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Sedimentology of shallow cores from the 2001 Rockall-Hatton drilling programme.

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Sedimentology of shallow cores from the 2001 Rockall-Hatton drilling programme.

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Ten shallow cores were examined to assess sedimentary environments, primarily of carbonate rocks. Four (quadrant 57-16, cores 16, 17, 18 and 19) were taken from the western margin of Rockall Bank. Four (57-17, cores 05, 07, 08 and 09) are in the vicinity of the Sandastre igneous centre in the Hatton-Rockall Basin. One (57-12/41) is from the top of the Anton Dohrn Seamount and one (58-12/09) is from the northern Rockall Trough). Other cores taken during the 2001 cruise did not contain significant sedimentary material.

1 Introduction

Ten shallow cores (rock drill – DR, vibrocore – VE or gravity core - CS) from the Rockall-Hatton area were examined. Core locations are detailed in Table 1 and Figures 1, 2.

Core number	**Location**	**Core Recovered**	**Lithology**	**Water depth**
57-12/41DR	Anton Dohrn	1.14 m	Sand + limestone	667 m
57-16/16DR	Rockall Bank	0.48 m	Soft carbonate + pebbles	602 m
57-16/17VE	Rockall Bank	2.52 m	Sand, mud + carbonate	602 m
57-16/18VE	Rockall Bank	2.71 m	Sand, carbonate + mud	670 m
57-16/19VE	Rockall Bank	3.07 m	Carbonate	666 m
57-17/05DR	Hatton-Rockall Basin (Sandastre)	4.40 m	Carbonate on breccia	963 m
57-17/07DR	Hatton-Rockall Basin	1.68 m	Tuffaceous siltstones	810 m
57-17/08DR	Hatton-Rockall Basin	3.81 m	Carbonate on sandstone	691 m
57-17/09DR	Hatton-Rockall Basin	0.94 m	Conglomerate	936 m
58-12/09CS	Rockall Trough	3.35 m	Soft clay	1935 m

Table 1 Core details.

Cores were examined using a hand lens and binocular microscope with a maximum magnification of ×20. Observations were integrated as far as possible with existing reports on petrology (Lott, 2002) and micropalaeontology (Riding, 2001; Wilkinson, 2002).

2 Core Description

2.1 ANTON DOHRN: 57-12/41

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

0.00 – 0.12 m

The top part of the core comprises foraminiferal (foram) 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 – 0.60 m

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 0.37 m.

The top of the upper cycle is a dark brown to black band 40 mm 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 60 mm 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 8 mm 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 – 1.14 m (TD)

Bioclastic limestone with variable cementation, topped by a dark band. The dark band is 9 – 18 mm 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.

2.2 ROCKALL BANK: 57-16/16, 17, 18 AND 19

Of the four cores taken from Rockall Bank, one comprises unconsolidated calcareous sediment, two contain a succession of calcareous sands and muds and one consists of calcareous mud overlain by a dark crust.

2.2.1 57-16/16

This core contains 0.35 m of unconsolidated chalk underlain by two large pebbles (basalt and quartzite). The basal 0.09 m 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 1 mm 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; Table 2).

Core	**57-16/16**	**57-16/17**	**57-16/18**	**57-16/19**
Sample depths / Biostratigraphy	0.20 m Neogene 0.48 m Neogene	0.53 m Mid Pleistocene – Holocene **Late Miocene** 1.38 m Mid-late Pleistocene **Late Miocene**	0.27 m Mid Pleistocene 0.67 m Pleistocene **(no older than) late Miocene** 2.33 m Neogene **(no older than) late Miocene (post N 16)**	0.15 m Pleistocene **(no older than) mid Miocene (N9)** 2.98 m Neogene **Older than mid Miocene (pre N9)**

Table 2 Summary of biostratigraphic data for Rockall Bank cores. Dinoflagellate ages are in plain type, foraminiferal ages in bold.

2.2.2 57-16/17 and 57-16/18

These two cores contain 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 0.20 m. The bioturbation appears to comprise horizontal to incline up to 45^{o} burrows up to 10 mm in diameter, and is assigned tentatively to a *Planolites* type.

Both cores consist of a succession of sediments with variable grain size and colour. All of the lithologies contain sand sized (0.2 – 0.4 mm) 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 (Figure 3) including the basal 0.50 m of the core. This sequence suggests that there is a cyclicity in the deposition of foram sands. The variations in lithology from the topmost 'cycle', 0.41 m thick, is described in detail in Figure 3.

In core 57-16/18 foram rich sands are less common and white calcareous muds, some of which show subtle grading, more abundant (Figure 4). 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 (Table 2). 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 (James Riding, pers comm.) further work is required to clarify the age of the sediments.

2.2.3 57-16/19

This core consists of 3.07 m 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 – 0.12 m

The dark band at seabed is 12 mm 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 – 3.07 (TD)

The 0.10 m 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 0.10 m 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 0.30 m has been bioturbated and contains well defined burrows up to 10 mm in diameter, filled by foram sand that is slightly darker than the fine-grained matrix. These burrows, horizontal to inclined at 60^{o}, 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 0.55 m. 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 0.80 m. 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 3.00 m is 15 mm in thickness and appears to comprise lithified carbonate. It is possible that this lithification involves silicification.

2.3 HATTON-ROCKALL BASIN: 57-17/05, 07, 08 AND 09

The four cores studied in this area are taken from the area of the Sandastre igneous centre, from various topographic highs interpreted to be locations where igneous rock would crop out at or near the seabed.

Three cores consist of carbonate overlying epiclastic (clasts of devitrified glassy volcanic rock) material, one core contains a bioclastic rich basaltic conglomerate. All four cores have yielded a dinoflagellate fauna that is typical of the Neogene but has not been dated with greater precision (Riding, 2001).

2.3.1 57-17/05

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

0.00 - ?0.02 m

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

0.02 – 0.26 m

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 30 mm 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 bafflestone.

0.26 – 4.40 m (TD)

Below 0.26 m 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 50 mm in size. There is some down-core variation in grain size but no grading or distinct bases to beds.

2.3.2 57-17/07

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

0.00 – 0.06 m

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

0.06 – 0.08 m

Between 0.06 and 0.08 m a thin bed of lithified carbonate containing several dark bands is present. There are up to 4 dark bands, 1 – 2 mm 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 volcaniclastic material.

0.08 – 1.68 m (TD)

The majority of the core consists of fine-grained volcaniclastic material showing horizontal bedding, displacive calcite veining and some soft sediment deformation (Figure 5). The material is described as tuffaceous siltstone cemented by veins of calcite spar (Lott, 2002). No non-volcanogenic clasts were identified. Much of this volcaniclastic 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 0.41 m the volcaniclastics 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 8 mm in thickness and have a lenticular geometry. There is a suggestion of bedding at 50^{o} to horizontal within the core, cut by the veining.

Between 0.41 and 0.63 is a zone of laminated tuffs with laminae 5 – 12 mm 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 1.36 m the volcaniclastics 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 1.68 (TD) is a zone of laminated tuffs with laminae 5 – 8 mm 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.

2.3.3 57-17/08

This core contains 3.81 m of sediment with a 0.45 m capping of carbonate.

0.00 - 0.12 m

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

0.12 – 0.54 m

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 20 mm in diameter but most are <2 mm. Although much finer-grained this material appears to be similar petrographically to the volcaniclastic breccia in core 58-17/05.

0.54 – 0.56 m

Foram sand with some bands of volcaniclastic material.

0.56 - 0.87 m

Lithified carbonate with some coarse-grained material at the base (Figure 6). 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 20 mm 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.

0.87 – 3.81 m (TD)

Pebbly volcaniclastic sandstone, epiclasts cemented by calcite spar.

2.3.4 57-17/09

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

0.00 - 0.14 m

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

0.14 - 0.94 m (TD)

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

2.4 ROCKALL TROUGH: 58-12/09

Gravity core 58-12/09 recovered 3.35 m 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 – 10 mm in diameter, filled with a slightly sandier sediment, possibly a form of *Planolites*. There is a gradual colour change in the topmost 0.70 m with the core becoming darker and more consolidated with depth.

Below 0.70 m the core is homogeneous bioturbated mud to 2.13 m 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 10 mm, and transitional over 2 – 3 mm. There are small 'flame' structures above the boundary. There is one vertical burrow into the underlying mud, 1 mm wide and 8 mm 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 2.13 m. 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 0.53 m (Wilkinson, 2002).

3 Discussion

The ten cores can be subdivided into four groupings based on their location.

In all cores surficial sediment of foram sand and / or gravel consisting of lithic pebbles is observed. The sand is commonly unconsolidated and may represent Holocene deposition. In one core a soft chalk is present at seabed.

On Anton Dohrn Seamount 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 seabed. 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 proved roughly 5 m of bioclastic material of mid-Miocene age overlying 3.5 m 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.

The 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 0.10 m in thickness. Both cores are topped by foram sands, a lithology that is also seen deeper in the succession. 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 100 ms (roughly 90 m). 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 10 m 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 – 500 m 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.

The four cores from the Hatton-Rockall Basin, around the Sandastre igneous centre, represent deposition of volcaniclastic deposits overlain by, and in 57-17/08 interbedded with, carbonates.

The volcaniclastic sediments are different in each of the cores recovered, but appear with the exception of core 57-17/09 to be related. Volcaniclastics from cores 57-17/05, 07 and 08 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 57-17/05 and 08 respectively may have been deposited subaerially then cemented by marine calcite spar during transgression. The fine-grained volcaniclastics in core 57-17/07 show evidence of soft sediment deformation and slumping that indicates a marine environment. It cannot be ascertained whether the volcaniclastics 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 57-17/05 and 08.

The difference in textural maturity between angular breccia (57-17/05) and sandstone (57-17/08) suggests that weathering and sorting of the volcanic material took place over a short distance. The presence of devitrified volcaniclastic 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 volcaniclastics.

The basaltic conglomerate in core 57-17/09 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 volcaniclastics.

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 57-17/08 the interbedding of carbonate and volcaniclastic 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 volcaniclastic 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.

In the deep Rockall Trough core 58-12/09 contains 3.35 m 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 2.13 m does not appear to correspond with the palaeoclimatic changes inferred by the palynology.

4 Conclusions

On Anton Dohrn seamount unconsolidated foram sand overlies bioclastic carbonate containing several cycles of weathering, forming manganoan hardgrounds. The carbonate might be of Palaeogene age by analogy with nearby cores.

On Rockall Bank a series of sediments, tentatively interpreted to be Oligocene-Miocene in age, were laid down in a slope setting where hemipelagic calcareous ooze formed a background input, interspersed with pulses of coarse-grained sediment from the shelf. Coarse-grained sediments become less common with depth. One core appeared to recover soft ooze that might be younger in age.

In the Hatton-Rockall Basin weathered igneous rocks make up topographic highs, suggesting prolonged and multi-phase erosion before the present topography was formed. The overlying, and in one case possibly interbedded, carbonates are themselves complex, containing hardgrounds, erosion surfaces and lags.

5 Recommendations for Further Work

Further work is necessary in the first instance to resolve the conflicts in interpreted age as shown in Table 2. The suggested further biostratigraphic analyses are listed below.

- A general biostratigraphic analysis of the carbonate in core 57-12/41.
- Use of calcareous nannoplankton to attempt to resolve the age of carbonate in the cores from Rockall Bank.
- Use of calcareous nannoplankton and foraminifera to determine the age(s) of the carbonates in the Hatton-Rockall Basin, in particular core 57-17/08 where carbonate and volcaniclastic sediments are interbedded.
- Analysis of the coralline macrofauna from core 57-17/05 accompanied if appropriate by Sr isotopic dating.

In addition some mineralogical analyses would help to clarify core composition and would complement the thin section analyses carried out.

- XRD analysis of a dark band to identify hardground to identify mineralogy.
- XRD analysis of the coralline carbonate in core 57-17/05 to determine whether sufficient aragonite is present to allow Sr isotope dating.
- XRD analysis of the red and black minerals within core 57-17/07.
- XRD of the fine-grained carbonate in 57-17/08 to determine if the hard, brittle nature is a result of silicification or dolomitization.
- XRD may also be carried out to confirm the composition of the black clasts scattered through the carbonate. They are interpreted to be basalt, however some are glassy and rounded in form and have some similarities to pelleted glauconite.

References

Most of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.

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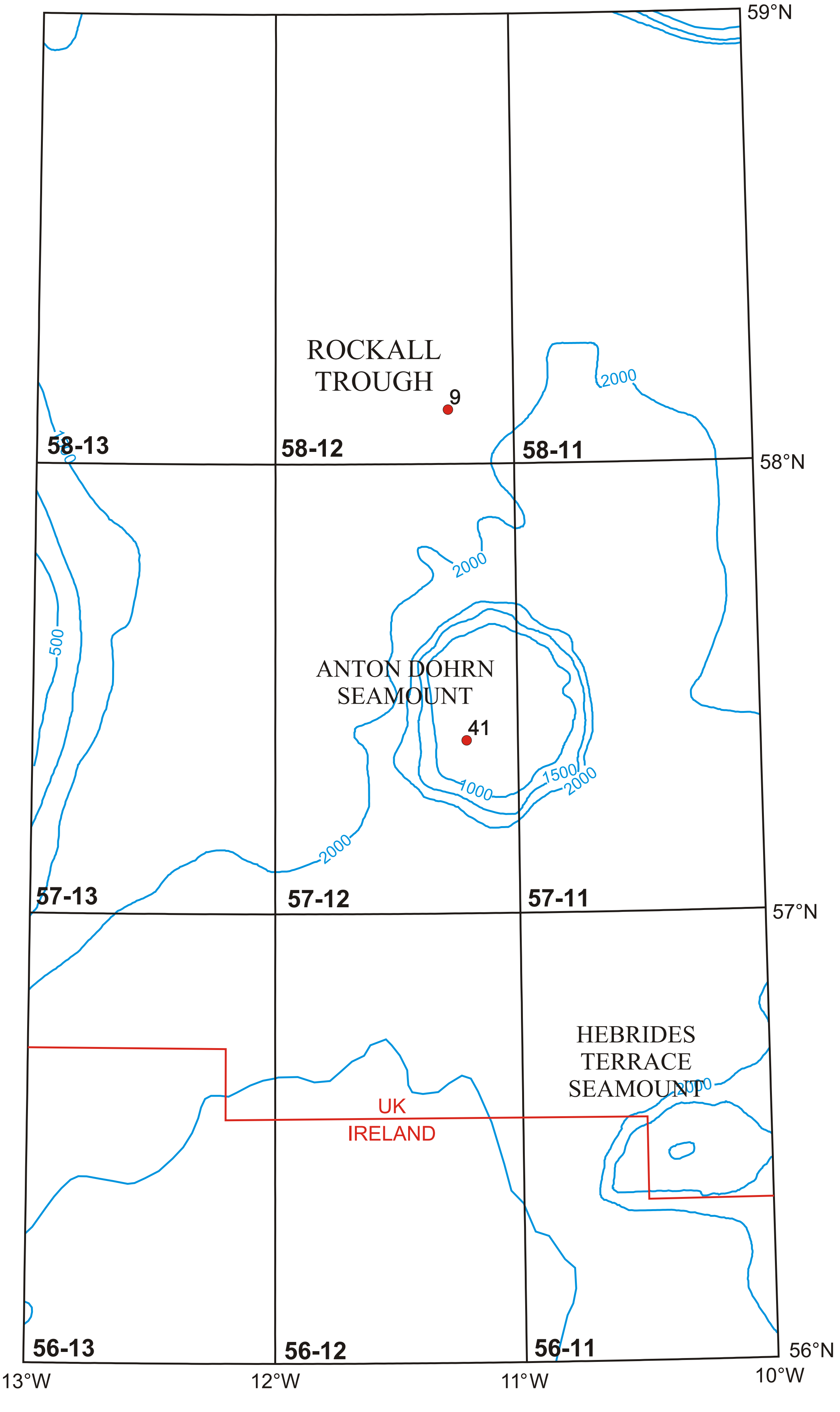


Figure 1 Sample site map, Anton Dohrn Seamount and Rockall Trough.

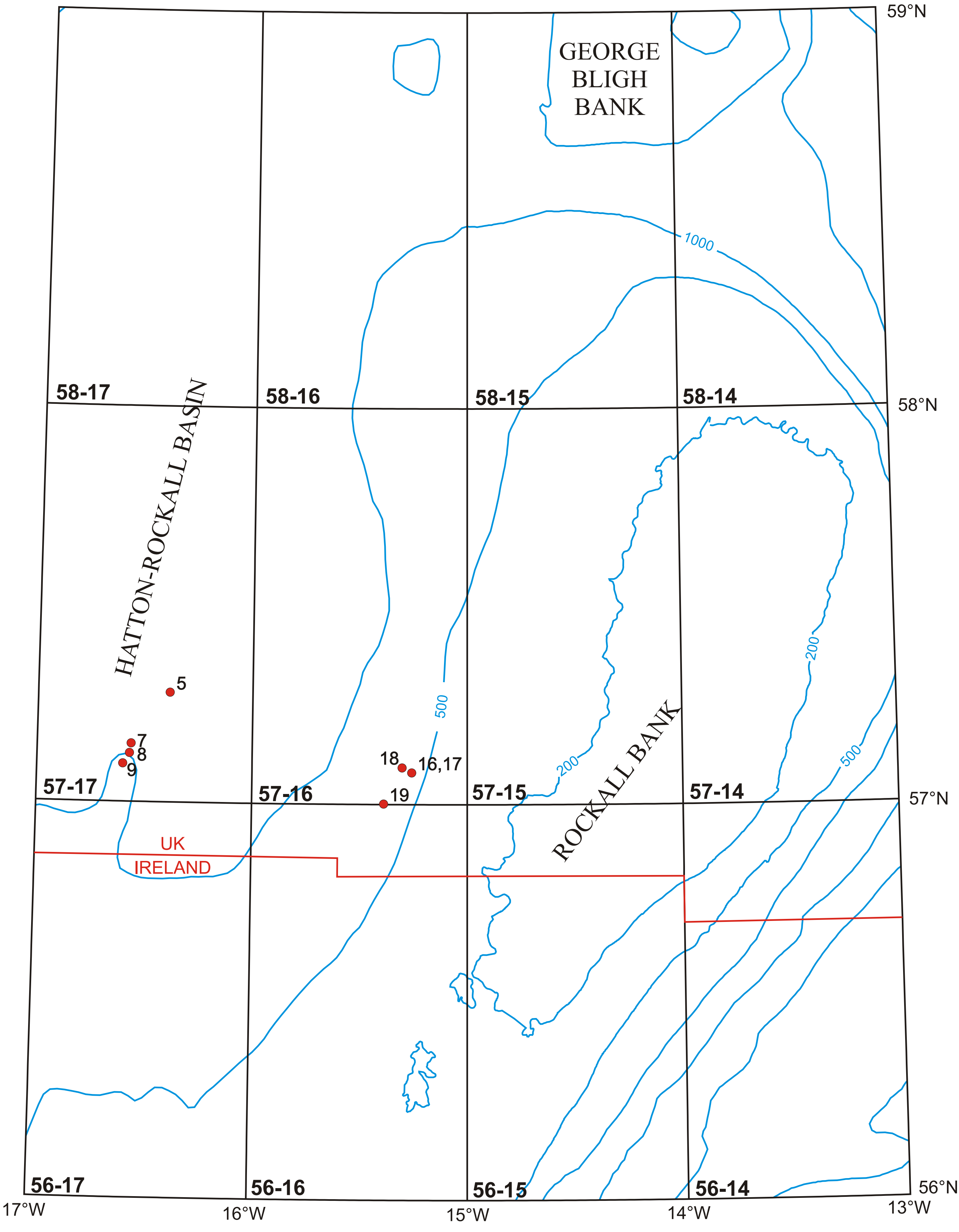


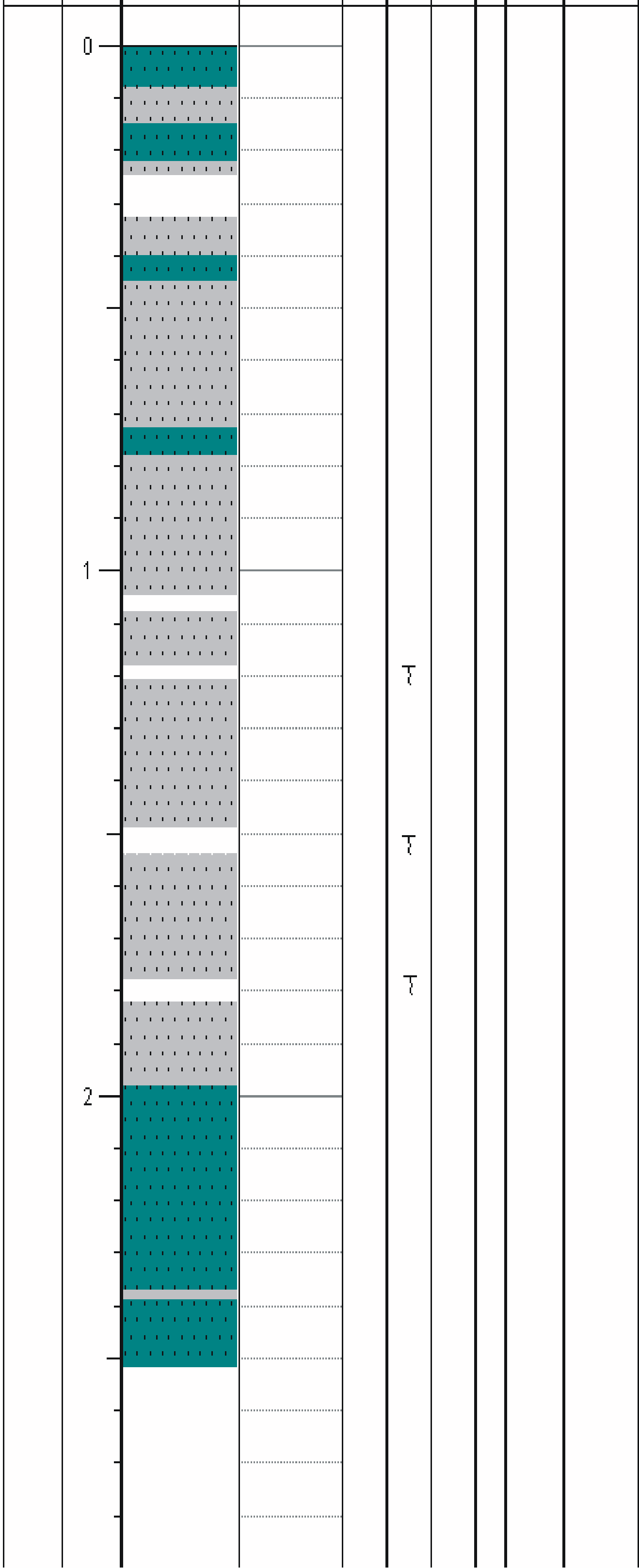
Figure 2 Sample site map, Rockall Bank and Hatton-Rockall Basin.

BGS CORE NO: 57-16/17

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

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

AGE | DEPTH (m) | LITHOLOGY | ROP 0 time (mins) 240 | BEDDING | STRUCTURE | BED FORMS | DISTURBANCE | SAMPLE | COLOUR | DESCRIPTION



0.00-0.08 Moderately coarse grained green foram sand (2.5Y 6/2) with mollusc and echinoderm fragments, dark ?basalt clasts.
0.08-0.09 Muddy grey foram sand (2.5Y 7/1).
0.09-0.15 Green foram sand interbedded with brown muddy sand (10YR 6/4).
0.15-0.22 Green foram sand (2.5Y 7/3).
0.22-0.25 Muddy brown foram sand.
0.25-0.33 Muddy white carbonate (10YR 8.1), some coarse shell, foram fragments.
0.33-0.40 Muddy brown foram sand.
0.40 Start of second 'cycle' topped by foram sand.
0.40-0.73 Second cycle of varying lithologies as above.

0.73-1.08 Third cycle as above, muddy white carbonate between 1.05 and 1.08.

1.08-1.98 Varying lithologies as above, muddy white carbonate at 1.18-1.21, 1.49-1.54, 1.78-1.82. White bands are intensly bioturbated.

1.98-2.52 Green foram sand overlain by a shell lag with pebbles of basalt and gneiss. Muddy foram sand at 2.37-2.39.

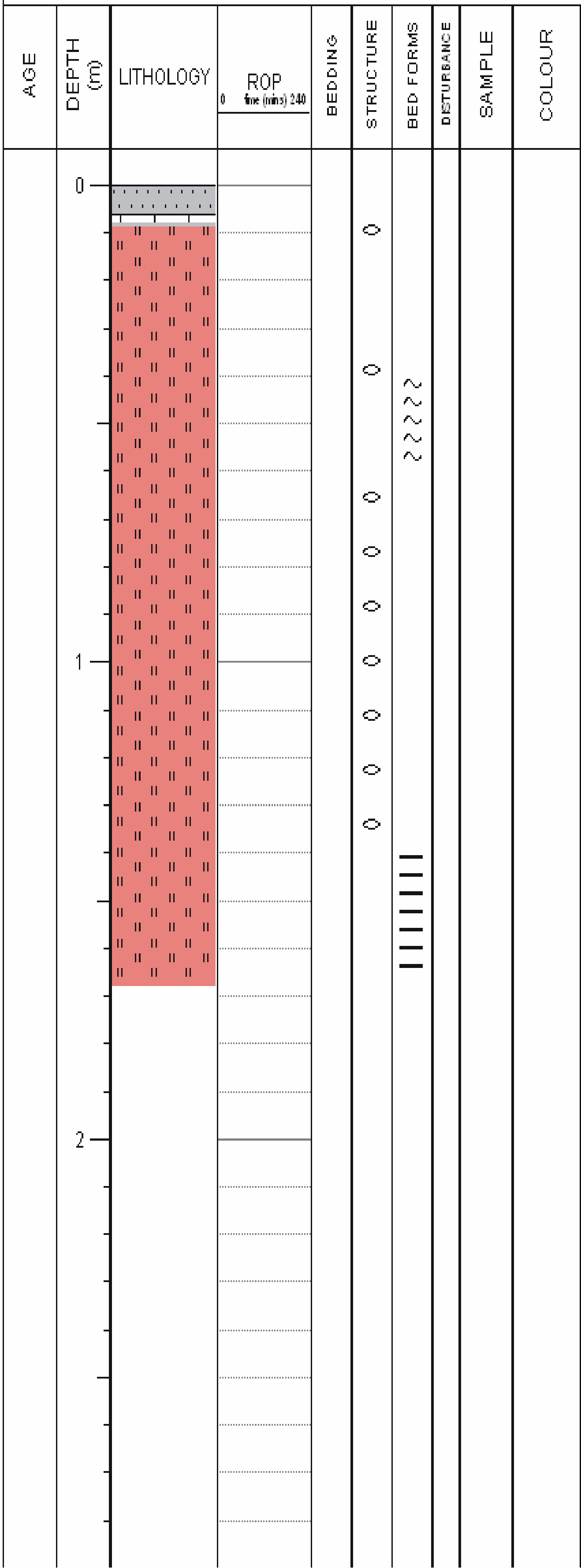
2.52 Base of core.

FIGURE 3: Summary log of core 57-16/17, the topmost 0.41m is described in detail.

BGS CORE NO: 57-17/07

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Approximate Position	Sandastre				
Latitude	57° 08.80' N	**Licence Block**	348/28	**Vessel**	James Clark Ross
Longitude	16° 33.79' W	**BGS Plan No**	K109	**Station Keeping**	DP
Navigation	DGPS	**Total Depth**	1.68m	**Dates of Drilling**	17/08/2001
Map Area		**Water Depth**	810m	**Geologists**	A. Leslie



DESCRIPTION

0.00-0.06 Unconsolidated sand and gravel.

0.06-0.08 Lithified carbonate with Mn crusts, lithic clasts.

0.08-0.09 Sandy conglomerate with reworked clasts of Mn.

0.09-0.41 Massive volcaniclastics with calcite veining, most abundant in topmost 0.2m and at base.

0.41-0.63 Bedded, deformed volcaniclastics - slumped unit.

0.63-1.36 Massive volcaniclastics with abundant calcite veining.

1.36-1.68 Parallel laminated volcaniclastics, horizontal bedding.

1.68 Base of Core.

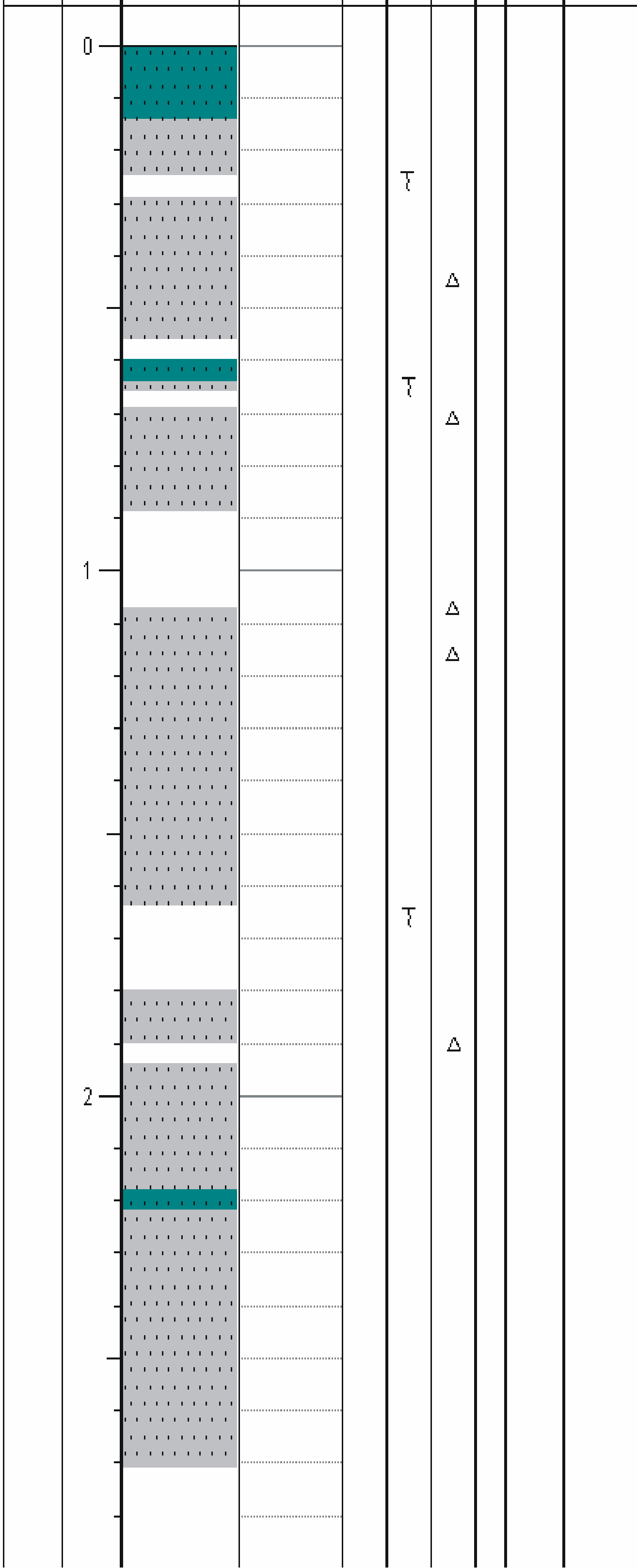
FIGURE 5: Summary log of core 57-17/07.

BGS CORE NO: 57-16/18

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	15° 18.204' W	**BGS Plan No**	K142	**Station Keeping**	DP
Navigation	DGPS	**Total Depth**	2.71m	**Dates of Drilling**	17/08/2001
Map Area		**Water Depth**	670m	**Geologists**	A. Leslie

AGE | DEPTH (m) | LITHOLOGY | ROP 0 time (mins) 240 | BEDDING | STRUCTURE | BED FORMS | DISTURBANCE | SAMPLE | COLOUR | DESCRIPTION



0.00-0.14 Green foram sand.

0.14-2.71 Varying lithologies as in 57-16/17.

Muddy white carbonate at 0.25-0.29, 0.56-0.60, 0.66-0.69, 0.89-1.07, 1.64-1.80, 1.90-1.94. Some are part obscured by bioturbation.

Green foram sands at 0.60-0.64, 2.18-2.22.

Grading up units (subtle) bases at 0.43, 0.79, 1.07, 1.15, 1.90. Grading is partially obscured by bioturbation. The graded bed at 0.43m has a lag of shells, basalt, sandstone, gneiss pebbles and quatrz.

2.71 Base of core.

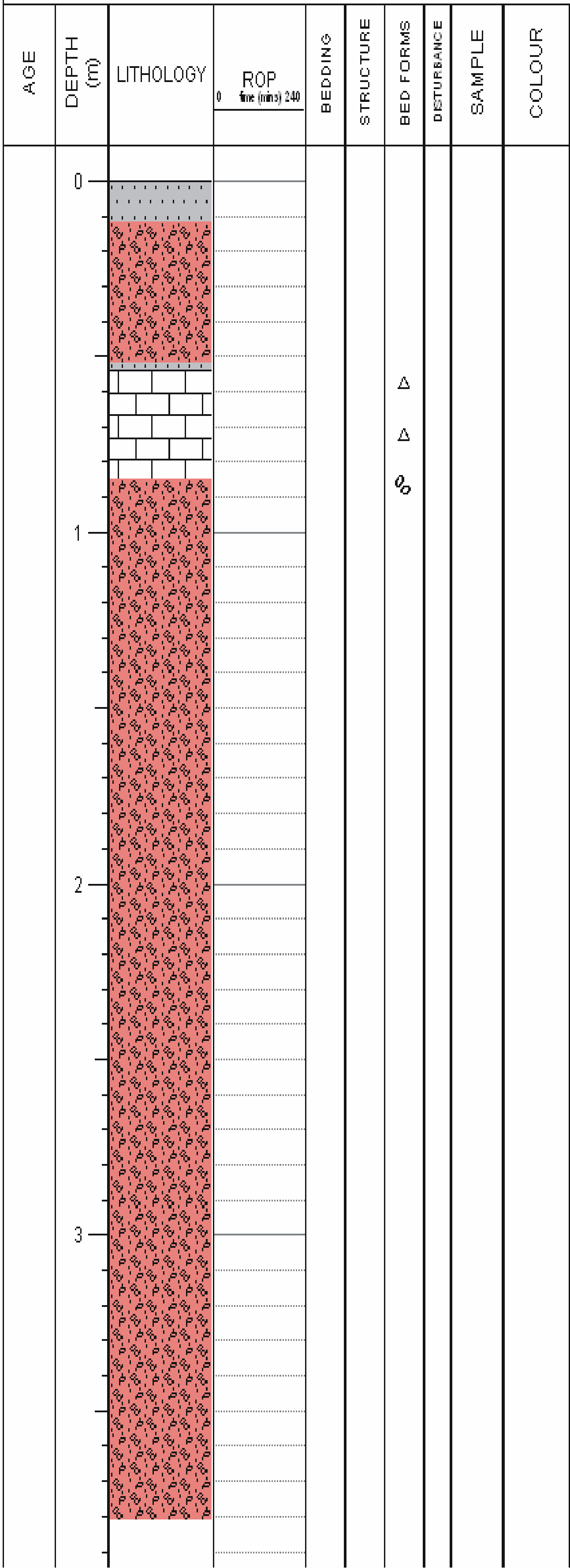
FIGURE 4: Summary log of core 57-16/18.

BGS CORE NO: 57-17/08

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**	3.81m	**Dates of Drilling**	18/08/2001
Map Area		**Water Depth**	691m	**Geologists**	A. Leslie



DESCRIPTION

0.00-0.12 Foram sand.

0.12-0.52 Volcaniclastic pebbly sand.

0.52-0.54 Foram sand, several lags containing basalt pebbles. Stepped erosion surface with Mn crusts.
0.54-0.85 Fine grained carbonate with horizontal, diffuse laminae. Shells common. Conglomerate at 0.25 contains orange volcaniclastics.
Four units of foram rich, coarse grained carbonate. Grading at some bases of units, volcaniclastics common at topmost unit.
Two units of fine grained carbonate, erosion surfaces between units show truncation of volcaniclastic fragments.
Massive carbonate, predominantly fine grained with possible foresets in foram rich upper section.
Coarse grained shelly carbonate. Graded unit.
Breccia with fragments of volcaniclastic material and Mn crusts.
0.85-3.81 Volcaniclastic pebbly sands.

3.81 Base of core.

FIGURE 6: Summary log of core 57-17/08.