

- 2 DEC 1998

BRITISH GEOLOGICAL SURVEY
MARINE REPORT SERIES
BGS TECHNICAL REPORT WB/98/29C

Commercial-in-Confidence

**SITE SURVEY AND GRAVITY CORING
(IRISH SHELF AND ROCKALL BANK)**

RRS Challenger

Ken Hitchen and Joanne Cavill

(GEOLOGY + GEOPHYSICS)

Geographical Index
Irish Rockall Trough

Subject Index
Site survey, gravity coring

Work done for
Rockall Studies Group of Irish PIP

Bibliographic reference
Hitchen, K. and Cavill, J. A. 1998. Site survey and gravity coring (Irish Shelf and Rockall Bank).
BGS Technical Report WB/98/29C

British Geological Survey
Petroleum and Marine Geology Group
Murchison House
West Mains Road
Edinburgh EH9 3LA
UK

Tel: 0131 667 1000 (s'board)
Fax: 0131 668 4140 (direct)
Email: k.hitchen@bgs.ac.uk

(c) NERC 1998



British
Geological
Survey

SUMMARY

(BTU = Base Tertiary unconformity; WD = Approximate water depth)

CONTENTS

1.	Introduction	3
2.	Notes on the site surveys and positioning	4
3.	Site survey gravity cores	12
4.	Steaming route gravity cores	14
5.	Gravity core descriptions	16
6.	Reference	24

SUMMARY

(BTU = Base Tertiary unconformity; WD = Approximate water depth)

Location 1

Close to a minor fault in Tertiary. Move borehole 1km to NNE? Soft sea floor at drilling location but slopes at 3.3°. The BTU is approximately 130ms below sea bed at the original site and also at the suggested new location. WD is 1468m.

Location 1A

Ideal drilling location on technical grounds. Soft sea floor at drilling location. Negligible sea floor slope at 1.6°. The BTU is approximately 200ms below sea bed. WD is 1032m.

Location 2

Recent slumping has occurred at the proposed drilling location (which is sited on a small ledge on the slope). This process may be responsible for the hard sea floor at the drill site by removing loose sediment down the 1.4° slope. Muddy sands were recovered in the NW of the survey area. The BTU is approximately 180ms below sea bed. WD is 1460m

Location 2A

Recent slumping has occurred at the proposed drilling location. This process may be responsible the hard sea floor in this area by removing loose sediment downslope. The drill site is on a slope of 3.4°. The BTU is approximately 165ms below sea bed. WD is 853m.

Location 3

The BTU does not produce a good reflector precisely at the intended drill location so prognosis cannot be confirmed. The drill site is on a slope of 7.6° which may cause difficulties for spudding in. The sea bed is very soft. Some slumping may have occurred in the recent geological past. WD is 1459m.

Location 3A

Recent slumping has occurred at the proposed drilling location. The average slope is 5.7° to the NW but the drill site itself is on a ledge in an erosion channel where the BTU is at a shallow depth below the sea bed. The slope has still a sediment cover. WD is 1110m.

Location 4

Ideal drilling location on technical grounds but BTU not imaged on seismic data. Thickness of Tertiary overburden may be greater than prognosed. Sub-Tertiary target unclear. Borehole difficult to locate on any available data. Soft sea floor at drilling location but slopes at 2.6°. WD is 1306m.

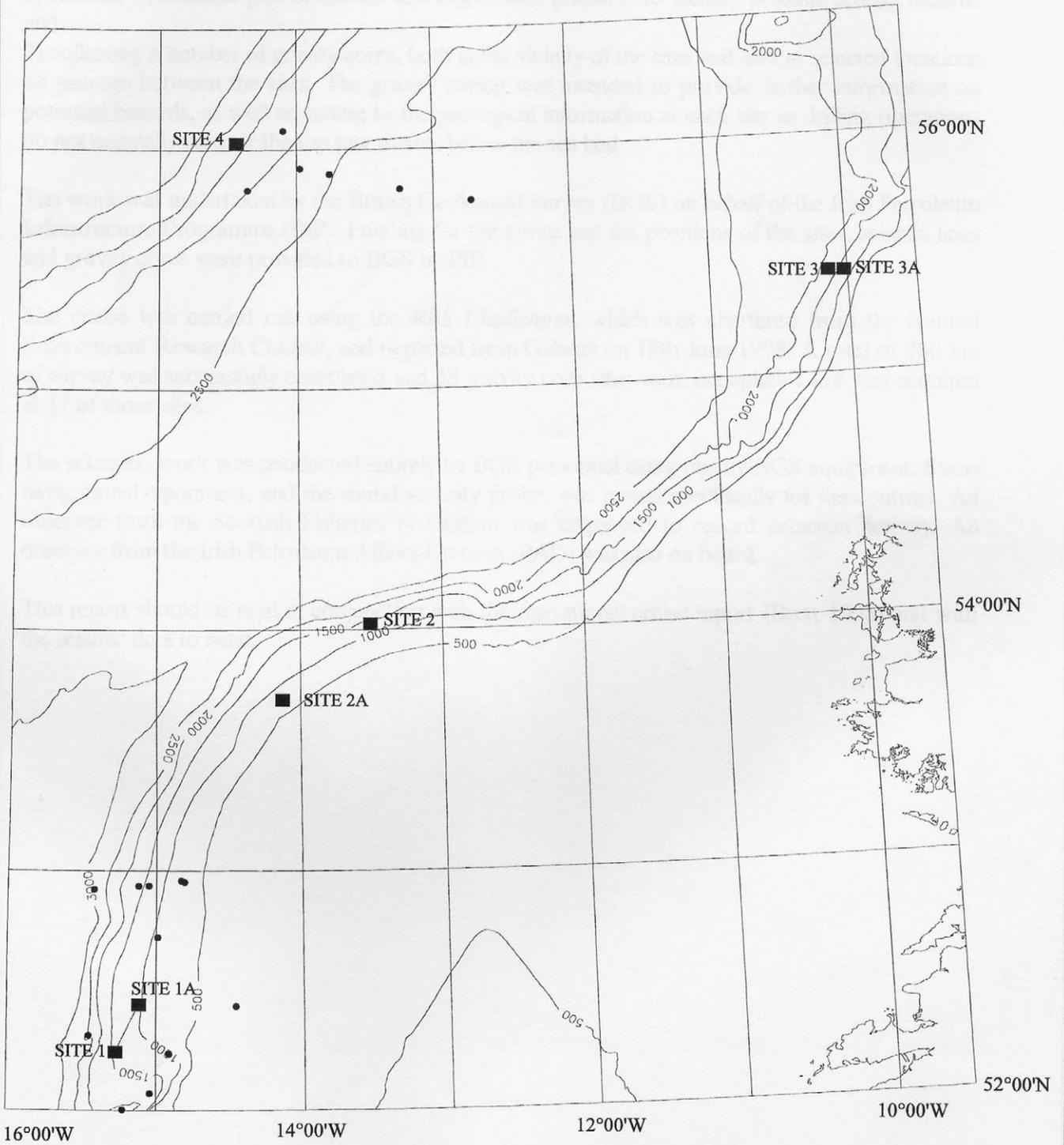
LOCATION DIAGRAM

I. INTRODUCTION

PROJECT BGS98SS - RRS CHALLENGER

The aim of the cruise was to obtain six gravity cores at six possible drill sites in the Irish Foreland Trough and one on the eastern flank of Rockall Bank. The surveys provided:

(1) a detailed grid of tracks and survey lines primarily to sites



- Borehole sites.
- Steaming route gravity cores.



British Geological Survey

2. NOTES ON THE SITE SURVEYS AND POSITIONS

1. INTRODUCTION

The aim of the cruise was to conduct site surveys across six possible drill sites in the Irish Rockall Trough and one on the eastern flank of Rockall Bank. The surveys involved:

- 1) running a restricted grid of sparker and airgun lines primarily to identify possible drilling hazards and
- 2) collecting a number of gravity cores, both in the vicinity of the sites and also at selected locations on passage between the sites. The gravity coring was intended to provide further information on potential hazards, as well as adding to the geological information at each site as drilling operations do not normally recover the top few metres below the sea bed.

The work was undertaken by the British Geological Survey (BGS) on behalf of the Irish Petroleum Infrastructure Programme (PIP). Funding for the cruise and the positions of the sites, seismic lines and gravity cores were provided to BGS by PIP.

The cruise was carried out using the *RRS Challenger*, which was chartered from the Natural Environment Research Council, and departed from Galway on 18th June 1998. A total of 286 km of survey was successfully completed and 58 gravity core sites were occupied. Core was acquired at 47 of those sites.

The scientific work was conducted entirely by BGS personnel using mainly BGS equipment. Some navigational equipment, and the sound velocity probe, was rented specifically for the contract. An observer from the Scottish Fisheries Federation was employed to record cetacean activity. An observer from the Irish Petroleum Affairs Division (PAD) was also on board.

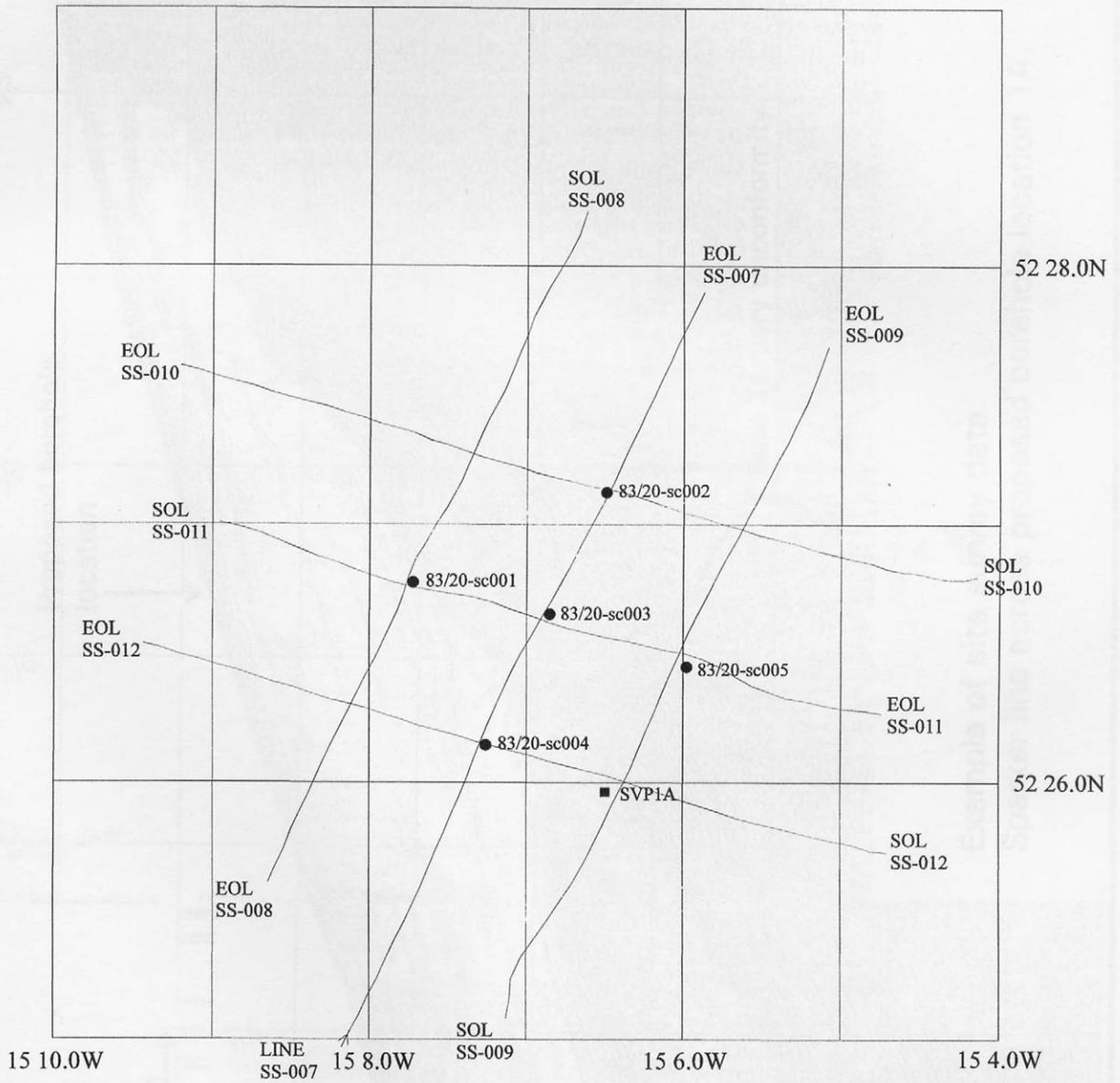
This report should be read in conjunction with the operational cruise report (Brett 1998) and with the seismic data to hand.

2. NOTES ON THE SITE SURVEYS AND POSITIONING

A small airgun array, sparker unit and echo-sounder were fired continuously along each line. The data were recorded digitally with both sparker and airgun profiles displayed on screen in real time. In addition, analogue sparker records were printed on the ship for immediate interpretation. Processed hard copy airgun records were available shortly after completion of each line.

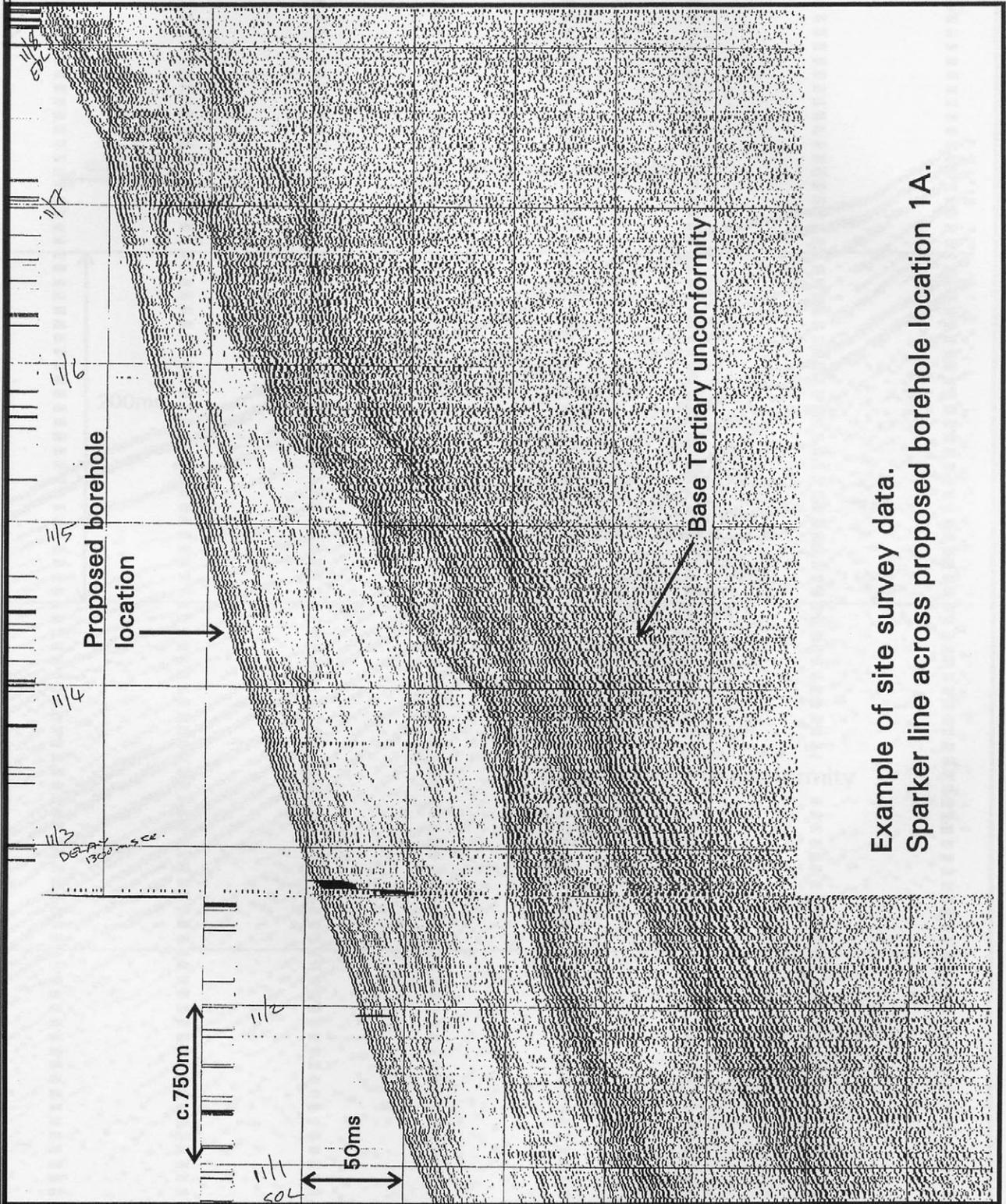
For positioning a VERIPOS DGPS system, supplied by SubSea Offshore was used. The system comprised two Sercel NR 103 DGPS receivers with corrections from either an HF radio link or via satellite using a link into the vessel's satcom aerial. Output from the NR103 receivers was processed and logged by a Qubit TRAC IV navigation processor/logger with positions corrected to the European Datum (1950) on the International Spheroid. The Qubit system also provided fix mark outputs to analogue recorders, a vessel steering display and logged position data to tape at one minute intervals. Water depth, derived from the airgun or sparker return, was also logged. Navigation data was also output from the NR103 directly to the CODA DA200 system. When coring a manual fix was generated as the corer hit the sea bed.

BOREHOLE LOCATION 1A (at centre of grid).



- Gravity core location
- Sound velocity probe location



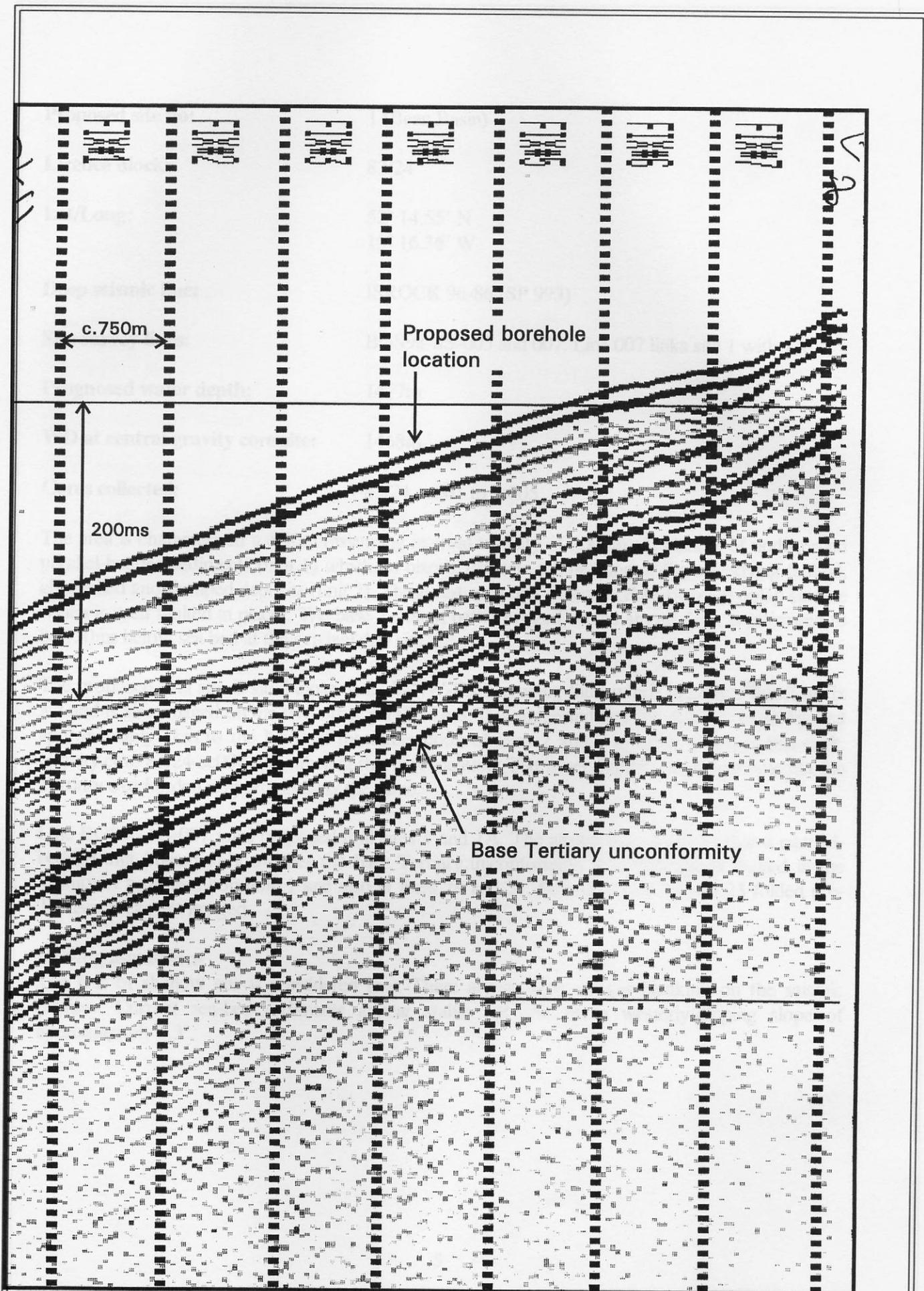


Example of site survey data.
 Sparker line across proposed borehole location 1A.

Example of site survey data
 Sparker line across proposed borehole location



British Geological Survey



Example of site survey data

Airgun line across proposed borhole location 1A



British
Geological
Survey

Proposed site no:	1 (Bean Basin)
Licence block:	83/24
Lat/Long:	52° 14.55' N 15° 16.36' W
Deep seismic line:	ISROCK 96-86 (SP 993)
Site survey lines:	BGS98-SS-003 and 007. Line 007 links site 1 with 1A.
Prognosed water depth:	1477m
WD at central gravity core site:	1468m
Cores collected:	83/24-sc001 to sc005

The area is characterised a c.50m (assuming interval velocity of 2000m.s^{-1}) blanket of undisturbed parallel-bedded sediments (unit 1) which, in places, truncate the bedding of the underlying faulted, channelled and slumped deposits (unit 2). These rest on a mid Tertiary (?late Eocene) onlap surface which is itself faulted in places. The base Tertiary, better imaged on the airgun data, is estimated to be 130ms below sea bed at the original drill site.

The proposed drill site is sited close to an WNW-ESE trending fault which intersects line 7 at fix 3.7 and is also imaged on the two other parallel lines. It is suggested that the drill site be re-located approximately 1km to the NNE at the intersection of lines 2 and 7 in order to avoid this fault. Gravity core 83/24-sc004 was taken at this new location. The water depth is shallower here but the Tertiary overburden is approximately the same.

Line BGS98-SS-007 joins proposed drill sites 1 and 1A. The airgun record shows that a parallel-bedded unit immediately overlies the base Tertiary unconformity. This package is faulted in the vicinity of proposed borehole 1 and also at fixes 29 and 31. Between fixes 17 and 23 folded pre-Tertiary rocks are imaged.

Drilling assessment

The risk of shallow gas is considered low. There are no signs of gas blanking on the seismic profiles. Current sea-bed sediments appear stable but rest on a westerly-dipping slope of approximately 3.3° .

Proposed site no:	1A (Bean Basin)
Licence block:	83/20
Lat/Long:	52° 26.43' N 15° 06.88' W
Deep seismic line:	SG 97-12--418-03A (SP 1415)
Site survey lines:	BGS98-SS-007 and 011. Line 007 links site 1 with 1A.
Prognosed water depth:	1073m
WD at central gravity core site:	1032m
Cores collected:	83/20-sc001 to sc005

The geology is essentially the same as at site 1 although the sediments of unit 2 (see above) are less disturbed here. At the drill site unit 1 sediments onlap a low mound of unit 2 (see line 7 fix 38). Unit 2 sediments onlap the major mid-Tertiary surface, below which reflectivity is much greater. The base Tertiary unconformity is imaged on both sparker and airgun records and is approximately 200ms below sea bed at the proposed drill site.

Drilling assessment

The risk of shallow gas is low. There are no signs of gas blanking on the seismic profiles. The sea bed dips westwards at approximately 1.6°. Hard horizons may be encountered at unconformities. Good gravity core recovery suggests no difficulties for spudding in.

Proposed site no:	2 (Northern Porcupine Bank)
Licence block:	16/28
Lat/Long:	54° 01.34' N 13° 30.85' W
Deep seismic line:	ISROCK 96-34 (SP 787)
Site survey lines:	BGS98-SS-021 and 024
Prognosed water depth:	1457m
WD at central gravity core site:	1460m
Cores collected:	16/28-sc001 to sc005

The youngest Tertiary in the area (eg line 20 fixes 6 to 8 and start of line 21) is well-bedded and up to 100ms thick. The upper part produces strong reflections, the lower part less so. In places, these reflectors are truncated at the sea bed. Underlying this is a more confused unit which becomes seismically more transparent deeper in the section. The base Tertiary unconformity is well imaged on all the records. It is a uniform surface dipping consistently towards the north west and is smoother than the sea bed surface. Truncation of underlying Mesozoic sediments at the unconformity is seen particularly well on airgun lines 21, 22 and 24. The depth to the BTU at the proposed drill site is confirmed at approximately 180ms.

The sea-bed topography appears gently undulating on the NE-SW lines but is seen to dip in a general NW direction on the NW-SE lines. The average slope on line 24 is 3.6°. A prominent 'shelf' occurs on this slope (line 23 fix 5, line 24 fix 2.5, line 25 fix 5) on which the drill site has been located. A steep canyon occurs near the start of line 20. It is approximately 150m depth but is not seen on any other line.

Gravity cores at this site recovered either a fine-grained muddy sand (16/28-sc001 and 002) or a few pebbles (16/28-sc004 and 005). The sandy cores were obtained in the north of the survey area. The rest of the area is assumed to have a hard sea bed. The attempted core at the proposed borehole site recovered nothing (core number 16/28-sc003).

Drilling assessment

The risk of shallow gas is low. There are no signs of gas blanking on the seismic profiles. The slope at the proposed dill site is 1.4°. The variable recovery from the gravity cores suggests the presence of stones on the sea floor which may affect spudding in.

Proposed site no:	2A (Northern Porcupine Bank)
Licence block:	75/10
Lat/Long:	53° 42.77' N 14° 07.58' W
Deep seismic line:	ISROCK 96-46 (SP 800)
Site survey lines:	BGS98-SS-014 and 018
Prognosed water depth:	860m
WD at central gravity core site:	853m
Cores collected:	75/10-sc001 to sc004

Lines BGS98-SS-14 (at fix 6.5) and BGS98-SS-18 (at fix 5.8) cross the proposed borehole site. On line 14, at approximately 70ms below the sea bed, a prominent reflector is imaged. This can be traced on all the lines. Below this the reflectors are parallel bedded with little or no thickness changes between them. Above, the various units have a combined thickness which is thicker to the NW of the site and thinner to the SE. On strike lines (NE-SW) these units onlap, and are cut out, by each other. On dip lines this can be seen to represent slumped deposits. Some slumps can be traced on adjacent lines (eg line 16 fixes 8-9, line 18 fix 8.5 and line 19 fix 1).

The deepest reflector on the sparker data represents the base Tertiary unconformity which is conformed at c.165ms below the sea bed at the proposed drill site. Sparker records do not image beneath this. However the airgun shows some NW Mesozoic dips truncated at the unconformity.

Gravity core recovery around site 2A was poor. Only a few pebbles were recovered from four different locations. Nothing was recovered at the proposed borehole site. The sea floor is assumed to be hard or pebbly with little or no soft sediment cover. This may be due to the combined effects of slumping and bottom currents both of which will tend to keep the slope clear.

Drilling assessment

The risk of shallow gas is low. There is no sign of gas blanking on the seismic profiles. The regional slope of the sea bed is 3.4° to the NW. Hard horizons may be encountered at the unconformities. The recovery from gravity cores suggests the sea bed to be stoney or hard and this will affect spudding in.

Proposed site no:	3 (Erris Ridge)
Licence block:	11/20
Lat/Long:	55° 25.01' N 10° 07.21' W
Deep seismic line:	DGER 96-22 (SP 2030)
Site survey lines:	BGS98-SS-43 and 47. Line 41 links site 3 with 3A.
Prognosed water depth:	1459m
WD at central gravity core site:	1463m
Cores collected:	11/20-sc006 to sc010

The geology is best imaged on the strike lines (NE-SW) and line 41 rather than the dip lines (NW-SE). The Tertiary comprises a well-bedded unit, unit 1, (about 200ms thick in places, line 45 fix 3) overlying a seismically more transparent unit 2. The bottom of this unit is the base Tertiary unconformity (BTU) which defines the Erris Ridge in this area. Unit 1 contains a discontinuity which is visible on all the strike lines. The Erris Ridge appears to have affected sedimentation during the Tertiary and in places may well be affecting the sea floor at the present time. No structure is imaged beneath the unconformity and the airgun data confirm that the top of the ridge is probably faulted and very irregular in form.

At the proposed drill site the sea floor dips to the north-west at 7.6° and the water depth is 1459m. The dip lines suggest that downslope sediment movement has occurred in the geologically recent past. The depth to the base Tertiary unconformity cannot be confirmed as, precisely at the drill site, it does not produce a strong reflector. The seismic data here are somewhat indistinct. If rocks beneath the BTU are the main target it may be prudent to move the proposed drilling location, perhaps to line 47 fix 5, or to site 3A where the BTU is better imaged.

Five gravity cores were taken around site 3 (11/20-sc006-010). All comprise sandy mud or muddy sand and are in excess of 2m in length confirming the very soft nature of the sea bed sediment in this vicinity.

Drilling assessment

The risk of shallow gas is low. There is no sign of gas blanking on the seismic profiles. Zones devoid of reflectors (line 43, fixes 4.5-5.4) resemble sediment remoulding associated with liquefaction and former slope failure. The proposed drill location, in a trough on a regional slope of 7.6°, may have acted as a site of recent deposition providing a soft sea bed for spudding in. However the steep slope may prove problematical.

Proposed site no:	3A (Erris Ridge)
Licence block:	11/20
Lat/Long:	55° 25.24' N 10° 01.37' W
Deep seismic line:	NWI-91-116 (SP 830)
Site survey lines:	BGS98-SS-36 and 39. Line 41 links site 3 with 3A.
Prognosed water depth:	1114m
WD at central gravity core site:	1110m
Cores collected:	11/20-sc001 to sc005

The geology at site 3A comprises a well-bedded unit 1, over 200m thick in places, on a transparent unit 2 on a mottled unit 3, the bottom of which is the base Tertiary unconformity (BTU) which defines the Erris Ridge in this area. This succession is best seen on line 38 between fixes 1 and 5. Nothing is imaged below the BTU. Units 2 and 3 are cut out by the Erris Ridge which has an irregular form and has clearly affected sedimentation during the Tertiary and possibly continues to affect the sea bed at the present time.

The strike lines (NE-SW) show that an erosive channel, aligned WNW-ESE and up to 100m deep, has been cut into unit 1. This is best seen on line 36 between fixes 5 and 7. The erosion has almost cut down as far as the BTU which is therefore close to the sea bed. The prognosis that it is about 72ms below the sea bed is probably fairly accurate. The proposed drilling location is situated within the erosive channel on a small ledge (line 39 fix 3.8).

Five gravity cores were collected within the survey area (11/20-sc001-005). All comprise muds although the very top of core 003 (at the proposed drill location) is perhaps very slightly sandier.

Drilling assessment

The risk of shallow gas is low. There is no sign of shallow gas on the seismic profiles. Although the overall regional slope is about 5.7° to the NW the proposed drill site is situated on a ledge within a trough. The gravity cores showed good penetration of very soft muds so spudding in should not prove problematic.

Proposed site no:	4 (Rockall Bank)
Licence block:	78/28
Lat/Long:	56° 01.67' N 14° 26.91' W
Site survey lines:	BGS98-SS-27 and 32
Deep seismic line:	WRM 96-110 (SP 1275)
Prognosed water depth:	1320m
WD at central gravity core site:	1306m
Cores collected:	78/28-sc004 to 008

The seismic data in the area were affected by the very prominent ridge (assumed to be metamorphic basement) which is aligned NE-SW to the SE of the proposed borehole location. This caused problems with side-swipe and diffractions. Furthermore the weather was poor at the time of acquisition and seismic penetration is poor. To the SE of the ridge no reflectors can be picked. To the NW, both the sparker and airgun image only a limited amount of geology with neither source obtaining a convincing return from the base Tertiary unconformity which therefore cannot be identified with certainty. No dipping Mesozoic reflectors can be seen on either data set. The high-resolution data can be correlated with the deep seismic line WRM 96-110.

At the proposed borehole location (line 27 fix 5.5 and line 32 fix 5.2) the problems outlined above preclude confirmation of the borehole prognosis although it may be that the thickness of the Tertiary has been underestimated here necessitating moving the drilling site to the SE. This will increase the risk of penetrating Permo-Triassic or metamorphic basement rocks beneath the base Tertiary unconformity rather than Mesozoic.

Gravity core 78/28-sc008 was collected at the borehole site and comprises a fine sand with some forams. The other cores in the pattern recovered muddy sand. Three attempts (78/28-sc001, 002 and 003) were made to obtain a core at steaming route site 4.6 which was a basement ridge target within the survey area. The first had nil recovery and the subsequent two attempts brought up coral, with some live specimens in 002. The final attempt at this site was abandoned to prevent further environmental damage and as success (a basement sample) seemed highly unlikely.

Drilling assessment

The risk of shallow gas is low. There is no sign of shallow gas on the seismic profiles. To the SE of line 32 fix 2.5 parallel bedding is apparent whereas to the NW any bedding is masked. This latter effect does not appear to be gas blanking and is always at least 1km NW of the proposed drill site. The sea bed at the drill location dips to the SE at approximately 2.6°. Gravity core samples indicate a sandy sea floor to at least 1.58m depth so top hole stability may be a problem. The possibility of coral in the vicinity causing a locally uneven sea bed should be considered.

3. SITE SURVEY GRAVITY CORES

Five gravity core drops were made at each of the seven sites, one on the actual proposed drill site and four others at the intersections of the short survey lines. Positions in lat/long are given in Brett (1998). Only a single attempt was made at each core drop location. All drops were within specification (not more than 100m off target position). A standard 3m long core barrel was generally used. However if a hard sea bed was suspected a shorter barrel, or sometimes a 'rock' barrel was deployed.

A maximum of two subsamples of core was taken for geochemical analysis. The upper two centimetres of each subsample was bagged and frozen. The lower eight centimetres was covered in sodium azide, tinned and frozen. Some samples were taken for environmental analysis (as directed by RSG in a fax received after departure from Galway) and sent to the Freshwater Research Centre (FRC), Dublin.

Survey Site	Designation	TD (m)	Geochem	Comments
1	83/24-sc001	1.70	0.65-0.75 1.60-1.70	At borehole location.
1	83/24-sc002	2.65	1.55-1.65 2.55-2.65	
1	83/24-sc003	2.06	0.96-1.06 1.96-2.06	
1	83/24-sc004	1.49	0.39-0.47 1.39-1.49	At borehole location.
1	83/24-sc005	2.44	1.34-1.44 2.34-2.44	
1A	83/20-sc001	1.81	0.71-0.81 1.71-1.81	
1A	83/20-sc002	2.02	0.92-1.02 1.92-2.02	
1A	83/20-sc003	2.40	1.30-1.40 2.30-2.40	At borehole location.
1A	83/20-sc004	2.12	1.02-1.12 2.02-2.12	
1A	83/20-sc005	2.16	1.06-1.16 2.06-2.16	At borehole location.
2	16/28-sc001	1.17	-	
2	16/28-sc002	1.40	1.30-1.40	
2	16/28-sc003	-	-	At borehole location. Nil recovery.
2	16/28-sc004	-	-	Few small pebbles.
2	16/28-sc005	-	-	Few small pebbles.

2A	75/10-sc001	-	-	13 small pebbles only.
2A	75/10-sc002	-	-	At borehole location. Nil recovery.
2A	75/10-sc003	-	-	Nil recovery.
2A	75/10-sc004	-	-	10 small pebbles and few shells.

Only four gravity cores were attempted at site 2A due to poor weather conditions, lack of success (a hard sea bed) and damage to core barrels.

3	11/20-sc006	2.52	1.42-1.52 2.42-2.52	
3	11/20-sc007	2.11	1.01-1.11 2.01-2.11	
3	11/20-sc008	2.41	1.31-1.41 2.31-2.41	At borehole location.
3	11/20-sc009	2.08	0.88-0.98 1.98-2.08	
3	11/20-sc010	2.31	1.21-1.31 2.21-2.31	
3A	11/20-sc001	2.02	0.92-1.02 1.92-2.02	
3A	11/20-sc002	2.43	1.33-1.43 2.33-2.43	
3A	11/20-sc003	1.57	0.48-0.58 1.47-1.57	At borehole location.
3A	11/20-sc004	2.22	1.13-1.23 2.12-2.22	
3A	11/20-sc005	2.09	1.00-1.10 1.99-2.09	
4	78/28-sc004	0.88	0.78-0.88	
4	78/28-sc005	1.47	0.37-0.47 1.37-1.47	
4	78/28-sc006	0.50	0.40-0.50	
4	78/28-sc007	1.58	0.48-0.58 1.48-1.58	
4	78/28-sc008	0.48	0.38-0.48	At borehole location.

4. STEAMING ROUTE GRAVITY CORES

Up to two attempts were made at each site except at site 4.6 where four attempts were specified. However the corer was deployed only three times here to avoid further damage to coral, some of which was live. All drops were within specification (not more than 100m off target position). A standard 3m long core barrel was generally used. However if a hard sea bed was suspected or experienced a shorter barrel, or sometimes a 'rock' barrel was deployed.

A maximum of two subsamples of core from each drop was taken for geochemical analysis. The upper two centimetres of each subsample was bagged and frozen. The lower eight centimetres was covered in sodium azide, tinned and frozen. Some samples were sent for environmental analysis (as directed by RSG in a fax received after departure from Galway) to the Freshwater Research Centre (FRC), Dublin.

Site	Designation	TD (m)	Geochem	Target / Comments
1.2	83/29-sc001	2.81	1.71-1.81 2.71-2.81	Canyon axis, sedimentological.
1.3	83/30-sc001	2.77	1.67-1.77 2.67-2.77	Canyon axis, sedimentological.
1.4	74/21-sc001	-	-	Carbonate mound. Rock barrel deployed, sea bed sample only.
	74/21-sc002	0.79	0.69-0.79	Second attempt. No 'blank'.
1.5	83/23-sc001	-	-	Spur, sedimentological. No core obtained. Sample regarded as from sea bed retained in shoe.
	83/23-sc002	1.61	0.50-0.60 1.51-1.61	Second attempt.
1.6	83/5-sc002	1.15	1.05-1.15	Slump body, sedimentological. Only 1 geochem sample.
1.7	83/5-sc001	1.10	1.00-1.10	Slump body, sedimentological. Only 1 geochem sample.
1.8	83/3-sc001	-	-	Slump body, sedimentological. No recovery.
	83/3-sc002	2.82	1.72-1.82 2.72-2.82	Second attempt.

GRAVITY CORE DESCRIPTIONS				
1.9	75/18-sc001	0.68	0.58-0.68	Carbonate mound. Only 1 geochem sample. Bent barrel.
1.10	74/1-sc001	1.66	0.55-0.65 1.56-1.66	Carbonate mound. No shoe sample.
1.11	74/1-sc002	0.35	-	Carbonate mound. No geochem. Bent barrel. No shoe sample.
	74/1-sc003	0.99	0.89-0.99	Second attempt. Only 1 geochem sample. Bent barrel.
1.12	74/6-sc001	2.09	0.97-1.07 1.99-2.09	Seep. No shoe sample.
4.2	77/9-sc001	1.26	0.10-0.20 1.16-1.26	Sediment waves. No shoe sample.
4.3	78/30-sc001	1.70	0.60-0.70 1.60-1.70	Carbonate mound.
4.4	8/1-sc001	1.88	0.78-0.88 1.78-1.88	Edge of debris flow deposit. No shoe sample.
4.5	8/2-sc001	2.39	1.32-1.42 2.29-2.39	Debris flow deposit. No shoe sample.
4.6	78/28-sc001	-	-	Basement ridge. Rock barrel. No recovery.
	78/28-sc002	-	-	1.5m barrel. Lots of coral, some live.
	78/28-sc003	-	-	1.5m barrel. Some coral. Within area of site 4. Fourth drop abandoned for environmental reasons.
4.7	8/9-sc001	2.49	1.39-1.49 2.39-2.49	Debris flow.
4.8	9/7-sc001	2.80	1.72-1.82 2.70-2.80	Debris flow. No shoe sample.

5. GRAVITY CORE DESCRIPTIONS

Each gravity core was cut into lengths in order to facilitate sub-sampling, for geochemical analysis, or for storage purposes. None of the cores was cut longitudinally. The following descriptions are based on the inspection of the cut ends of each length. The colours are classified according to the soil description colour charts of Munsell.

Core 8/1-sc001

- Sea bed Not collected – surface sample lost through top of core barrel
0.86m Mud (colour 2.5Y5/2) with rare sand (forams and lithic clasts). Very soft. High plasticity..
1.88m Mud (2.5Y5/2) with some sand (mostly forams and some lithic fragments). Very soft. High plasticity.

Core 8/2-sc001

- Sea bed Grey mud (2.5Y6/2) with occasional forams.
0.38m Grey sandy mud (2.5Y6/2).
1.32m Grey sandy mud (2.5Y5/2) with minute shell debris.
2.39m As above but colour 10YR6/1.

Core 8/9-sc001

- Sea bed Brown mud (10YR6/3) with few forams and quartz grains.
0.49m Grey mud (10YR5/1) with a few forams.
1.49m Grey mud (10YR5/1). More foram-rich than above.
2.39m Brown/grey mud (2.5Y4/2). Foram-rich with occasional rounded lithic fragments.

Core 9/7-sc001

- Sea bed Grey mud (10YR6/1) with a few forams.
0.82m Grey mud (10YR5/1).
1.82m Fine-grained foram sand (2.5Y5/2) with minute lithic fragments.
2.70m Grey mud (2.5Y6/2) with a few forams.

Core 11/20-sc001

- Sea bed Very muddy sand (2.5Y5/2) containing lithic clasts, forams and shell fragments.
0.92m Mud (2.5Y4/2) with rare sand fragments. Very soft. High plasticity.
2.02m Mud (2.5Y4/2) with black specks of (?)volcanic material. High plasticity.

Core 11/20-sc002

- Sea bed Grey foram-rich mud (2.5Y4/2).
0.44m Grey mud (2.5Y4/2). No forams.
2.33m Grey foram-rich mud (2.5Y4/2).

Core 11/20-sc003

- Sea bed Medium-grained sand (5Y4/3) of forams, quartz grains, lithic fragments and broken shell debris.
0.58m Dark grey mud (5Y3/2)
1.47m Dark grey mud (2.5Y4/2) with minute black ?lithic fragments.

Core 11/20-sc004

- Sea bed Brown mud (10Y5/3) with forams, quartz grains and lithic fragments.
0.33m Grey mud (10YR4/1). Very few forams.
2.22m Grey mud (10YR4/1). Little clastic debris. Some minute lithic fragments.

Core 11/20-sc005

- Sea bed Grey/brown mud (10YR4/2) with a few forams and minute lithic fragments.
1.10m Grey mud (10YR3/2).
2.09m Grey mud (10YR3/1) with black (?)carbonaceous/igneous rock fragments.

Core 11/20-sc006

- Sea bed Sandy mud (2.5Y5/2) with forams and lithic clasts. Very soft.
1.42m Mud (2.5Y4/2) with some sand-sized forams and lithic clasts and larger (up to 2cm) black, weathered and partially degraded (?)volcanic material. Very soft.
2.52m Mud (2.5Y4/2) with rare sand-sized forams and (?)volcanic clasts. Very soft. High plasticity.

Core 11/20-sc007

- Sea bed Very muddy sand (2.5Y5/2) containing forams and lithic clasts. Very soft.
1.01m Slightly sandy mud (2.5Y4/2) with forams and lithic clasts. Very soft. High plasticity.
2.11m Mud (2.5Y4/2) with rare sand-sized lithic and (?)volcanic fragments. Very soft. High plasticity.

Core 11/20-sc008

- Sea bed Very muddy sand (2.5Y6/2) with forams and lithic fragments. Very soft.
1.41m Slightly sandy mud (2.5Y4/2) with forams and lithic fragments. Very soft. High plasticity.
2.41m Mud (2.5Y4/2) with some sand clasts. Very soft. High plasticity.

Core 11/20-sc009

- Sea bed Muddy sand (2.5Y6/2) with forams and lithic fragments. Very soft.
0.98m Slightly sandy mud with mostly lithic clasts and some larger fragments of weathered (?)volcanic rock up to 4mm across. Very soft. High plasticity.
2.08m Very slightly sandy mud (2.5Y4/2) containing a few small (up to 2mm) black (?)volcanic clasts. Very soft. High plasticity.

Core 11/20-sc010

- Sea bed Muddy sand (2.5Y5/2) with lithic clasts and forams. Very soft.
1.31m Slightly sandy mud (2.5Y4/2) with lithic clasts and forams. Very soft. High plasticity.
2.31m Very soft mud (2.5Y4/2). High plasticity.

Core 16/28-sc001

Reduced length core barrel was deployed. Recovered full. Top of core may not be actual sea bed. Core very disturbed.

'Sea bed' Fine sand composed mainly of forams and quartz grains in minor clay matrix. Also small rounded lithic clasts of at least two distinct lithologies.

1.17m Similar to above. Possibly higher mud content. Sample more adhesive. Also large cobble recovered in shoe.

Core 16/28-sc002

Sea bed Fine-grained sand (10YR6/3) comprising forams, some broken shell debris and lithic clasts.

0.40m As above possibly with higher fines content.

1.40m Mud (10YR5/6). Fewer lithics than above.

Core 16/28-sc003

Nil recovery.

Core 16/28-sc004

No core recovered, just a few small pebbles (two lithologies) and some muddy sand.

Core 16/28-sc005

No core recovered. A few small pebbles (maximum 3.5cm across) of three different igneous/metamorphic lithologies.

Core 74/01-sc001

Sea bed Live and dead coral and very soft mud.

0.55m Very soft mud (2.5Y5/2) containing coral.

1.66m Slightly sandy mud (2.5Y6/2) containing coral.

Core 74/01-sc002

Sea bed Medium-grained foram-rich sand (2.5Y5/2) with broken shell debris, spines and at least two types of rounded lithic fragments.

0.35m Very fine sand to mud (2.4Y5/2) with forams, broken shell debris and very small, disseminated black lithic fragments. Also large pebble which probably prevented the corer from penetrating deeper.

Core 74/01-sc003

Sea bed Greyish, fine to medium-grained sand (2.5Y5/2) comprising mainly forams but also with small broken shells, echinoid spines and lithic fragments.

0.99m As above.

Core 74/06-sc001

- Sea bed Fine-grained foram-rich sand (2.5Y5/2) with filaments and very fine comminuted black specks (?volcanic fragments).
- 1.07m Dark grey clay (10YR4/2).
- 1.99m Fine to medium-grained foram-rich sand with black, rounded lithic fragments and small broken shell debris.

Core 74/21-sc001

- Rock barrel deployed. No core recovered but sample obtained (assumed from sea bed).
- 'Sea bed' Grey, gritty clay (10YR6/1) containing forams and coral fragments up to 2cm long.

Core 74/21-sc002

- Sea bed Grey clay (10YR6/3) containing fragmented bryozoan mats and branching coral.
- 0.69m Gritty, grey clay (10YR6/1) containing coral debris.

Core 75/10-sc001

No core recovered. Thirteen pebbles (maximum length 1.0cm) of various igneous/metamorphic rock lithologies obtained.

Core 75/10-sc002

No core recovered.

Core 75/10-sc003

No core recovered.

Core 75/10-sc004

No core recovered but poorly sorted, angular pebbles (up to 2.5cm length) obtained. Mainly igneous/metamorphic rock lithologies.

Core 75/18-sc001

- Sea bed Grey mud (2.5Y5/2) containing fragments of dead coral. Forams and broken shell debris also present.
- 0.68m Grey mud (2.5Y6/2) with minute broken shell debris. Almost devoid of forams.

Core 77/09-sc001

- Sea bed Mud (2.5Y6/2) with sand-sized forams and lithic clasts. Very soft. Fairly high plasticity.
- 0.10m Mud (2.5Y5/2). Very soft. High plasticity.
- 1.26m Very soft mud (2.5Y6/2). Fairly high plasticity.

Core 78/28-sc001

No recovery.

Core 78/28-sc002

No core recovered but lots of coral, including live specimens, obtained.

Core 78/28-sc003

No core recovered. Dead coral obtained.

Core 78/28-sc004

Sea bed Muddy sand (10YR6/3), mainly forams and lithic clasts. Very soft.
0.88m Muddy sand (10YR7/3). Forams, lithic clasts and echinoid spines in very soft matrix. Also large fragments of dead coral.

Core 78/28-sc005

Sea bed Muddy, foraminiferal sand (2.5Y6/2) with lithic clasts. Very soft.
0.47m Slightly sandy mud (2.5Y4/2). Very soft. High plasticity.
1.47m Slightly sandy mud (2.5Y5/2) with lithic clasts and forams. Very soft.

Core 78/28-sc006

Sea bed Muddy sand (2.5Y6/2) with lithic clasts and forams. Very soft.
0.40m Very muddy sand (2.5Y4/2) containing forams, lithic clasts and spines.
0.50m Mud (2.5Y5/2). Minor quartz and shell debris. Very soft.

Core 78/28-sc007

Sea bed Slightly muddy, foraminiferal sand (2.5Y6/2) with lithic clasts.
0.58m Very muddy sand (2.5Y5/4), mostly forams and lithic clasts.
1.58m Slightly muddy foram-rich sand (2.5Y4/4) with lithic clasts. Very soft.

Core 78/28-sc008

Sea bed Foraminiferal sand (2.5Y7/2) with rare lithic fragments. Very soft.
0.48m Foraminiferal sand (2.5Y6/2) with lithic clasts up to 1mm long. Very soft.

Core 78/30-sc001

Sea bed Sandy mud (2.5Y6/4) with forams and lithic clasts. Very soft.
0.70m Mud (2.5Y4/2) with rare shell fragments and quartz grains. Very soft. High plasticity.
1.70m Mud (2.5Y5/2 and 10YR8/1) with forams and quartz grains. Some metamorphic pebbles up to 1.0cm across. Very soft. High plasticity.

Core 83/03-sc001

No recovery.

Core 83/03-sc002

Sea bed Slightly muddy foram-rich sand (10YR7/3) with lithic clasts.
0.82m Sandy foram-rich mud (10YR5/4) with angular lithic clasts.
1.72m Very sandy mud (2.5Y5/4) with predominantly angular lithic clasts up to 5mm long. Soft, non-cohesive, low plasticity.
1.82m Angular, black-green pebble 3cm across with linear fabric.
2.82m Very sandy mud (10YR4/4) with forams and lithic clasts. Soft.

Core 83/05-sc001

Sea bed Sandy mud (2.5Y7/2) with forams and lithic clasts.
1.10m Slightly sandy mud (2.5Y7/2) with forams and lithic clasts.

Core 83/05-sc002

Sea bed Sandy mud (2.5Y7/2) with forams and angular lithic clasts. Very soft.
1.05m Slightly muddy foram-rich sand (2.4Y7/2) with angular lithic clasts up to 1mm across. Soft, cohesive.
1.15m Poorly sorted sand (10YR6/4) with forams, spines and angular lithic clasts, up to 5mm across, and some shell fragments.

Core 83/20-sc001

Sea bed Mud (2.5Y6/4) with some fine sand comprising forams and lithic fragments. Very soft. A few sponge spicules.
0.71m Mud (2.5Y5/2) with forams and lithic fragments. Very soft.
1.81m Sand (10YR6/3) comprising mainly forams and some lithic and shell fragments. Firm, cohesive.

Core 83/20-sc002

Sea bed Sandy mud (2.5Y6/2) containing sponge spicules, forams and lithic fragments. Very soft.
0.92m Mud (2.5Y5/2) with some quartz grains, lithic fragments, forams and shell debris.
2.02m Slightly muddy sand (2.5Y7/2), mostly forams but with some shell and angular lithic fragments. Fairly cohesive.

Core 83/20-sc003

Sea bed Very sandy mud (2.5Y6/2) comprising mainly lithic and shell fragments and sponge spicules.
0.40m Mud (2.5Y5/2) with some quartz grains and lithic fragments up to 1mm across. Very soft. High plasticity.
1.40m Sandy mud (2.5Y5/2) with forams and lithic fragments. Soft.
2.40m Mud (2.5Y5/4) with some quartz grains and shell fragments. Very soft. High plasticity.

Core 83/20-sc004

Sea bed Muddy sand (2.5Y6/2) comprising mainly forams but also with lithic and shell fragments and sponge spicules. Soft.
1.02m Mud (2.5Y5/2). Very soft, cohesive/plastic.
2.12m Mud (2.5Y5/2). Very soft, cohesive, high plasticity. Some sponge spicules.

Core 83/20-sc005

Sea bed Very muddy sand (2.5Y6.2) containing forams and lithic fragments. Very soft.
0.28m Mud (2.5Y5/2) with rare lithic grains. Very soft. High plasticity.
1.06m Mud (2.5Y5/2) with few sand and shell fragments. Very soft.
2.16m Foraminiferal sand (2.5Y7/2). Fairly firm and cohesive.

Core 83/23-sc001

No core recovered. Sea bed sample only.

Sea bed Pebbles (up to 4cm long) black, structureless, angular and igneous/metamorphic in origin in pale brown clay (10YR5/4) containing a few forams and minor shell debris.

Core 83/23-sc002

Sea bed Very fine sand to mud (10YR6/3) with forams, broken shell debris and angular to rounded black lithic fragments.

0.60m Quartz sand (10YR4/3) but with black lithic pebbles.

1.61m Cream/white stiff clay (10YR8/1). Moderate reaction with HCl.

Core 83/24-sc001

Sea bed Slightly sandy mud (2.5Y6/2). Very soft. Moderate reaction with HCl.

0.75m Sandy mud (10YR5/3). Very soft. Moderate reaction with HCl.

1.60m Foraminiferal sand with some quartz grains and shell fragments.

Core 83/24-sc002

Sea bed Slightly sandy mud (10YR6/2). Very soft.

0.65m Mud (2.5Y5/4) Very soft.

1.65m Mud (10YR8/2) with some quartz grains. Metamorphic pebble 2cm across.

2.65m Foraminiferal muddy sand (10YR6/3) with black metamorphic sand grains.

Core 83/24-sc003

Sea bed Sandy mud (2.5Y6/4) with some forams. Very soft.

1.06m Very muddy sand (2.5Y5/2) with forams and black sand grains. Very soft.

2.06m Very muddy sand (2.5Y5/2), mostly forams. Fairly soft.

Core 83/24-sc004

Sea bed Mud (2.5Y6/4) with some forams and lithic fragments.

0.47m Very sandy mud (2.5Y5/4) with forams and lithic fragments.

1.49m Slightly muddy foram-rich sand (10YR7/2) with red/orange and black sand grains.

Core 83/24-sc005

Sea bed Mud (2.5Y6/4), very soft with some forams and lithic fragments.

0.44m Sandy mud (2.5Y5/6) with lithic clasts (up to 1mm) and forams. Fairly soft.

1.44m Foraminiferal sand (10YR8/1). Some laminations (2.5Y6/4) of muddy sand up to 2mm thick.

2.44m Mud (2.5 Y5/4) with some sand grains. Fairly soft.

Core 83/29-sc001

Sea bed Pale grey gritty clay (10YR7/1) containing forams and other shell debris.

0.71m Grey clay (2.5Y4/2) with black particulate matter.

1.71m Grey clay (2.5Y3/2).

2.81m Grey clay (10YR4/1) with some forams.

Core 83/30-sc001

Sea bed	Mud (2.5Y6/2) with sand-sized forams and lithic clasts.
0.77m	Mud (2.5Y5/2) with rare sand clasts. Very soft. High plasticity.
1.77m	Fairly sandy mud (2.5Y4/2) with forams and lithic clasts. Very soft.
2.77m	Mud (2.5Y5/2) with rare fine sand clasts and shell fragments. Very soft. High plasticity.

6. REFERENCE

Brett, C.P. 1998. Irish Rockall Trough. Drill Site Survey. RRS Challenger. Operations Report. BGS Technical Report WB/98/28C.