/Quaternary. A questionable specimen of the Carboniferous spore *Lycospora pusilla* was recorded at 2.42m-2.45m. The dinoflagellate cysts *Brigantedinium simplex* (0.53m-0.56m), ?*Brigantedinium* sp. (0.96m-1.00m and 2.42m-2.45m), *Operculodinium centrocarpum* (1.40m-1.45m) and *Spiniferites elongatus* (1.40m-1.45m) were recorded. The presence of *Brigantedinium simplex* and *Spiniferites elongatus* are indicative of a Mid-Late Pliocene or Holocene age (Harland, 1992, fig. 5.2). The similarity in lithology suggests that all the samples are from the same genetic sequence and therefore are of similar age. The sparsity of the dinoflagellate cyst floras cannot distinguish whether the succession represents glacial or interglacial conditions.

FORAMINIFERA OF SAMPLE 57-16/17

Ian Wilkinson

Five samples were taken for analysis from this short core.

0.51-0.53m

0.94-0.96m

1.38-1.40m

2.01-2.03m

2.40-2.42m

The lowest sample analysed, from 2.40-2.42m, contained granitic and basaltic fragments. It was slightly shelly and echinoid spines were also observed. Of the benthonic foraminifera, *Cibicidoides kullenbergi/mundulus* (the two are probably synonymous) was common. Although a diverse association was seen, the remainder of the species were rare or very rare. Agglutinated taxa (e.g. *Bigenerina cylindrica* and *Textularia* sp.) were rare. The planktonic element was dominated by two species, abundant *Globigerina bulloides* (although some of these may be the Miocene species *G. praebulloides*) and frequent *Globorotalia* cf *continua* and very rare *Globigerina ciperoensis*. Two species of *Orbulina* were present, although very rare: *Orbulina universa* and *Orbulina suturalis*.

A similar association was recovered from a depth of 2.01-2.03m in a shelly sand with small quartz, schist and basalt fragments). Foraminifera were common, the fauna being dominated by *Gyroidinoides* sp, although benthonic species were generally rare. *Paromalina crassa*, *Cibicidoides kullenbergi/mundulus* and *Cibicidoides* sp occurred in rare proportions, but the remainder were very rare. Of the planktonic element, *Globigerina bulloides* was again abundant and *Globorotalia* cf *continua* was common, but the remaining species were rare (*Orbulina universa*, *Globigerina quinquiloba* and *Neogloboquadrina pachyderma*) or very rare (*Globorotalia crassaformis*). *N. acostaensis* are more characteristic of colder waters and *G. crassaformis* is unusual north of the Transitional Zone.

Although present in small numbers in the lower two samples, *Paromalina crassa* becomes abundant in the shell sample from 1.38-1.40m and *Rectoglandulina* is frequent. Other species include *Sigmoilopsis schlumbergeri*, *Melonis barleeianum* and *Oridorsalis umbonatus*, although in very small numbers. *Globigerina bulloides* and *Globorotalia* cf *continua* continue to dominate the planktonic element, but sinistral *Neogloboquadrina acostaensis* becomes frequent at this level and very rare *Globorotalia crassaformis* and *Orbulina universa* are also present.

There is a slight change in the fauna at 0.94-0.98m where common *P crassa* is joined by frequent *Planularia ariminensis* and *Cibicides refulgens*. However, the number of large, robust specimens is noticeably reduced in the sample, compared to that at 1.38-1.48m, and diversity is also reduced. The presence of very rare *Pullenia bulloides*, *Bulimina marginata* and *Cibicidoides kullenbergi/mundulus* are worth noting. *Neogloboquadrina acostaensis* are both present in rare proportions, *Orbulina universa* fragments were noted and *G. bulloides* is again abundant.

The highest sample examined, from 0.51-0.53m was shelly and foraminifera were very abundant and diverse. The benthonic element is dominated by *Paromalina crassa*, but *Cibicidoides* sp, *Cibicidoides kullenbergi/mundulus* and *Oridorsalis umbonatus* are frequent. *Uvigerina venusta saxonica* and *Epistominella exigua*, *Trifarina angulosa*, *Karrerriella novangliae* and *Sigmoilopsis schlumbergeri* also occur in small numbers.

In conclusion, the presence of *Orbulina universa* throughout the borehole (and very rare *O. suturalis*) indicates an age no older than the mid Miocene, at which horizon its inception forms an important datum. Very rare specimens of *Globigerina ciperoensis* are probably reworked from the Oligocene/early Miocene. At several horizons, *Neogloboquadrina acostaensis* was recorded suggesting a *late Miocene to early Pliocene* age.

The benthonic species, are characterised by *Paromalina crassa*, *Oridorsalis umbonatus*, *Planularia ariminensis*, *Epistominella exigua* are deep water forms and found on the slope off Europe today. Although extant today, *Planularia ariminensis* first appeared in the mid Miocene (N16) and is particularly found in water depths between about 300 and 500m although it has been recorded down to c.800m. The Miocene age is confirmed by the presence of rare *Uvigerina venusta saxonica*, which is apparently confined to the Late Miocene, although it has been found in the early Pliocene (reworked?) in the North Sea.

NANNOFOSSILS OF SAMPLE 57-16/17

Jackie Lees

Three samples were taken for analysis from this short core.

0.56m

1.40m

2.42m

All of the samples were highly productive, and preservation was moderately good. *E. huxleyi* was present throughout the sequence, along with a varied selection of geophyrocapsids, indicating NN21 (latest Pleistocene to Early Holocene). Some possible reworking from NN19 (Early Pleistocene) was also evident throughout, based on the occurrence of *Pseudoemiliana*, along with some Palaeogene reworked taxa.

SEDIMENTOLOGY OF SAMPLE 57-16/17

Alick Leslie

See discussions under 57-16/18 and 57-16/19.

SAMPLE 57-16/18

SITE DETAILS

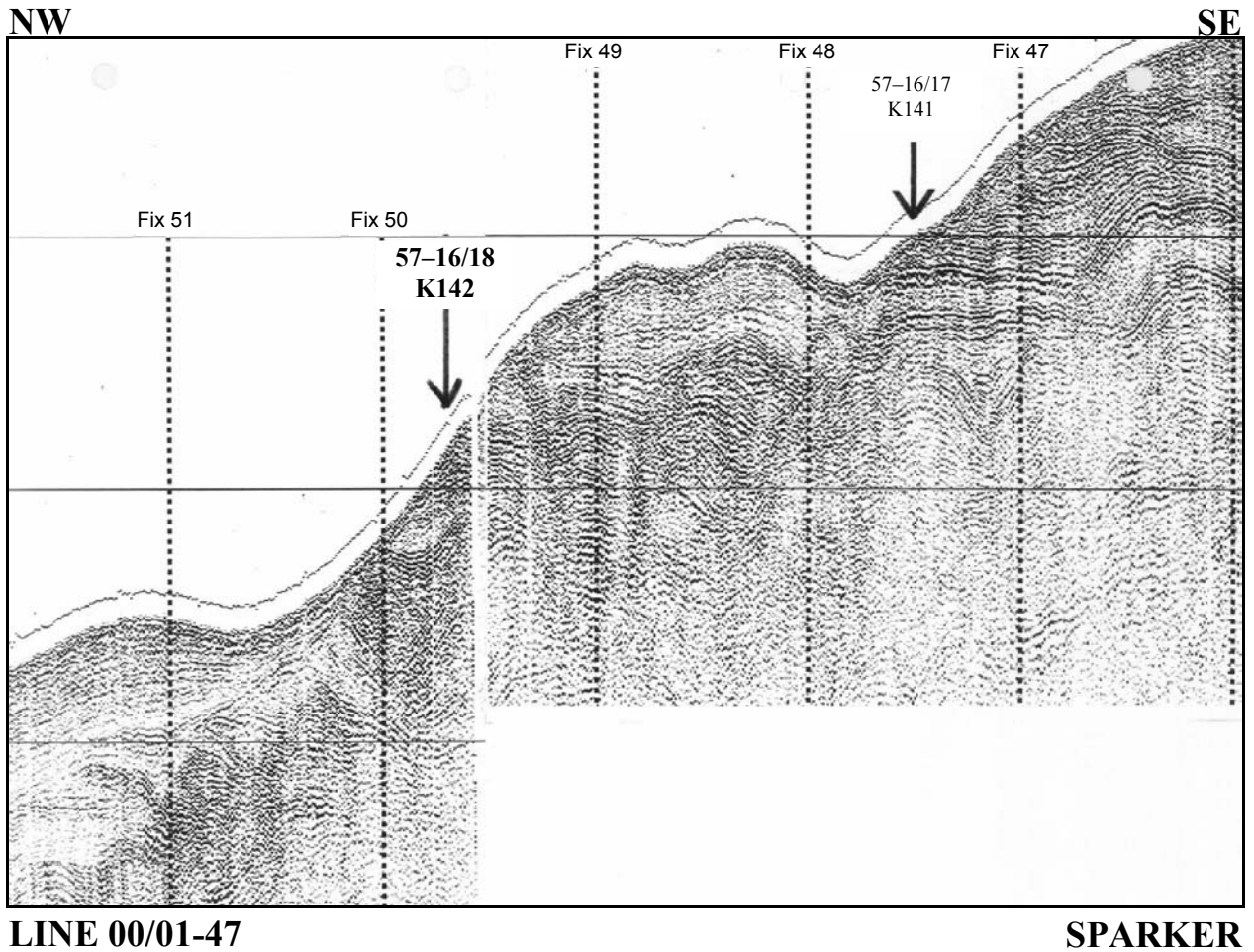
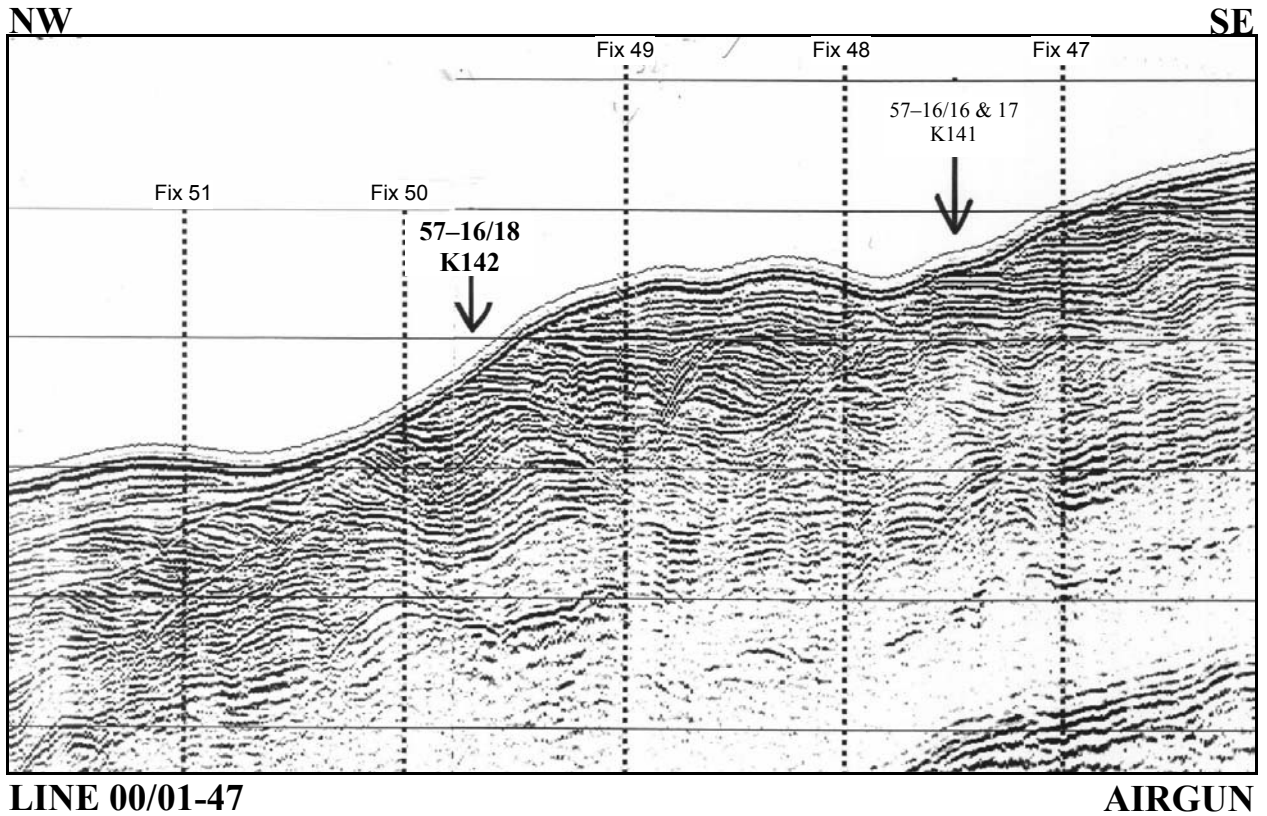
Date of drilling:	17th August 2001
Original site number:	K142
Latitude:	57° 5.55'N
Longitude:	15° 18.204'W
Location:	West flank of Rockall Bank
Line and fix number:	00/01-47 49.7
Equipment:	BGS vibrocore
Core length:	2.71m
Lithology:	Fine, muddy sand, silt and clay.
Age:	Late Pleistocene to Holocene (NN21)

SUMMARY

The aim at this site was to sample the interval between two regionally significant unconformities in the area – presumed to be the equivalent of C10 (Early Pliocene) and C30 (Late Eocene) of the Rockall Trough. Seismic data suggest that the sediment recovered should be older than that at 56-16/16 and 17.

The topmost part of the core (sample 0.27-0.30m) was deposited during the Ipswichian of Flandrian interglacial period. Below this level, sparse Miocene palynomorphs and forams are present. If these are *in situ* then the forams *Orbulina universa* and *Neogloboquadrina acostaensis* indicate ages of ‘no older than mid Miocene (N9)’ and ‘no older than late Miocene (N16-17)’ respectively. This is compatible with the age prognosed from the seismic data. However the nannofossil data suggest a Pleistocene age with the earlier forms being reworked.

Reworked palynomorphs have been identified, notably from the Carboniferous and Toarcian. Reworked nannofossils from the Palaeogene and Upper Cretaceous were noted.



BGS CORE NO: 57-16/18VE



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

West Rockall Bank

Latitude	57° 05.55'N	Licence Block	349/29	Vessel	James Clark Ross
Longitude	015° 18.204'W	BGS Plan No	K142	Station Keeping	DP
Navigation	DGPS	Total Depth	3.19m (Rec. 2.71m)	Dates of Drilling	17/08/2001
Map Area		Water Depth	670m	Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0									FORAMINIFERAL SAND
	0.27m							Paly		<p>Foraminiferal sand, muddy, with interbedded silty calcareous muds, sand grains predominantly microfossils, with some lithic fragments, including basalt, metamorphic minerals and quartz (angular to subrounded terrigenous grains). Very variable colour and percentage of sand. Some sharp boundaries, others gradational. Evidence of burrowing.</p> <p>0.00-0.11 m: brownish grey, fine muddy sand. 0.11-0.24 m: grey to brown, silty. 0.24-0.37 m: very pale grey, silty, some burrowing. 0.37-0.46 m: coarser sand, slightly graded. 0.46-0.53 m: mottled grey-brown, variable mud content. 0.53-0.55 m: brown calcareous clay. 0.55-0.58 m: pale cream, sharp base, very calcareous, micritic. 0.58-0.60 m: brown, burrowed(?) base. 0.60-0.63 m: very pale. 0.63-0.66 m: grey. 0.66-0.89 m: brown, mottled, very muddy. 0.89-1.19 m: white, very micritic.</p> <p>1.19-1.47 m: mottled brown, darker toward the base. 1.47-1.60 m: mud, silty sand. 1.60-1.67 m: brown. 1.67-1.86 m: white, pale grey. 1.86-2.15 m: brown, variegated colour and grain size. 2.15-2.20 m: brown, muddier unit. 2.20-2.34 m: less mud. 2.34-2.39 m: muddier.</p> <p>2.39-2.71 m: brown, variegated colour and size, pebble at base - tabular siltstone - marks on sample from hacksaw during core liner cutting.</p>
	0.31m							MPal		
	0.33m							MPal		
	0.45m							MPal		
	0.67m							Paly		
	0.70m							MPal		
	1.01m							MPal		
	1.03m							Paly		
	1.50m							Paly		
	1.53m							MPal		
	1.55m							MPal		
	2.39m							Paly		
	2.36m							MPal		
	2.38m							MPal		

PALYNOLOGY OF SAMPLE 57-16/18

Jim Riding

Five samples were taken for analysis from this short core.

0.27-0.30m (cream clay)

0.67-0.70m (sandy, light brown clay)

1.03-1.06m (cream clay)

1.50-1.53m (light brown clay)

2.33-2.36m (light brown clay)

Samples between 1.03m and 2.36m

The interval between 1.03m and 2.36m produced sparse organic residues and extremely sparse palynofloras. The residues are relatively rich in wood fragments with resistant mineral grains. Amorphous organic material is absent and palynomorphs are rare. The sparse palynomorph associations are poorly-preserved. This is clearly an organic-lean succession; the light brown clay at 2.33m-2.36m only produced sufficient residue to make up one microscope slide.

The richest palynomorph flora is from 2.33m-2.36m. Several pollen grains of Neogene/Quaternary aspect were encountered. These include an extremely poorly-preserved grain of *Chenopodium* pollen and occasional indeterminate spores and pollen. No Quaternary dinoflagellate cysts are present. However, some evidence of Carboniferous and Jurassic reworking was observed. Single specimens of a spore of Carboniferous aspect and the dinoflagellate cyst *Nannoceratopsis deflandrei* subsp. *senex* are present. The probable Carboniferous spore is indeterminate. *Nannoceratopsis deflandrei* subsp. *senex* is typical of the early Toarcian (Riding *et al.*, 1999; Bucefalo Palliani and Riding, 2000) and may represent reworking of the upper part of the Dunlin Group.

The samples at 1.50m-1.53m and 1.03m-1.06m lack any definite reworking. The sparse palynofloras include the miospores bisaccate pollen, Compositae pollen and triporate pollen. The dinoflagellate cysts *Brigantedinium* spp. and *Operculodinium centrocarpum* are present at 1.50m-1.53m. These, and the Compositae pollen at this depth, suggest a Quaternary age, although *Operculodinium centrocarpum* does range into the Neogene (Harland, 1992).

Sample at 0.67m-0.70m

This sample produced an abundant organic residue, which is dominated by relatively dark amorphous organic material; wood is also present in large proportions. Palynomorphs, however, are sparse. The dinoflagellate cysts *Brigantedinium* spp. and *Operculodinium centrocarpum* and the occasional triporate pollen grain suggest a Quaternary age. However, the palynofloras are dominated by reworked grains. A single, thermally mature, specimen of the Carboniferous spore *Lycospora pusilla* is present. This specimen is blackened and thus has a high thermal alteration index. The majority of the allochthonous palynomorphs are of Lower Jurassic aspect. These include *Cerebropollenites* sp., *Chasmatosporites* spp., *Classopollis classoides*, *Classopollis* spp., *Halosphaeropsis liassica* and *Nannoceratopsis* sp. Preservation is poor to fair and the thermal alteration index is relatively high. *Halosphaeropsis liassica* is a microplankton taxon which is extremely characteristic of the Lower Toarcian (Bucefalo Palliani and Riding, 2000), especially when accompanied by amorphous organic material. The remainder of the flora is entirely consistent with an early Toarcian age. This reworking is thought to represent the incorporation of the upper part of the Dunlin Group, similar to the sample at 2.33m-2.36m.

Sample at 0.27m-0.30m

The youngest sample yielded a moderately abundant palynoflora of Quaternary dinoflagellate cysts and miospores. Wood is also common and plant tissue and resistant mineral grains are present. No evidence for reworking was observed. Quaternary dinoflagellate cysts are prominent and relatively diverse. They comprise *Bitectatodinium tepikiense*, *Brigantedinium cariacense* (cyst of *Protoperidinium avellanum*), *Brigantedinium simplex* (cyst of *Protoperidinium conicoides*), *Brigantedinium* spp., ?cyst type A of Harland (1977), *Impagidinium patulum*, *Impagidinium sphaericum*, *Nematosphaeropsis labyrinthea*, *Operculodinium centrocarpum*, *Quinquecuspis concretum*, *Selenopemphix quanta*, *Spiniferites elongatus*, *Spiniferites frigidus*, *Spiniferites ramosus* and *Spiniferites* spp. The occurrences of *Brigantedinium cariacense* and *Quinquecuspis concretum* are indicative of a Late Pleistocene to Holocene age (Harland, 1992, fig. 5.2; Mudie and Harland, 1996, fig. 8). Furthermore, *Brigantedinium simplex*, *Selenopemphix quanta*, *Spiniferites elongatus* and *Spiniferites frigidus* have Mid Pleistocene range bases (De Vernal *et al.*, 1992, fig. 13; Harland, 1992, fig. 5.2). *Operculodinium centrocarpum* dominates the dinoflagellate cyst floras, comprising 58.6% of the dinoflagellate cyst assemblage. This diversity of the assemblage, the dominance of *Operculodinium centrocarpum*, and the occurrences of *Nematosphaeropsis labyrinthea*, *Selenopemphix quanta*, *Spiniferites elongatus* and *Spiniferites mirabilis* indicates deposition during a temperate, interglacial phase (Harland, 1992). The presence of *Impagidinium* spp. indicates that this sample was deposited in deep water, probably in an outer shelf setting (Harland, 1992). In terms of Stages, the sample is probably Ipswichian or Flandrian. The miospores are not age diagnostic.

FORAMINIFERA OF SAMPLE 57-16/18

Ian Wilkinson

Five samples were taken for analysis from this short core.

0.31-0.33m

0.65-0.67m

1.01-1.03m

1.53-1.55m

2.36-2.38m

The stratigraphically lowest sample from 2.36-2.38m depth, which was very shelly, contained abundant *Paromalina crassa* and frequent *Cibicides refulgens*. Very rare *Uvigerina venusta* cf *saxonica*, *Trifarina angulosa*, *Cibicides lobatulus*, *Cibicidoides kullenbergi/mundulus*, *Pyrgo murrhina* and *Sigmoilopsis schlumbergeri*. Common *Globorotalia* cf *continua* and *Neogloboquadrina acostaensis* together with frequent *Globigerina bulloides/praebulloides* dominate the planktonic element. However, *Orbulina universa* and *Globorotalia scitulus* are also present.

At 1.53-1.55m it was similar to that from 2.36-2.38, although diversity was reduced. *Paromalina crassa* dominated, *Cibicides refulgens* was common, and rare or very rare specimens of *Pyrgo murrhina*, *Melonis barleeianum*, *Pullenia bulloides*, *Sigmoilopsis schlumbergeri* and *Planulina araminensis* also occurred. Of the planktonic foraminifera, *Globigerina bulloides* and *Globorotalia continua* are common and *Orbulina universa* and *Neogloboquadrina acostaensis* are rare. The assemblage at 1.01-1.03m is essentially similar to that at 1.53-1.55m.

At 0.65-0.67m the benthos is diverse, dominated by *Paromalina crassa*, but the remaining species were generally rare or very rare. *Oridorsalis umbonatus*, *Bulimina marginata* and *Trifarina angulosa* were amongst these. *Rupertina stabilis*, a species which ranges from the Miocene to Recent, also occurred in small numbers. The latter species is a deep water form characteristic of the lower slope and water depths in excess of 2000m although in the cold waters of the Faroe Channel (North Atlantic) it has been found in waters of about 1100m depth. It was used by Murray (1979) to indicate deep waters for the Pleistocene west of the Rockall Bank. The planktonic element of the fauna is identical to that described above.

The highest sample examined, from a depth of 0.31-0.33m, contained abundant *Paromalina crassa*, common *Cibicides refulgens* and frequent *Uvigerina venusta saxonica* and *Cibicidoides kullenbergi/mundulus*. Other species include rare or very rare *Quinqueloculina 'seminulum'*, *Rupertina stabilis*, *Oridorsalis umbonatus*, *Sigmoilina schlumbergeri* and *Epistominella exigua*. The planktonic element is as described above.

It may be concluded that the age of the sequence of this short core is within the upper part of the Miocene. *Orbulina universa*, which is found rarely throughout the borehole indicates the age is no older than mid Miocene (N9) and the presence of *N. acostaensis* implies an age no older than the late Miocene (N16-17). At times, the water depths appear to have been much deeper than those for borehole 57-16/17, for the presence of *Rupertina* suggests depths of at least 1100m and perhaps more.

NANNOFOSSILS OF SAMPLE 57-16/18

Jackie Lees

Four samples were taken for analysis from this short core.

0.33m

0.70m

1.55m

2.38m

All of the samples were highly productive, and preservation was moderate to good. *E. huxleyi* was present throughout the sequence, along with a varied selection of geophyrocapsids, indicating NN21 (latest Pleistocene to Early Holocene). Some possible reworking (although this could also result from a wide sample interval) from NN19 (Early Pleistocene) was evident at 0.70m and below, based on the occurrence of *Pseudoemiliana*, along with Late Cretaceous and Palaeogene reworked taxa.

SEDIMENTOLOGY OF SAMPLE 57-16/18

Alick Leslie

Cores 57-16/17 and 18 comprise a series of bioturbated sediments containing foraminiferal sands, muddy sands and muds. The majority of the sediment appears to be calcareous and bioclastic in origin. There is some evidence for grading in some beds and one pebble lag was identified. Fine-grained beds are grey, brown or white colour.

Bioturbation is pervasive throughout both cores but is not sufficient to have obscured stratification. Bioturbation index (Droser and Bottjer 1986) is 3 (10 – 40% of original bedding disturbed). Maximum visible 'drawdown' of sediment in burrows is in the region of 0.20m. The bioturbation appears to comprise horizontal to incline up to 45° burrows up to 10mm in diameter, and is assigned tentatively to a *Planolites* type.

Cores 57-16/17 and 18 consist of a succession of sediments with variable grain size and colour. All of the lithologies contain sand sized (0.2 – 0.4mm) foraminifera, other bioclastic debris and some lithic clasts and pebbles. The most common lithologies are as follows:

Foram rich sands, light brownish grey (Munsell® colour 2.5Y 6/2)

Muddy foram sands, light grey (2.5Y 7/1)

Muddy foram sands, light yellowish brown (10YR 6/4)

Sandy muds, white (10YR 8/1)

Both cores are topped by foram rich sand also containing molluscan and echinoderm fragments, fragments of black basaltic rocks, some quartz and feldspar. In core 57-16/17 the foram rich sand occurs at several horizons including the basal 0.50m of the core. This sequence suggests that there is a cyclicity in the deposition of foram sands.

In core 57-16/18 foram rich sands are less common and white calcareous muds, some of which show subtle grading, more abundant. The successions in the two cores cannot at present be correlated. The similarity in composition suggests that they were supplied from the same sediment sources and were probably contemporaneous.

Biostratigraphic analysis of both cores is problematical. In both cores foraminiferal analysis suggests an age within the upper Miocene while dinoflagellates suggest that much of the core is Pleistocene in age. Neither dataset appears to be definitive and while it is possible that a Pleistocene succession overlies Miocene sediments (Jim Riding, pers comm.) further work is required to clarify the age of the sediments.

See also discussion under 57-16/19.

SAMPLE 57-16/19

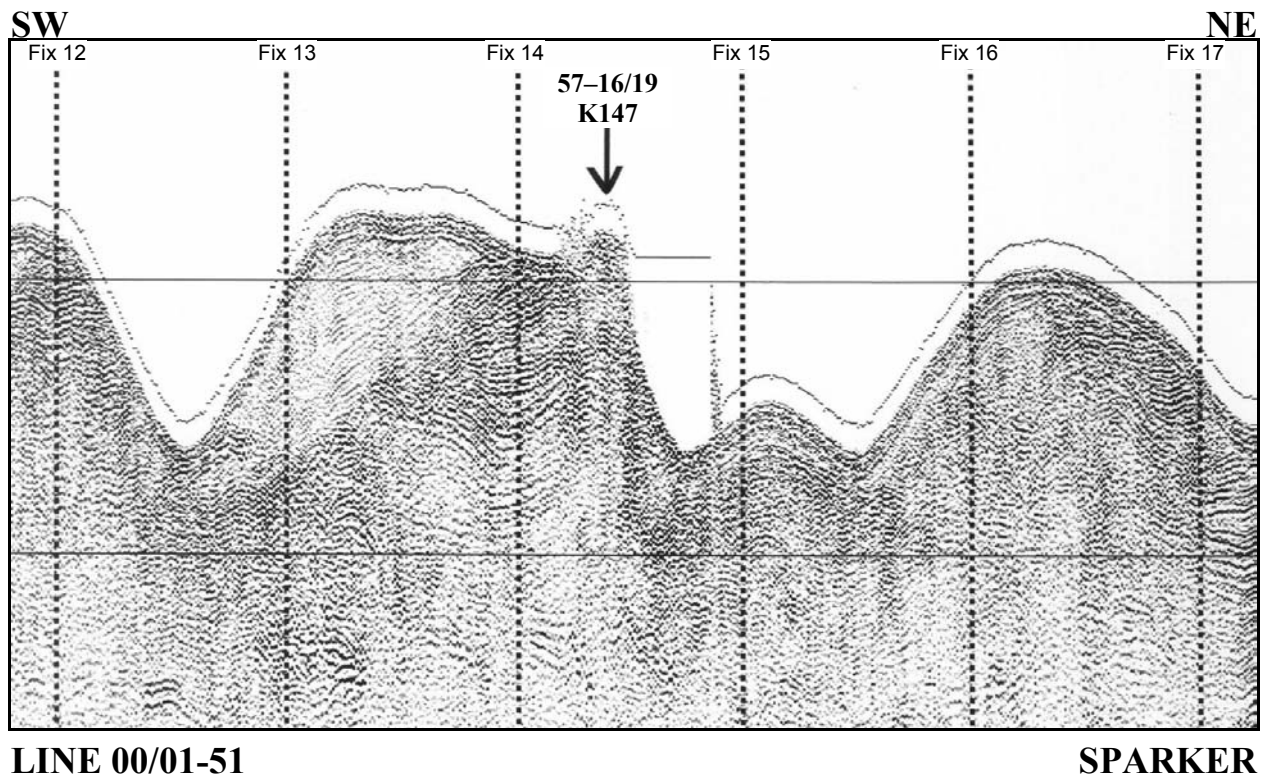
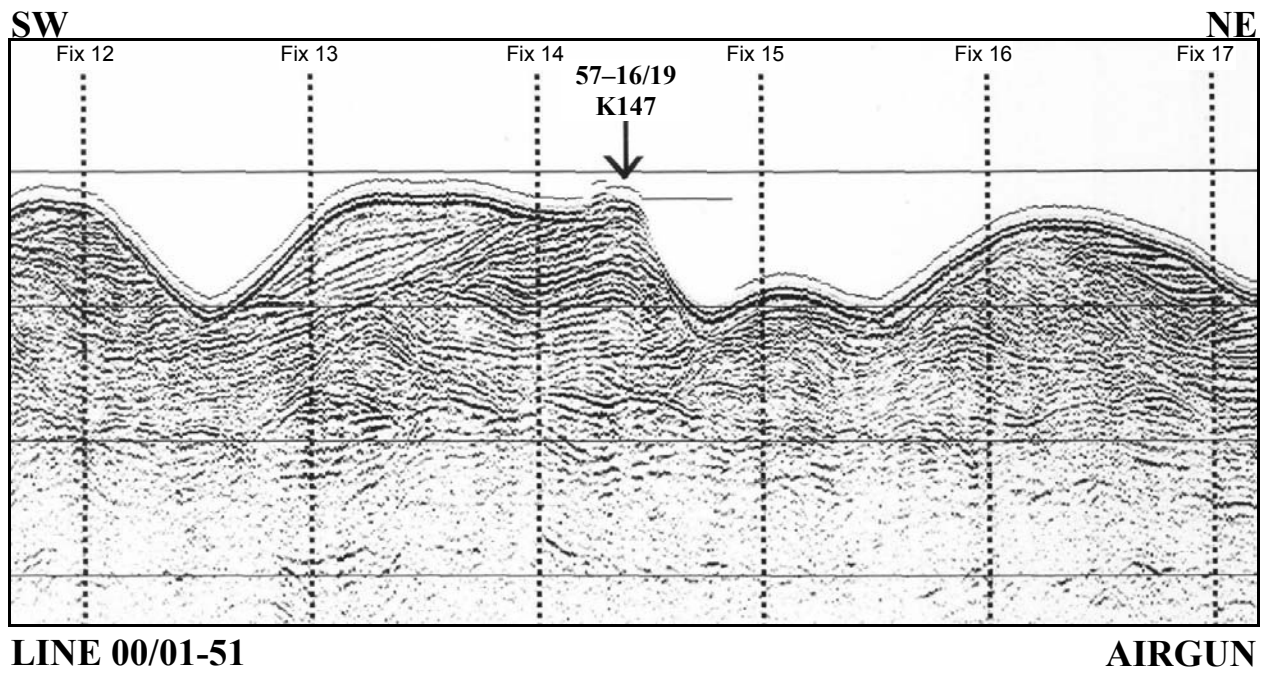
SITE DETAILS

Date of drilling:	19th August 2001
Original site number:	K147
Latitude:	57° 00.053'N
Longitude:	15° 23.229'W
Location:	West flank of Rockall Bank
Line and fix number:	00/01-51 14.4
Equipment:	BGS vibrocore
Core length:	3.07m
Lithology:	White and cream muds and clay
Age:	Close to Lower/Middle Miocene boundary (forams)

SUMMARY

An excellent core was obtained at this site. Palynomorphs were sparse and did not constrain the age of the core to better than Neogene/Quaternary with no evidence of reworking. The forams constrained the age quite tightly and indicated that water depths at the time were very deep and in the cold part of the North Atlantic Ocean.

The suggested age fits with that prognosed from the seismic data.



BGS CORE NO: 57-16/19VE



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position	West Rockall Bank		
Latitude	57 00.0533' N	Licence Block	349/29
Longitude	15 23.2292' W	BGS Plan No	K147
Navigation	DGPS	Total Depth	3.31m (Rec 3.07m)
Map Area		Water Depth	666m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	19.08.2001
		Geologists	R Gatliff & C Morri

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0							Paly 0.15m MPal 0.17m		0-12 cm Hard manganese crust, irregular burrowed surface, colour reddish brown 5Y4/4. Underlying sediment is compacted.
	1							Paly 0.65m MPal 0.67m MPal 1.17m Paly 1.20m		12-81 cm Heavily bioturbated/burrowed and well mixed clacareous muds. Colour varies in top 12-34 cm. Burrows infilled with foram sands, colour light grey 7/N. Burrows end at 81 cm.
	2							Paly 1.68m MPal 1.70m		81-307 cm Homogeneous white, clacareous clay/ooze, very firm. Contains rare broken shelly fragments. Becomes coarser at 207 cm toward the base of the core. At 307 cm large ~7 cm silica cemented fragment consisting of broken shell fragments and bryzoans. Colour white, 8/N.
	3							Paly 2.50m MPal 2.52m Paly 2.96m MPal 2.98m		The drill landed at the initial site on a slope of about 30 degrees. The ship was moved approximately 20 m in a SW direction and the core was taken with the drill at an angle of about 16 degrees.
	4									
	5									
	6									

PALYNOLOGY OF SAMPLE 57-16/19

Jim Riding

Six samples were taken for analysis from this short core.

0.15-0.17m (cream clay)

0.65-0.67m (white clay)

1.20-1.22m (white clay)

1.68-1.70m (white clay)

2.50-2.52m (white clay)

2.96-2.98m (white clay)

The samples were all prepared using the mineral acid technique, except the basal one, at 2.96m-2.98m, which was prepared using sodium hexametaphosphate. All samples are unlithified white/cream clay which, macroscopically, appears to be organic-lean. Upon preparation, the samples all proved extremely organically sparse. Resistant mineral grains proved abundant and wood fragments are also present. Palynomorphs were rare; typically less than 10 specimens per microscope slide were recorded. These palynofloras are overwhelmingly dominated by pollen grains. Forms present include undifferentiated bisaccate pollen *Erica*, ?Gramineae, *Picea* and triporate forms. No evidence of reworking was observed. This assemblage is not biostratigraphically significant, although the preservation, and absence of typically Palaeogene forms, strongly suggests the Neogene/Quaternary. A single, questionable specimen of the dinoflagellate cyst *Bitectatodinium tepikiense* was observed at 2.96m-2.98m. This species is extant, and has its range base in the early Miocene (Powell, 1992). Therefore on the basis of the limited palynological evidence, the age of this unit is probably Miocene to Quaternary. *Bitectatodinium tepikiense* is present in the Quaternary samples in this study (see other sections). Therefore, it is possible that the samples are Quaternary. It is possible that this contention could be proved using seismic evidence.

FORAMINIFERA OF SAMPLE 57-16/19

Ian Wilkinson

Six samples were taken for analysis from this short core.

0.17-0.19m

0.67-0.69m

1.17-1.19m

1.70-1.72m

2.52-2.54m

2.98-3.00m

The lowest sample, from a depth of 2.98-3.00m was found to be extremely shelly including echinoid plates and frequent bryozoa. The benthonic foraminiferal association was dominated by abundant *Planularia ariminensis*, common *Cibicidoides kullenbergi*, and frequent *Uvigerina semiornata*, *Lenticulina* spp and *Cibicidoides dutemplei*. Planktonic species were found rarely in the sample, with the exception of *Globigerina bulloides/praebulloides* (these two species are difficult to separate at the latitude of the boreholes), which is more frequent. The absence of *Orbulina universa* is possibly significant here, for that form appears in N9, in the lowest Middle Miocene. Unlike the other boreholes discussed above, the foraminifera community is dominated by the benthos.

At 2.52-2.54m, bryozoa are abundant. Foraminifera are less numerous and less diverse, although frequent *Cibicidoides kullenbergi*, *Cibicidoides dutemplei* and *Fontbotia wuellerstorfi* were present. The last named species is characteristic of cold, bathyal conditions and first appeared at the base of the Middle Miocene (in N9). Planktonic species were very rare. A similar fauna was recorded from 1.70-1.72m.

The sample from 1.27-1.29m again contained abundant bryozoa. *Epistominella exigua* and *Fontbotia wuellerstorfi* are frequent, but this species also contained rare *Siphonina tenuicarinata*, a species that ranges through from the Eocene to the early Miocene and has also been reported from the earliest Mid-Miocene (N9). Planktonic species are again rare, but include rare *Globigerina bulloides/praebulloides*.

The shelly sample from 0.67-0.69m was again rich in bryozoa and echinoid spines were also present. *Cibicidoides kullenbergi* and *C. dutemplei* are frequent and *Fontbotia wuellerstorfi* is common. A single specimen of *Marginulina* sp cf *M. wetherelli* (an early Tertiary species) also occurred in the sample.

The overlying sample (from 0.17-0.19m) was essentially similar, but significantly very rare *Orbulina universa* was present. This is the only record of the species in the borehole, but indicates an age no older than N9.

In conclusion, this borehole appears to be very close to the Early/Middle Miocene boundary. The lower sample is Lower to Middle Miocene in age, but the sample at 2.52-2.54m is considered to be of Mid Miocene age on the basis of the occurrence of species such as *Fontbotia wuellerstorfi*. *Orbulina universa*, the diagnostic species marking N9, is not present until the highest sample examined at 0.17-0.19m. Water depths were deep. Murray (1991) places his *wuellerstorfi* association at 1360-4280m in the cold parts of the Atlantic Ocean, where it is associated with the North Atlantic Deep Water mass.

SEDIMENTOLOGY OF SAMPLE 57-16/19

Alick Leslie

This core consists of 3.07m of white carbonate with varying degrees of lithification. At the surface is a dark band. At a depth of 3.00 m a hardground of lithified carbonate is present.

0.00 – 0.12m

The dark band at sea bed is 12mm thick and has a reddish brown (5Y 4/4) colouration. There is some relief at the surface, suggesting a possible enhancement of crystallisation around burrows, or exhumation of silicified burrows within the dark band.

0.12 – 3.07m (TD)

The 0.10m of carbonate underlying the dark band is hard and appears to be lithified. It is possible that this carbonate has been compacted by the hard band during drilling. The unconsolidated carbonate underlying the 0.10m is similar in appearance and colour, grey (N7) to white (N8) fine-grained carbonate, predominantly nannoplankton but with some coarse-grained forams. The carbonate below 0.30m has been bioturbated and contains well defined burrows up to 10mm in diameter, filled by foram sand that is slightly darker than the fine-grained matrix. These burrows, horizontal to inclined at 60°, might be referred to as *Planolites*. There is no stratification to be disturbed but the Bioturbation Index is 2 – discrete, isolated burrows. The source of the foram sand that fills the burrows cannot be identified. There is a trace of a sand layer at the top of the core, and another at a depth of 0.55m. The sand source for the burrows might be related to these, however the sand filled burrows do not extend above 0.30 m and it is possible that a sand at this level has been removed by erosion after a phase of bioturbation.

The discrete burrows become less common with depth and are not seen below 0.80m. There is still some evidence for subtle bioturbation of the sediment. Scattered patches of dark material, presumably iron oxyhydroxides, appear to be related to burrow structures. There is also a very subtle pattern of deformation on a scale of the '*Planolites*' burrows that suggests pervasive bioturbation of the sediment without a contrast in lithology between the matrix and burrows. This biodeformation (Wetzel, 1984) cannot be quantified in terms of percentage of sediment disturbed but is present throughout the core.

The hardground at 3.00m is 15mm in thickness and appears to comprise lithified carbonate. It is possible that this lithification involves silicification.

Discussion of samples 57-16/16, 17, 18 and 19

These four cores from Rockall Bank show a range of sedimentary lithologies. Cores 57-16/16 and 57-16/19 are composed mostly of fine-grained carbonate, white or grey with little sedimentary structure. In 57-16/16 the upper carbonate is unconsolidated, while in 57-16/19 the upper carbonate underlies a manganoan hardground and has been lithified or compacted.

Cores 57-16/17 and 57-16/18 contain a succession of foram sands, muddy sands, muds and white fine-grained carbonates. Interbedding of these lithologies is complex with beds commonly under 0.10m in thickness. Both cores are topped by foram sands, a lithology that is also seen deeper in the succession. Core 57-16/18 contains a greater proportion of white carbonate. The two successions cannot be correlated by lithology.

Depositional environment for the four cores is assumed to be a slope with episodic, possibly down-slope, input of coarse-grained bioclastic material and a background hemipelagic deposition of fine-grained calcareous material, possibly nannoplankton. The dominance of input of calcareous nannoplankton is low in 57-16/17, more significant in 57-16/18 and greatest in 57-

16/16 and 57-16/19. Core 57-16/19 was taken from a topographic high, seismic line 00/01-51 suggests a mound or high at the location for a depth of over 100ms (roughly 90m). It is possible that the sediment in this core represents an area bypassed by down-slope supply of coarse-grained bioclastic sediment.

The seismic line 00/01-47 and 00/01-51 suggests that there is Oligocene – Miocene sediments at or near seabed in all four cores. Core 57-16/16 might have recovered a veneer of recent unconsolidated carbonate. The lack of similar carbonate at the top of core 57-16/17, no more than 10m distant, is problematic. The white carbonate might infill a local depression at seabed or represent a discontinuous seabed cover in an area swept by currents. Cores 57-16/17, 18 and 19 might represent earlier periods of deposition; the lithification of carbonate in cores 57-17/17 and 18 suggests an older, possibly Palaeogene age, but verification of this needs further biostratigraphic analysis.

Interpreted palaeodepths range from 300 – 500m for core 57-16/17 to >1300 m in 57-16/19 (Wilkinson 2002). The differences in palaeodepth are considerable from cores relatively close together. Palaeodepths are greatest in the core where coarse-grained sediment is least abundant. Without more definitive biostratigraphic resolution of the core successions, it is difficult to determine exactly which sediments are likely to be correlatives.

SAMPLE 57-17/5

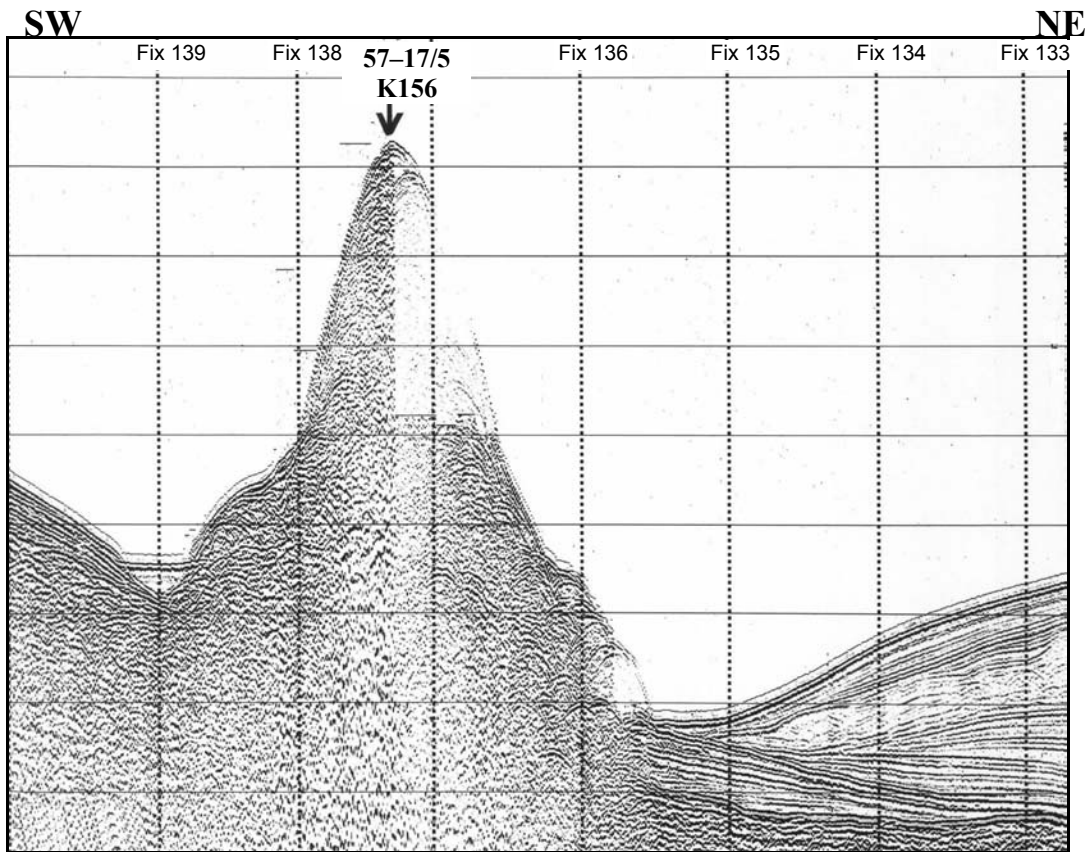
SITE DETAILS

Date of drilling:	17th August 2001
Original site number:	K156
Latitude:	57° 16.602'N
Longitude:	16° 23.232'W
Location:	Hitchen's Nob, Sandastre volcano, Hatton Basin
Line and fix number:	00/01-54 137.3
Equipment:	BGS rockdrill
Core length:	4.40m
Lithology:	Thin fossiliferous limestone overlying carbonate-Cemented, clast-supported volcanic agglomerate.
Age:	To be confirmed.

SUMMARY

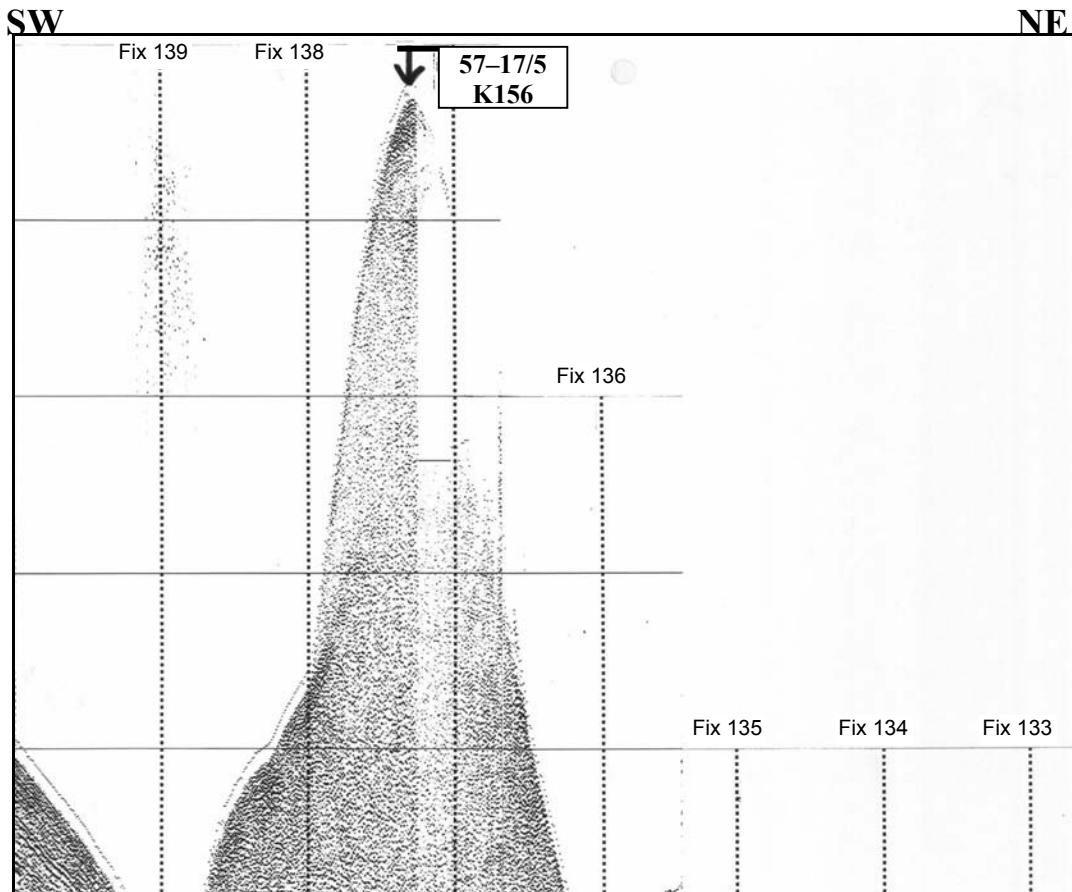
This is one of five sample sites on the top of the Sandastre volcano. The drilled structure (Hitchen's Nob), which is only imaged on a single NE-SW seismic line, appears to be a parasitic cone on the flank of the main Sandastre volcano.

On regional considerations the age of the volcanic clasts of the agglomerate is likely to be Late Palaeocene to Early Eocene. Eocene limestones have been proven to rest directly on basaltic lavas on Anton Dohrn and George Bligh Bank and that may be the case here also. A Pleistocene age is suggested from foraminiferal analysis of the carbonate, however no definitive ages have yet been determined for the agglomerate or the limestone.



LINE 00/01-54

AIRGUN



LINE 00/01-54

SPARKER

BGS CORE NO: 57-17/5DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position

Sandastre

Latitude	57° 16.602'N	Licence Block	348/24	Vessel	James Clark Ross
Longitude	016° 23.232'W	BGS Plan No	K156	Station Keeping	DP
Navigation	DGPS	Total Depth	4.64m (Rec. 4.40m)	Dates of Drilling	17/08/2001
Map Area		Water Depth	963m	Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0							Paly 0.14m MPal 0.14m MPal 0.14m MPal 0.14m TS 1.98m		<p>CARBONATE-CEMENTED VOLCANIC BRECCIA OVERLAIN BY CHALK</p> <p>Nearly continuous recovery of dolomite or Mg-calcite-cemented volcanic breccia overlain by chalk (fossiliferous limestone).</p> <p>0.00-0.26 m: The fossiliferous limestone is fine grained, and shows a weak reaction with dilute HCl. Contains broken corals, shelly fragments and angular lithic clasts of varying size and colour. Well cemented. Colour light grey 2.5Y 7/2.</p> <p>0.26- 4.40 m: The breccia is clast supported, cemented by either dolomite or Mg calcite (does not react with HCl on fresh surface; will react if powdered). The clasts range in size from ~1 mm to possibly larger than the core diameter (>5 cm), e.g. at 1.96 m. Most clasts are <1-2 cm in size. No evidence of grading, although there is a variation in clast size. The clasts are thoroughly altered to Fe oxyhydroxides that range from dark reddish brown (most of core) to a lighter orange brown (e.g. between 2.70 to 3.10 m), making it impossible to tell the origin of all clasts. However, where structures/textures are preserved, the clasts appear to be highly vesicular, and probably basaltic in origin. The vesicles have been filled by carbonite (dolomite or Mg-calcite), creating spherical sand size grains that stand out against the red of the Fe oxyhydroxides. Some clasts have stretched vesicles. Preservation of skeletal olivine microphenocrsts is observed rarely. Many of the clasts contain dark, crystalline material of unknown origin. In some cases these look like they may be evidence of small crustal xenoliths. Surprisingly, there may be some thin fragments of unaltered glass on the rims of some clasts (rare!).</p> <p>Also present, but probably forming less than 1% of the clasts, are small greenish brown, mud-rich clasts. These may be indicative of the overlying sediment at the time of eruption of the breccia.</p> <p>Vugs are lined with globular looking carbonates with euhedral terminations on the spherical globs.</p>



PALYNOLOGY OF SAMPLE 57-17/5

Jim Riding

The single sample from 0.14m-0.16m was analysed and comprised white, conglomeratic, fossiliferous (shelly) limestone. It was processed twice, firstly using sodium hexametaphosphate and hydrogen peroxide and secondly using hydrochloric acid. Both techniques produced virtually identical residues. The organic residues from the samples are extremely sparse, the most abundant constituent being resistant mineral grains. Wood, resinite, other plant tissues and palynomorphs are all rare. The preservation of the palynomorphs is extremely poor. Pollen grains are the most abundant palynomorph group and include bisaccate grains, small spherical grains and triporate forms. Unequivocal dinoflagellate cysts were absent, although some rare, questionable specimens of *Bitectatodinium tepikiense* were observed. Several mineralised foraminifera are also present. No reworking was recognised. The sparsity of the pollen flora and the dubious nature of the *Bitectatodinium tepikiense* precludes a detailed age assessment. However the assemblage is entirely consistent with the Neogene and Quaternary.

FORAMINIFERA OF SAMPLE 57-17/5

Ian Wilkinson

Only a single sample, from a depth of 0.14-0.16m, was examined from this borehole (MPA50846). As the sample was indurated, a thin section was cut. Benthonic taxa were not found, but planktonic species were more common. Whereas the presence of *G. crassaformis* and *G. inflata* first appeared during the Pliocene, the first up sequence occurrence of *Globorotalia truncatulinoides* is indicative of N22 and N23 (Pleistocene) (BOLLI & SAUNDERS, 1985).

NANNOFOSSILS OF SAMPLE 57-17/05

Jackie Lees

A single sample was taken for analysis.
0.14-0.16m

The sample was sparsely productive. The assemblage contained no really definitive taxa, with only *D. productus* possibly been indicative of the Miocene-Pliocene (according to Perch-Nielsen 1985) although Young (1998, pp.236-237) regarded such taxa (closed central-area reticulofenestrids) as being biostratigraphically useless.

PETROGRAPHY OF SAMPLE 57-17/5

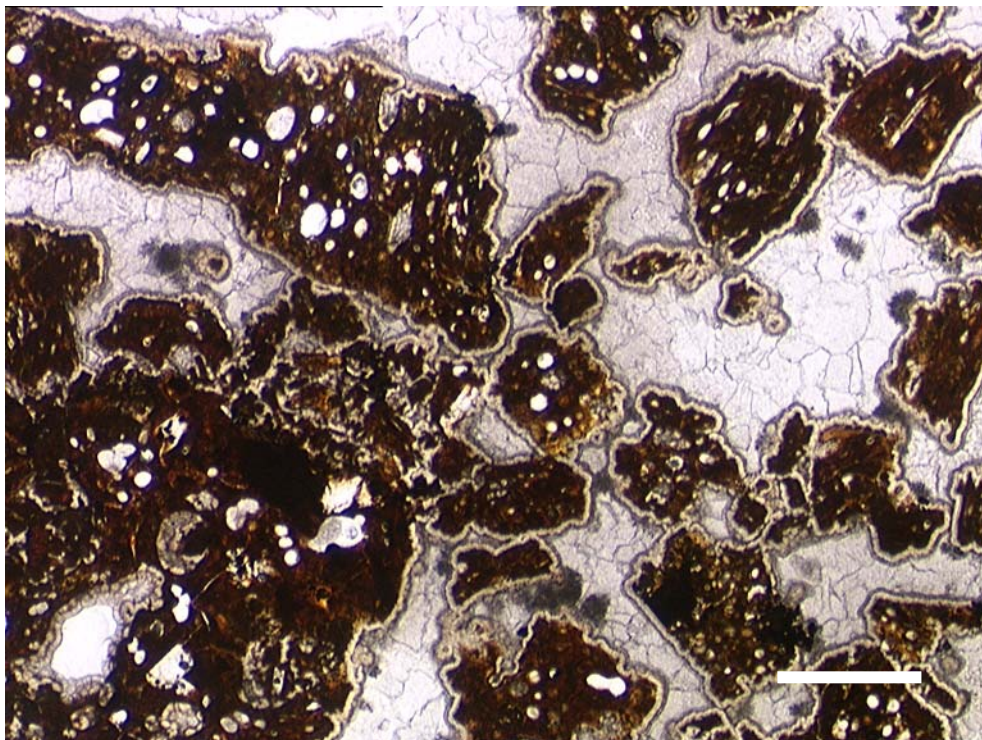
Graham Lott

A sample from 1.38m was studied in hand specimen and thin section.

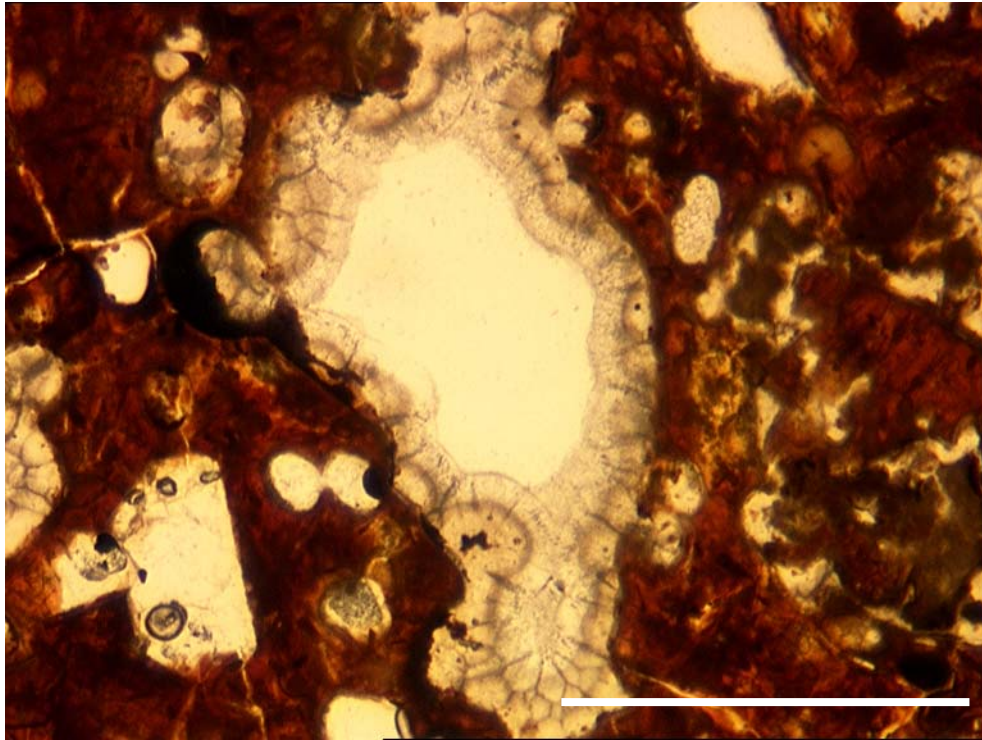
Hand specimen

Breccia of dark reddish brown to light orange-brown clasts in a coarse carbonate cement.

Thin section



Scale bar is 1mm



Scale bar is 1mm

The sample comprises irregularly shaped and sized (medium sand to granule grade), dark reddish brown grains of devitrified volcanic glass floating in a pervasive, sparry carbonate cement.

Internally the grains show a finely vesicular amygdaloidal fabric. The irregular grain margins are coated with narrow, isopachous and radial fringing cements of either cryptocrystalline silica or zeolite. Similar cements also occlude or partially occlude some of the amygdales within the glassy fabric.

Occasional relict pyroxene crystals survive within some of the altered glassy grains. No non-volcanic detrital material is evident in the sample.

Macroporosity

None. The pervasive spar carbonate cement occupies all of the intergranular area, occluding any primary porosity.

Comment

The precise mineralogical composition of the low birefringent fringing cements cannot be readily identified in thin section and further study using the SEM/Electron Microprobe should be carried out if more precise information is required.

SEDIMENTOLOGY OF SAMPLE 57-17/5

Alick Leslie

This core contains 4.40m of sediment with a 0.26 m capping of lithified coralline carbonate.

0.00 - 0.02m

The top of the core is light grey unconsolidated foram sand containing some lithic clasts.

0.02 – 0.26m

The carbonate consists of a lithified white to light grey limestone containing what appear to be solitary corals, shells and some forams in a fine-grained matrix. The corals appear to be relatively intact, up to 30mm in length. They appear to be solitary corals but the density of the bioclasts suggests that they may have formed a network sufficient to trap and accumulate fine-grained sediment, forming a baffestone.

0.26 – 4.40m (TD)

Below 0.26m is a breccia consisting of brown devitrified volcanic material (epiclasts) cemented by calcite or possible dolomitic spar. The volcanic material contains some intragranular silica cement (Lott 2002). The breccia is clast supported, clasts are angular to sub angular, up to 50mm in size. There is some down-core variation in grain size but no grading or distinct bases to beds.

See also discussion under 57-17/9

SAMPLE 57-17/6

SITE DETAILS

Date of drilling:	17th August 2001
Original site number:	K145
Latitude:	57° 12.54'N
Longitude:	16° 28.02'W
Location:	Sandastre volcano, Hatton Basin
Line and fix number:	00/01-48 30.85
Equipment:	BGS rockdrill
Core length:	3.10m
Lithology:	Carbonate-cemented, clast-supported volcanic agglomerate.
Age:	To be confirmed.

SUMMARY

Almost identical core to 57-17/5 but perhaps with slightly smaller clasts.

BGS CORE NO: 57-17/6DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Sandastre	
Latitude	57° 12.54'N	Licence Block	348/23
Longitude	016° 28.02'W	BGS Plan No	K145
Navigation	DGPS	Total Depth	4.88m (Rec. 3.10)
Map Area		Water Depth	891m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	17/08/2001
		Geologists	P. Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0	M M M M M									CARBONATE-CEMENTED VOLCANIC BRECCIA OVERLAIN BY PEBBLES (MIXED LITHOLOGY)
	0.00-0.09 m	M M M M M									0.00-0.09 m: Pebbles of mixed lithology, 1-4 cm in size. Approximately half are of metamorphic origin, including some quartz or quartzite; one is heavily coated with MnO. The rest of the pebbles appear to be fine grained extrusive igneous rocks. One is clearly an altered piece of scoria.
	0.09-3.10 m	M M M M M									0.09-3.10 m: Clast supported, volcanic breccia, similar to that at site 57-17/5DR, but on average finer grained and more uniform throughout in terms of clast size. Clast size ranges from ~1 to 10 mm. All clasts are totally altered to reddish brown Fe-oxyhydroxides. Vesicles filled with dolomite/Mg-calcite (spherical shapes). No obvious layering or grading. MnO(?) patches are present throughout the core. The core pieces from 2.89 to bottom of the core, have a coating of pale brown mud. This mud is not apparent higher up in the core, suggesting the breccia may have overlain a layer of mud (not recovered).
	3	M M M M M									
	4										
	5										
	6										



SAMPLE 57-17/7

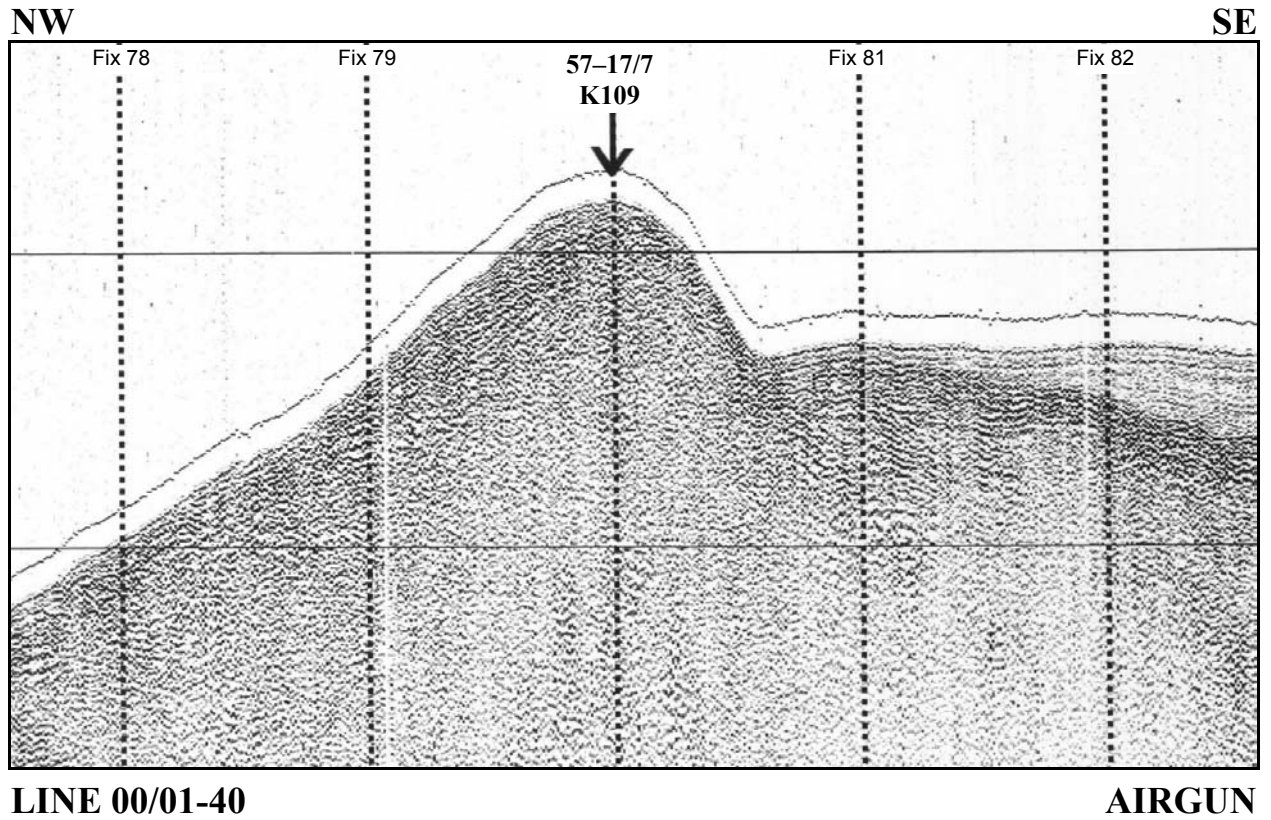
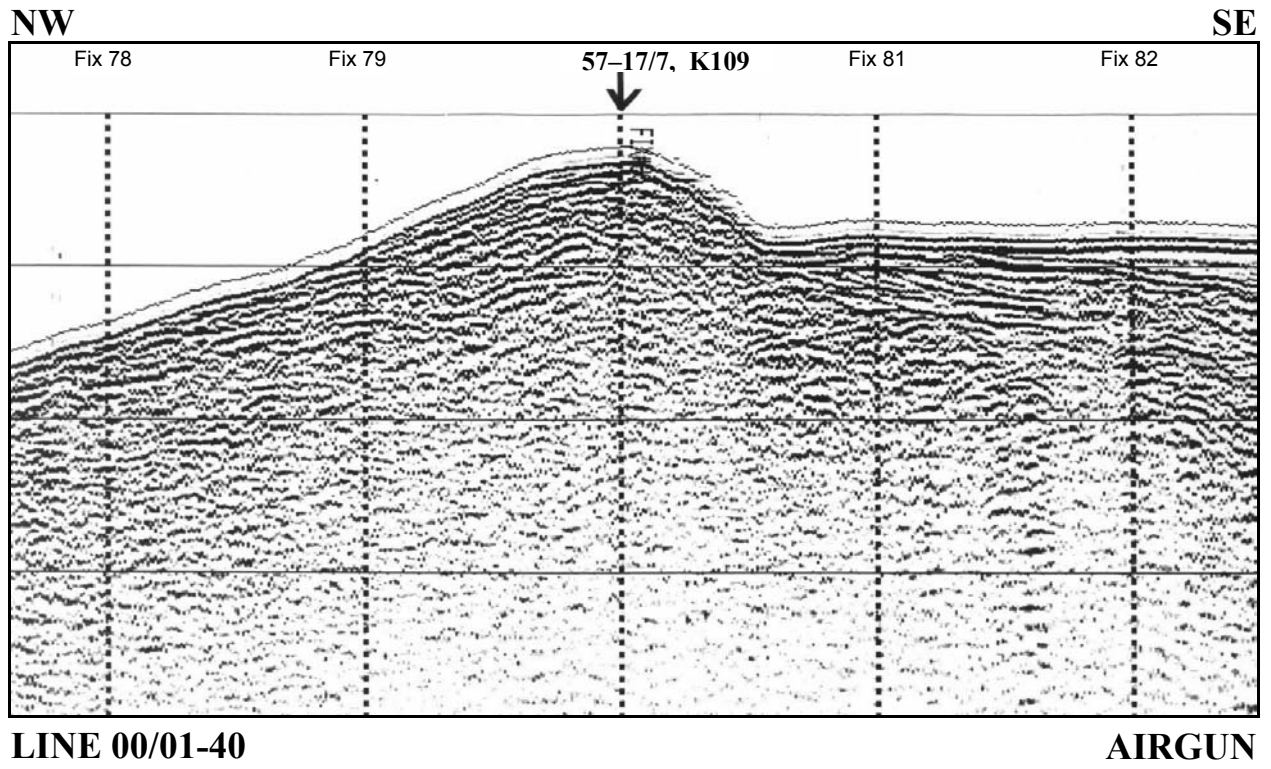
SITE DETAILS

Date of drilling:	17th August 2001
Original site number:	K109
Latitude:	57° 8.80'N
Longitude:	16° 33.79'W
Location:	Sandastre volcano, Hatton Basin
Line and fix number:	00/01-40 80.00
Equipment:	BGS rockdrill
Core length:	1.68m
Lithology:	Gravel on thin limestone on brown, muddy (?tuffaceous) siltstones.
Age:	To be confirmed.

SUMMARY

This short core sampled the sedimentary layer which overlies the volcanic bulk of the of the Sandastre volcano. The sediments are varied, possibly tuffaceous, and cut by veins of ?calcite and ?dolomite.

The palynological preparations yielded insufficient specimens for an age determination.



PALYNOLOGY OF SAMPLE 57-17/7

Jim Riding

Two samples were taken for analysis from this short core.

0.50-0.52m (brown, laminated sandy siltstone)

1.61-1.64m (light brown, laminated mudstone)

The samples were both processed using sodium hexametaphosphate and both residues are extremely sparse palynologically. Resistant mineral grains are common at both horizons; wood and palynomorphs proved sparse. Palynomorph preservation is also extremely poor. Some pollen grains are present and include bisaccate forms, Gramineae (grass) pollen, small spherical pollen and indeterminate morphotypes. No dinoflagellate cysts were observed. Occasional mineralised foraminifera are also present. No evidence of reworking was recognised. The sparsity of the pollen flora precludes a detailed age assessment, however the assemblage is consistent with the Neogene and Quaternary.

PETROGRAPHY OF 57-17/7

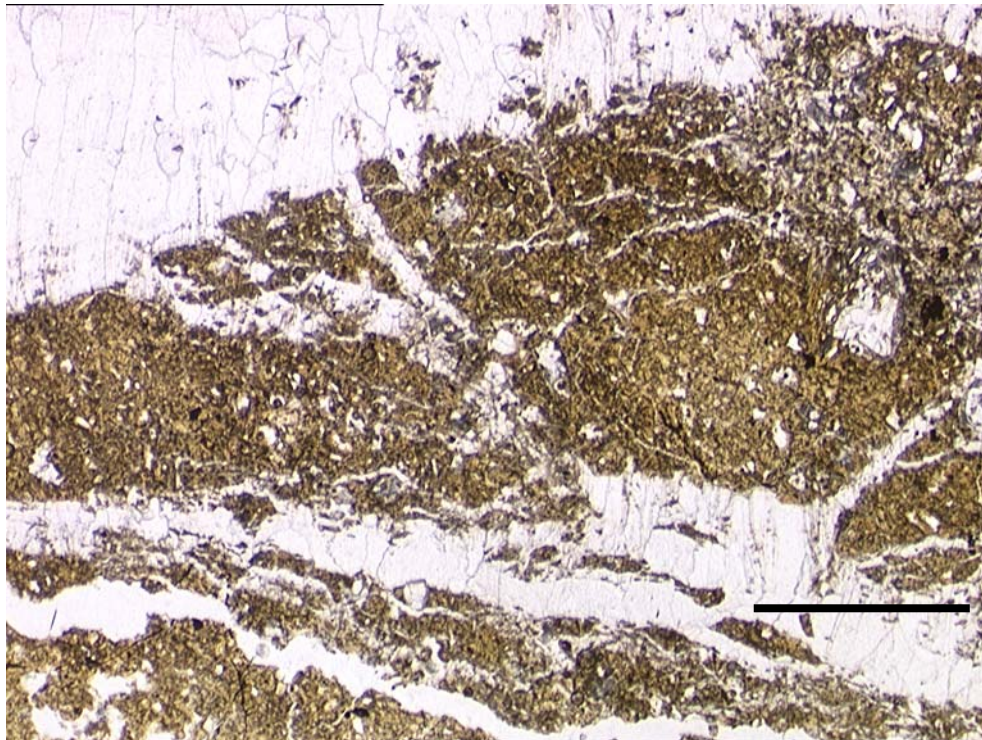
Graham Lott

A sample from 0.86m was studied in hand specimen and thin section.

Hand specimen

Tuffaceous, brown, calcareous siltstone

Thin section



Scale bar is 1mm

Irregularly shaped shards or layers of devitrified volcanic glass separated by spar carbonate cement.

The volcanic material has a finely fragmented, vesicular, amygdaloidal texture partially replaced and / or cross-cut by carbonate-filled fractures. No non-volcanic detrital material is evident in the sample.

Macroporosity

None evident

SEDIMENTOLOGY OF SAMPLE 57-17/7

Alick Leslie

The core consists of 1.68m of sediment, with fine-grained volcanoclastic sediments overlying a thin (0.08m) veneer of foram-rich carbonate.

0.00 – 0.06m

The core is topped by unconsolidated foram sand, containing some gravel sized clasts of what may be a metamorphic rock.

0.06 – 0.08m

Between 0.06 and 0.08m a thin bed of lithified carbonate containing several dark bands is present. There are up to 4 dark bands, 1 – 2mm in thickness, some appear to be associated with recrystallisation of a black mineral within the carbonate. There are also some reworked clasts of black material within the carbonate. The base of the carbonate is a thin gravel bed containing clasts of black material and orange / red volcanoclastic material.

0.08 – 1.68m (TD)

The majority of the core consists of fine-grained volcanoclastic material showing horizontal bedding, displacive calcite veining and some soft sediment deformation. The material is described as tuffaceous siltstone cemented by veins of calcite spar (Lott 2002). No non-volcanogenic clasts were identified. Much of this volcanoclastic unit shows fracturing and disintegration. This was not observed during core collection and appears to be related to exposure and hydration expansion of smectitic clay. Some veins contain crystals of black and red minerals within the calcite matrix.

Between 0.09 and 0.41m the volcanoclastics are massive but disturbed by calcite veining, in particular in the upper part and at the base. Colour ranges from light grey (2.5Y 7/2) to pale yellow (2.5Y 8/4). Veins are commonly horizontal or sub-horizontal, up to 8mm in thickness and have a lenticular geometry. There is a suggestion of bedding at 50° to horizontal within the core, cut by the veining.

Between 0.41 and 0.63m is a zone of laminated tuffs with laminae 5 – 12mm in thickness showing folding and deformation. There is downlap onto the underlying tuffs at the base of and possibly also within the unit. There is some evidence for loading (pillow structures) of light coloured laminae into underlying dark sediment, this appears to have occurred before disturbance and folding.

Between 0.63 and 1.36m the volcanoclastics are massive and disturbed by calcite veining throughout the section. At the top of this unit is what appears to be a hardground or erosion surface. Overlying the hardground is a vein filled by fibrous calcite, with a strongly red coloured mineral at the centre. This texture is distinct from the majority of the calcite veining in the core.

Between 1.36 and 1.68m (TD) is a zone of laminated tuffs with laminae 5 – 8mm in thickness. Laminae are grayish brown (2.5Y 5/2) to light yellowish brown (2.5Y 6/4), horizontal and show little evidence for disturbance – irregularities in bedding may

reflect the onset of loading. Thicker, more coarse-grained laminae are lighter in colour.

See also discussion under 57-17/9.

SAMPLE 57-17/8

SITE DETAILS

Date of drilling:	18th August 2001
Original site number:	K144
Latitude:	57° 07.32'N
Longitude:	16° 34.17'W
Location:	Sandastre volcano, Hatton Basin
Line and fix number:	00/01-48 21.40
Equipment:	BGS rockdrill
Core length:	3.81m
Lithology:	Limestone/sandstone on pebbly, occasionally conglomeratic, sandstone
Age:	Possibly Neogene and Late Eocene (see discussion below)

SUMMARY

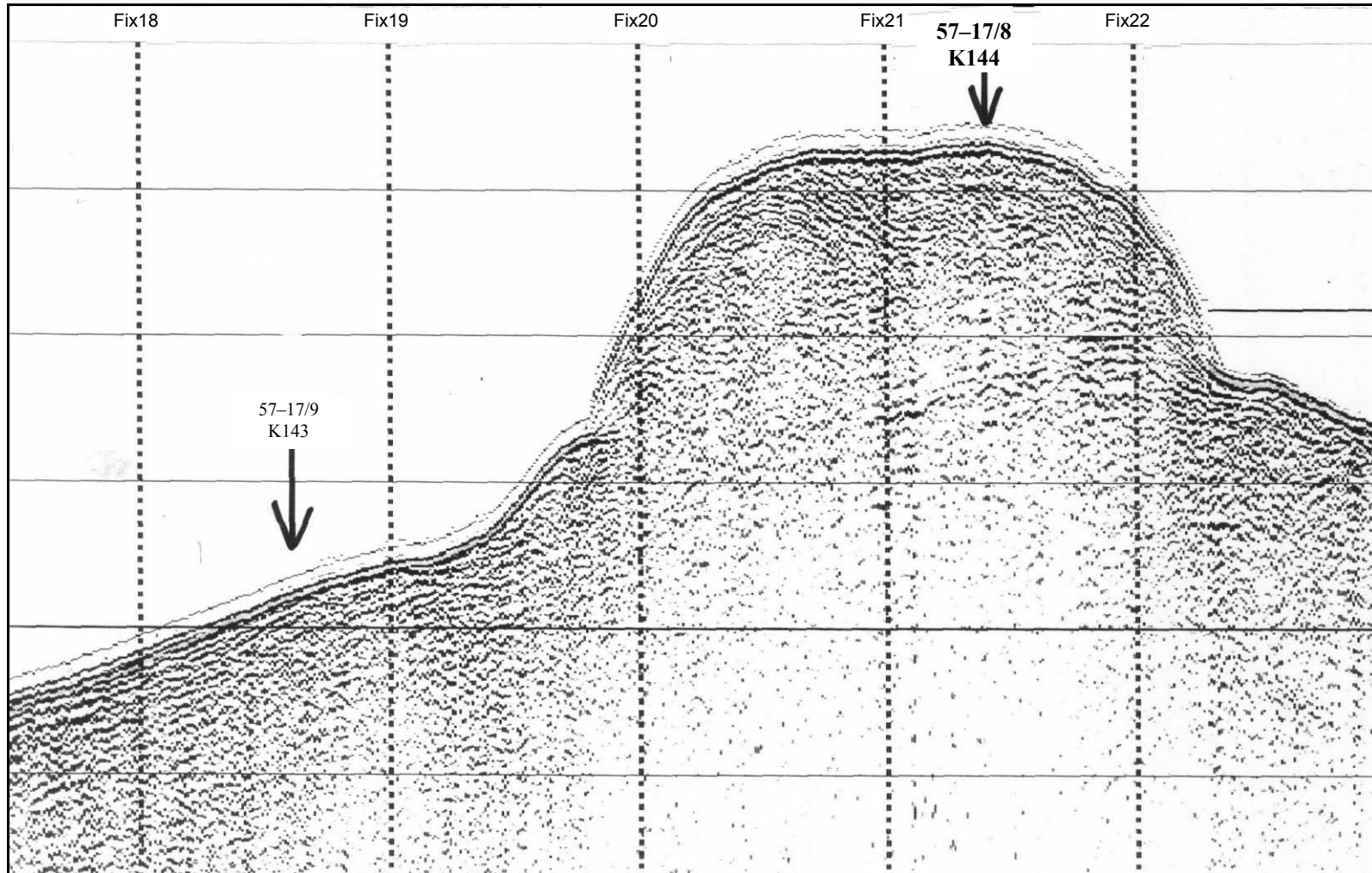
This sample was taken from the highest point of the Sandastre volcano. The result was surprising – instead of the core comprising primarily volcanic material it was mostly sandstone or pebbly sandstone. Some bedding and crude grading is apparent.

In the overlying limestone the palynomorph analysis did not yield a diagnostic age. The nannofossils suggested a ?Neogene-Pleistocene (NN1 – NN21) age for the upper three sub-samples but this is based on a very poorly preserved assemblage. The lowermost sub-sample (0.38-0.40m) was dominated by mainly Palaeogene taxa, ranging from NP4 to NP17. The nannofossil analyses were not definitive.

Foraminiferal analysis suggests a Neogene age for the upper two samples and a Palaeogene age for the lower two.

SW

NE



LINE 00/01-48

AIRGUN

BGS CORE NO: 57-17/8DR



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Sandastre

Latitude 57° 07.32'N **Licence Block** 348/28 **Vessel** James Clark Ross
Longitude 16° 34.17'W **BGS Plan No** K144 **Station Keeping** DP
Navigation DGPS **Total Depth** 4.11m (Rec 3.81m) **Dates of Drilling** 18/08/2001
Map Area **Water Depth** 691m **Geologists** R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0							MPal 0.05m MPal 0.06m Paly 0.07m MPal 0.16m MPal 0.16m MPal 0.22m MPal 0.22m MPal 0.38m MPal 0.38m TS 1.75m TS 3.64m		<p>LIMESTONE AND CONGLOMERATE</p> <p>0 - 0.17 m Limestone, calcarenite, muddy (micritic), very pale, predominantly microfossils (forams) with quartz, mafic rock fragments, angular to subrounded, loosely cemented, with a tabular 2 cm basaltic pebble cemented to top of core - believed to be at or close to seabed. Small pebbles (including mafic and ?metamorphic material) concentrated at the base, where there is a very sharp base, with a Mn-rich crust.</p> <p>0.17 - 0.43 m Limestone, predominantly micritic and very hard, thin and irregular bedding. Not all areas fizz suggesting High Mg - many forams etc preserved. Some shells concave-up suggesting low energy. Clasts of orange material (see above) form lenses (lags?) in upper part and occur as isolated clasts (particularly at 0.22 m and 0.30 m, ?ejecta). Basal 8 cm is much coarser with many larger (2 mm) fossils. There is a 1 cm ?Mn oxide crust at base/top of next unit.</p> <p>0.43 - 3.81 m Pebbly sandstone, very well cemented with ?High Mg calcite - fizzes not very strongly, but more so when scratched. Could be dolomitic, but clear/white, no obvious rhombs). Clasts are mostly orange and yellow, often with vesicles, may be ejecta; also fine mafic clasts, large and small, plus individual crystal grains. Lower part dipping at 15 degrees approx. Grain size varies, with very sandy interval 1.58-1.93 m. Occasional limestone clasts (?forams). A crude grading can be seen 0.83-1.58 m, although no sharp base recognised. At 2.53 m there is a sharp junction - possibly diagenetic. Some thin semi-vertical carbonate veining (weak fizz) (2.53 - 2.76 m and close to base of core)</p>



PALYNOLOGY OF SAMPLE 57-17/8

Jim Riding

A single sample for analysis was taken from this short core.
0.07-0.09m (cream, foram-rich limestone)

The lithology appears to be oolitic, however, the small subspherical objects are not ooids, but individual foraminifera. It was processed using sodium hexametaphosphate. The sample proved to be extremely palynologically sparse. Resistant mineral grains were relatively common. Wood, other plant tissue and palynomorphs, however, are rare. Sparse pollen grains are the only palynomorph group present and include bisaccate grains, small spherical pollen and a tricolpate morphotype. No evidence of reworking was recognised. The sparsity of the pollen flora precludes a detailed age assessment, however the assemblage is consistent with a Neogene-Quaternary age.

FORAMINIFERA OF SAMPLE 57-17/8DR

Ian Wilkinson

The slightly indurated sample from a depth 0.05-0.08m (MPA50847) was found to be very rich in foraminifera, although benthonic species were very rare and apparently mainly reworked. Although *C. teretis* is often a good marker of the Pleistocene, the red-stained specimens of *H. mexicana* is probably reworked from the Oligocene and the fragment of *Cibicidoides* resembles species in the Eocene. However, the abundant sinistrally coiled, cold water morph, of *N. pachyderma* suggests that the assemblage is of Pleistocene age and *Globorotalia crassaformis* and *Globorotalia inflata* indicates that the assemblage is no older than Pliocene.

A thin section of indurated limestone at a depth of 0.16-0.17m (MPA50848) contains frequent planktonic foraminifera, although dominated by indeterminate "*Globigerina* spp" and the remainder are rare. The occurrence of *Orbulina universa* is important as the species first appeared in the 'mid' Miocene (foraminiferal Zone N9) and ranges through to the Recent (BOLLI & SAUNDERS, 1985). *Globorotalites cf inflata*, if correctly identified, implies an age no older than the late Pliocene, but the cut of the slide makes identification uncertain.

The thin section of the indurated limestone at a depth of 0.22-0.28m (MPA50849) is the only sample to contain Palaeogene foraminifera. Foraminifera are rare, but include *Globigerinatheka index*, which is restricted to the mid and late Eocene (P11-P17), *Pseudohastigerina cf. wilcoxensis* (early and mid Eocene) and *Globigerina* sp cf *yegauensis* (mid Eocene to mid Oligocene) (TOUMARKINE & LUTERBACHER, 1985). A mid (?to late) Eocene age is suggested. Unfortunately the stratigraphically lowest sample examined, a coralline limestone from a depth of 0.38-0.40m (MPA50850), was devoid of foraminifera so that biostratigraphical conclusions are not possible.

NANNOFOSSILS OF SAMPLE 57-17/8

Jackie Lees

Four samples were taken for analysis from this short core.

0.05-0.08m

0.16-0.17m

0.22-0.28m

0.38-0.40m

All of the samples were productive, although preservation was generally poor and abundance low. The assemblages contained no really definitive Quaternary taxa, although single specimens of *C. leptoporus* (NN2-21, Early Miocene-Pleistocene) at 0.05-0.08m, and *U. sibogae* and *H. carteri* at 0.16-0.17m (respectively, NN16-21, Plio-Pleistocene, and Neogene-Pleistocene, NN1-21) were identified. *D. productus* occurred throughout (range: Miocene-Pliocene, according to Perch-Nielsen (1985), although Young (1998, pp.236-237) regarded such taxa - closed central-area reticulofenestrids - as being biostratigraphically useless. Thus, the core is tentatively dated as Neogene.

However, predominantly Palaeogene taxa are the main component of the assemblage at 0.38-0.40m, and the co-occurrence of *C. reticulum* and *C. grandis* provide an age of Late Eocene (NP16-17), presumably reworked. However, NP4-11 (Paleocene-Early Eocene) is also indicated by *S. primus* and *E. macellus* in this sample, and it is thus probable that there is some older Eocene reworking in here as well.

(Following a telephone conversation between Ken Hitchen and Jackie Lees on 22nd March 2002, subsequent to the above comments being written, Jackie admitted that the Palaeogene specimens from 0.38-0.40m depth were as likely to be in situ as reworked).

DISCUSSION ON BIOSTRATIGRAPHIC AGE OF SAMPLE 57-17/8

Ian Wilkinson

(Derived from email comments by Jackie Lees)

Palaeoecology

Apart from indicating that the assemblages are typical high-latitude nannofloras (as opposed to low-latitude), in a broad biogeographic sense, there is little palaeoecological data that the nannofossils provide, other than the environment is 'normal' marine. They can't be used to indicate depth, salinity, etc. Nannofossils can be used as palaeo-environmental tools in the context of long-term indicators of climate change based on variations in biogeographic patterns. This is obviously irrelevant here.

Biostratigraphy

D. productus (Miocene-Pliocene) is present in the lowermost sample. However, there were no other indicators of Miocene or Pliocene being present, which is unusual. It is not clear whether this is the result of preservational or glacial phenomena, when looking at material out of context. So, having discussed the results with BGS geologists, it seemed possible that the late Eocene was *in situ*, and that the presence of *D. productus* could have been due to contamination.

Now that the geological relationships of the different samples are known, a change in interpretation is appropriate. If the Eocene nannoflora, previously assumed to be reworked, are now considered to be *in situ*, and the younger species are considered contaminants, the following interpretation can be made:

1. the sample at 0.38-0.40m was the only one that yielded a poor- to moderately-preserved assemblage, the rest of the samples were generally very poor.
2. the assemblage at 0.38-0.40m is Late Eocene (based on *C. reticulum* & *C. grandis*).
3. the sample from 0.16-0.17m contains *R. umbilicus*, which has a range of NP16-22 (Late Eocene-Early Oligocene),
4. the topmost sample (0.05-0.08m) contains *R. bisecta* (NP16-25, Late Eocene-Late Oligocene).

So if the Paleogene specimens are considered to be *in situ*, the whole core would be Late Eocene.

When the samples have such a mixture of taxa from different ages, it's difficult to make any sense of the data, particularly without all the available geological background information. When cores are examined, reworking of older taxa into younger assemblages is easier to explain and more probable than postulating contamination of older associations by younger specimens. However, the latter seems to be more likely here, and it is assumed that some of the samples submitted were contaminated.

Foraminiferal analysis indicates that the uppermost two samples in the foraminiferal limestone (0 – 0.17m) are late Pliocene to Pleistocene in age while the sample from the top of the micritic limestone (0.17 – 0.43m) is mid- to late Eocene. This interpretation would appear to correspond best with the observed lithologies.

PETROGRAPHY OF 57-17/8

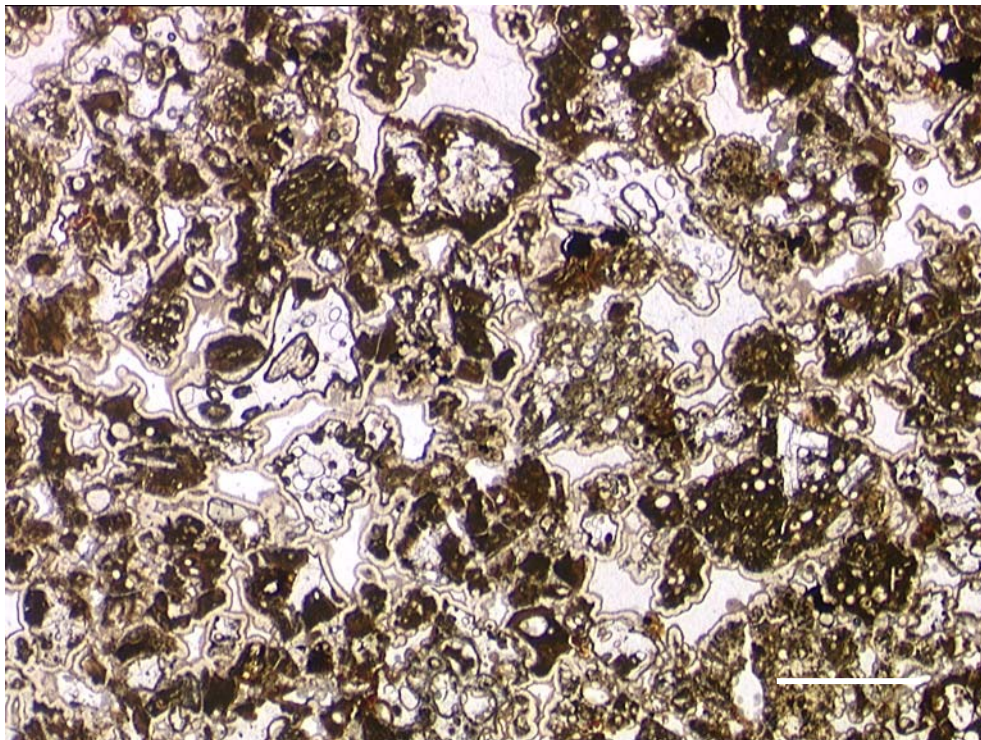
Graham Lott

Samples from 1.75m and 3.64m were studied in hand specimen and thin section.

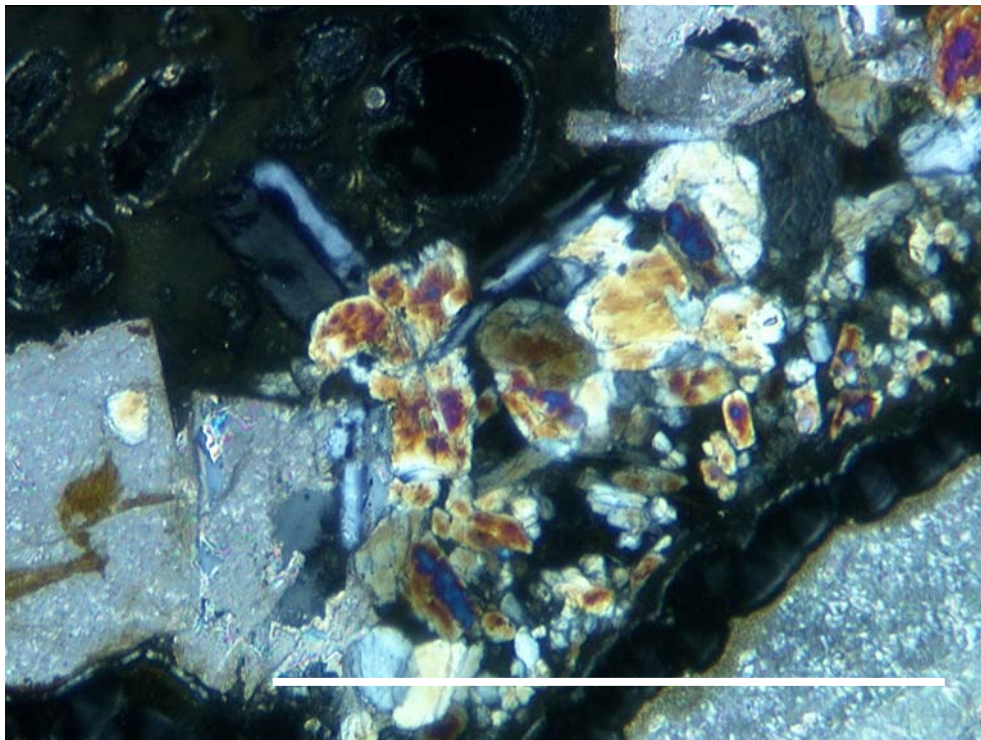
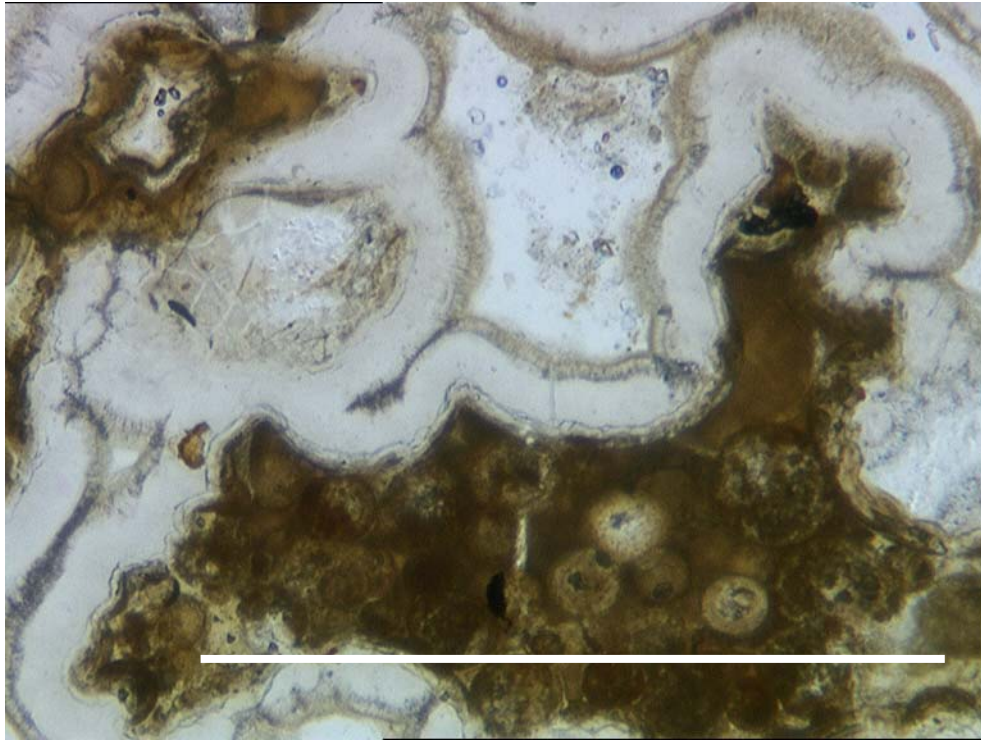
Hand specimen (1.75m)

Variegated, pebbly, volcanoclastic, sandstone

Thin section (1.75m)



Scale bar is 1mm



Thin section (1.75m)

Similar in character to sample 57-17/5 (1.38m) but with smaller devitrified glassy fragments in a pervasive carbonate cement.

The sample comprises irregularly shaped and sized (medium to very coarse sand grade), pale yellow-brown to dark reddish brown grains of devitrified volcanic glass in a pervasive, sparry carbonate cement.

Internally the grains show a finely vesicular, amygdaloidal fabric probably resulting from de-gassing of the vitreous lava flow. The irregular grain margins are pervasively coated with narrow, double, isopachous and radial fringing cements of either cryptocrystalline silica or zeolite. Similar cements also occlude or partially occlude some of the amygdales within the glassy fragments.

Tabular plagioclase and pyroxene phenocrysts occasionally survive within some grains.

No non-volcanic detrital material is evident in the sample.

Macroporosity

None. The pervasive spar calcite cement occupies all of the intergranular area, occluding any primary porosity and sometimes partially replacing the volcanic grains.

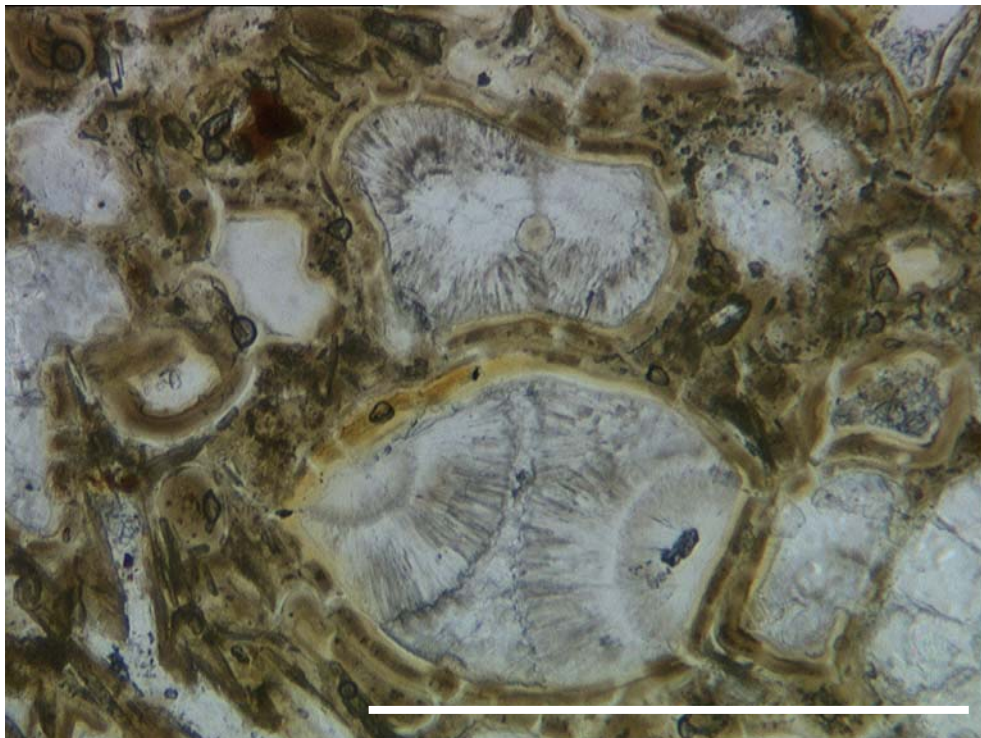
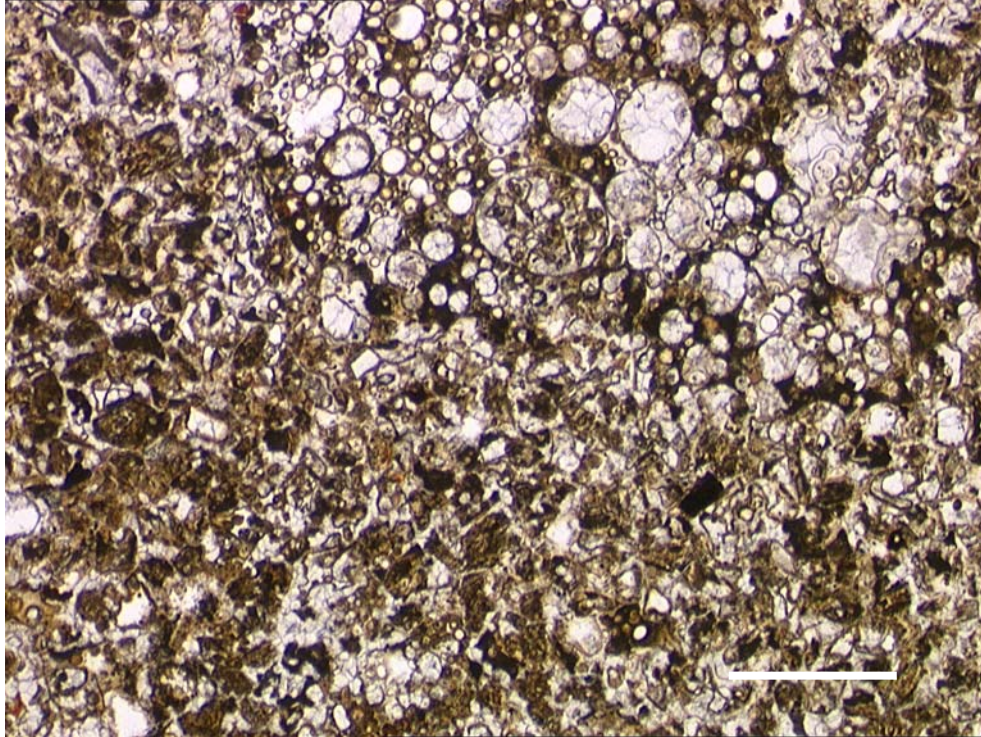
Comment

The precise mineralogical composition of the low birefringent fringing cements cannot be readily identified in thin section and further study using the SEM/Electron Microprobe should be carried out if more precise information is required.

Hand specimen from (3.64m)

Variegated, pebbly, volcaniclastic sandstone

Thin section (3.64m)



Scale bar is 1mm

Thin section (3.64m)

Similar in character to samples from 57-17/5 (1.38m) and 57-17/8 (1.75m) but with smaller devitrified glassy fragments in a pervasive carbonate cement.

The sample comprises irregularly shaped and sized (medium to very coarse sand grade), pale yellow-brown occasionally dark reddish brown grains of devitrified volcanic glass in a pervasive, sparry carbonate cement.

Internally the grains show a very well developed vesicular, amygdaloidal fabric. The irregular grain margins are sometimes coated with narrow, isopachous and radial, fringing cement of either ?cryptocrystalline silica or ?zeolite. The amygdales may show an original concentrically laminated filled structure or are occluded by later acicular ?zeolite cements.

Tabular plagioclase and pyroxene phenocrysts occasionally survive within some grains.

No non-volcanic detrital material is evident in the sample.

Macroporosity

None. The pervasive spar calcite cement occupies all of the intergranular area, occluding any primary porosity and commonly extensively replacing some of the volcanic grains.

SEDIMENTOLOGY OF SAMPLE 57-17/8

Alick Leslie

This core contains 3.81m of sediment with a 0.43m capping of carbonate.

0.00 - 0.17m

The top of the core contains a consolidated foram sand containing some gravel sized basaltic clasts.

0.17 - 0.43m

Lithified micritic carbonate with some coarse-grained material at the base. The carbonate is predominantly fine-grained, very brittle and may be siliceous in places. Some coarser grained bands appear to contain forams and shell debris. At the base is 20mm of gravelly carbonate containing reworked sandstone clasts. Overlying this lag is a layer of variable thickness containing black bands and some reworked black material. The overlying carbonate contains several units with erosive bases. In some, forams at the base suggest a grading up structure. Two erosive bases appear to cut clasts of sandstone, suggesting that there was some lithification before erosion took place. Some horizons contain a number of clasts of orange volcanogenic material. The top of the unit contains several horizons of conglomerate or breccia, and one erosion surface shows a stepped geometry.

0.43 – 0.3.81m (TD)

Underlying the carbonate is pebbly sandstone consisting of orange clasts of devitrified volcanic material (epiclasts) cemented by calcite spar (Lott 2002). Clasts are sub rounded to sub angular, up to 20mm in diameter but most are <2 mm. Although much finer-grained this material appears to be similar petrographically to the volcanoclastic breccia in core 58-17/5.

See also discussion under 57-17/9.

SAMPLE 57-17/9

SITE DETAILS

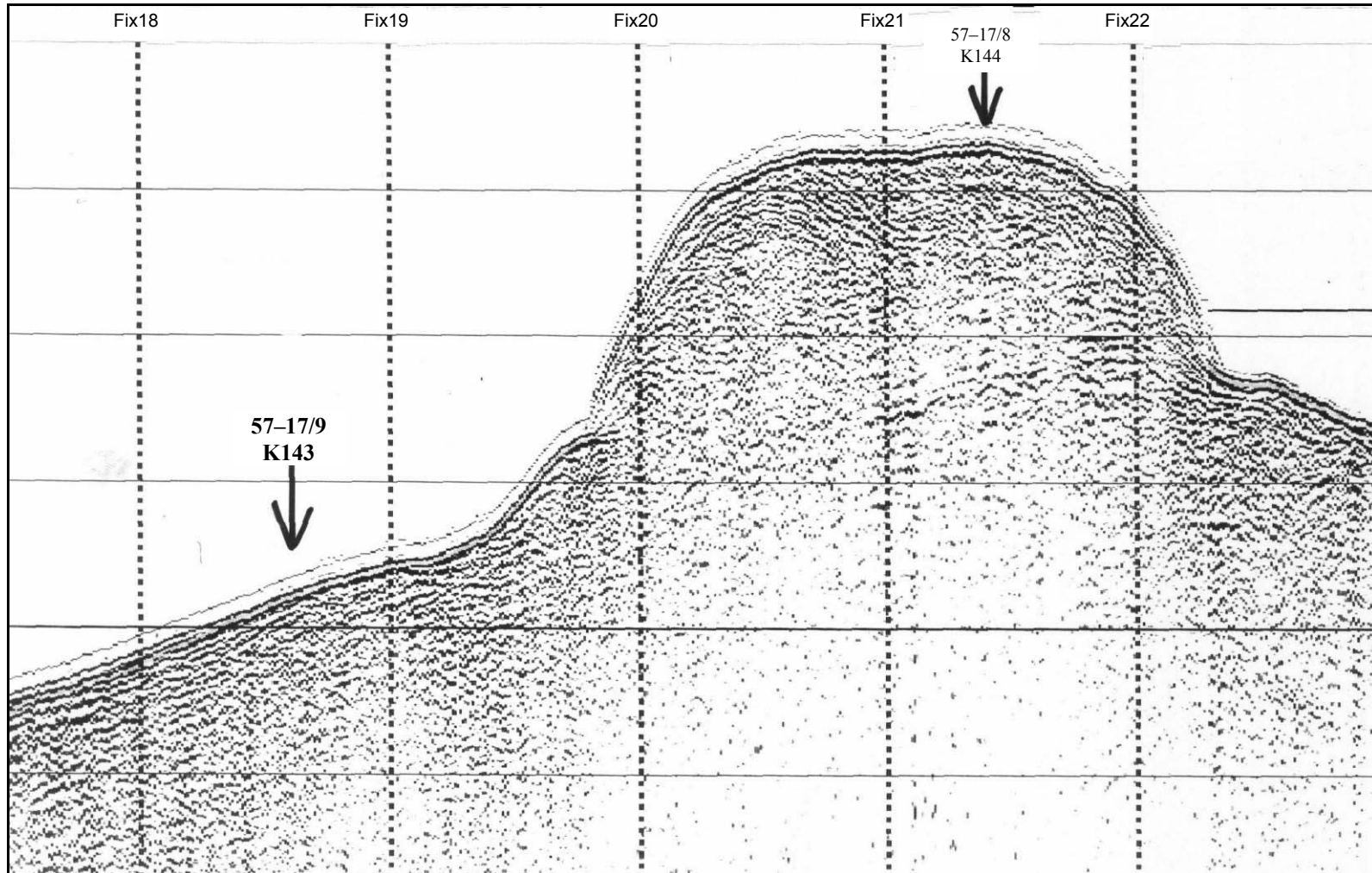
Date of drilling:	18th August 2001
Original site number:	K143
Latitude:	57° 05.694'N
Longitude:	16° 36.078'W
Location:	Sandastre volcano, Hatton Basin
Line and fix number:	00/01-48 18.6
Equipment:	BGS rockdrill
Core length:	0.94m
Lithology:	Pebbly limestone/sandstone
Age:	To be confirmed.

SUMMARY

This site was located near the top of the former volcano. The recovered core was sedimentary but contained volcanic material as pebbles or clasts in the conglomerate.

SW

NE



LINE 00/01-48

AIRGUN

BGS CORE NO: 57-17/9DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Sandastre	
Latitude	57° 05.694' N	Licence Block	348/27
Longitude	16° 36.078' W	BGS Plan No	K143
Navigation	DGPS	Total Depth	4.16m (Rec 0.94m)
Map Area		Water Depth	936m
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	18/08/2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP m/s	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
	0		0 50					TS 0.24m		<p>CONGLOMERATES OF VOLCANIC CLASTS WITH LITHIC CLAY AND CARBONATE</p> <p>0 - 0.14 m Sandy gravel, muddy, dark grains with pale matrix, several angular basalt pebbles, one large (5cm) mafic gneiss with encrusting fauna, one quartz pebble. Most of the basalt pebbles are aphyric, but at least one has large feldspar crystals. Within the sand there is a prominent orange weathered grain type, with a red mineral in cracks, plus many carbonate shell fragments and complete microfossils.</p> <p>0.14 - 0.46 m Conglomerate, many grains well rounded, spherical and oblate, most <5 mm, most grains are rock fragments of igneous ejecta, tuff, lava origin; many are orange (with a black coating) or grey, some red with vesicles, some angular fragments (shards?). Low porosity because of a pale muddy matrix and carbonate cement.</p> <p>0.46 - 0.61 m Conglomerate as above, but less well cemented and recovered rubble only.</p> <p>0.61 - 0.80 m Limestone, conglomeratic calcarenite. Pebble lithology is very similar to the unit above, with all the coarsest material consisting of lithic fragments similar to those found above. However about 70% of the sediment is medium-fine carbonate shells and unidentifiable calcite fragments. Most pebbles are rounded to subrounded, with a range of shapes within the carbonate fraction.</p> <p>0.8 - 0.94 m Pebbly sand/fine conglomerate, muddy matrix, poorly cemented rubble, much darker than above, and although still calcareous, no obvious bioclasts or carbonate cement.</p>
	1									
	2									
	3									
	4									
	5									
	6									



PETROGRAPHY OF SAMPLE 57-17/9

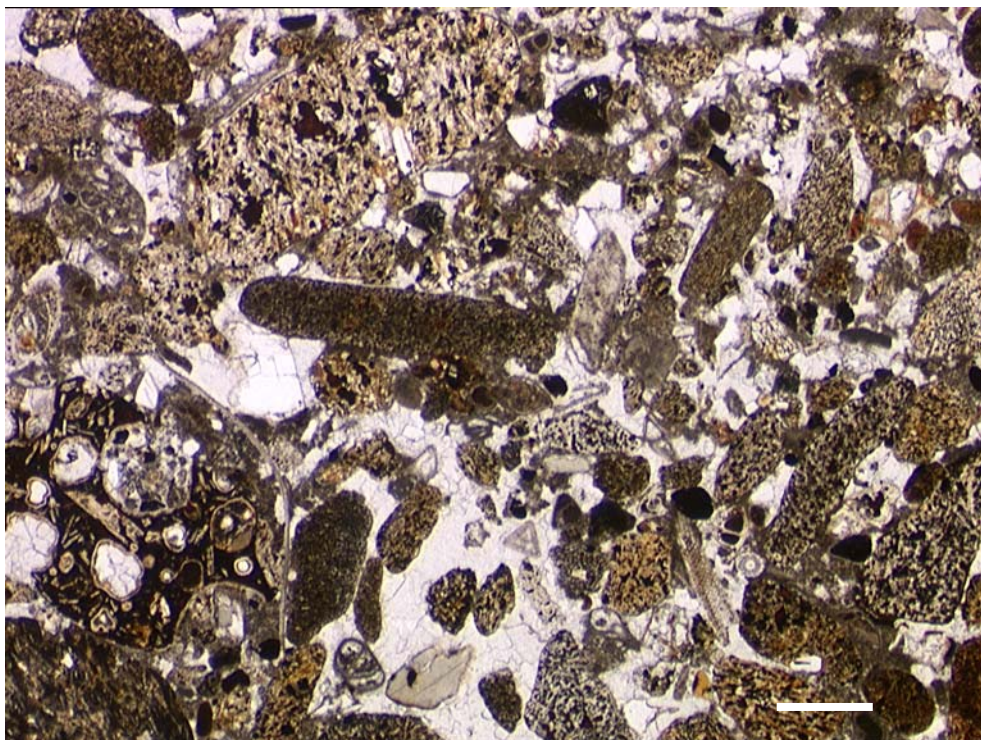
Graham Lott

A sample from 0.24m was studied in hand specimen and thin section.

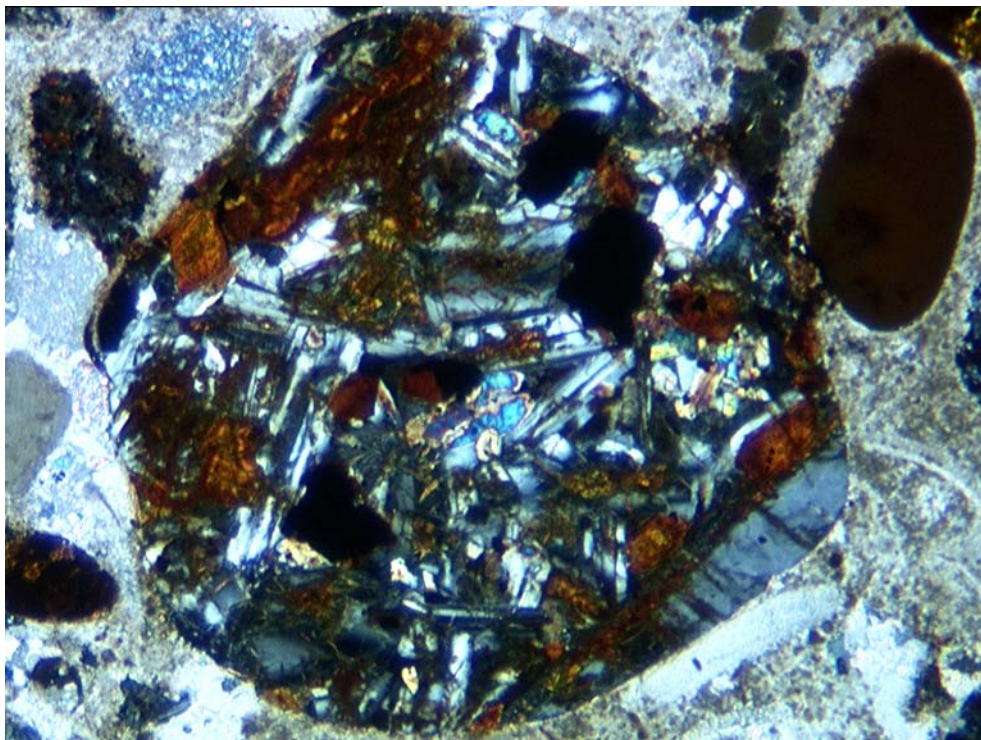
Hand specimen

Variegated, pebbly, volcaniclastic sandstone

Thin section



Scale bar is 1mm



Scale bar is 1mm

Thin section

The rock framework is dominated by well-rounded fine sand to granule-grade basaltic volcanic fragments and abraded bioclastic fragments and detrital quartz grains in a pervasive sparry carbonate cement.

The volcanic grains dominantly comprise cryptocrystalline to very finely crystalline grains with meshworks of tabular plagioclase feldspar and corroded pyroxene phenocrysts commonly occurring in an altered, ferruginous, finely crystalline matrix. Reddish brown, devitrified, vesicular glassy grains are also sparsely present.

The bioclastic fragments are moderately common and include include, foraminifera tests, bivalve, bryozoan, algal, echinoid (plates and spines) and gastropod fragments, as well as a proportion of unidentifiable abraded material.

Detrital quartz grains are sparsely present and range from fine to very coarse sand-grade grains.

Cementation

Pervasive sparry carbonate cement

Macroporosity

None evident

SEDIMENTOLOGY OF SAMPLE 57/17-9

Alick Leslie

The core contains a basalt conglomerate with varying amounts of carbonate overlain by a surficial gravel.

0.00 - 0.14m

Sandy gravel containing clasts of orange volcanoclastics, basalt and metamorphic rocks. The sandy matrix contains abundant foram and shell fragments.

0.14 - 0.94m (TD)

Fine-grained conglomerate consisting mostly of rounded to sub rounded clasts of basalt, uncommon devitrified glassy grains. Pebbles are up to 20mm in diameter, mostly 1 - 5mm. The conglomerate is cemented by carbonate, cementation is variable and below 0.45m the material is unconsolidated. This conglomerate is clast supported but the sediment contains abundant shelly and foram material and between 0.60 and 0.80m carbonate bioclasts are more common than basalt. There are faint indications of horizontal bedding and some imbrication of clasts.

Discussion on samples 57-17/5, 7, 8 and 9.

These four cores from the Hatton-Rockall Basin, around the Sandastre igneous centre, represent deposition of volcanoclastic deposits overlain by, and in 57-17/8 interbedded with, carbonates.

The volcanoclastic sediments are different in each of the cores recovered, but appear with the exception of core 57-17/9 to be related. Volcanoclastics from cores 57-17/5, 7 and 8 are all formed from epiclasts of devitrified, glassy, basic igneous rock, commonly with a strong orange colour (Lott 2002), possibly palagonite. This material is presumably derived from weathering of the Sandastre igneous centre. The sandstone and breccia in cores 57-17/5 and 8 respectively may have been deposited subaerially then cemented by marine calcite spar during transgression. The fine-grained volcanoclastics in core 57-17/7 show evidence of soft sediment deformation and slumping that indicates a marine environment. It cannot be ascertained whether the volcanoclastics are reworked fines from eroded volcanic rocks or pyroclastic deposits. The similarity in petrography (Lott 2002) suggests that they have been subjected to the same weathering conditions as the coarse grained epiclastics from cores 57-17/5 and 8.

The difference in textural maturity between angular breccia (57-17/5) and sandstone (57-17/8) suggests that weathering and sorting of the volcanic material took place over a short distance. The presence of devitrified volcanoclastic material on topographic highs suggests a significant period of weathering and deposition of the igneous centre before submergence, and also a significant period of weathering in the marine environment after deposition of the volcanoclastics.

The basaltic conglomerate in core 57-17/9 appears to have reworked unaltered basalt in a relatively high energy marine environment, suggesting that some fresh basalt was exposed and weathered. This sediment may be much younger in age than the volcanoclastics.

The carbonates have a complex history. Erosion surfaces, some associated with dark manganoan crusts, are common suggesting a complex depositional environment. The coralline carbonate might represent relatively shallow water conditions, other carbonates are not so depth definitive. The age of the various carbonates has not been determined, however the surficial sand and gravel is assumed to be Holocene.

In 57-17/8 the interbedding of carbonate and volcanoclastic sand suggests a Palaeogene age for much of the carbonate, including a foram-rich sand that is similar to the deposit at seabed. If the sand is a subaerial deposit then there must have been significant fluctuations in sea level. There is no evidence for reworking of biogenic material within the upper sand, or for an erosion surface formed during exposure of the topmost carbonate. If the volcanoclastic sand is submarine then there is no evidence for any bioclastic input during its deposition, something that is not seen in other cores from the area. Biostratigraphic analyses of the carbonate above and below the upper sand might resolve this issue.

SAMPLE 58-08/227

SITE DETAILS

Date of drilling:	7th August 2001
Original site number:	JD20
Latitude:	58° 29.140'N
Longitude:	7° 23.648'W
Location:	Hebrides Shelf
Line and fix number:	84/06-20 46.35
Equipment:	BGS rockdrill
Core length:	0.04m
Lithology:	Metamorphic basement
Age:	?Lewisian (Archaean)

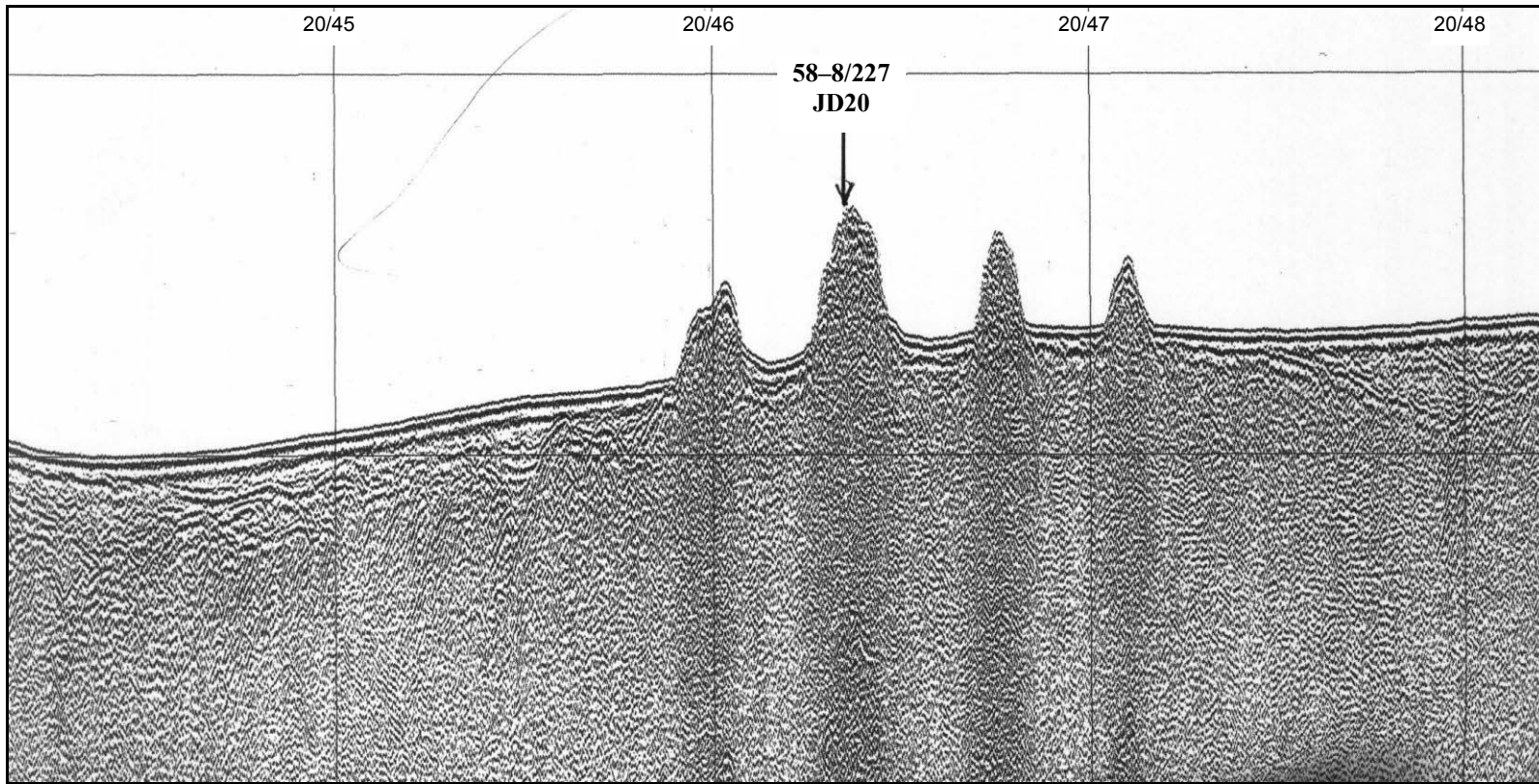
SUMMARY

A single, very short piece of cored, coarse-grained metamorphic basement was recovered comprising large crystals of quartz, feldspar and biotite.

A second attempt was made as 58-08/228.

NW

SE



LINE 84/06-20

SPARKER

BGS CORE NO: 58-08/227DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Flannan Ridge

Latitude	58° 29.1397'N	Licence Block	154/19	Vessel	James Clark Ross
Longitude	007° 23.6479'W	BGS Plan No	JD20	Station Keeping	DP
Navigation	DGPS	Total Depth	0.38m (Rec. 0.045m)	Dates of Drilling	7.8.01
Map Area	Lewis	Water Depth	66m	Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP 0 m/s 50	BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
Lewisian	0	# d # g d f # d							pale pink	<p>COARSE GRAINED METAMORPHIC ROCK</p> <p>Coarse grained metamorphic rock, with large crystals of quartz, feldspar and biotite (deformed). No obvious foliation.</p> <p>Surface encrusted with coral, worms etc. Also small brittle stars and limpets. Indicates exposure of bare rock at the seafloor.</p>
	0.2									
	0.4									
	0.6									
	0.8									
	1.0									
	1.2									
	1.4									
	1.6									
	1.8									
	2.0									
	2.2									
	2.4									



SAMPLE 58-08/228

SITE DETAILS

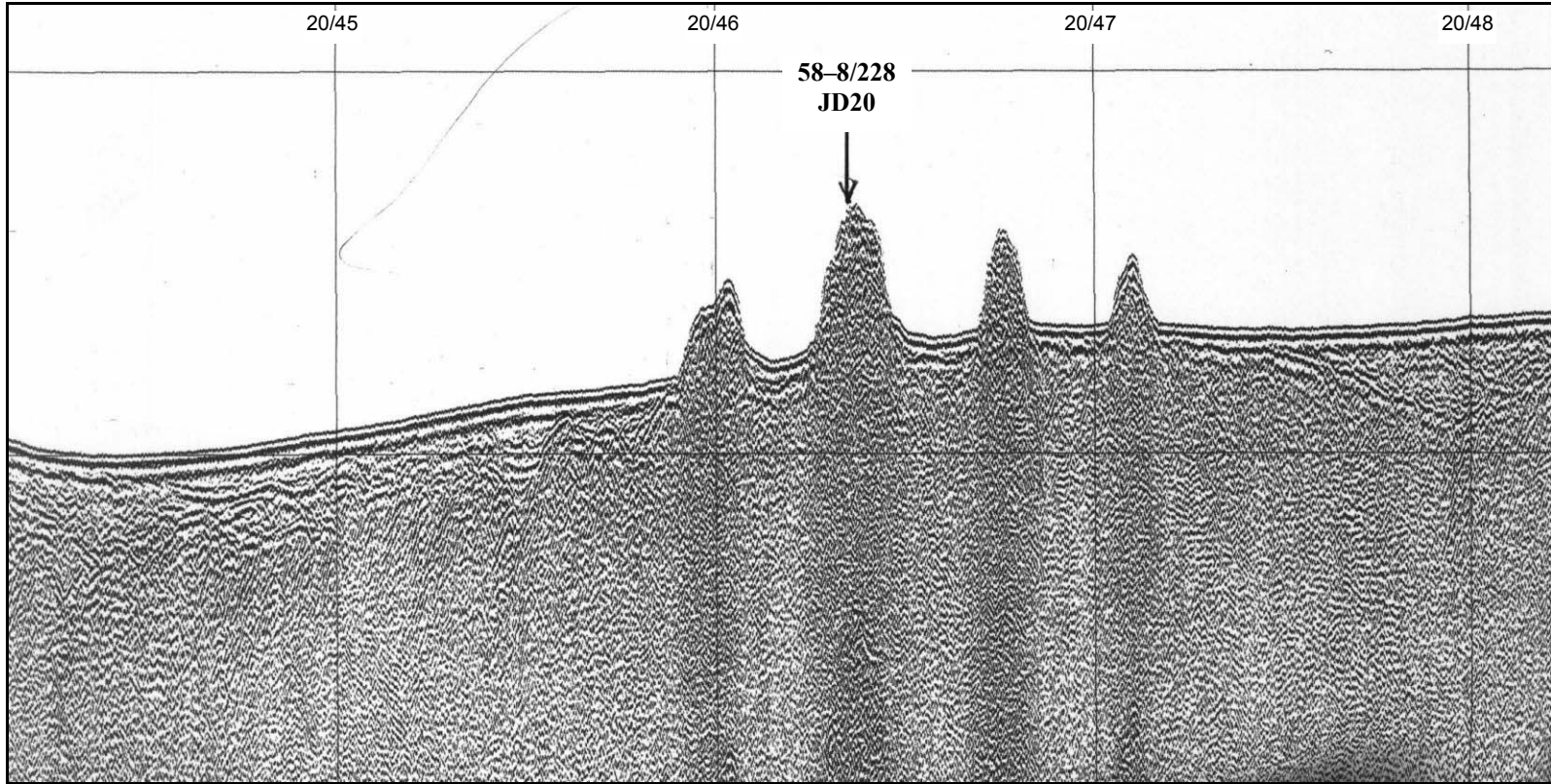
Date of drilling: 7th August 2001
Original site number: JD20
Latitude: 58° 29.140'N
Longitude: 7° 23.648'W
Location: Hebrides Shelf
Line and fix number: 84/06-20 46.35
Equipment: BGS rockdrill
Core length: 0.98m
Lithology: Granitic pegmatic
Age: ?Lewisian (Archaean)

SUMMARY

This was the second attempt at this site. An excellent solid, coarse-grained pegmatitic core of quartz, feldspar and mica was recovered.

NW

SE



LINE 84/06-20

SPARKER

BGS CORE NO: 58-08/228DR



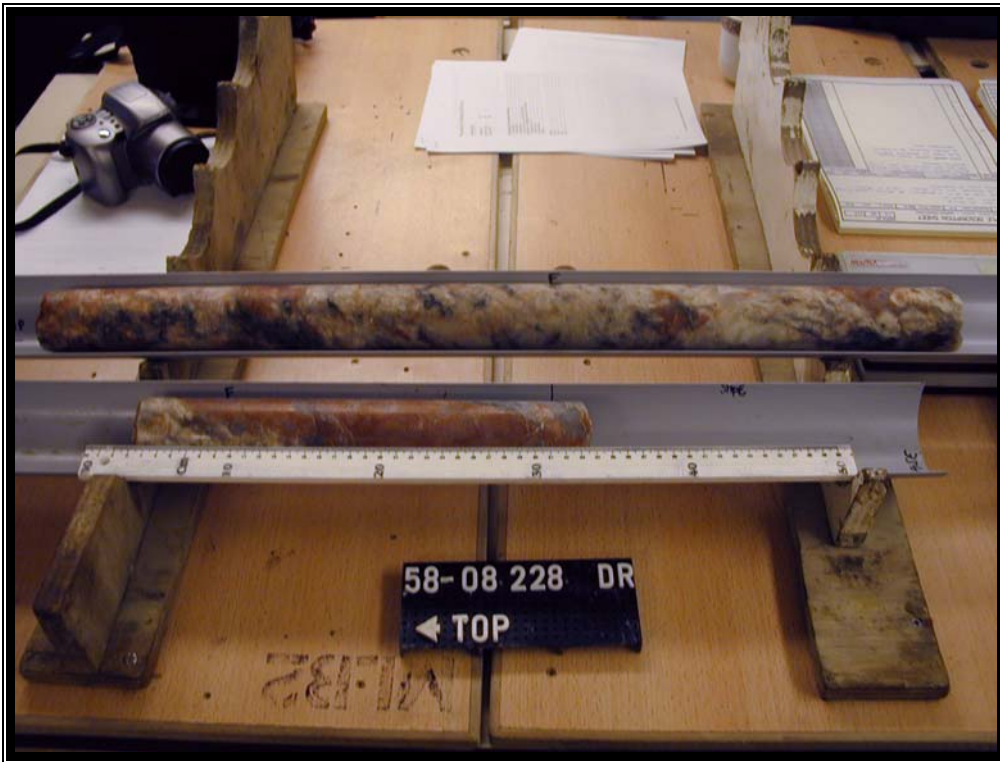
British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Flannan Ridge

Latitude	58° 29.1397'N	Licence Block	154/19	Vessel	James Clark Ross
Longitude	007° 23.6479'W	BGS Plan No	JD20	Station Keeping	DP
Navigation	DGPS	Total Depth	1.32m (Rec. 0.98m)	Dates of Drilling	7.8.01
Map Area	Lewis	Water Depth	66m	Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
Lewisian	0	# d # g d f # d d f # d # g d f # d f # d # g d f # d # d # g d f # d d f # d # g d f # d # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d f # d # g d f # d d f # d # g d f # d # d # g d f # d							ICChem 0.19m	white and pink	COARSE GRAINED METAMORPHIC ROCK Metamorphic rock - pegmatite: very coarse crystals of quartz, feldspar and micas (deformed biotite), minor patches of brecciation, predominant dipping fabric at about 40 degrees.
	1							TS 0.90m		0-0.80 m: predominantly pale, quartz with feldspar and biotite. 0.80-0.98 m: predominantly pink feldspar with subordinate quartz and large deformed, and locally brecciated biotite.	
	2										Surface encrusted with one polyp. Indicates exposure of bare rock at the seafloor.
	3										
	4										
	5										
	6										



PETROLOGY OF SAMPLE 58-08/228

Emrys Phillips

Registered number: N3720

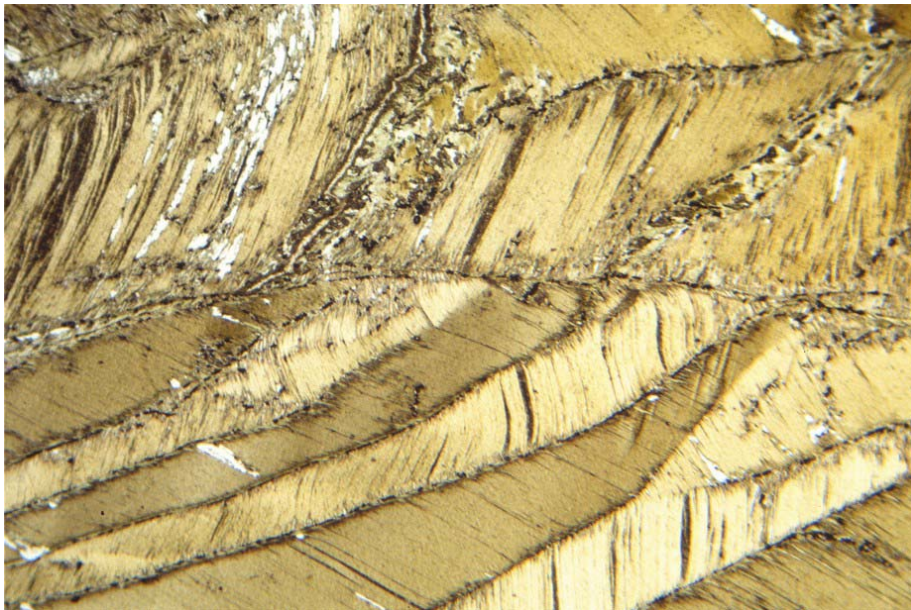
Thin section from 0.90-0.98m depth.

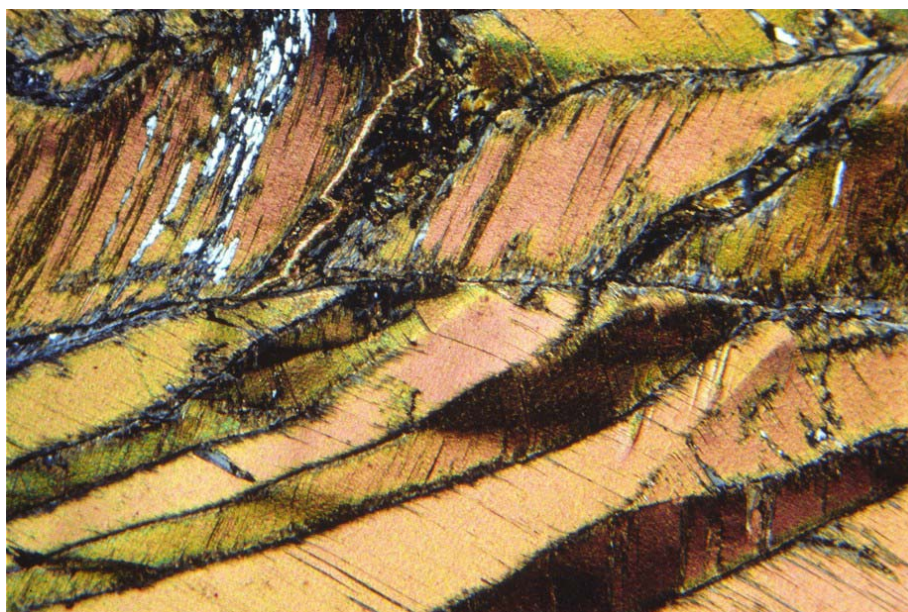
Rock Type: deformed granitic pegmatite

Mineralogy: major – quartz, biotite, K-feldspar, plagioclase
alteration – chlorite, muscovite, carbonate, opaque oxides

Photomicrographs:

Photomicrographs of deformed biotite crystal (N3720), plane and crossed polarised light.





Description: This thin section is of an altered, deformed, very coarse-grained granite pegmatite. The thin section is dominated by a few large crystals of K-feldspar, biotite and quartz which have all undergone varying degrees of intracrystalline deformation and/or cataclasis. Biotite is moderately pleochroic, varying from yellow-brown to brown in colour, and forms larger crystals up to *c.* 20 mm in length. Internal deformation of biotite resulted in the kinking of the basal (001) cleavage with contemporaneous chloritic alteration being focused the axial surfaces of these brittle structures. The kinks are angular in form with distinct fractures running along the axial planes of the micro-folds. Kinking and fracturing has resulted in the fragmentation of the large crystals of biotite into a number of elongate, lenticular relicts which have undergone varying degrees of chloritisation. The originally large biotite crystals are enclosed within a reaction rim of pale green chlorite, minor muscovite/white mica and fine-grained granular carbonate; the latter appears to be replacing chlorite. Elongate quartz inclusions have also been noted along the cleavage planes within biotite.

Quartz within this pegmatitic rock has been replaced by an aggregate of variably strained new-grains and sub-grains which contain irregular to lenticular relicts of the originally larger crystals. K-feldspar (microcline) forms large (*c.* 10.0 to 20.0 mm in size) crystals which possess a distinctive undulose extinction and have undergone of cataclasis rather than ductile intracrystalline deformation. The feldspar exhibits minor alteration to white mica and/or carbonate along these fractures. A number of the fractures are defined by narrow zones of cataclasite and/or dynamic recrystallisation. These large microcline crystals are locally perthitic (vein perthite) and may also contain small crystals of rare plagioclase.

Deformation of this pegmatite appears to have been brittle in nature resulting in cataclasis of feldspar and biotite, with deformation probably accompanying alteration.

GEOCHEMICAL DATA FOR SAMPLE 58-08/228

Sample name	Depth	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃ t	Mn ₃ O ₄	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃	Cr ₂ O ₃	SrO	ZrO ₂	BaO	NiO	CuO	ZnO	PbO	LOI	Total	
	(metres)	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
58-08/228	0.19-0.49	73.33	0.02	15.26	0.31	<0.01	0.09	2.25	5.00	2.16	<0.01	<0.1	<0.01	0.05	<0.02	0.06	<0.01	<0.01	<0.01	<0.01	0.55	99.08	

XRFS Data		Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Rb	Sr	Zr	Mo	Ag	Cd	Sn	Sb	Te	Ba	W	Tl	Pb	Bi
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
58-08/228	0.19-0.49	<2	2	8	<2	<1	10	9	16	<1	<1	<1	4	69	421	11	<1	<1	<1	1	<1	<1	494	<1	<1	20	<1

ICP-MS Data		Y	Nb	Cs	La	Ce	Pr	Nd	Sm	Eu	Tb	Gd	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
58-08/228	0.19-0.49	0.6	0.9	0.4	0.3	0.5	0.06	0.3	0.06	0.10	0.02	0.07	0.08	0.02	0.07	0.01	0.07	0.02	0.4	<0.5	<0.1	0.88

SAMPLE 58-08/229

SITE DETAILS

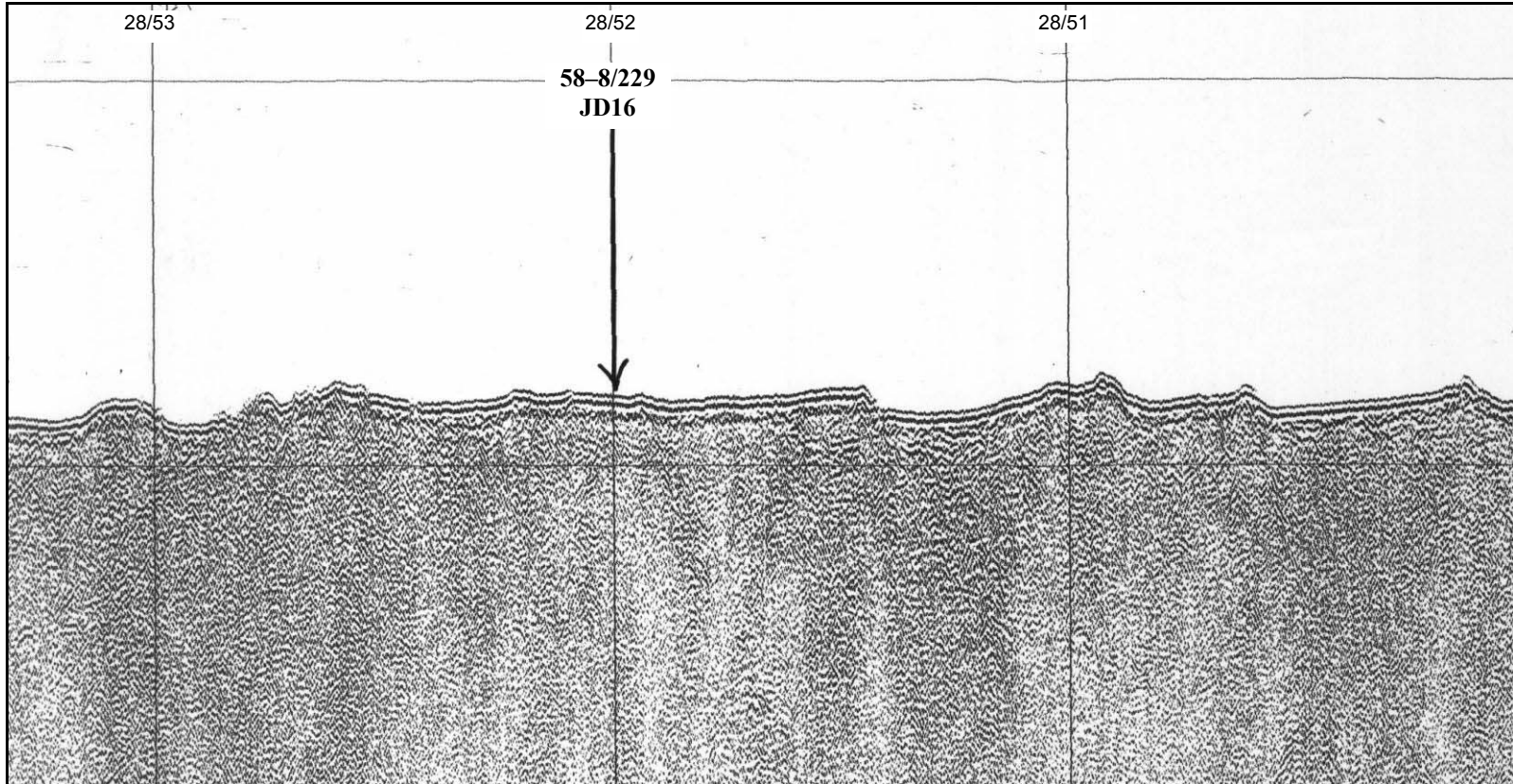
Date of drilling: 8th August 2001
Original site number: JD16
Latitude: 58° 8.874'N
Longitude: 7° 57.738'W
Location: Hebrides Shelf
Line and fix number: 84/06-28 52.00
Equipment: BGS rockdrill
Core length: 0.0m
Lithology: Gravel
Age:

SUMMARY

No core was recovered, only gravel composed mainly of metamorphic rock fragments but with a few volcanic pebbles.

SW

NE



LINE 84/06-28

SPARKER

BGS CORE NO: 58-08/229 DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Flannan Ridge

Latitude	58° 8.874' N	Licence Block	154/26	Vessel	James Clark Ross
Longitude	007° 57.738' W	BGS Plan No	JD16	Station Keeping	DP
Navigation	DGPS	Total Depth	0.99m (Rec. 0.99m)	Dates of Drilling	08/08/2001
Map Area	Lewis	Water Depth	105m	Geologists	R. Gatliff, C.Morri

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0	[Patterned Lithology]									<p>SURFICIAL DEPOSIT ON SEAFLOOR (PREDOMINANTLY METAMORPHIC)</p> <p>Unconsolidated, poorly sorted sediment including pebbles, 1-5 cm in diameter, angular to sub-rounded. Predominantly feldspathic metamorphic rock fragments, with subordinate metabasic and basaltic volcanic pebbles.</p>
	1										
	2										
	3										
	4										
	5										
	6										



SAMPLE 58-08/230

SITE DETAILS

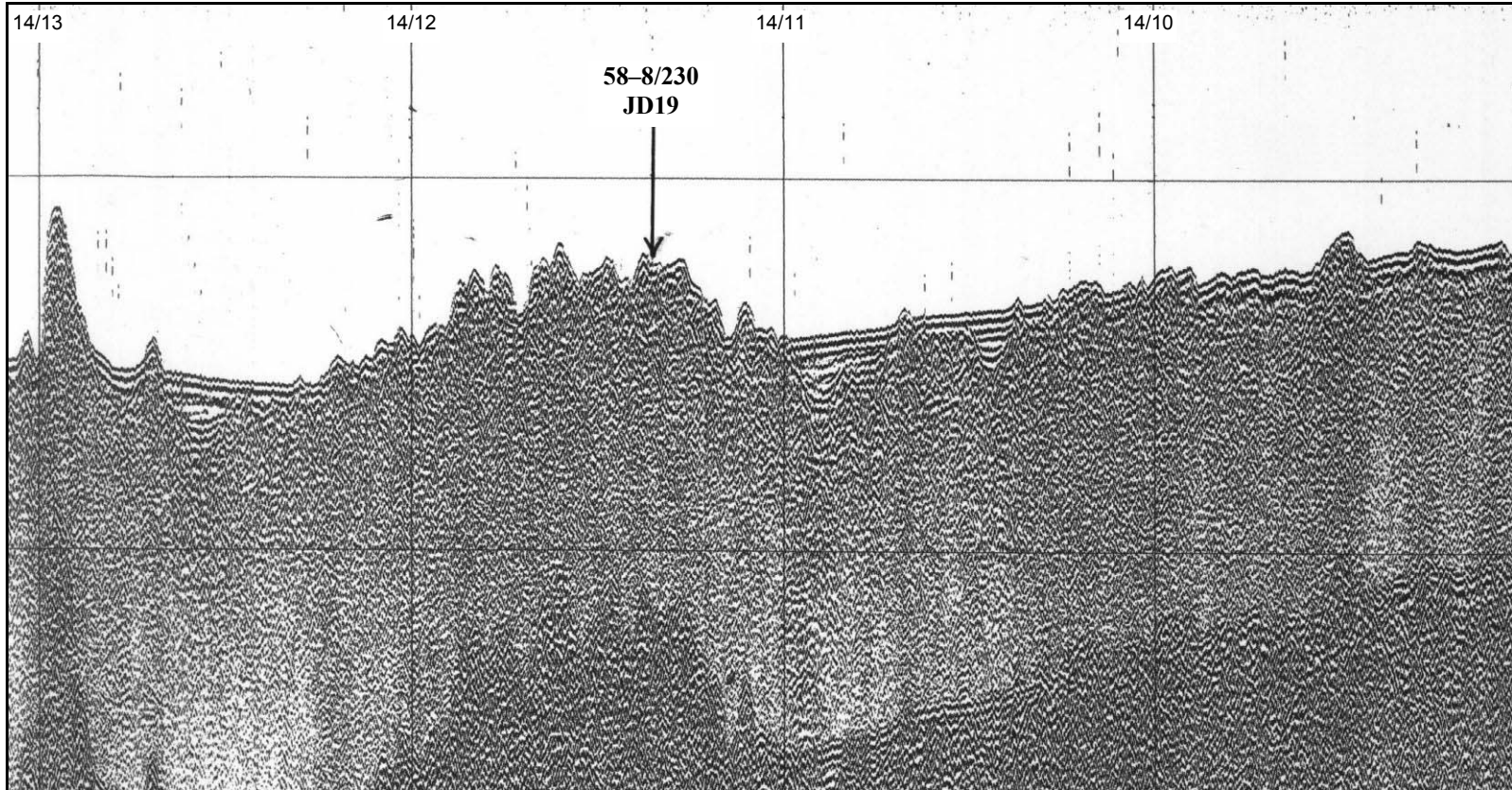
Date of drilling:	8th August 2001
Original site number:	JD19
Latitude:	58° 1.488'N
Longitude:	7° 53.625'W
Location:	Hebrides Shelf
Line and fix number:	84/06-14 11.35
Equipment:	BGS rockdrill
Core length:	1.33m
Lithology:	Alkali granitic rock
Age:	?Lewisian (Archaean)

SUMMARY

An excellent basement core was recovered comprising quartz-feldspar-amphibole-garnet gneiss.

NW

SE



LINE 84/06-14

SPARKER

BGS CORE NO: 58-08/230DR



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position Flannan Ridge

Latitude	58° 01.488' N	Licence Block	154/26	Vessel	James Clark Ross
Longitude	007° 53.625' W	BGS Plan No	JD 19	Station Keeping	DP
Navigation	DGPS	Total Depth	2.04m (Rec. 1.33m)	Dates of Drilling	8.8.2001
Map Area	Lewis	Water Depth	64m	Geologists	Gatliff & Kempton

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
LEWISIAN	0	# d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f #									<p>AMPHIBOLE GARNET GNEISS</p> <p>1.33 m of GNEISS, weak foliation, pinkish, equant minerals up to 10 mm across. Quartz, feldspar, amphibole, garnet, sphene (?). Amphibole and garnet intergrowth (?garnet after amphibole) May have steeply dipping fractures and veins. Thin quartz veins; one 5 mm ?chlorite veins toward base of core.</p> <p>Clear pavement outcrop, encrusting worms on upper surface indicating exposure of bare rock on the seafloor.</p>
	1	# d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f #									
	2	# d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f #									
	3	# d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f #									
	4	# d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f #									
	5	# d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f #									
	6	# d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f # # d # g d f # d d f # d # g d f #									



PETROLOGY OF SAMPLE 58-08/230

Emrys Phillips

Registered number: N3721

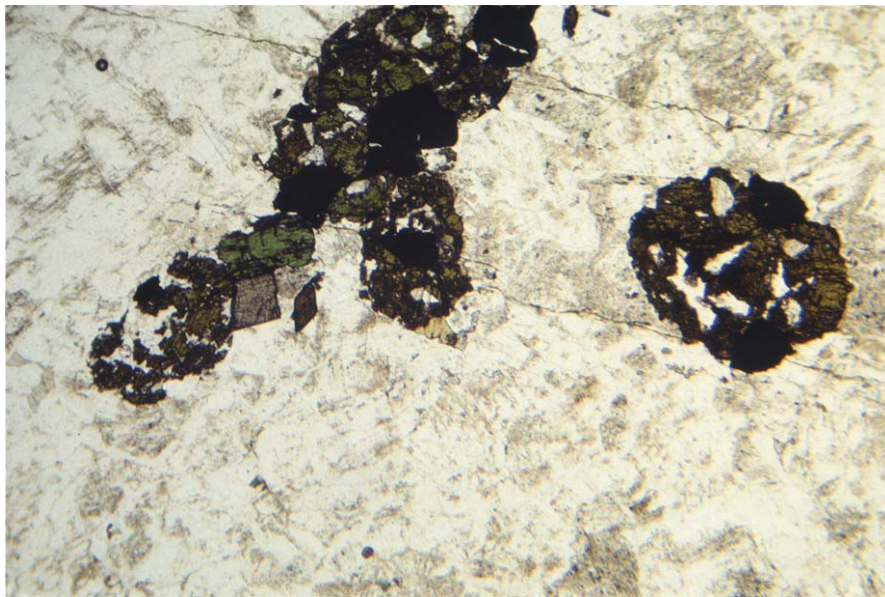
Thin section from 0.78m depth.

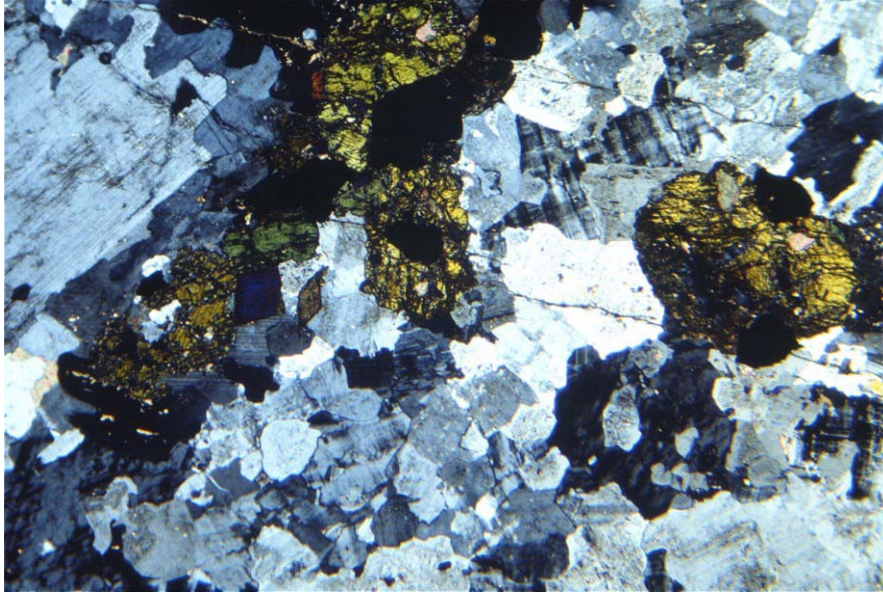
Rock Type: recrystallised alkali granitic rock

Mineralogy: major – plagioclase, K-feldspar, amphibole, biotite
minor – opaque minerals, titanite, garnet, apatite
alteration – opaque oxides, muscovite/white mica, carbonate, sericite,
clay minerals, clinozoisite

Photomicrographs:

Photomicrographs of a recrystallised alkali granitic rock (N3721), plane and crossed polarised light.





Description: This thin section is of a coarse-grained, holocrystalline, inequigranular, variably recrystallised or metamorphosed, feldspathic, weakly foliated ?alkali granitic rock. The rock is mainly composed of irregular to locally interlocking plagioclase and subordinate K-feldspar with no obvious quartz present. Sub-solidus recrystallisation has resulted in the modification of the original texture of the rock. A weak pre-full crystallisation fabric is defined by the variable shape alignment of plagioclase laths.

Plagioclase forms twinned and untwinned, anhedral to irregular, lath-shaped crystals which exhibit a slight dusty appearance under plane polarised light. Very fine grained muscovite or white mica flakes have been noted included within, or replacing plagioclase. A weak zonation within plagioclase is preserved by the preferential alteration of the cores of these zoned crystals. Pockets of finer grained plagioclase are also present included within intergranular poikilitic K-feldspar crystals. K-feldspar is weakly perthitic and possesses well developed microcline twins and is slightly finer grained and intergranular to plagioclase.

Traces of opaque minerals, titanite and garnet are present within this possibly alkaline granitic rock. Garnet is yellow-brown in colour and forms small anhedral crystals. Minor to trace amphibole is rimmed and partially replaced by bright green coloured ?chloritised biotite.

GEOCHEMICAL DATA FOR SAMPLE 58-08/230

Sample name	Depth	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃ t	Mn ₃ O ₄	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃	Cr ₂ O ₃	SrO	ZrO ₂	BaO	NiO	CuO	ZnO	PbO	LOI	Total					
	(metres)	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%				
58-08/230	0.62-0.86	61.81	0.32	18.98	2.22	0.09	0.28	2.45	6.78	4.45	0.05	<0.1	<0.01	0.42	0.03	0.33	<0.01	<0.01	<0.01	<0.01	1.04	99.25					
XRFS Data		Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Rb	Sr	Zr	Mo	Ag	Cd	Sn	Sb	Te	Ba	W	Tl	Pb	Bi
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
58-08/230	0.62-0.86	<2	40	4	<2	<1	8	52	21	<1	<1	<1	<1	40	>1500	240	<1	<1	1	2	1	<1	2631	<1	<1	24	1
ICP-MS Data		Y	Nb	Cs	La	Ce	Pr	Nd	Sm	Eu	Tb	Gd	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	Th	U					
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg				
58-08/230	0.62-0.86	12.7	13.9	0.1	42.1	106.3	11.77	44.9	6.75	1.92	0.58	4.80	2.79	0.48	1.13	0.16	0.98	0.14	4.4	<0.5	4.2	1.56					

SAMPLE 58-12/9

SITE DETAILS

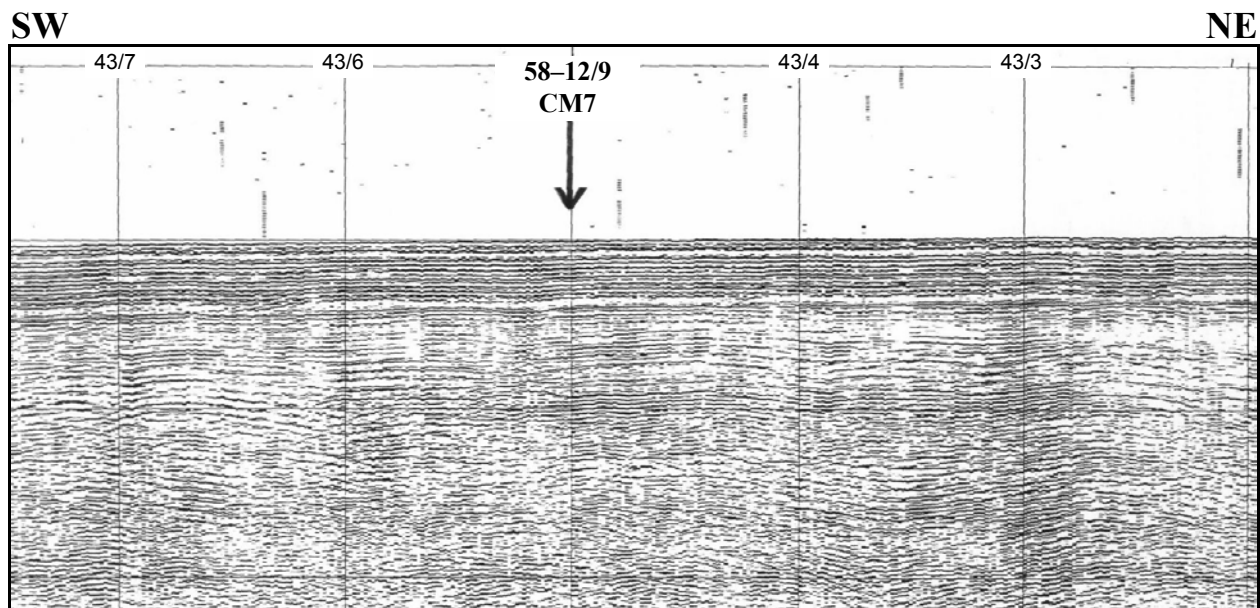
Date of drilling:	13th August 2001
Original site number:	CM7
Latitude:	58° 7.31'N
Longitude:	11° 16.458'W
Location:	Central Rockall Trough
Line and fix number:	92/01-43 5.0
Equipment:	BGS gravity core
Core length:	3.35m
Lithology:	Clay
Age:	Either Wolstonian-Ipswichian or Devensian-Flandrian (based on palynology)

SUMMARY

The core is predominantly clay of variable colour. Both the palynology and foram analyses indicate that the lower part of the core was deposited during a glacial period whilst the upper part was deposited during an interglacial period. Hence the core spans either Wolstonian to Ipswichian or Devensian to Flandrian.

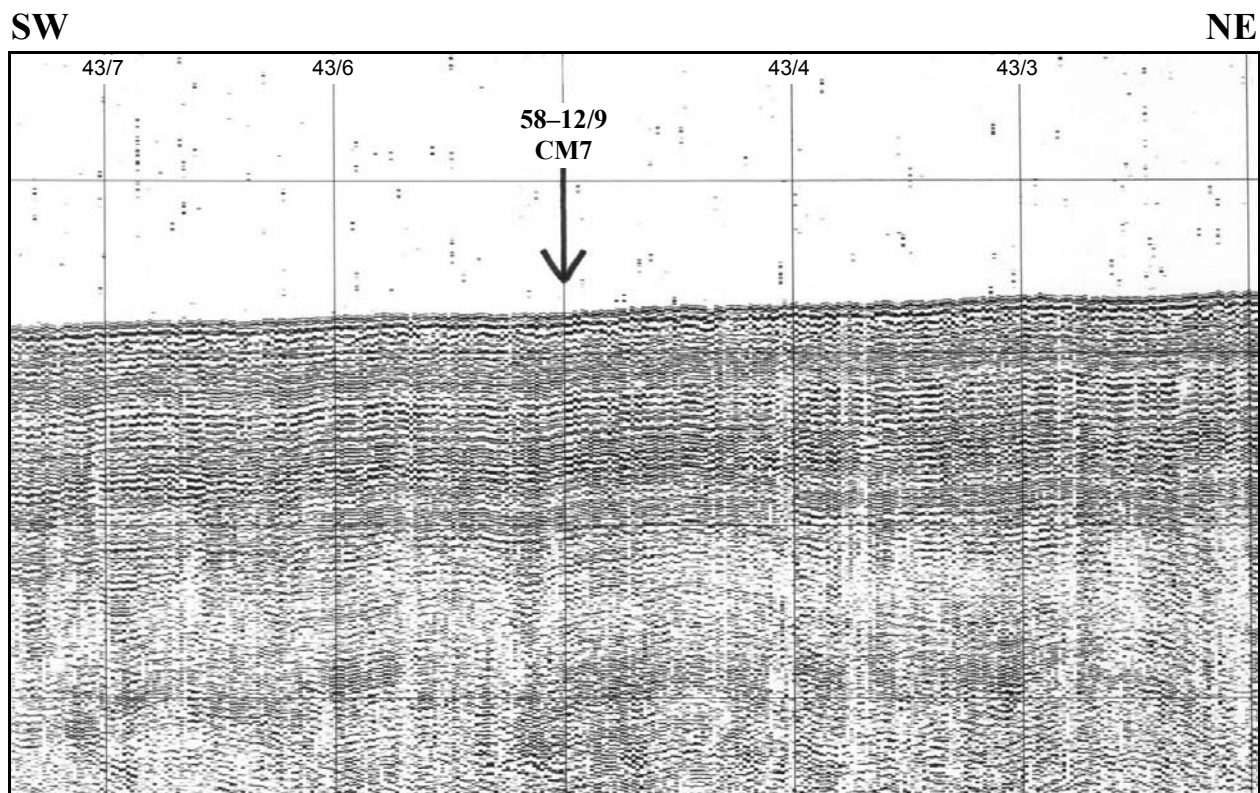
Re-worked Carboniferous and Mesozoic palynomorphs have been noted at 0.05-0.06m and 0.50-0.51m.

Re-worked Namurian, Norian/Rhaetian-early Sinemurian, Kimmeridgian, Lower Cretaceous and Palaeogene palynomorphs have been noted at 3.30-3.31m.



LINE 92/01-43

AIRGUN



LINE 92/01-43

AIRGUN

BGS CORE NO: 58-12/9 CS



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position		Cent. Rockall Trough	
Latitude	58 07.31'N	Licence Block	
Longitude	011 16.458'W	BGS Plan No	CM7
Navigation	DGPS	Total Depth	3.35m (Rec 3.35)
Map Area	Harker	Water Depth	1935
		Vessel	James Clark Ross
		Station Keeping	DP
		Dates of Drilling	13.8.2001
		Geologists	R. Gatliff

AGE	DEPTH (m)	LITHOLOGY	ROP		BEDDING	STRUCTURE	BED FORMS	DISTURBANCE	SAMPLE	COLOUR	DESCRIPTION
			0	50							
	0										0-0.49 m Clay, sandy at the top of the core, mottling and zoophycos burrows. Colour 2.5Y 6/1.
	1										0.49-0.98 m Transitional boundary marked by a change in colour to 2.5Y 5/2. Frequency of burrows and mottles decreasing, becomes more homogeneous.
	2										0.98-2.13 m Smooth homogeneous clay, small silt patches, colour 2.5Y 4/2. Basal contact is sharp.
	3										2.13-2.67 m Striking change in colour to light yellowish brown 2.5Y 6/3. Some sand infilled burrows, zoophycos burrows, small lithic clasts and a lonestone at 2.60 m. Boundary is gradational, changing to:
	4										2.67-3.35 m Smooth homogeneous clay, some sulphidic spotting, colour 2.5Y 4/2.
	5										
	6										

PALYNOLOGY OF SAMPLE 58-12/9

Jim Riding

Three samples for analysis were taken from this short core.

0.05-0.06m (dark grey clay)

0.50-0.51m (dark grey clay)

3.30-3.31m (dark grey clay)

This gravity core was taken in the middle of the Rockall Trough, north of the Anton Dohrn seamount. The samples were all prepared using sodium hexametaphosphate.

Sample at 3.30m-3.31m

This sample produced an extremely rich organic residue and palynoflora. Dark wood fragments and palynomorphs are dominant. Other plant tissues and resistant minerals are rare; amorphous organic material is entirely absent. Due to the preparation using sodium hexametaphosphate, other microfossils are present and these comprise relatively rare radiolaria and diatoms.

Both indigenous and allochthonous palynomorphs are present. Quaternary palynomorphs are prominent and comprise both dinoflagellate cysts and spores/pollen. The dinoflagellate cysts are of relatively low diversity and include *Achomosphaera andalusiensis*, *Bitectatodinium tepikiense*, *Brigantedinium cariacense* (cyst of *Protoperidinium avellanum*), *Brigantedinium simplex* (cyst of *Protoperidinium conicoides*), *Brigantedinium* sp. nov. of Harland (1983) (cyst of *Protoperidinium punctulatum*), *Brigantedinium* spp. and *Operculodinium centrocarpum*. Species of *Brigantedinium* overwhelmingly dominate the indigenous dinoflagellate cysts, representing 92.1% of this flora. The occurrence of *Brigantedinium cariacense* and *Brigantedinium* sp. nov. of Harland (1983) is indicative of a Late Pleistocene-Holocene age (Harland, 1992, fig. 5.2). Furthermore, the dominance of the genus *Brigantedinium* indicates that the sample was deposited during a glacial episode with seasonal or permanent sea-ice. This glacial interpretation is based on modern ecological observations (Harland, 1992). Because of this cold palaeoenvironmental interpretation, a Holocene age is precluded. The probable Late Pleistocene age means that the sample is either Wolstonian or Devensian. The apparently indigenous pollen grains are dominated by bisaccate pollen grains and also include *Stereisporites* spp.; these forms are not stratigraphically significant. Other miospores present are also relatively long ranging from the Palaeogene to the Quaternary.

Allochthonous (reworked) palynomorphs of Carboniferous, Jurassic, Cretaceous and Palaeogene age were also observed. Carboniferous spores are relatively common and include *Cingulizonates* spp., *Densosporites* spp., *Lycospora pusilla* and *Tripartites trilinguis*. The occurrence of *Tripartites trilinguis* is indicative of a Namurian source. The Jurassic miospores *Callialasporites turbatus*, *Callialasporites microvelatus*, *Callialasporites* sp., *Cerebropollenites macroverrucosus*, *Classopollis classoides*, *Coronatispora valdensis* and *Kraeuselisporites reissingeri* are present in relatively low proportions. Furthermore, the Jurassic dinoflagellate cysts *Cribroperidinium* cf. *globatum*, *Cribroperidinium?* *longicorne* and *Pareodinia ceratophora* are also rarely present. The Jurassic reworking is unequivocally multiphase. *Kraeuselisporites*

reissingeri ranges from the Late Triassic to Early Jurassic (Norian/Rhaetian to early Sinemurian) (Morbey, 1978; Morbey and Dunay, 1978), the range base of *Callialasporites* spp. is close to the Early-Mid Jurassic transition and *Cribroperidinium? longicorne* is characteristic of the Kimmeridgian Stage (Riding and Thomas, 1988). Kimmeridgian reworking is common in the Quaternary, for example the Tills of East Anglia and eastern Aberdeenshire (e.g. Riding, 2001). Minor levels of input of Lower Cretaceous strata is evidenced by the occurrences of the spores *Appendicisporites* and *Cicatricosisporites*. A single specimen of the typically Palaeogene dinoflagellate cyst *Cordosphaeridium gracile* was observed, and hence indicating stratigraphical recycling of Palaeogene strata. The pollen grain *Trudipollis hammenii* also probably represents Palaeogene reworking.

Samples at 0.05m-0.06m and 0.50m-0.51m

These two samples also yielded extremely rich organic residues and palynofloras. Quaternary dinoflagellate cysts dominate the association, with occasional wood fragments and miospores. Other plant tissues and resistant mineral grains are extremely rare and amorphous organic material is absent. The samples were prepared using sodium hexametaphosphate and silicious microfossils which are similar in size, such as diatoms, radiolaria and silicoflagellates, are diverse and abundant.

Both indigenous Quaternary and rare allochthonous palynomorphs were observed. Quaternary dinoflagellate cysts are both diverse and prominent; they comprise *Achomosphaera andalousiensis*, *Bitectatodinium tepikiense*, *Brigantedinium simplex* (cyst of *Protoperidinium conicoides*), *Brigantedinium* sp. nov. of Harland (1983) (cyst of *Protoperidinium punctulatum*), *Brigantedinium* spp., *Impagidinium patulum*, *Impagidinium sphaericum*, *Impagidinium* spp., *Nematosphaeropsis labyrinthea*, *Operculodinium centrocarpum*, *Quinquecuspis concretum*, *Selenopemphix nephroides*, *Selenopemphix quanta*, *Spiniferites elongatus*, *Spiniferites frigidus*, *Spiniferites* cf. *membranaceus*, *Spiniferites mirabilis*, *Spiniferites* spp. and *Trinovantedinium capitatum*. *Operculodinium centrocarpum* dominates the dinoflagellate cyst floras (45.2% at 0.50m-0.51m and 66.9% at 0.05m-0.06m). The occurrences of *Brigantedinium* sp. nov. of Harland (1983) and *Quinquecuspis concretum* are indicative of a Late Pleistocene-Holocene age (Harland, 1992, fig. 5.2; Mudie and Harland, 1996, fig. 8). The samples are also stratigraphically above Late Pleistocene strata (see section 2.5.1, above). Furthermore, several other species have range bases in the Mid Pleistocene; these include and *Brigantedinium simplex*, *Trinovantedinium capitatum*, *Selenopemphix quanta*, *Spiniferites elongatus* and *Spiniferites frigidus* (De Vernal *et al.*, 1992, fig. 13; Harland, 1992, fig. 5.2). The preponderance of *Operculodinium centrocarpum*, together with *Nematosphaeropsis labyrinthea*, *Selenopemphix quanta*, *Spiniferites elongatus*, *Spiniferites mirabilis* and *Trinovantedinium capitatum* indicates deposition during a temperate, interglacial phase. This is based upon modern ecological evidence (Harland, 1992). The presence of species of *Impagidinium*, coupled with the rarity of indigenous miospores and plant material, indicates that this unit was deposited in relatively deep water, in an outer shelf setting (Harland, 1992). Because the underlying sample at 3.30m-3.31m is Late Pleistocene (section 2.5.1), the interval between 0.05m and 0.51m is probably Ipswichian or Flandrian in age. The apparently indigenous miospores, which include forms such as *Alnipollenites* and triporate pollen, are not age diagnostic. Other palaeontological techniques or AMS dating would be required to make this distinction.

Reworked palynomorphs are present in extremely low numbers. The Carboniferous spore *Lycospora pusilla* and a tetrad of the Mesozoic pollen *Classopollis classoides* were recorded at 0.50m-0.51m and 0.05m-0.06m respectively. No unequivocal Cretaceous and Palaeogene palynomorphs were observed.

FORAMINIFERA OF SAMPLE 58-12/9

Ian Wilkinson

Three samples for analysis were taken from this short core.

0.06-0.08m

0.51-0.53m

3.28-3.30m

All samples yielded only low diversity faunas of a generally poor preservation.

The lowest sample from 3.28-3.30m contained rare *Globorotalia inflata* and very rare *Neogloboquadrina pachyderma* (sinistrally coiled). The latter is a cold water Quaternary species, however conclusions cannot be drawn from this poor fauna.

Diversity was improved in the sample from 0.51-0.53m depth. Planktonic species dominated with frequent *Globorotalia crassaformis* and *Globigerina bulloides* together with rare *Orbulina universa* and *Globorotalia inflata*. This fauna places the borehole within the Transitional Fauna Province (sensu Bé, 1977) with temperatures between 10 and 18°C. However, the presence of frequent sinistrally coiled *Neogloboquadrina pachyderma* and only rare dextrally coiled forms, places the assemblage into the cooler part of the province. The sinistral form is more characteristic of waters cooler than the 7.2°C Spring isotherm. Benthonic species are rare, but include *Sigmoilina schlumbergeri*, *Pullenia quinqueloba* and *Fontbotia wuellerstorfi* and the association is indicative of bathyal waters with temperatures up to about 4°C and probably associated with the NADW.

The sample at 0.06-0.08 was extremely small and dominated by planktonic foraminifera, including frequent dextrally *Neogloboquadrina pachyderma*, *Globigerina bulloides* and *Globorotalia inflata*, very rare *Orbulina universa* and common indeterminate planktonic fragments. This places the site within the Transitional foraminiferal Province and unlike the previously described association, the frequent dextrally coiled *N. pachyderma* places it in the warmer part of the province.

SEDIMENTOLOGY OF SAMPLE 58-12/9

Alick Leslie

Gravity core 58-12/09 recovered 3.35m of mud from the Rockall Trough. The core is very fine-grained, contains a small quantity of sand and few dropstones. Some bioturbation is evident – sub horizontal burrows 4 – 10mm in diameter, filled with a slightly sandier sediment, possibly a form of *Planolites*. There is a gradual colour change in the topmost 0.70m with the core becoming darker and more consolidated with depth.

Below 0.70m the core is homogeneous bioturbated mud to 2.13m where there is a sharp colour change from dark grayish brown above (2.5Y 4/2) to light yellowish brown (2.5Y 6/3). This boundary is slightly undulating, with a relief of 10mm, and transitional over 2 – 3mm. There are small ‘flame’ structures above the boundary. There is one vertical burrow into the underlying mud, 1 mm wide and 8mm in height, tapering downwards. There is no other indication of bioturbation across the boundary despite evidence for pervasive bioturbation above and below.

The underlying muds appear to be very slightly coarser grained and may be more carbonate rich than those above 2.13m. The mud gradually darkens with depth to become dark grayish brown. The mud is bioturbated by *Planolites*-like burrows.

Biostratigraphic data suggest that the core is late Pleistocene, with a glacial or transitional succession overlain by temperate (possibly post-glacial or Holocene) muds above 0.53m (Wilkinson 2002).

This short core comprises 3.35m of muds presumably representing the last glacial – interglacial transition. The sediments are very fine-grained but subtle changes in grain size imply some influence by contour-parallel currents. The colour boundary at 2.13m does not appear to correspond with the palaeoclimatic changes inferred by the palynology.

References

- BÉ, A.W.H. 1977. An ecological, zoogeographic and taxonomic review of Recent Planktonic foraminifera. *In*: Ramsey, A.T.S. (ed) *Oceanic Micropalaeontology*, 1, 1-100.
- BUCEFALO PALLIANI, R. AND RIDING, J. B. 2000. A palynological investigation of the Lower and lowermost Middle Jurassic strata (Sinemurian to Aalenian) from North Yorkshire, UK *Proceedings of the Yorkshire Geological Society*, 53, 1-16.
- DE VERNAL, A., LONDEIX, L., MUDIE, P. J., HARLAND, R., MORZEDEC-KERFOURN, M.-T., TURON, J.-L. AND WRENN, J. H. 1992. Quaternary organic-walled dinoflagellate cysts of the North Atlantic Ocean and adjacent seas: ecostratigraphy and biostratigraphy. *In*: HEAD, M. J. AND WRENN, J. H. (eds). *Neogene and Quaternary Dinoflagellate Cysts and Acritarchs*, 289-328. Dallas, American Association of Stratigraphic Palynologists Foundation.
- DROSER, M J, AND BOTTJER, D J. 1986. A semiquantitative field classification of ichnofabric. *Journal of Sedimentary Petrology*, 56, 558-559.
- HARLAND, R. 1977. Recent and Late Quaternary (Flandrian and Devensian) dinoflagellate cysts from marine continental shelf sediments around the British Isles. *Palaeontographica Abteilung B*, 164, 87-126.
- HARLAND, R. 1983. Distribution maps of recent Dinoflagellate Cysts in bottom sediments from the North Atlantic Ocean and adjacent seas. *Palaeontology*, 26, 321-387.
- HARLAND, R. 1992. Dinoflagellate cysts of the Quaternary System. *In*: POWELL, A. J. (ed). *A stratigraphic index of dinoflagellate cysts*. British Micropalaeontological Society Publications Series, 253-273. London, Chapman and Hall.
- LEES, J.A. 2002. BGS Rockall Trough/Plateau “?Palaeogene” samples: Nannofossil report. *British Geological Survey Internal Report IR/02/051*.
- LOTT, G K, 2002. Petrographic description of thin sections from five shallow core samples in the Sandastre area, Rockall Bank. *British Geological Survey Commercial Report, CR/02/16*.
- MARTINI, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. FARINACCI (ed). *Proceedings of the Second Planktonic Conference Roma 1970*. Edizioni Tecnoscienza, Rome, 2: 739-785.
- MORBAY, S. J. 1978. Late Triassic and Early Jurassic subsurface palynostratigraphy in northwestern Europe. *Palinologia número extraordinario*, 1, 355-365.
- MORBAY, S. J. AND DUNAY, R. E. 1978. Early Jurassic to Late Triassic dinoflagellate cysts and miospores. *In*: Thusu, B. (ed). *Distribution of biostratigraphically diagnostic dinoflagellate cysts and miospores from the northwest European continental shelf and adjacent areas*. Continental Shelf Institute Publication, 100, 47-59.
- MUDIE, P. J. AND HARLAND, R. 1996. Chapter 21. Aquatic Quaternary. *In*: JANSONIUS, J. AND MCGREGOR, D. C. (eds). *Palynology: principles and applications*. American Association of Stratigraphic Palynologists Foundation, Dallas, 2, 843-877.
- MURRAY, J.W. 1979. Cenozoic Biostratigraphy and paleoecology of sites 403 to 406 based on foraminifers. Initial Report of the DSDP, 48, 415-430.
- MURRAY, J.W. 1991. *Ecology and palaeoecology of benthic foraminifera*. Longman Scientific & Technical.
- SKINNER, A.C. 2001. BGS Atlantic Margin Project. Rockdrilling, vibrocoreing and gravity coring from RRS James Clark Ross. *BGS Operations Report CR/01/230*.
- PERCH-NIELSEN, K. 1985. Cenozoic calcareous nannofossils. *In*: BOLLI, H.M, SAUNDERS J.B. & PERCH-NIELSEN K. (eds). *Plankton Stratigraphy*, 427-554. Cambridge University Press.
- POWELL, A. J. 1992. Dinoflagellate cysts of the Tertiary System. *In*: POWELL, A. J. (ed). *A stratigraphic index of dinoflagellate cysts*. British Micropalaeontological Society Publications Series, 155-251. London, Chapman and Hall.
- RIDING, J. B. 2001. A palynological investigation of samples from the 2001 Rockall-Hatton Drilling Programme. *British Geological Survey Internal Report IR/01/172*, 7 p. (unpublished).
- RIDING, J. B. AND THOMAS, J. E. 1988. Dinoflagellate cyst stratigraphy of the Kimmeridge Clay (Upper Jurassic) from the Dorset coast, southern England. *Palynology*, 12, 65-88.
- RIDING, J. B., FEDOROVA, V. A. AND ILYINA, V. I. 1999. Jurassic and lowermost Cretaceous dinoflagellate cyst biostratigraphy of the Russian Platform and northern Siberia, Russia. *American Association of Stratigraphic Palynologists Contributions Series*, No. 36.

- STOKER, M. S., HITCHEN, K. AND GRAHAM, C. C. 1993. The Geology of the Hebrides and West Shetland shelves, and adjacent deep-water areas. *British Geological Survey Offshore Regional Report*, London, HMSO.
- WETZEL, A. 1984. Bioturbation in deep-sea fine-grained sediments: influence of sediment texture, turbidite frequency and rates of environmental change. In: STOW, D. A. V. AND PIPER, D. J. W. (eds). *Fine-grained Sediments: Deep-Water Processes and Facies*. Geological Society Special Publication 15, 595-608.
- WILKINSON, I. P. 2002. Foraminifera from cores from the Rockall area. *British Geological Survey Internal Report, IR/02/002*.
- YOUNG, J.R. 1998. Neogene. In: BOWN, P.R. (ed). *Calcareous Nannofossil Biostratigraphy*. BMS Publication Series, 225-265. Kluwer Academic Press.