British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Sonne Cruise SO-166
CONDRILL
Rockdrilling Report

BGS Report CR/02/282N

A.C. Skinner

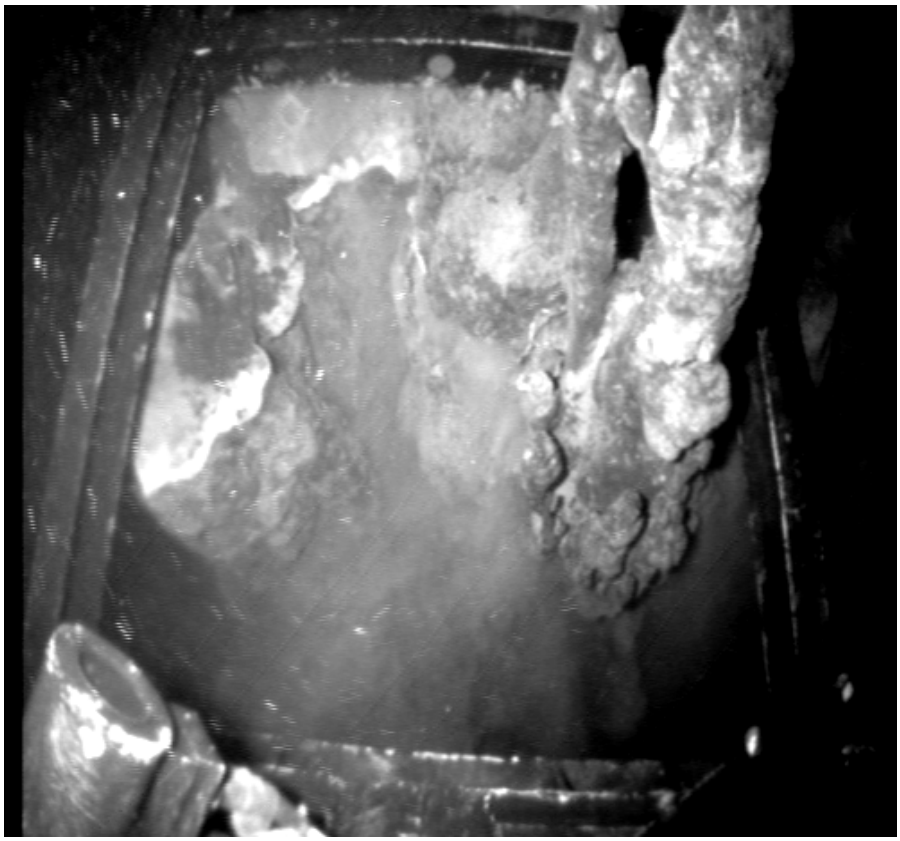
With contributions from N. Campbell, E. Gillespie and D. Smith.

Key words

Sonne Cruise SO-166,
BGS 5m Seabed Rockdrill,
Conical Seamount,
Edison Seamount,
TUBAF Seamount,
Lihir, Papua New Guinea,
PACMANUS,
Roman Ruins,
Desmos,
Su Su Knolls,
Snowcap

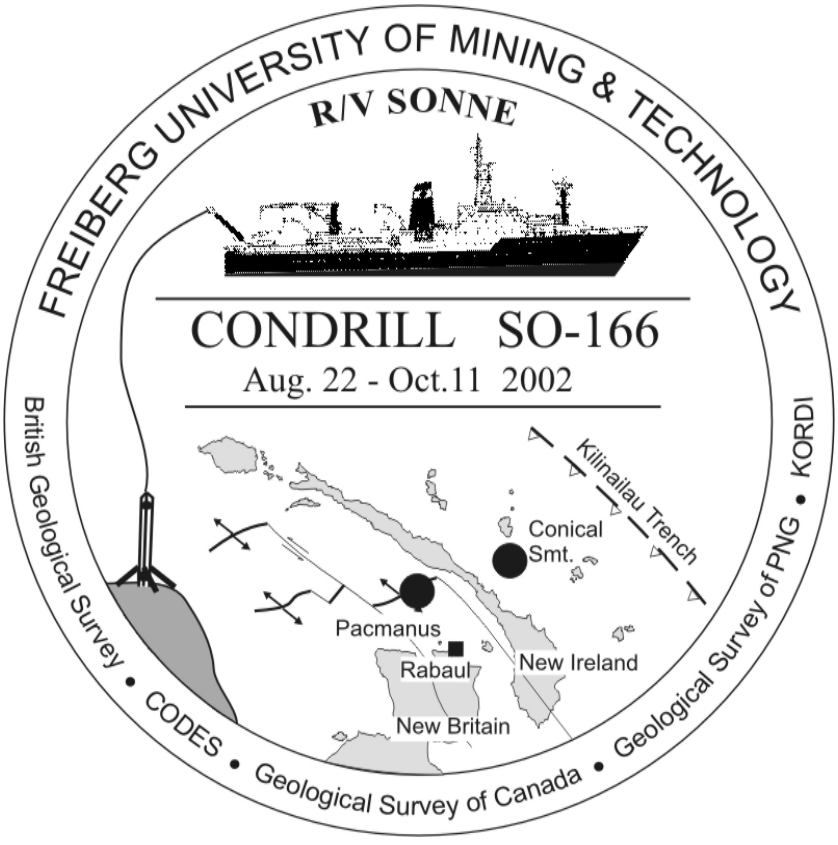
Reference

Skinner. A.C. et. al. 2002. Sonne Cruise SO-166, Rockdrilling Report.



One of The BGS 5m Rockdrill leg frames encompassing a Sulphide Chimney

Contents



CONDRILL SO-166 Logo depicting the Operations Area and Participants

Executive Summary

The British Geological Survey (BGS) were contracted by the Technical University of Freiberg to undertake rockdrilling in the area of Conical Seamount offshore Papua New Guinea as part of a scientific programme with international participation organised by Professor Peter Herzig. The work was conducted from the German Research Vessel RV Sonne which had some modifications made to the stern superstructure to allow the positioning of the rockdrill on the stern.

The logistics of mobilising the heavy equipment required for rockdrilling were organised by Alister Skinner of BGS and Thomas Kuhn of the TU – Freiberg. The finally agreed solution was to ship the BGS equipment to San Francisco, California and there mobilise it on to RV Sonne. Thereafter the equipment would transit the Pacific on RV Sonne and be fitted out for operations in Rabaul, Papua New Guinea prior to the commencement of the scientific part of the cruise.

The BGS equipment left Edinburgh Scotland on the 8th July 2002 and arrived in Oakland around the 15th August 2002. A Skinner had already made arrangements with local facilities to accept the BGS consignment from Oakland to San Francisco, outside of the port jurisdiction, in order to assemble the drill there. This was due to Longshoremen regulations which did not allow for non-dock personnel and labour to operate inside the port area.

A. Skinner and N. Campbell of BGS and T. Kuhn of TU-Freiberg travelled to San Francisco on the 22nd of August. Over the next two days the rockdrill, winch and other equipment was built up and installed on to the vessel with the assistance of local labour, the longshoremen and the ship's crew. The shipping containers, specially prepared to accept the BGS equipment were also shipped aboard Sonne. At this stage no launch/recovery tests could be made with the equipment and all was seafastened for the voyage across the Pacific to Papua New Guinea.

Visas for accompanying BGS personnel were obtained via the PNG High Commission in London using information supplied by TU-Freiberg and the BGS operations crew flew into Rabaul on the 13th September to join RV Sonne on the 14th. Final parts of the mobilisation were completed on the 14th and 15th September. The vessel then sailed for scientific operations at Conical Seamount area, South of Lihir Island in Papua New Guinea waters and latterly at the PACMANUS area between New Ireland and New Britain.

The operation was successful although the drill was beset by technical problems at the start of operations. All were resolved and the drill performed beyond expectations given the very rugged topography and unexpected geology, proved by the cores collected. Details of the drilling operations are contained in the following pages and appendices of this report.

Demobilisation was in Suva, Fiji on the 10th and 11th of October. Much of the equipment was disassembled coming into Rabaul (where the scientific party disembarked) and on the way from Rabaul to Suva (where there was appropriate craneage to demobilise the rockdrilling equipment). The BGS equipment was re-packed into the original shipping containers which were carried onboard. These were offloaded for commercial container shipping back to UK. The BGS personnel then disembarked the vessel for transit back to the UK.

1 Mobilisation

The BGS equipment departed Edinburgh in one soft-top 40' container and one flatbed 20' container. These were shipped to Oakland then San Francisco, California, USA.

In San Francisco the rockdrill components were unloaded from the 40' container together with the control cabin in a yard outside of the dock gates. The rockdrill was then built up and loaded on to a flatbed trailer, together with the control cabin, for transportation into the docks. This avoided Longshoremen problems inside the dock.

On board the vessel a short meeting with the Captain established what we would be able to do in San Francisco regarding loading/working etc. and this had to be strictly adhered to in order to avoid problems with the longshoremen. A winch bed for the BGS winch being prepared by local welders was modified after discussion between N. Campbell and the Chief Engineer, as it did not appear to be strong enough. The winch bed was completed on the morning of the 24th and the winch was then set on it and welded into position on the bed. Meanwhile the Ship's electrician had run power cables to the winch switchgear point in the deck seismic compressor room and the positions of the 40' container, control cabin, and flatbed container were agreed with the Captain prior to loading by the longshoremen. A further 20' container with equipment from Germany was also due to arrive and needed to be placed in lower hold prior to loading the BGS flatbed on the deck over the hatch.

On the 24th the rockdrill was also lifted on board the vessel, the control cabin sited and power lines to the winch connected to allow fixing the cable to the sheave and the sheave up into the 'A' frame. The winch cable was then secured to the rockdrill and tensioned up after the sheave was fixed and the welding around the winch was completed.

On the morning of the 25th a final check was made on equipment positions and then all equipment was seafastened. RV Sonne departed San Francisco at 1200hrs en route for Rabaul, Papua New Guinea.

The BGS Operations crew comprising A. Skinner, N. Campbell, D. Smith and E. Gillespie departed Edinburgh on the evening of 9th September and arrived in Rabaul on 13th September together with most of the shipboard scientific party. After joining the vessel on the morning of the 14th September the rockdrill was fully mobilised for operations, power was connected to the control cabin, the core bench was set out on the deck and various spares and consumables boxes were readied in the 40' container. A launch and recovery of the rockdrill was not possible until the 15th September and after the ship had sailed from Rabaul. This was carried out in quiet water outside Rabaul Harbour and was successfully accomplished. Operational anchoring points were then welded at the stern and on the deck in front of the drill to allow routine launch/recovery and security. The Boatswain had also prepared two wire rigging lines for hooking to the outboard legs and tensioning on the mooring winches for added security during passage. These were also used to move the rig into recovery position when it did not come up 'square on' to the transom. (The original trawl ramp has been filled in but a 'step' has been left on the stern at each side of the original ramp position). When all of this had been completed the drill was positioned over the stern in a vertical position, the hydraulics filled and vented and a 'wet test' of all functions carried out. All systems were operating properly and the vessel then proceeded to the first operations area at Conical Seamount, south of Lihir Island.

Appendix 1 gives details of the BGS 5m Rockdrilling equipment.

2 Operations

The BGS 5 metre rockdrill was deployed during routine drilling operations over the stern of the vessel, using the ships 35 Tonne S.D.L. 'A' frame gantry in conjunction with the BGS Umbilical winch.

The deployment method chosen was the traditional 3-point system as used by BGS for the past 20 years. This launch and recovery method allows for safe and controlled transfer of the drill rig from a horizontal deck storage position, into a vertical outboard position, and allows for total control of the equipment in most weather conditions and sea states during the critical period of launch and recovery.

After deployment, the drill progress to the sea floor was monitored both by the winch control operator using the winch metering system and by the drill operator using the drill depth display on the drilling console. The drill was routinely lowered at a speed of 50 metres per minute. This progress to the sea floor was communicated at intervals to the bridge officer controlling the DP system.

At 40 metres above seabed the descent was halted until clearance to land the rig on the seabed was given by the bridge officer. On receiving the OK to proceed, the rig was lowered slowly for the last 40 metres, monitoring the height above seabed indicated on the drilling console, until contact was made with the seabed.

Drill rig inclination during the landing was constantly monitored by the drill operator and communicated to the winch controller. As rig inclination angles in excess of 25° from the vertical are unacceptable for reasonable drilling, on many occasions the rig was lifted back up from the seabed, the ships position changed by a few metres, and the rig re-lowered to the seabed.

On achieving a suitable landing site a seabed photograph was taken, and drilling commenced. As the project progressed to the PACMANUS area, where the topography was even more rugged, pre-land photos were taken at some locations to try to ascertain the nature of the seabed topography (see frontispiece).

On completion of the drilling operation and after retraction of the drill barrel back into the frame, the winch operator recovered the drill from the seabed. Recovery speed was 40 metres per minute and again progress was communicated at intervals to the bridge officer. During the period when the drill was being recovered to the surface the seabed photograph was uploaded via the umbilical, and the drill site, log information, graphs, etc. were processed by the drill operator.

At the surface the drill frame was recovered to the deck and secured in its storage position. The drill barrel assembly was removed and taken to the core-handling bench, and the components of the barrel assembly were dismantled to allow for core removal.

Once the core had been removed, the components were cleaned and reassembled, and the completed barrel assembly was installed back into the drill frame ready for deployment at the next drill site.

A variety of core bits were carried to allow for variations in the geology around the basaltic rock type known to be present. Surface set round and stepped profile diamond bits, impregnated diamond bits of matrix grade 7-10 and TC drag bits were all carried. The bulk of the work was carried out with the surface set stepped profile and the grade 9 matrix impregnated diamond bits, both of which proved equally suitable for the rubbly and pebbly formations which were present in most of the areas drilled. In the PACMANUS area both were also equally good at cutting sulphide mineralised rocks.

Appendix 2 contains a daily log of the BGS activity and Appendix 3 details of the drilling at each site.

3 Demobilisation

Demobilisation was carried out according to a plan drawn up by N. Campbell and agreed with the Captain, Chief Officer and Boatswain.

Upon completion of the final drill site, on the morning of the 3rd October, and on the way in to Rabaul to disembark the scientific party, demobilisation of the rockdrill commenced.

The core barrel was not replaced but cleaned and re-stowed in the 40' container together the swivel head, Kelly and core bit. The cable harnesses, camera, light and bracket, transponder bracket, flush pumps, motors and echo sounders were all removed, cleaned and stowed in their relevant boxes. The vibrocorer head unit was stropped to the top of the frame and the rig re-launched and recovered in a vertical position. With the assistance of the crew, and using the BGS winch and ships 'A' frame in conjunction the three rig legs were dismantled and removed one by one and placed on the deck away from the area of work. The remaining central section of the rig was lifted up until the base was level with the top crash bars aft of the 'A' frame, the base was stropped off and the head of the rig lowered to deck. The BGS umbilical cable was then removed from the head of the rig and temporarily secured to the base to allow removal of the strops and lowering of the base to deck in a controlled fashion. Finally the BGS umbilical cable was attached to three lifting slings secured so as to balance the rig and it was lifted inboard to a point up the deck where the ship's cargo handling crane could pick it up. The rig frame was then secured for passage.

Whilst still in the calm water outside Rabaul Harbour, preparations were made inside the 40' container for re-stowage of all equipment and spares. The ship's crew, removed the BGS sheave from its 'A' frame fixing, lowered it to the deck and after the umbilical cable was removed it was stowed in the carrying frame on the 20' flat rack.

Following the disembarkation of the scientific party in Rabul on the evening of the 3rd October the vessel commenced passage to Suva in Fiji.

Demobilisation of the rockdrilling equipment continued. However the weather was too bad on passage for any crane work or lifting of heavy items to be carried out. The umbilical winch, power pack hydraulics and electrical connections were dismantled and the winch and power pack prepared for shipping. The electrical supply from the ship to the BGS control box was shut down, all cabling was disconnected and stowed.

Re-arranging of 40' container equipment and loading for shipping had to await better weather and the calmer conditions of Fiji. Again, with the help of the ship's crew, this was done using ship craneage and the whole made ready for a single lift to the dockside by shore crane.

The winch welds to the base frame were removed by burning them off and the power pack was unbolted from the deck. The BGS flat rack container was positioned on the jetty and the winch lifted from the ship on to it, then bolted down and chain secured. The power pack was also positioned on the flat rack and secured.

Remaining tools and equipment were then loaded into the rear of the 40' container and the doors closed. Finally the containers were handed over to the agent for shipping by container freight back to UK. BGS personnel completed all formalities for disembarking and took leave of RV Sonne.

4 Conclusions

Drilling operations in water depths between 1000 and 1200m were conducted in the area of Conical Seamount, south of Lihir Island, Papua New Guinea between the 16th and 27th September. The vessel then sailed southwards round New Ireland and north of Rabaul (New Britain) to the PACMANUS area, to survey in an area of hydrothermal activity and 'black smokers'. Following this survey grab samples and drill cores were taken in water depths ranging from 1600 to 1920m between 29th September and 3rd October.

The operation was successful and good data was obtained from all areas where drilling was attempted. At PACMANUS good core was obtained from massive sulphide and sulphide-mineralised rocks.

Initial technical problems coupled with unexpected geology and difficult drilling conditions throughout made the operation frustrating at times. The technical problems, mainly relating to hydraulic systems and one electric motor, together with minor electronic problems were all resolved using the spares carried. Some may have been caused by the heat on deck which was in excess of 30 degrees centigrade at times and caused expansion of oils and heating of all systems packages which were then plunged into much colder water at 1000-1700m water depth on a regular basis. The seawater cooling system fitted to the umbilical winch power pack worked well and kept the hydraulic oil temperature in the system at optimum working temperature. Repairs to equipment were carried out while working with spare systems or during periods when other work was being undertaken.

The geology at Conical Seamount was not quite as anticipated from previous observations and grabs in that it was not the hard rock expected. Instead it was a mixture of fractured rock, rubbly lavas and poorly cemented mineralised areas. The drill performed well under those conditions and justified the modifications made to the drill to allow bit weight control. It would have been more difficult, if not impossible to achieve the penetrations which were made, without bit blocking, had this facility not been available.

The rugged topography was expected and, as anticipated, caused problems in landing the rig at the desired drilling positions and with sufficient stability to attempt drilling. (Less than 25 degrees of inclination of rig to seabed). However, the use of the rig-installed downward-looking echo sounder and the integrated pitch/roll inclinometer allowed for controlled landing and slope monitoring before cable tension was finally released and the rig allowed to sit on the seabed. The installed seabed camera system allowed for a photo of an area close to the drill bit (through one of the drill frame leg structures). This allowed the drill operator to make an assessment of the likely stability of the rig on the seabed prior to commencement of drilling.

A total of 59 core sites were occupied. Two sites had to be abandoned for technical reasons and of the remainder only one did not contain core. The quality and length of the cores obtained reflects the nature of the underlying geology, much of which was unknown. The coring of massive sulphide deposits in the PACMANUS area demonstrated an extension of the proven capability of the BGS rockdrilling system.

5 Acknowledgements

The BGS team would like to thank all those who participated in the cruise and who helped with the drilling operations. In particular we thank Professor Peter Herzig and Dr. Thomas Kuhn for selecting the rockdrill for their science cruise and for being constructive and flexible during the shipboard operations which minimized scientific downtime when equipment was being repaired.

The rockdrill mobilization in San Francisco, under Captain Andressen and the ship's crew, was conducted smoothly and efficiently despite various labour problems with longshoremen. The final mobilization in Rabaul and the subsequent operation and demobilization of the equipment was a safe and efficient experience thanks to the excellent co-operation, professional ability and willingness shown by Captain Kull, his officers and crew. They helped to make our work much easier and were a pleasure to work with.

Appendix 1 Equipment Data Sheets

BGS 5m Rockdrill/ Vibrocorer System

BGS 5m Seabed Rockdrill and Vibrocorer

Rockdrill Specifications

Steel, open structure frame with electro-hydraulic power pack, flush pumps, vibrator motor and seabed microprocessor control capable of coring rock formations to a depth of 5m below seabed in up to 2000m of water.

Overall Dimensions : 7.7m high with 5.5m span at extremities of feet

Weight in Air : 3.5 tonnes

Core Barrel : BGS Hex steel outer core barrel with steel inner barrel

Core Size: 50mm

Core Bit Types: T.C., Surface and Impregnated Diamond

Core Bit R.P.M.: 0-600, infinitely variable

Power Requirements: 380/415VAC, 3 phase, 50Hz, 30A supply

Vibrocoring Mode Option

By interchange of core barrels and a different processor-controlled operation the same unit is enabled to operate as a soft sediment/non cohesive sediment sampler capable of coring up to 5m below seabed in up to 2000m of water.

Core Barrel : Steel, 102mm O.D. with 83mm I.D. Polycarbonate liner

Core Size: 83mm retained in plastic liner

Core Bit Type: Hardened steel cutting shoe

Operational Requirements

Stable platform with good position keeping (D.P. or moorings) together with an 'A' frame or Crane with at least 10 tonnes SWL. For shallow water operations (up to 350m in good conditions) separate power and hoist cables can be used. If deeper, or in high current or sea states, a winch with combined signal/power/hoist cable is required. It can be provided by BGS.

Deck space to store and deploy rig, 8' x 6'6" x 6'6" high control cabin, 7m x 1.2m x 1m high core bench and sundry spares and consumables including 6m long liner tubes.

BGS Combined Signal/Power/Hoist Umbilical Winch

This unit allows operations with the seabed Rockdrill/vibrocorer in water depths to 2000m without recourse to additional cables. A special sheave, also supplied by BGS is required for the cable and an additional 1m of headroom is required in the deployment system to allow for this.

Winch/Power Pack Specifications and Requirements

The winch is electro-hydraulically operated from its own power pack and can be operated from a local control on the power pack or by a remote control box. A line meter showing metres out and line speed is fitted at both locations.

Winch base dimension: 3m x 3.2m x 2.2m high

Winch weight: 17 tonnes

Power Pack base dimension: 2m x 1m x 1.7m high

Power Pack weight: 2 tonnes

Power Requirements: 415VAC, 3 phase, 100A

Above

Sequence of launch or recovery positions for Rockdrill/ Vibrocorer

Left

Core Barrel installation and removal position

Below

BGS Power Pack and Umbilical Winch

Appendix 2 Daily Log of BGS Activities

Note: All times are local to the area of operations.

July 2002

Monday 8th July – N. Campbell co-ordinates despatch of all prepared equipment from Edinburgh UK to San Francisco USA.

Wednesday 10th July - A. Skinner meets with Agent in San Francisco (following an ODP TEDCOM Meeting) and agrees a plan of accepting shipment and mobilising to vessel. Have to modify pre-plan as union dock labour does not allow non-longshoremen to work at port. Agree that work will be done outside in SF Enterprises yard. Advise TU-Freiberg and Ship Managers of this.

August 2002

Wednesday 21st August

N. Campbell and A. Skinner travel to San Francisco to Mobilise RV Sonne with equipment despatched from Edinburgh. Meet with T. Kuhn, Technical University of Freiberg, in San Francisco.

Thursday 22nd August

Picked up by agent and taken to vessel. Meet with Captain and external yard personnel at San Francisco Enterprises (SFE). Commence external yard work. No shipboard work on BGS equipment until next day. Agree layout and cable runs with ship personnel and modify winch sub frame with welding company hired in by vessel. Winch sub frame 'Z' beams supplied are not suitable on their own and tie-bars and additional tie-downs requested for it to be strong enough to take winch and its mode of operation.

Open 40' container in SFE yard, remove some equipment to allow unloading of rockdrill components and build rockdrill with local help and craneage. Re-arrange 40' container equipment into layout for working on vessel. Load rockdrill and control container on separate flatbed for taking directly to Sonne in morning.

Agree load plan for all onboard equipment. Welding on winch bed modifications continues.

Friday 23rd August

Welding on winch bed continues while awaiting refrigerated container for offloading remaining scientific cargo from last cruise. Equipment from SFE yard into dock after initial problems with who drives which trailer. Manage to load control container and Rockdrill before midday. Load winch and power pack after lunch and position electrical control panel in compressor room for electrician to make ship's connection. Load 40' container, commence welding of winch to winch bed and preparation of umbilical sheave for accepting cable and attaching to 'A' frame. All BGS equipment on board by 1500hrs and awaiting one more 20' container with laboratory equipment from Germany. Secure rockdrill in sailing position with feet inboard (just) and secured with chains. Complete winch to sub frame welding and make all electrical and hydraulic connections to winch and power pack. Secure all equipment remaining in 40' container for sea journey. Power up winch and run out cable, reeve through sheave and hoist sheave to 'A' frame and secure. Freiberg container arrives at 1705hrs, emptied and placed in the lower hold. The hatch was then closed and the BGS flatbed container repositioned on top.

Complete connection of winch cable to rockdrill, secure all hydraulic hoses, make electrical connection to control container, generally tidy up and rust-protect spooling gear on winch for sea-voyage.

Saturday 24th August

Check over all installations, ensure all sea fastening done, close containers and check with ship that all is in order for vessel leaving port. Campbell, Kuhn and Skinner disembark vessel.

Vessel departs for Rabaul at 1200hrs.

September 2002

Monday 9th September

BGS personnel Campbell, Gillespie, Skinner and Smith depart Edinburgh at 1600hrs to arrive Rabaul on 13th September.

Friday 13th September

Arrive Rabaul with other ships complement met in Cairns/Port Moresby, stay in hotel overnight.

Saturday 14th September

Arrive at vessel 0945hrs. Check in, obtain cabin allocation then commence remainder of BGS mobilisation.

Prepare winch for operations, remove rust protection from spooling gear, grease bearings, fit remote control cables and control panel. Put electrical harnessing and water flush systems on rig, prepare core barrel, prepare computer links, set up operations control for winch and drilling. Move core bench from container to working position on deck and sort out 40' container for spares/consumables accessibility.

Complete on deck function test of drill sensors/signals and general communication.

Sunday 15th September

Depart Quay at 0720hrs, sail out of Rabaul then heave to in sheltered water for testing of rig deployment/recovery. Work with crew to obtain suitable operations system. Pad eyes welded at stern and forward of rig resting position for operations securing. Final hydraulic filling and wet test checks then made and all drill systems operational by mid afternoon.

Scientific and safety briefing in late afternoon and ship facilities and organisational briefing in evening as ship continued on passage to survey area.

Monday 16th September

OFOS camera system being run in morning so complete drill set-up. Camera and light fittings installed and system tested – all OK. Deploy drill in afternoon after checking station keeping on bridge with DGPS all in order. Use surface set stepped profile diamond bit for first trials.

Deploy Drill on site 02RD at 1314hrs, water depth 1058m. Unable to hold stable position on seabed – rig continually falling over. Lift 1m above seabed and take seabed photo (02RD01.jpg). Seabed difficult to see due to sediment being stirred up. Attempt to land a further three times but rig falls over each time. Core barrel slips down frame and it is not possible to retract it back into the frame so commence recovery of rig to stern of vessel at 1410hrs.

With rig at surface observe that core barrel is bent in three places so secure barrel with safety lines before recovering rig to deck. Then recover core barrel by cutting and removing with crew assistance and a personnel basket rigged outboard.

Complete checks for other damage and replace the core barrel assembly.

Redeploy rig on same site at 1625hrs, water depth 1060m. At seabed at 1650hrs and attempt to land twice with no success – each time rig falls over as seabed slope is too steep. At 1702hrs when checking core barrel is fully retracted the main electric motor to the hydraulic system produces an overload current and does not function. Commence recovery of rig to deck at 1704hrs.

Upon recovery initial electrical measurements indicate a faulty motor so advise Chief Scientist of need for some time-consuming repairs. Vessel diverts to other scientific objectives while drill is repaired.

With ship's crew assistance stand rig upright at stern of vessel and bring inboard. This allows easier access to hydraulic power pack system using tugger winches on 'A' frame. Remove existing power pack assembly and replace with spare. Fill and vent new system and complete all checks by 2115hrs. Secure rig in upright position overnight, ready for wet testing in morning.

Tuesday 17th September

At 0830hrs remove drill from upright position on deck and into water. Test all drill functions in water at stern of vessel and all operating properly.

Deploy drill on site 03RD at 0844hrs in water depth of 1068m. Rig on seabed at inclination of approximately 10 degrees. Take seabed photo (03RD1.jpg) then commence coring. Make penetration of 1.0m in 40 minutes then no further penetration so retract and recover rig at 0955hrs. Download seabed photo (03RD1.tif) to file on way to surface. Upon recovery to deck remove core barrel, empty and clean. 0.25m of pebbles in core barrel. Replace core bit with a G9 impregnated diamond bit on evidence of type of pebbles collected in core barrel.

Deploy rig at site 04RD at 1100hrs in 1062m water depth. Land with inclination of approximately 9 degrees. Take seabed photo (04RD1.jpg) and commence drilling at 1129hrs. Stop drilling at 1301hrs with a penetration of 3.64m and no further progress. Recover to deck, download seabed photo (04RD1.tif) on way to surface, secure rig, remove and empty core barrel. 0.50m of rubbly/pebbly material collected. Replace core barrel in rig.

Deploy rig at site 05RD in 1063m water depth at 1418hrs. Land on seabed with inclination of approximately 9 degrees at 1441hrs. Take seabed photo (05RD1.jpg) and commence coring at 1450hrs. Generally fast penetration rate with full 5.0m penetration achieved. Commence recovery of rig at 1620hrs.

Recover to deck, download seabed photo (05RD1.tif) on way to surface, secure rig, remove and empty core barrel. 0.30m of rubbly/pebbly material collected. Replace core barrel in rig.

Deploy at site 06RD in 1083m water depth at 1724hrs.

Land with inclination of approximately 14 degrees. Take seabed photo (06RD1.jpg) and commence drilling at 1750hrs. Stop drilling at 1820hrs with a penetration of 1.1m and no further progress.

Recover to deck, download seabed photo (06RD1.tif) on way to surface, secure rig, remove and empty core barrel. 1.1m of rubbly/pebbly core material collected. Replace core barrel in rig.

Deploy at site 07RD in 1095m water depth at 1915hrs. Rig at seabed but unable to land after three attempts as seafloor slope is too great. Move vessel four times up until 2038hrs, each time attempting to land rig with no success. Land at 2056hrs on 25 degree slope and take a seabed photo (07RD1.jpg). Seabed appears smooth and therefore not a safe slope to drill on. Move vessel two more times and at 2144hrs in 1061m water depth land rig on seabed with an inclination of 6 degrees. Take seabed photo (07RD2.jpg) and commence coring at 2200hrs. Achieve 2.12m penetration before stalling out at 2246hrs. Retract core barrel and commence recovery of rig to surface at 2252hrs. Recover to deck, download seabed photo (07RD2.tif) on way to surface, secure rig, remove and empty core barrel. 0.75m of pebbly core material collected.

Replace core barrel in rig, secure deck for other overnight operations and close down drilling operations at 2345hrs.

Wednesday 18th September

Deploy drill at site 08RD in 1099m water depth at 0826hrs. Land at 0855hrs on 21 degree slope and take seabed photo (08RD1.jpg). Commence coring on site at 0900hrs and achieve 1.37m final penetration before bit is blocked and no further penetration is possible. Stop drilling at 0948hrs and commence recovery to deck. Recover to deck, download seabed photo (08RD1.tif) on way to surface, secure rig at 1017hrs and empty core barrel. 1.0m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 09RD in 1108m water depth at 1040hrs. Land on seabed at 1106hrs on a slope of approximately 17 degrees and take seabed photo (09RD1.jpg). Start drill at 1112hrs and commence coring. Achieve final penetration of 1.06m before bit is blocked and no further penetration possible. Commence recovery of rig at 1152hrs, download seabed photo (09RD1.tif) on way to surface and recover to deck at 1224hrs. 0.85m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 10RD in 1082m water depth at 1246hrs. Land on seabed at 1310hrs on a slope greater than 30 degrees so lift off again. Try to land a further three times with no success before lifting off seabed and moving vessel. Land again at 1318hrs and try four times but steep angle encountered each time. Move vessel. Land again at 1330hrs and attempt two landings with negative results before pulling off and moving vessel again. Try to land once more at 1336 hrs, make four further unsuccessful attempts so pull off seabed 50m and move to new location. Land rig at 1354hrs with approximately 8 degrees inclination and take seabed photo (10RD1.jpg). Start drill at 1358hrs and commence coring. Achieve final penetration of 2.06m with much torquing, stalling and jamming at and after 1.93m before bit is blocked and no further penetration possible. Commence recovery of rig at 1550hrs, download seabed photo (10RD1.tif) on way to surface and recover to deck at 1620hrs. 0.81m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 11RD in 1062m water depth at 1649hrs. Land on seabed at 1711hrs on a slope of approximately 10 degrees and take seabed photo (11RD1.jpg). Start drill at 1712hrs and commence coring. Achieve final penetration of 2.09m with one stall at 1.72m and a stall and unable to restart at final penetration. Commence recovery of rig at 1843hrs, download seabed photo (11RD1.tif) on way to surface and recover to deck at 1911hrs. 0.50m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 12RD in 1078m water depth at 1930hrs while ship manoeuvres to position. Land on seabed at 2004hrs on a slope of greater than 30 degrees so lift up and re-land. Achieve position

with 21 degree inclination at 2006hrs and take seabed photo (12RD1.jpg). Start drill at 2012hrs and commence coring. Achieve final penetration of 1.05m before bit is blocked and no further penetration possible. Commence recovery of rig at 2045hrs, download seabed photo (12RD1.tif) on way to surface and recover to deck at 2115hrs. 0.23m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 13RD in 1095m water depth at 2143hrs. Land on seabed at 2211hrs on a slope of greater than 30 degrees so lift up. Attempt to land a further five times without success before moving vessel. Attempt to land in water depth of 1075m at 2222hrs a further five times but slope angle too great. Move vessel once more. Land at 2233hrs in 1085m water depth and with drill sitting at approximately 17 degrees. Take seabed photo (13RD1.jpg). Start drill at 2240hrs and commence coring. Coring continues through midnight.

Thursday 19th September

Continue coring at site 13RD. Achieve final penetration of 2.33m before motor stalls and unable to restart. Commence recovery of rig at 0004hrs, download seabed photo (13RD1.tif) on way to surface and recover to deck at 0030hrs. 1.45m of cored blocky and weathered material recovered. Replace core barrel in rig, end drilling operations for a period while ship carries out other scientific work.

Deploy drill at site 14RD in 1066m water depth at 0908hrs. Land on seabed at 0932hrs on a slope of approximately 17 degrees and take seabed photo (14RD1.jpg). Start drill at 0938hrs and commence coring. Achieve final penetration of 1.73m where no further progress due to bit blocking. Commence recovery of rig at 1048hrs, download seabed photo (14RD1.tif) on way to surface and recover to deck at 1118hrs. 0.50m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 15RD in 1073m water depth at 1143hrs. Land on seabed at 1205hrs on a slope of approximately 21 degrees and take seabed photo (15RD1.jpg). Start drill at 1209hrs and commence coring. Achieve final penetration of 1.5m with stalling and retraction required at 1.27m and a stall and unable to restart at final penetration. Commence recovery of rig at 1328hrs, download seabed photo (15RD1.tif) on way to surface and recover to deck at 1350hrs. 1.25m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 16RD in 1057m water depth at 1419hrs. Land on seabed at 1443hrs on a slope of approximately 10 degrees and take seabed photo (16RD1.jpg). Start drill at 1447hrs and commence coring. Achieve final penetration of 1.29m with variable progress and final bit blocking. Commence recovery of rig at 1547hrs, download seabed photo (16RD1.tif) on way to surface and recover to deck at 1615hrs. 0.65m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 17RD in 1083m water depth at 1637hrs. Land on seabed at 1702hrs on a slope of approximately 15 degrees and take seabed photo (17RD1.jpg). Start drill at 1708hrs and commence coring. Achieve final penetration of 3.48m with no stalls but some erratic progress and no further progress at finish. Commence recovery of rig at 1859hrs, download seabed photo (17RD1.tif) on way to surface and recover to deck at 1930hrs. 0.65m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 18RD in 1075m water depth at 1949hrs. Land on seabed at 2013hrs on a slope of approximately 2 degrees and take seabed photo (18RD1.jpg). Start drill at 2017hrs and commence coring. Achieve final penetration of 1.51m with one stall at 0.96m which was overcome. Commence recovery of rig at 2127hrs, download seabed photo (18RD1.tif) on way to surface and recover to deck at 2150hrs. 0.85m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 19RD in 1067m water depth at 2220hrs. Land on seabed at 2245hrs on a slope of approximately 12 degrees and take seabed photo (19RD1.jpg). Start drill at 2250hrs and commence

coring. Achieve final penetration of 1.49m where drill stalled out. Managed to restart after retraction but no further progress and at 2342hrs motor stalled and electrics tripped and no restart was possible. Commence recovery of rig at 2343hrs, download seabed photo (19RD1.tif) on way to surface and continue to recover to deck at midnight.

Friday 20th September

Continue to recover rig from site 19RD. Recover to deck at 0005hrs. 0.35m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 20RD in 1083m water depth at 0033hrs. Land on seabed at 0055hrs on a slope of greater than 30 degrees so lift off and re-attempt to land a further three times before moving position. Attempt to land at 0102hrs a further four times but no success so move position again. Land at 0109hrs at an angle of approximately 13 degrees and take seabed photo (20RD1.jpg). Start drill but unable to obtain any functions or continuity of operation so recover to surface to investigate.

At 0126hrs start to recover drill and lift off seabed then stop approx 45 metres above seabed to check further. Intermittent control from processor but no rotation possible so recover rig to deck. Download seabed photo (20RD1.tif) on way to surface.

Rig on deck at 0200hrs – all connectors checked but no obvious faults. The core barrel outer was replaced with a new one and core extension tube as the reamer/barrel connection had been wearing thin and broke upon recovery to deck. Launch into water for further testing – all faults still present. Back on deck and remove/replace cables and connectors. Re-launch and re-test but still erratic and unreliable performance so recover and change subsea processor. On re-test some functions now working but still no reliable rotation or retract and one flush pump erratic still. Recover to deck in a vertical position for further investigation.

As further fault finding/repairs is likely to take some time vessel reverts to other work on Edison Seamount while this is done.

Replaced Kelly gearbox motor and re-tested before work on /Edison Seamount commenced – no status change. Recover and make preparations to replace complete Kelly drive and one of the flush pumps.

At 1500hrs complete this work and launch and recover to deck in upright position to vent and fill hydraulics. Also carry out repairs to bent leg with pin missing.

At 1830hrs re-launch rig from vertical, bring back inboard, check core barrel and then deploy for wet test. All systems functioning, rig ready for re-use at 1900hrs.

Vessel continues with OFOS survey of TUBAF seamount as camera grab not functioning for work on Edison Seamount.

Carry out maintenance on equipment which was replaced. Subsea computer module repaired, main electric motor tested and is suspect taking a high current to operate even under no load. Kelly drive has tight spot and will require re-alignment but nothing obvious broken in it.

Saturday 21st September

Deploy drill at site 23RD in 1448m water depth at 0840hrs. Land on seabed at 0912hrs on a slope of approximately 20 degrees and take seabed photo (23RD1.jpg). Start drill at 0917hrs and commence coring. Achieve final penetration of 1.63m where drill stalled out. Could not manage to restart even after retraction and no further progress. Commence recovery of rig at 1021hrs, download seabed

photo (23RD1.tif) on way to surface and recover to deck at 1100hrs. 0.35m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 24RD in 1463m water depth at 1138hrs. Over the next three hours attempt landings on clam beds but not successful in finding the correct location. Take photos each time rig landed as the slope was favourable for landing and photos 24RD1.jpg to 24RD9.jpg plus 24RD3.tif, 24RD7.tif and 24RD9.tif were collected.

Commence recovery of rig to deck at 1441hrs and complete at 1520hrs. Not an official station as no drilling attempted.

Vessel now prepares to take TV grab sample but cable jams in sheave and has to be re-terminated so return to drilling on Edison Seamount.

Deploy drill at site 24RD in 1451m water depth at 1710hrs. Land on seabed at 1743hrs on a slope of approximately 11 degrees and take seabed photo (24RD10.jpg) which shows lots of clams. Start drill at 1747hrs and commence coring. Very high current required and reasonable penetration so probably just pushing through the clams. Achieve final penetration of 2.63m where drill stalled out. Managed to restart after retraction but no further progress beyond this point. Commence recovery of rig at 1903hrs, download seabed photo (24RD10.tif) on way to surface and recover to deck at 1950hrs. 0.30m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 25RD in 1091m water depth at 2054hrs. Land on seabed at 2120hrs on a slope of greater than 35 degrees so lift and try again. Continued this process for a further seven attempts with small ship position movements in between each. Finally move a greater distance at 2148hrs. Land on seabed at 2152hrs on a slope of approximately 16 degrees and take seabed photo (25RD1.jpg). Start drill at 2158hrs and commence coring. Achieve final penetration of 0.95m as no further progress at that point – no penetration and no torque so bit blocked. Commence recovery of rig at 2239hrs, download seabed photo (25RD1.tif) on way to surface and recover to deck 2301hrs. 0.30m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 26RD in 1073m water depth at 2324hrs. Land on seabed at 2348hrs on a slope of approximately 7 degrees and take seabed photo (26RD1.jpg). Start drill at 2352hrs and commence coring. Continue coring through midnight.

Sunday 22nd September

Continue coring on site 26RD. Achieve final penetration of 1.50m with stalling and difficult restarts from 1.21m down. Finally stop when no further penetration progress was being made. Commence recovery of rig at 0130hrs, download seabed photo (26RD1.tif) on way to surface and recover to deck at 0203hrs. 0.30m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 27RD in 1071m water depth at 0225hrs. Land on seabed at 0253hrs on a slope of approximately 7 degrees and take seabed photo (27RD1.jpg). Start drill at 0258hrs and commence coring. Achieve final penetration of 1.11m with no further progress. Commence recovery of rig at 0400hrs, download seabed photo (23RD1.tif) on way to surface and recover to deck at 0430hrs. 0.40m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 28RD in 1081m water depth at 0500hrs. Land on seabed at 0529hrs on a slope of greater than 25 degrees so pull off again. Attempt a further three landings with same result before moving ship. Attempt to land again at 0553hrs and this time slope is 21 degrees but not stable. Lift, retry and achieve approximately 11 degree inclination and stable rig. Take seabed photo (28RD1.jpg). Start drill at 0558hrs and commence coring. Achieve final penetration of 2.41m where penetration ceased and no further progress possible. Commence recovery of rig at 0655hrs, download seabed

photo (28RD1.tif) on way to surface and recover to deck at 0727hrs. 0.70m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 29RD in 1073m water depth at 0833hrs. Land on seabed at 0857hrs on a slope of approximately 10 degrees and take seabed photo (29RD1.jpg). Start drill at 0901hrs and commence coring. Achieve final penetration of 1.02m. Commence recovery of rig at 0948hrs, download seabed photo (29RD1.tif) on way to surface and recover to deck at 1020hrs. 0.15m of cored material recovered. Replace core barrel in rig with a G8 matrix impregnated diamond bit fitted.

Deploy drill at site 30RD in 1112m water depth at 1106hrs. Land on seabed at 1129hrs on a slope of approximately 15 degrees and take seabed photo (30RD1.jpg then 30RD2.jpg as first was before sediment settled). Start drill at 1136hrs and commence coring. Achieve final penetration of 3.14m after erratic progress and some stalling plus one electrical trip out. No further progress and no variation in torque or rpm with varying bit weight indicated that bit is blocked so stop coring. Commence recovery of rig at 1417hrs, download seabed photos (30RD1.tif and 30RD2.tif) on way to surface. Stop before sea surface and try retract and rotation – erratic readings on oil flow and slow response to controls. Recover to deck at 1500hrs. 0.15m of cored material recovered. Replace core barrel in rig.

At 1525hrs as ship is heading to Edison Seamount for TV Grab sampling take rig inboard to effect repairs.

Remove hydraulic system tank & motor assembly complete. Remove motor from tank and fit to spare tank which had faulty motor. Reassemble, fill and vent and re-connect electrics. Ready for wet testing at 2130hrs. This will be done following completion of grab sampling at transit back to Conical Seamount. Still undertaking grab sampling at midnight.

Monday 23rd September

Transited from Edison Seamount to Conical Seamount at slow speed while working on grab material.

Approach site 34RD at 0125hrs and prepare for drilling. Launch rig for tests at 0200hrs – rig responding to commands but still sluggish. Lower to seabed at 0233hrs. On way down the barrel descended in the frame and it was very slow in reacting to the retract command so recover to deck at 0312hrs in vertical position for more diagnostic tests. Checked oil levels and outputs from electronics bottle then compared outputs with other electronics bottle and on wet test more control was apparent with the new processor. However still no oil pressure to correct psi.

At 0500hrs survey work re-commences while the hydraulics tank is drained and stripped out for further testing. Test pressures with hand pump and this indicates that instrumentation is reading correctly and that there is a likely pump failure, or possibly a valve failure, which is less likely.

Drain oil from second hydraulic system and change all the filters. Take good electric motor from faulty system and fit it to this tank to make a complete assembly. Refill oil, fit system and top up and vent. Check all systems on deck then deploy for wet test. All rotation and retract systems functioning correctly but inclination is not. Upon recovery inclination resets and appears to be working properly so leave and monitor.

At 2100hrs secure system for survey work and continue with this through midnight.

Tidy up deck and workshop, put all waste oils to engine room disposal and secure all spares etc.

Tuesday 24th September

Continue with survey work until mid morning then make passage for Lihir. Inclinometers on rig are still erratic so remove electronics for inspection and replace inclinometer board with one from spare electronics bottle.

1230-1700hrs. Alongside at Lihir for Mine visit and for mine personnel to see around the ship.

1800-2100hrs OFOS survey was carried out over the area in front of the spoil dumping ground.

Mine personnel onboard for OFOS survey disembarked and vessel returns to survey work south of Lihir.

Wednesday 25th September

Continue survey work until 0800hrs then move to Conical Seamount for drilling.

Deploy drill at site 37RD in 1093m water depth at 0950hrs. Land on seabed at 1019hrs on a slope of greater than 30degrees so lift off then attempt a further two landings with no better success. Move vessel five times attempting to land two or three times each move with no success. Lift off seabed to 50m and move position. Land at 1106hrs on an inclination of approximately 5 degrees, take seabed photo (37RD1.jpg). Start drill at 1114hrs and commence coring. Achieve final penetration of 1.22m where no further penetration and no further progress. Commence recovery of rig at 1151hrs, download seabed photo (37RD1.tif) on way to surface and recover to deck at 1220hrs. 0.30m of cored material recovered. Replace core barrel in rig, fit a surface set, stepped profile diamond bit.

Deploy drill at site 38RD in 1081m water depth at 1306hrs. Land on seabed at 1331hrs on a slope of approximately 28 degrees (but stable) and take seabed photo (38RD1.jpg). Start drill at 1337hrs and commence coring. Achieve final penetration of 4.52m where drilling ceased as rig became unstable. Commence recovery of rig at 1514hrs, download seabed photo (38RD1.tif) on way to surface and recover to deck at 1515hrs. Only scrapings of clayey material from core bit recovered. Replace core barrel in rig.

Deploy drill at site 39RD in 1058m water depth at 1625hrs. Land on seabed at 1659hrs on a slope of approximately 22 degrees and take seabed photo (39RD1.jpg). Start drill at 1705hrs and commence coring. Achieve good penetration to 1.60m then rotation stalls and have to retract to restart. Restart and achieve penetration of 1.70m before having to stop as vessel is moving off position in strong current from changed direction. Commence recovery of rig at 1820hrs, download seabed photo (39RD1.tif) on way to surface and recover to deck at 1855hrs. 0.40m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 40RD in 1097m water depth at 1919hrs. Land on seabed at 1946hrs on a slope of approximately 25 degrees and take seabed photo (40RD1.jpg). Start drill at 1950hrs and commence coring. Achieve final penetration of 3.63m steadily reducing the water flush and stopping it for the last 15cm which blocked the bit. This was done to see if the material seen on the bit at RD38 could be recovered. It is not good drilling practice and as we use the flush for motor cooling also it was a one-off. Commence recovery of rig at 2045hrs, download seabed photo (40RD1.tif) on way to surface and recover to deck at 2125hrs. 0.40m of cored material recovered including cuttings and material from base of hole. Replace core barrel in rig.

Deploy drill at site 41RD in 1083m water depth at 2157hrs. Land on seabed at 2227hrs on a slope of approximately 32 degrees so lift and land twice more before achieving a stable angle of approximately 23 degrees and take seabed photo (41RD1.jpg). Start drill at 2235hrs and commence coring. Achieve final penetration of 1.03m where the rig began to be unstable and rocking on the seabed and drilling was stopped. Commence recovery of rig at 2341hrs, download seabed photo (41RD1.tif) on way to surface and recovering to deck at midnight

Thursday 26th September

Continue recovering rig from site RD41 to surface and land on deck at 0017hrs. 0.30m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 42RD in 1082m water depth at 0038hrs. Land on seabed at 0103hrs on a slope of approximately 17 degrees and take seabed photo (42RD2.jpg). Start drill at 0112hrs and commence coring. Achieve good penetration to 1.98m then rotation stalls and have to retract to restart. Restart and stall once more at 2.01m but again restart. Achieve penetration of 3.00m before stalling which stopped coring operations. Commence recovery of rig at 0254hrs, download seabed photo (42RD2.tif) on way to surface and recover to deck at 0340hrs. 1.5m of fractured but mainly intact core material recovered. Replace core barrel in rig.

Deploy drill at site 43RD in 1094m water depth at 0458hrs. Land on seabed at 0520hrs on a slope of greater than 35 degrees so lift off and attempt two further drops before moving position and trying again. Land a further two times with the same result. On the third attempt land on an angle of approximately 20 degrees and take seabed photo (43RD1.jpg). Start drill at 0546hrs and commence coring. Achieve good penetration to 4.47m then no further penetration achieved so stop. Commence recovery of rig at 0714hrs, download seabed photo (43RD1.tif) on way to surface and recover to deck at 0743hrs. 0.25m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 44RD in 1088m water depth at 0822hrs. Land on seabed at 0843hrs on a slope of approximately 25 degrees and take seabed photo (44RD1.jpg). Start drill at 0849hrs and commence coring. Achieve good penetration to 2.36m then stalls and retract to restart. Restart and achieve penetration of 2.67m before having to stop as ship starts to drift off position. Commence recovery of rig at 0950hrs, download seabed photo (44RD1.tif) on way to surface and recover to deck at 1020hrs. 0.55m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 45RD in 1055m water depth at 1044hrs. Land on seabed at 1108hrs on a slope of approximately 18 degrees and take seabed photo (45RD1.jpg). Start drill at 1112hrs and commence coring. Achieve good penetration to full core barrel length but too fast for core collection. Commence recovery of rig at 1230hrs, download seabed photo (45RD1.tif) on way to surface and recover to deck at 1300hrs. 0.30m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 46RD in 1063m water depth at 1312hrs. Land on seabed at 1338hrs on a slope of approximately 19 degrees and take seabed photo (46RD1.jpg). Start drill at 1342hrs and commence coring. Achieve good penetration to 4.07m then no further progress so stop and recover. Commence recovery of rig at 1430hrs, download seabed photo (46RD1.tif) on way to surface and recover to deck at 1510hrs. 0.55m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 47RD in 1056m water depth at 1606hrs. Land on seabed at 1631hrs on a slope of greater than 30 degrees so lift and land again. This time land on a slope of approximately 24 degrees and take seabed photo (47RD1.jpg). Start drill at 1630hrs and commence coring. Achieve good penetration to 5.01m which is maximum possible but mostly too fast for rock coring. Commence recovery of rig at 1821hrs, download seabed photo (47RD1.tif) on way to surface and recover to deck at 1856hrs. 0.27m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 48RD in 1056m water depth at 1914hrs. Land on seabed at 1937hrs on a slope of approximately 11 degrees and take seabed photo (48RD1.jpg). Start drill at 1943hrs and commence coring. Achieve good penetration to 1.20m then no further progress so stop and recover rig. Commence recovery of rig at 2044hrs, download seabed photo (48RD1.tif) on way to surface and recover to deck at 2116hrs. 0.65m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 49RD in 1058m water depth at 2135hrs. Wait 40m above seabed until 2255hrs while vessel re-positions due to changing weather and satellite stability. Land on seabed at 2257hrs on a slope of approximately 26 degrees and take seabed photo (49RD1.jpg). Start drill at 2300hrs and

commence coring. Achieve good penetration to 1.30m then very slow to 1.33m and no further penetration possible. Commence recovery of rig at 2358hrs, download seabed photo (49RD1.tif) on way to surface and continue to recover to deck at midnight.

Friday 27th September

Continue to recover rig from site 49RD to deck. Recover to deck at 0030hrs. 0.55m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 50RD in 1109m water depth at 0055hrs. Land on seabed at 0119hrs on a slope of greater than 30 degrees so lift off and retry twice more with the same result so lift off again and move vessel. Retry at new location three times with same result so move once more and this time land on a slope of approximately 25 degrees at the second attempt and take seabed photo (50RD1.jpg). Start drill at 0147hrs and commence coring. Achieve good penetration to 1.52m then continually stalling while trying to make progress and finally stop at 1.64m penetration and recover. Commence recovery of rig at 0231hrs, download seabed photo (50RD1.tif) on way to surface and recover to deck with a bent barrel at 0300hrs. 0.25m of cored material recovered. Renew core barrel in rig.

Deploy drill at site 51RD in 1078m water depth at 0345hrs. Land on seabed at 0409hrs on a slope of greater than 35 degrees so lift off and retry twice more but without success so move vessel and retry three more times with similar result so move vessel once more. This time land on a slope of approximately 20 degrees and take seabed photo (51RD1.jpg). Start drill at 0453hrs and commence coring. Achieve good penetration to 1.41m then no further progress and bit appears to be blocked so stop and recover. Commence recovery of rig at 0543hrs, download seabed photo (51RD1.tif) on way to surface and recover to deck at 0612hrs. 0.30m of cored material recovered. Replace core barrel in rig.

Deploy drill at site 52RD in 1069m water depth at 0645hrs. Land on seabed at 0712hrs on a slope of approximately 12 degrees and take seabed photo (52RD1.jpg). Start drill at 0720hrs and commence coring. Achieve full penetration to 5.0m with reduced water flush in last 25cm to try to recover what is not hard rock. Commence recovery of rig at 0850hrs, download seabed photo (52RD1.tif) on way to surface and recover to deck at 0922hrs. 0.0m of cored material recovered, only grey cuttings on bit. Replace core barrel in rig with grade 10 impregnated bit, as new location will be different material.

1000hrs secure rig to deck, coring at Conical Seamount completed. Vessel sails for Lihir, drops off samples for analyses then returns to south of Lihir to complete survey.

Scientific meeting in afternoon highlighting work done to date, division of cruise report duties and foretaste of things to come in the PACMANUS area.

Complete survey and on passage to PACMANUS at midnight.

Saturday 28th September

On passage around south of New Ireland to PACMANUS area. Stop for a visit to Big Pigeon Island after passing north of Rabaul, New Britain. Continue to PACMANUS and commence survey work with an OFOS traverse.

Sunday 29th September

Continue survey work until 0800hrs then prepare to work with TV grab. Sample collected but grab not operating properly so carry out some tests then decide to drill on Snowcap while grab undergoes

repairs. Remove core barrel from rig, replace impregnated diamond bit with surface set stepped profile diamond bit and replace core barrel in rig.

Deploy drill at site 57RD in 1670m water depth at 1400hrs. Stop 1-2m above seabed to take picture at 1438hrs. Land on seabed at 1442hrs but slope greater than 30 degrees so lift up wait and re land at 1445hrs on a slope of approximately 25 degrees and take seabed photo (57RD2.jpg). Start drill at 1449hrs and commence coring. Achieve penetration of 1.68m with reduced water flush, as material appears to be soft. Eventually friction on the barrel (low RPM, high torque, no bit weight) stops drilling before stalling out. Commence recovery of rig at 1329hrs, download seabed photos (57RD1.tif, 57RD2.tif) on way to surface and recover to deck at 1615hrs. 0.1m of cored dacite pebbles recovered. Leave core barrel on bench with new extension tube installed and surface set stepped profile diamond bit on. The bit may have to be changed depending on where the next drill site is.

As the TV Grab is now repaired work resumes with it for the remainder of the day.

Monday 30th September

Finish with grab in early hours of morning and re-commence drilling at Roman Ruins.

Deploy drill at site 60RD in 1692m water depth at 0225hrs. Stop 1m above seabed at 0247hrs to take picture which showed that a landing would be reasonable. Land on seabed at 0252hrs but slope greater than 30 degrees so lift up and re land a further two times before moving ship a little. At 0300hrs attempt to land three more times but with no success due to steep slope so move vessel a little more. At 0312hrs 1m off seabed take another photo (60RD1.jpg) and then land rig. The slope angle is 25 degrees but steady so take a further photo (60RD2.jpg) and commence drilling at 0320hrs. Achieve a penetration of 4.42m with reduced water flush as progress is made. Penetration eventually stops, probably with bit blocking. Commence recovery of rig at 0452hrs, download seabed photos (60RD1.tif, 60RD2.tif) on way to surface and recover to deck at 0543hrs. 0.9m of pebbles/core recovered. Replace core barrel in rig.

Deploy drill at site 61RD in 1674m water depth at 0615hrs. Stop 1m above seabed to take picture (61RDpreland1.jpg) at 0653hrs. Photo shows a cliff face so move vessel to new location in 1693m water depth. Take photo at new location at 0719hrs (61RDpreland2.jpg) before landing. Attempt to land on seabed three times after taking photo but each time slope greater than 30 degrees so lift up, move ship and attempt to land a further two times before moving the ship once again. Lower to 1m off seabed at 0756hrs and take another photo (61RDpreland3.jpg) which shows landing to be unsuitable, move vessel once more. Lower to within 1m of seabed at new location at 0811hrs, take photo (61RD1.jpg) which suggests it will be possible to land and at 0817hrs land rig. The slope angle is 17 degrees and steady so take a further photo (61RD2.jpg) and commence drilling at 0822hrs. Achieve a penetration of 2.77m with reduced water flush before penetration ceases, probably with bit blocking. Commence recovery of rig at 0930hrs, download seabed photos (61RD1.tif, 61RD2.tif) on way to surface and recover to deck at 1021hrs. 1.4m of mineralised core recovered. Replace core barrel in rig.

Deploy drill at site 62RD in 1680m water depth at 1218hrs. Stop 1-2 m above seabed and take photo (62RD1.jpg). Land on seabed at 1304hrs on a slope of approximately 17 degrees and take seabed photo (62RD2.jpg). Start drill at 1307hrs and commence coring. Achieve penetration to 2.43m where there was no further progress possible. Commence recovery of rig at 1343hrs, download seabed photo (62RD2.tif) on way to surface and recover to deck at 1433hrs. 0.35m of rubbly material recovered. Replace core barrel in rig.

Deploy drill at site 63RD in 1699m water depth at 1500hrs. Stop 1m above seabed and take photo (63RD1.jpg). Land on seabed at 1540hrs on a slope of greater than 33 degrees so lift off, stabilise and

re-land at 1542hrs. This time the landing is on a slope of approximately 24 degrees so take seabed photo (63RD2.jpg). Start drill at 1545hrs and commence coring. Achieve penetration to 2.71m where there was no further progress possible. Commence recovery of rig at 11628hrs, download pre-land and seabed photos (63RD1.tif, 63RD2.tif) on way to surface and recover to deck at 1718hrs. 0.5m of fractured core material recovered. Replace core barrel in rig.

Deploy drill at site 64RD in 1690m water depth at 1736hrs. Stop 2m above seabed to take picture (63RD1.jpg) at 1819hrs. Attempt to land on seabed two times after taking photo but each time slope greater than 30 degrees. Lift up, move ship, lower to 1m off seabed at 1829hrs and take another photo (64RD2.jpg). Attempt to land on seabed two times after taking photo but each time the slope is greater than 30 degrees. Lift up and move ship once again. Lower to within 1m of seabed at new location at 1850hrs, take photo (64RD3.jpg), lower to seabed at 1854hrs but again seabed slope is too great to operate on. Lift off once more and hold above seabed for some minutes, as ship position is not stable. Attempt to land once more at 1904hrs, take seabed photo (64RD4.jpg) with one leg touching and rig echo sounder still reading 2.8m above seafloor which suggests it is likely to be steep. Touch down at 1908hrs with inclination of approximately 27 degrees and uncertain stability, lift off and lower and achieve an approximate inclination of 14 degrees. Take a further photo (64RD5.jpg) and commence drilling at 1921hrs. Achieve a penetration of 3.35m before penetration ceases, probably with bit blocking. Commence recovery of rig at 2042hrs, download seabed photo (64RD5.tif) on way to surface and recover to deck at 2131hrs. 2.2m of fractured, mineralised core recovered. Replace core barrel in rig.

Deploy drill at site 65RD in 1688m water depth at 2200hrs. Stop 1.8m above seabed to take picture (65RD1.jpg – possibly on a fallen chimney) at 2241hrs. Attempt to land at 2244hrs but slope angle greater than 30 degrees so lift off, wait and then re-land. Slope angle still too great so move vessel. Take photo at new location at 2254hrs (65RD2.jpg) before attempting to land 2257hrs. Attempt to land on seabed four times but each time slope greater than 30 degrees so lift up and move ship again. Lower to seabed at 2313hrs and achieve stability at an angle of approximately 25 degrees. Take a seabed photo (65RD3.jpg); commence drilling at 2317hrs and at 4.3m depth at midnight.

October 2002

Continue on site 65RD. Achieve a penetration of 4.41m before penetration ceases, probably with bit blocking. Commence recovery of rig at 0016hrs, download seabed photo (65RD1.tif) on way to surface and recover to deck at 0106hrs. 0.4m of mineralised core recovered. Replace core barrel in rig.

Deploy drill at site 66RD in 1686m water depth at 0145hrs. Stop 1.5m above seabed at 0224hrs and take photo (66RD1.jpg). Land on seabed at 0227hrs on a slope of approximately 6 degrees and take seabed photo (66RD2.jpg). Start drill at 0237hrs and commence coring. Achieve penetration to 3.71m where there was no further progress possible. Commence recovery of rig at 0350hrs, download seabed photo (66RD2.tif) on way to surface and recover to deck at 0439hrs. 0.8m of fractured mineralised core material recovered. Replace core barrel in rig.

Deploy drill at site 67RD in 1666m water depth at 0510hrs. Stop 1.5m above seabed at 0555hrs and take photo which was not clear. Land on seabed at 0558hrs on a slope of approximately 8 degrees and take seabed photo (67RD1.jpg). Start drill at 0605hrs and commence coring. Achieve maximum penetration possible of 5.0m and take a further seabed photo before recovery (67RD2.jpg). Commence recovery of rig at 0743hrs, download seabed photos (67RD1.tif, 67RD2.tif) on way to surface and recover to deck at 0833hrs. 1.9m of fractured core material recovered. Replace core barrel in rig.

Deploy drill at site 68RD in 1689m water depth at 0903hrs. Stop to retract core barrel 40m above seabed at 0950hrs. Barrel retracted but immediately fell to base of rig again. All hydraulics appear to be functioning OK. Conclusion is that the retraction wire has broken. Commence recovery at 1005hrs, rig at stern at 1045hrs with broken retract wire and all vibrocorer guide bolts sheared. Replace retraction wire, all guide bolts and re-test functions and rig ready for re-deployment at 1225hrs.

Re-deploy drill at site 68RD in 1689m water depth at 1237hrs. Land on seabed at 1314hrs on a slope of greater than 35 degrees so lift off, allow to stabilise and re-land two more times with similar results so move vessel. Attempt to re-land at 1321hrs and slope is again greater than 35 degrees so lift off and try once more. This time the landing is on a slope of approximately 24 degrees so take seabed photo (68RD1.jpg). Start drill at 1329hrs and commence coring. Achieve penetration to 2.27m with some stalling and retraction required to restart. Stop coring at 1424hrs after no further progress achieved. Take picture of seabed before recovery (68RD2.jpg). Commence recovery of rig at 1429hrs, download seabed photo (68RD2.tif) on way to surface and recover to deck at 1520hrs. 0.42m of fractured and mineralised core material recovered. Replace core barrel in rig.

Deploy drill at site 69RD in 1692m water depth at 1537hrs. Land on seabed at 1615hrs on a slope of greater than 28 degrees so lift off 1.3m, allow to stabilise and take a photo (69RD1.jpg). The seabed appears rough and sloping. Attempt to land but slope angle is again greater than 30 degrees so lift and move ship. At 1629hrs attempt landing again at new position and on the second attempt the landing is on a slope of approximately 21degrees so take seabed photo (69RD2.jpg). Start drill at 1635hrs and commence coring. Achieve penetration to 4.96m where an earth trip at 1742hrs shut down the system and there was no further progress possible. With no power it was also impossible to retract the core barrel into the frame. Commence recovery of rig at 1757hrs, download pre-land and seabed photos (69RD1.tif, 69RD2.tif) on way to surface and recover to stern of vessel at 1848hrs. Core barrel bent and as there is likely to be core inside cannot risk tipping over rig and breaking the barrel and loosing it. Secure rig at stern, no obvious damage but unable to continue with recovery as scientists have already deployed grab from midships and are doing a traverse with it. Carry out function tests and various cable checks and find fault in main motor connection between motor and processor. Commence recovery of core barrel into frame at 2100hrs after grabbing completed using ship's mooring winch and snatch blocks to pull barrel up frame. Tie-off at top and recover rig to deck. 2.2m of mineralised core material recovered. Core barrel will have to be renewed.

Fault find on rig and main motor connection is suspect. Make re-termination to motor with new plug and lead to processor. Repair ready for testing prior to moulding at change of shift at Midnight. Vessel is meantime doing swath survey work.

Wednesday 2nd October

Complete test of cable repairs to main motor. Motor tested on brief deck run and all OK. Flush motor 2 has an intermittent fault but it is rarely used so decide to go with this possible fault and a working flush 1 motor. Pour mould on new cable connection and leave to cure. Renew core barrel and replace in rig. Retraction wire has to be re-spooled when rig is ready for deployment at the next location, as motor will have to be in the water for that. Repairs completed at 0300hrs.

Continue other survey work until 1000hrs.

TV camera attached to frame of rig at 1015hrs and rig launched. Retraction wire spooled on and drill and camera lowered below surface. Rotation and retraction tested ok. Retrieve camera and rig ready for deployment.

Deploy drill at site 71RD in 1920m water depth at 1045hrs. Tested out main motor on way by using retract and all in order. Stop 1.5m above seabed at 1136hrs and take photo (71RD1.jpg). Land on

seabed at 1139hrs on a slope of approximately 23 degrees and take seabed photo (71RD2.jpg). Start drill at 1143hrs and commence coring. Coring stopped abruptly at 1220hrs when rig suddenly tipped over. No warning of impending movement and electrical trip upon attempting to retract. However it was possible to restart and retract fully when rig had been lifted from seabed. Penetration achieved around 1.3m. Commence recovery of rig at 1225hrs, download seabed photos (71RD1.tif, 72RD2.tif) on way to surface and recover to deck at 1328hrs. 0.26m of fractured core material recovered. Core barrel not bent and replaced in rig.

Deploy drill at site 72RD in 1924m water depth at 1356hrs. Land on seabed at 1439hrs on a slope of approximately 8 degrees and take seabed photo (72RD1.jpg). Start drill at 1443hrs and commence coring. Penetration stops at 1.15m when no further progress was possible and it appeared that the bit was blocked. Commence recovery of rig at 1436hrs, download seabed photo (72RD1.tif) on way to surface and recover to deck at 1546hrs. 0.17m of fractured core material recovered. Replace core barrel in rig.

Deploy drill at site 73RD in 1920m water depth at 1646hrs. Attempt to land on seabed at 1720hrs. Try three times but each time slope greater than 32 degrees. Lift up, take picture (73RD1.jpg) then move ship. Attempt another landing at 1744hrs and achieve a landing on a slope of approximately 21 degrees. Take seabed photo (73RD2.jpg). Commence drilling at 1740hrs. Achieve a penetration of 4.62m before penetration ceases, probably with bit blocking. Commence recovery of rig at 1955hrs, download seabed photo (73RD2.tif) on way to surface and recover to deck at 2055hrs. 0.8m of fractured core recovered. Replace core barrel in rig.

Drilling then ceases for remainder of day, vessel carrying out swath survey.

Thursday 3rd October

Complete survey work at 0830hrs and proceed to drill location at SUSU knolls.

Deploy drill at site 74RD in 1522m water depth at 0853hrs. Land on seabed at 0927hrs on a slope of approximately 12 degrees and take seabed photo (74RD1.jpg). Start drill at 0932hrs and commence coring. Penetration stops at 3.19m when no further progress was possible and it appeared that the bit was blocked. Commence recovery of rig at 1045hrs, download seabed photo (74RD1.tif) on way to surface and recover to deck at 1125hrs. 0.25m of fractured core material recovered. Core barrel retained on deck as this is the last drill site of the project. At 1200hrs vessel sails for Rabaul, crew and BGS prepare for rig dismantling. At 1330hrs rig lifted to vertical position and legs removed one by one using 'A' frame and BGS cable. Rig then laid down with base stropped to 'A frame rails to keep base off deck. BGS cable then used to lift rig horizontally, strops removed and rig moved inboard into position where ship's heavy lift winch can pick it up. At 1600hrs, lying off Rabaul awaiting disembarkation of scientific personnel, Crew rig personnel basket and equipment and remove BGS sheave and cable from 'A' frame, and lower to deck. Cable removed and sheave placed in carrier on flat rack. Work stops for day at 1700hrs. Depart Rabaul for Suva, Fiji at around 2000hrs.

Friday 4th October

Weather has turned against us. Heading into moderate seas and force 6-8 wind. Deck awash at times so ensure all equipment is secure and cease outside work for day.

Saturday 5th October

Weather improved but still not suitable for moving equipment around. Disconnect umbilical winch hydraulics and protect spooling gear and hydraulic connections. Stow hydraulic hoses. Download

remainder of files from computer in control cabin and close down that computer. Cease outside work for day.

Sunday 6th October

Weather worse again. Isolate all electrical power to BGS control panel switchgear. Disconnect all electrical connections from BGS control panel to equipment. Remove BGS control panel and ship wiring to it.

Monday 7th October

On passage to Suva, weather unchanged.

Tuesday 8th October

On passage to Suva, weather unchanged.

Wednesday 9th October

On passage to Suva, weather unchanged.

Thursday 10th October

On passage to Suva, weather unchanged. Unable to make pilotage before closing time for day. Find shelter in lee of island and commence remainder of demobilisation. Remove 40' container soft-top, re-arrange equipment and load for shipping. Burn off welds holding winch to winch base to allow removal of winch. Prepare hold-down ties for winch on flatbed. Remove holding bolts and welded fixing on power pack frame ready for lifting.

Proceed to anchorage and await pilot.

Friday 11th October

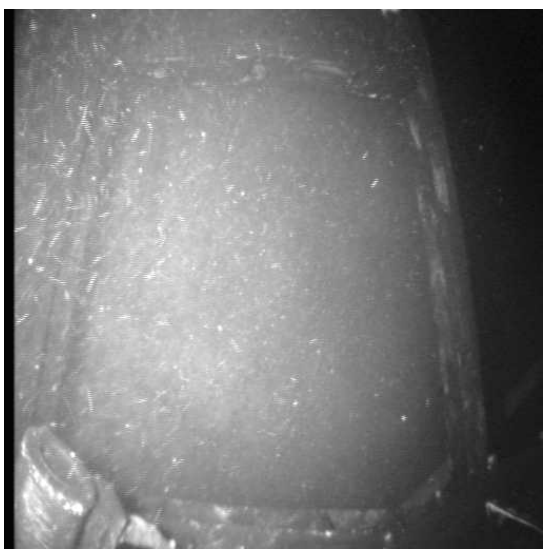
Arrive Suva and come alongside wharf.

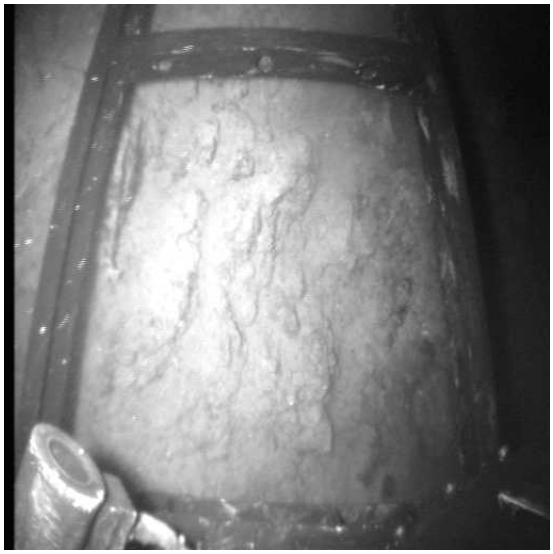
Commence shore crane work. Lift 40' container fully loaded to dockside and leave there for tools and minor equipment after completion of remainder of work. Remove flatbed rack to dockside and load with winch and power pack. Bolt power pack and winch to flatbed then chain and tension winch to flatbed. Put remainder of equipment in 40' container with protective clothing. All ready for shipping back to UK. Work complete.

Appendix 3 Drilling Data

Notes on the Graphs and Photos included in the following pages:-

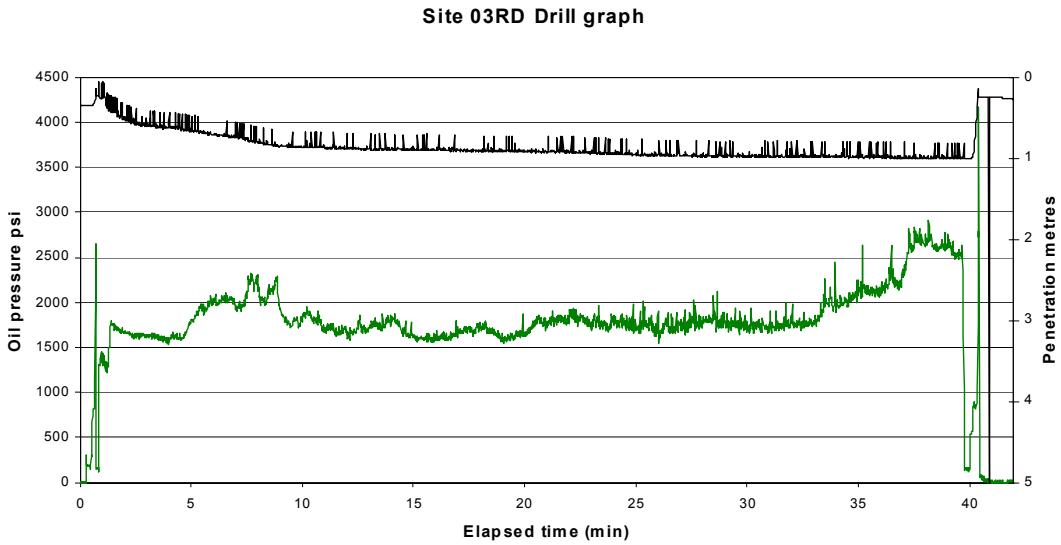
1. The graphs are part of a monitoring system used to determine the efficient operation of the drill while on the seabed and to provide diagnostic data from the drill functions.
2. The geology can be crudely linked to the penetration graph and the characteristics of Torque and RPM. Generally speaking if penetration is greater than 4-5cm/sec then the material is being flushed away and not cored.
3. Bit blocking can be detected by lack of penetration, smooth torque and RPM.
4. Bit sticking can be detected by variable torque coupled with inverse variability in RPM.
5. Wall friction can be detected by loss of RPM, possible higher torque but both generally smoother than for bit sticking and also by lack of penetration, as bit weight is not being transferred to the cutting edge.
6. The penetration is measured acoustically and suffers from extraneous noise and reflections. Generally the graph produced is not a thin line but the slope gradient is what is important for core diagnostics.
7. The photos are taken through one of the drill legs and cover a trapezoid area of 1.2m at base 1.2m sides and 1m across the top. They serve as a guide to what is being drilled but do not show the drilling location.

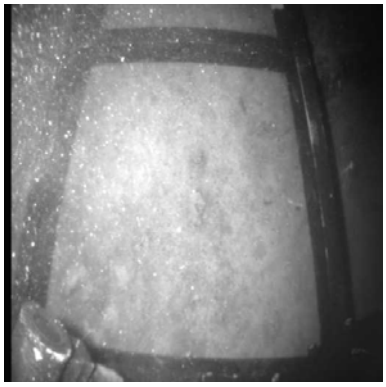




Site 02RD

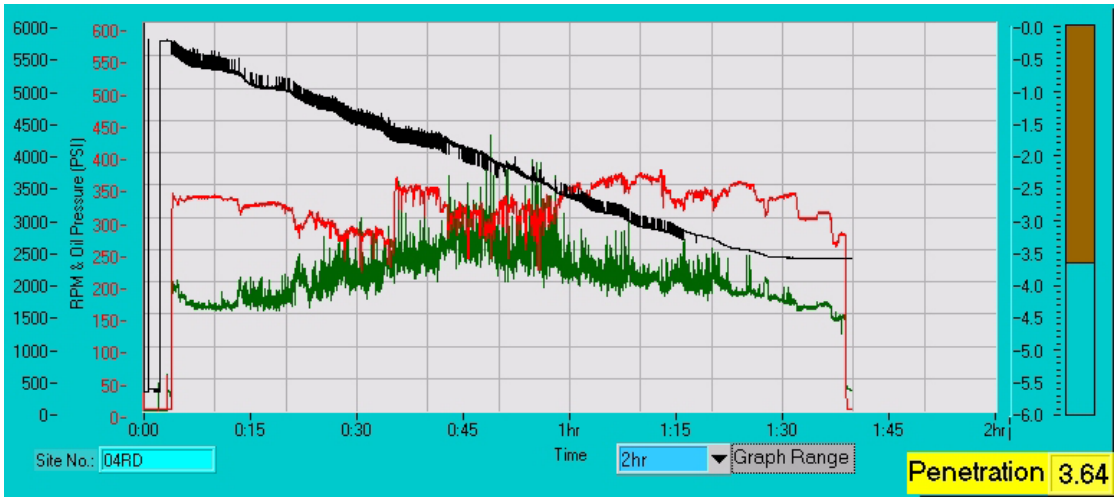
No coring possible at this site as the rig would not stay upright. Bent core barrel while trying to land and had to retrieve to deck. On second attempt main motor would not function so retrieve to deck and abandon site.

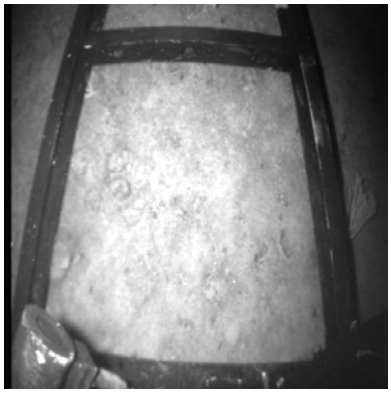




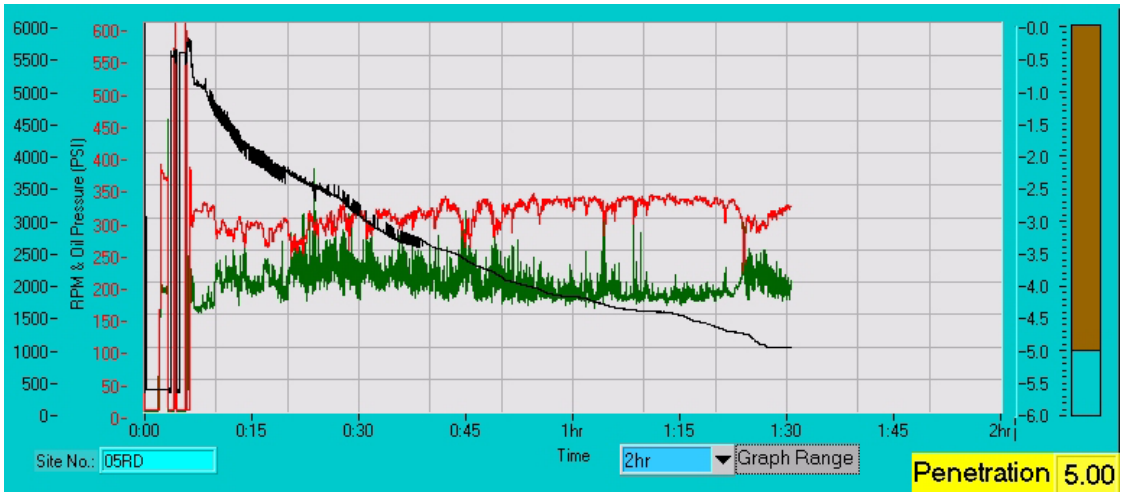
Site 03RD

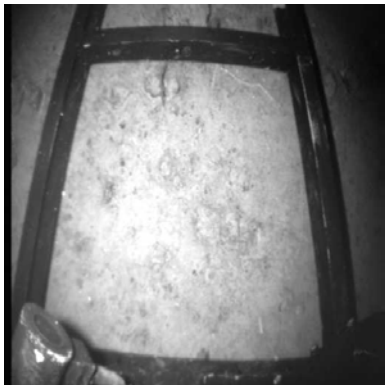
Rig lying on seabed at an angle of 10 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration 1.0m. then no further penetration indicating bit blockage
Graph from logged data.
Recovery 0.25m of rubble/pebbles collected in slow penetration close to start of coring.



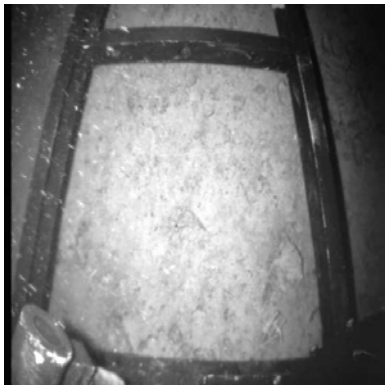


Site 04RD
Rig lying on a pebbly/rubbly surface at an angle of 9 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration smooth and relatively fast with some torquing up between 1.5 and 3.2m depth. At 3.64m no further penetration indicating bit blockage.
Recovery 0.5m of rubble/pebbles probably collected in the slow penetration depth 0.7-1.0m.

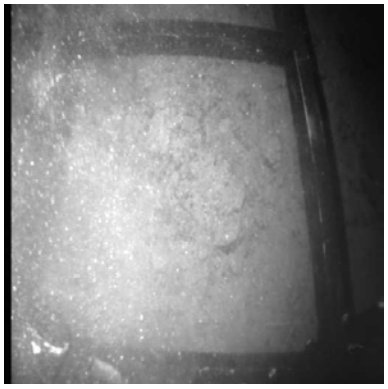




Site 05RD
Rig lying on a pebbly surface at an angle of 9 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration smooth and fast with variable torque throughout. A full penetration of 5.0m was achieved.
Recovery was 0.3m of rubble/pebbles and only indication of coring on graph is at 1.0m and 4.5m.

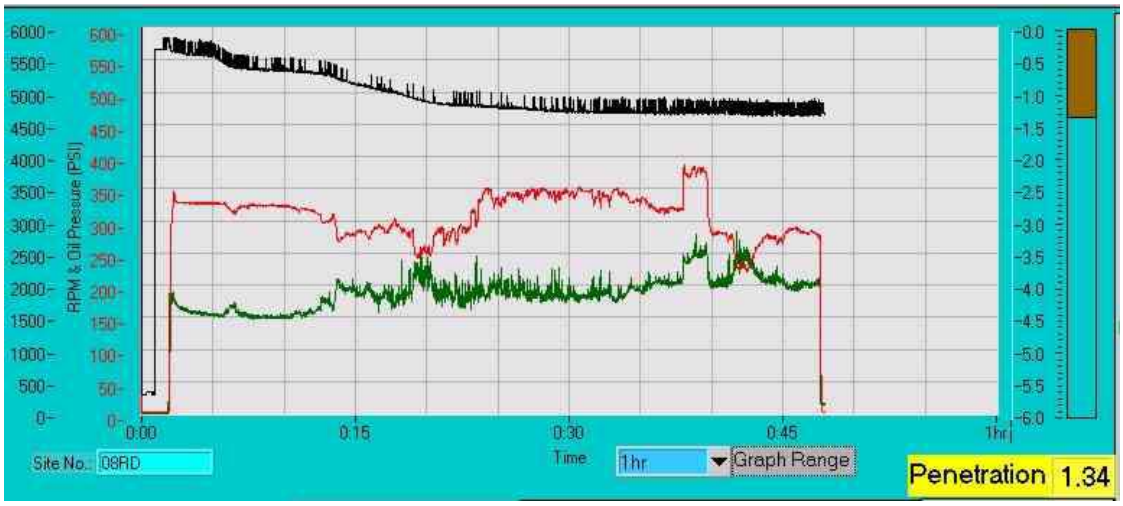


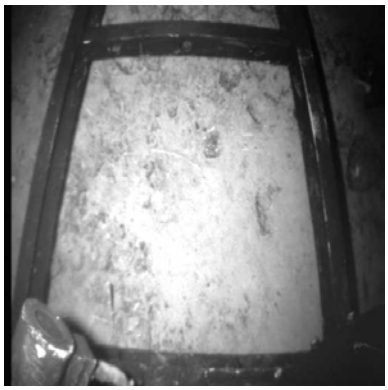
Site 06RD
Rig lying on a rubbly surface at an angle of 14 degrees to the vertical. A G9 Matrix impregnated diamond bit used.
Penetration smooth and slow with reasonable torque at start. This tailed off as penetration ceased and bit blocked allowing no further progress after 1.11m.
Recovery 1.1m of rubble/pebbles cored throughout the length of penetration.



Seabed Photo taken at 2056hrs showing seabed near actual site 07RD. Here the slope of 25 degrees to the vertical was too great for the rig to operate on.

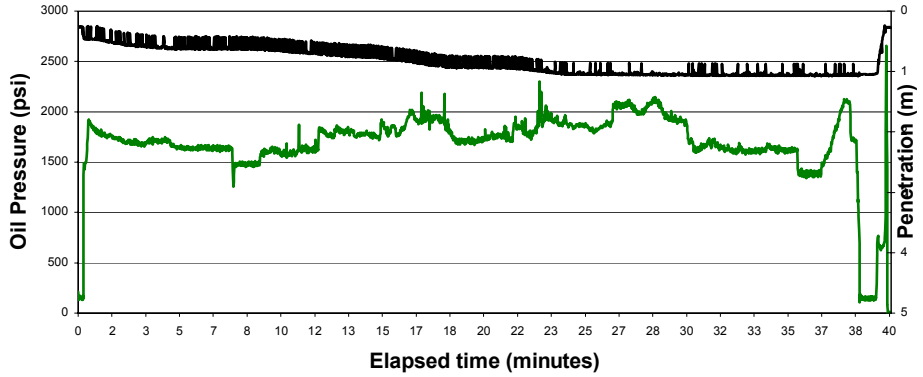
Site 07RD
Rig lying on a pebbly/rubbly surface at an angle of 6 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable, slower after 1.0m depth where some torque, then more torque to 1.25 and faster penetration to stall at 2.12m. Penetration of 1.36m shown after partial retraction of core barrel.
Recovery 0.75m of rubble/pebbles all collected above 1.25m.

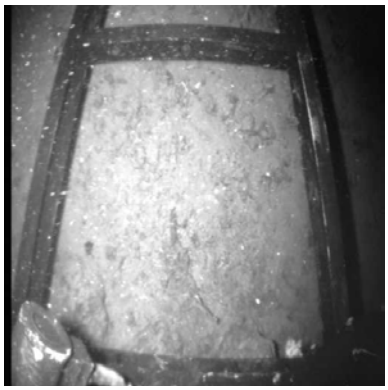




Site 08RD
Rig lying on a pebbly/rubbly surface at an angle of 21 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable, slower with higher torque after 0.75m depth and indications of bit blocking by 1.25m. Very slow penetration, probably with blocked bit to 1.37m where coring stopped.
Recovery 1.0m of rubbly core collected above 1.2m.

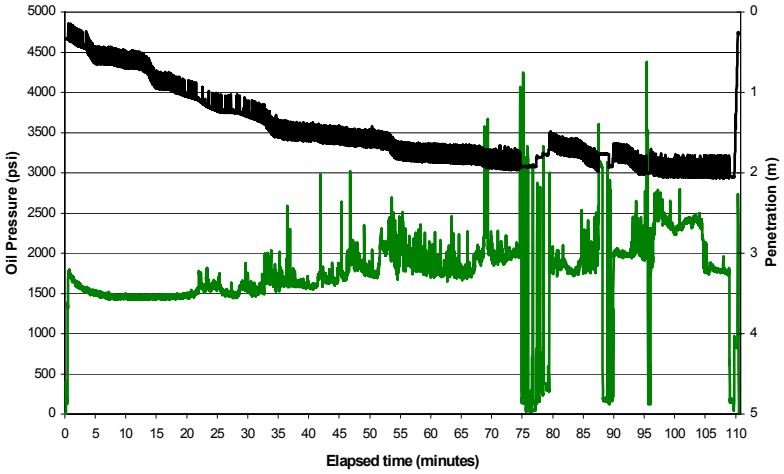
Site 09RD drill graph



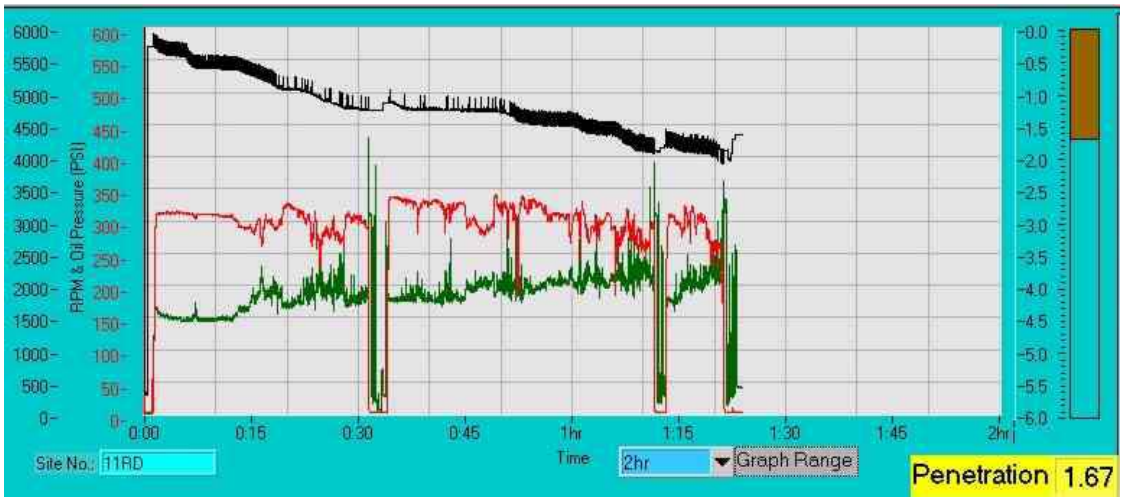


Site 09RD
Rig lying on a pebbly/rubbly surface at an angle of 17 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration relatively smooth and steady, slower after 1.0m depth where bit was probably blocked.
Stop coring at penetration indication of 1.06m.
Graph from logged data.
Recovery 0.85m of rubbly core from throughout.

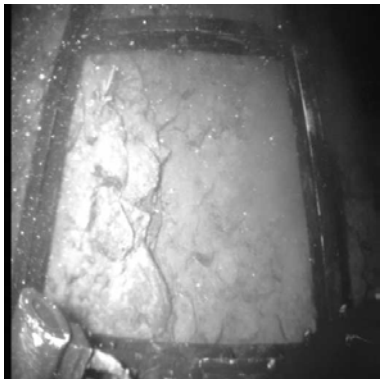
Site 10RD Drill graph



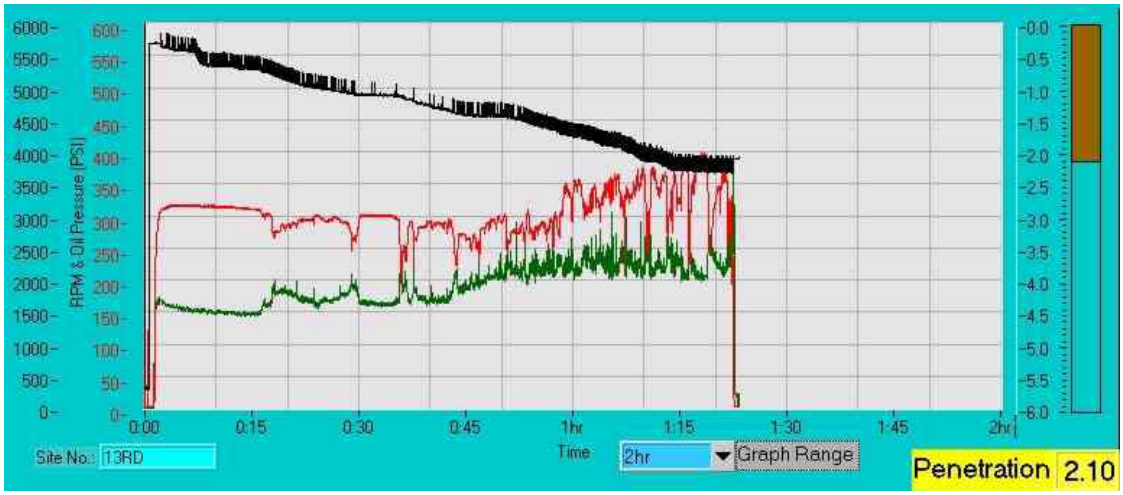
Site 10RD
Rig lying on a rubbly surface at an angle of 8 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable, symptomatic of bit blocking and recovering. Slower after 1.75m depth where high torque and stalling to 2.06m where coring stopped, as no progress. Graph from logged data.
Recovery 0.81m of rubble collected above 1.8m.



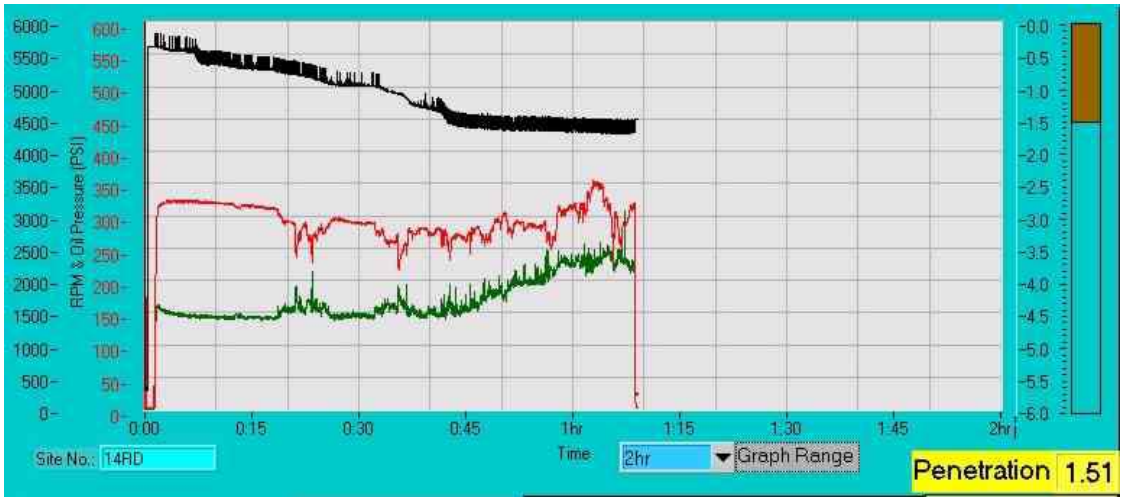
Site 11RD
Rig lying on a pebbly/rubbly surface at an angle of 10 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable and stepped indicating bit blocking. Stalled for a period after 1.25m. Further torquing and stalling before stopping at 2.09m. Penetration of 1.67m shown after partial retraction of core barrel.
Recovery 0.50m of rubble collected throughout. 1.25m.

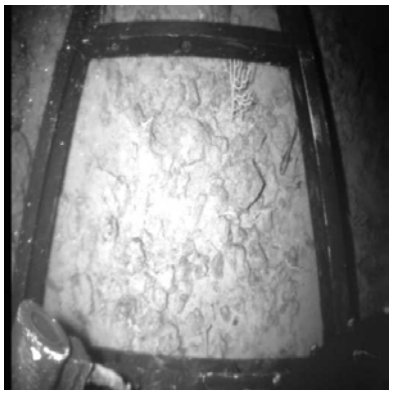


Site 12RD
Rig lying on a ?rock surface at an angle of 21 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable rate slowing to zero and probable bit blockage at 1.0m depth. Variation of RPM and Bit weight make no difference.
Recovery 0.23m of rubbly core collected above 0.75m and possibly in two areas.

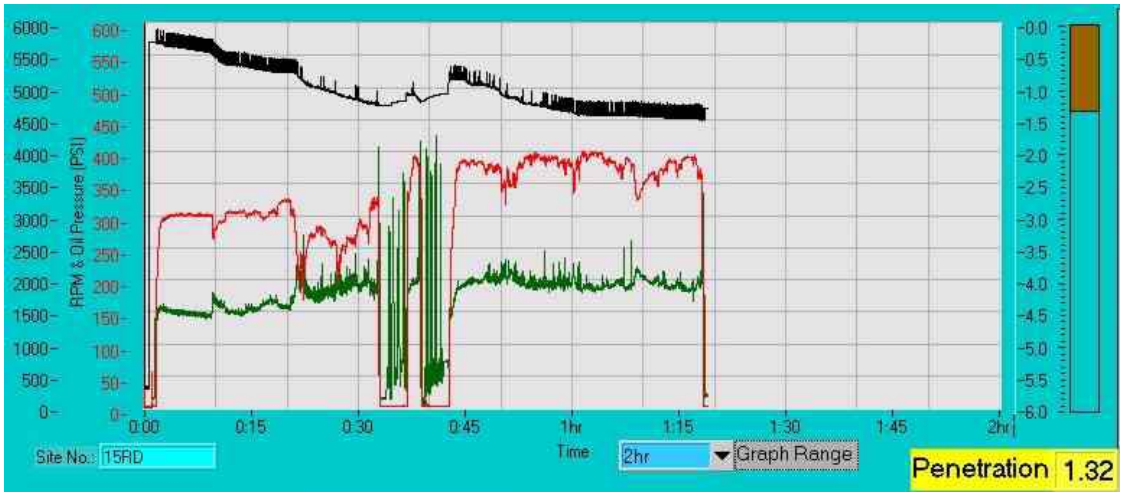


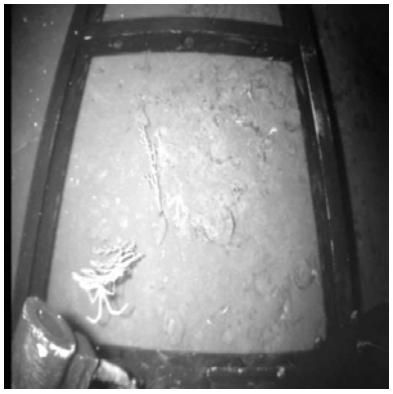
Site 13RD
Rig lying on a rubbly surface at an angle of 17 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable with even torque with spikes to 1.5m penetration. Thereafter penetration speeds up, torque builds up and stalls at 2.38m. Penetration of 2.1m shown after partial retraction of core barrel.
Recovery 1.45m of fractured core probably all collected between 0.5 and 1.5m.



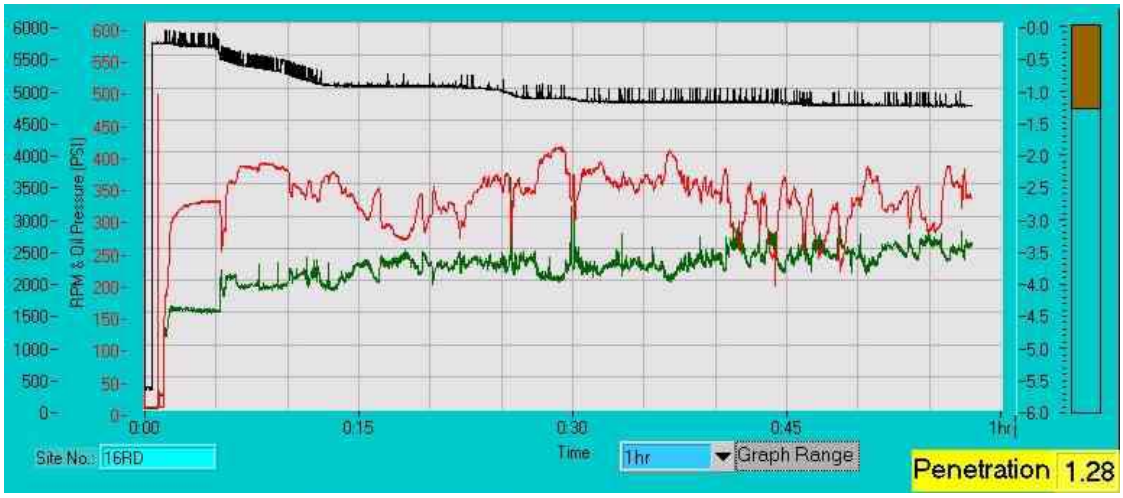


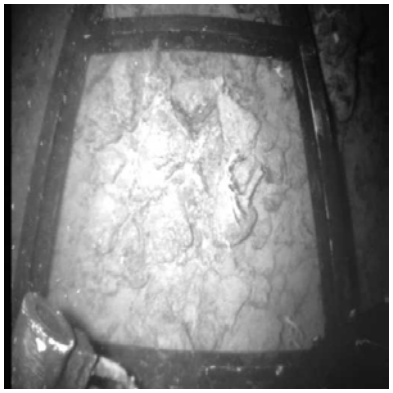
Site 14RD
Rig lying on a pebbly/rubbly surface at an angle of 17 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable, slightly stepped indicating bit blocking and restarting, some torquing but after 1.73m no further progress. (bottom of graph curve).
Recovery 0.50m of fractured core all collected above 1.4m.



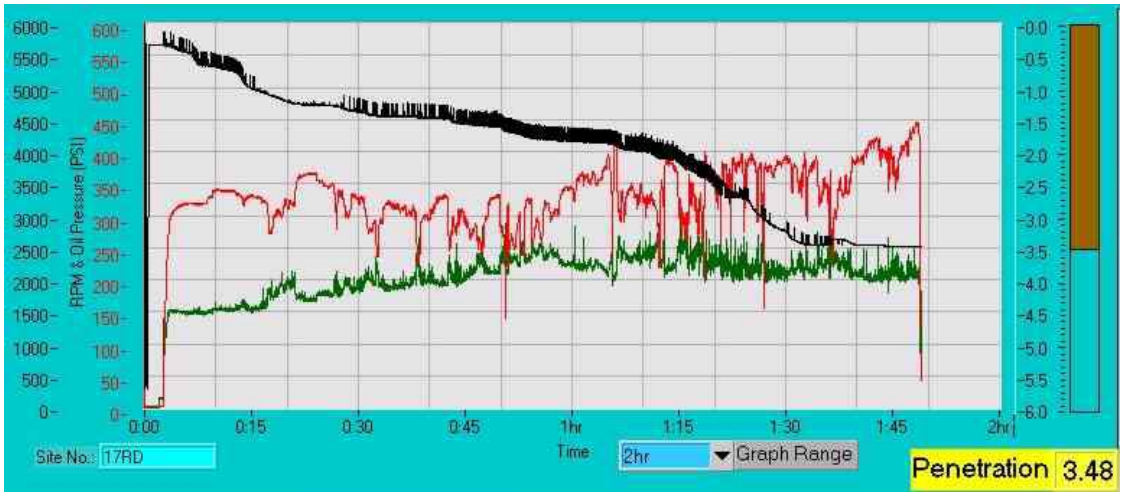


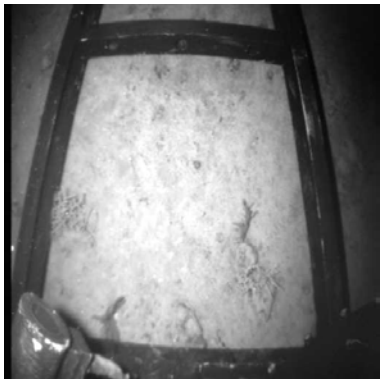
Site 15RD
Rig lying on a rubbly surface at an angle of 21 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable, bit blocking and stalling. Retraction required to restart. No further penetration after 1.5m and stop coring. Penetration of 1.32m shown is top of curve line.
Recovery 1.25m rubbly core collected throughout.



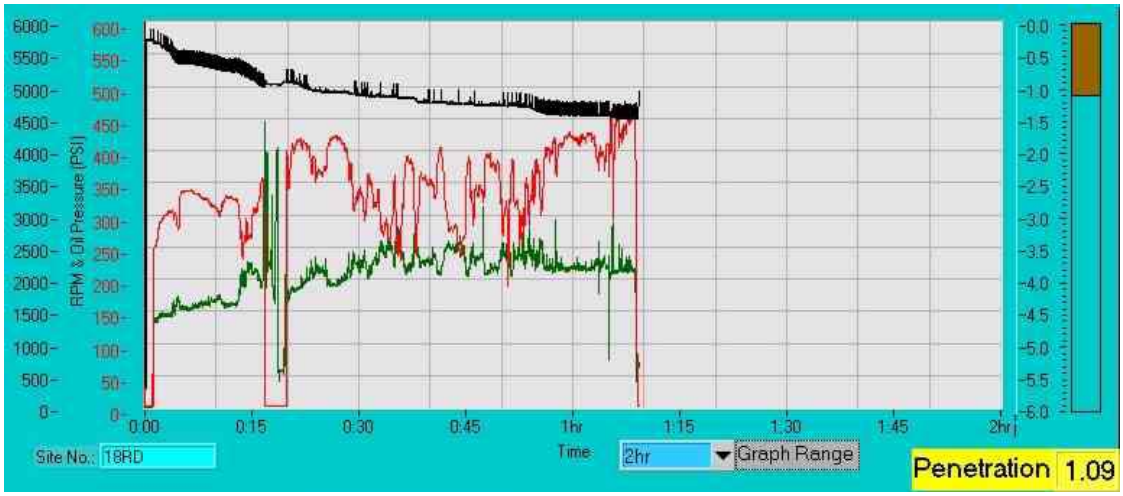


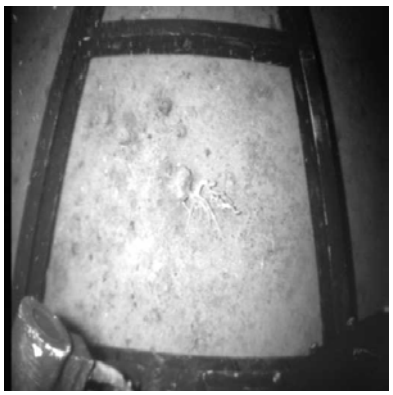
Site 16RD
Rig lying on a pebbly/rubbly surface at an angle of 10 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable, slower after 1.0m depth. Torque variation similar throughout despite RPM changes. Stop at 1.29m penetration, no further progress and probable bit blocking.
Recovery 0.65m rubbly core collected above 1.2m.



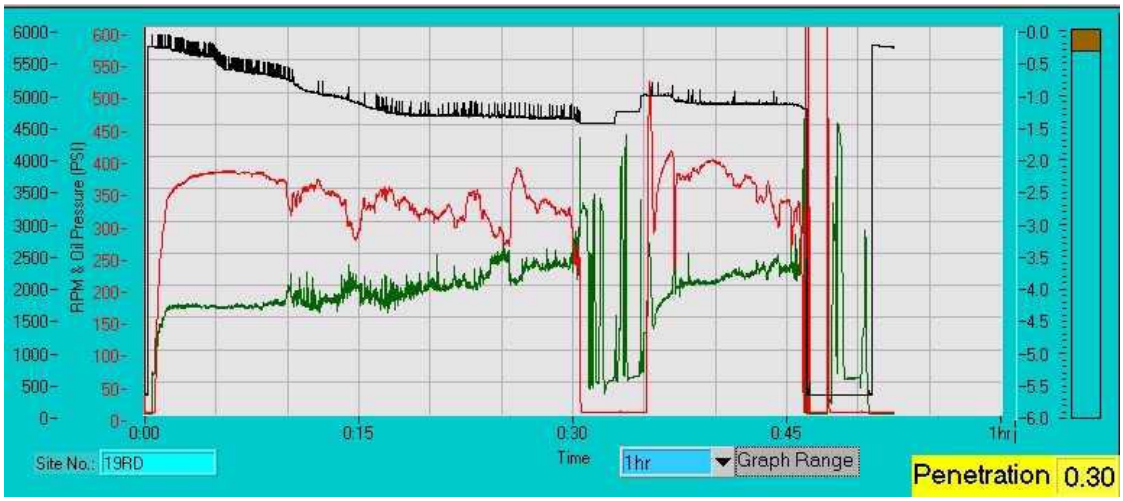


Site 17RD
Rig lying on a rubbly surface at an angle of 15 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable, slower 1.4-2.2m then it speeds up again. Torque and RPM show spikes throughout. Coring stopped at 3.48m with no further penetration and bit blocked.
Recovery 0.65m of rubbly core probably collected between 1.4 and 2.2m.



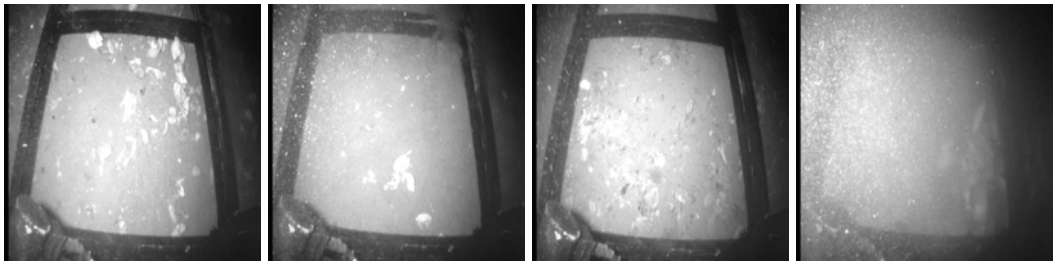


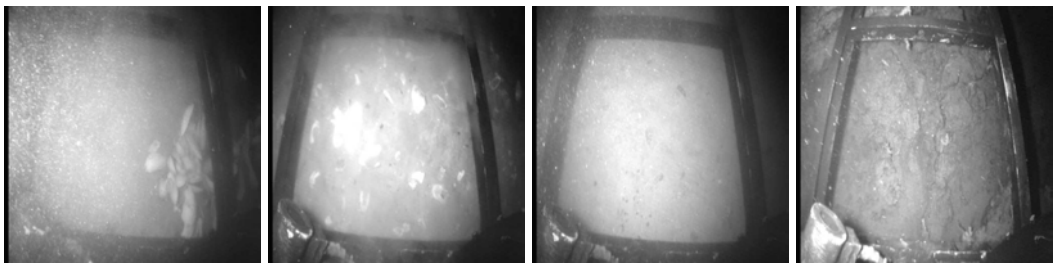
Site 18RD
Rig lying on a pebbly surface at an angle of 2 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration fast, slower then stalled before restart at smoother, slower pace. Bit blocked after 1.4m depth. Coring stopped at 1.51m penetration – no progress. Penetration of 1.09m shown as top of graph line.
Recovery 0.85m of rubbly core probably from 0.6-1.25m.

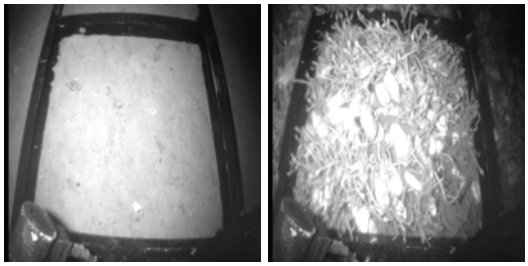


Site 19RD
Rig lying on a pebbly/rubbly surface at an angle of 12 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration variable but relatively fast to 1.4m then much stalling, retractions to restart and no further progress so stop. Penetration of 0.3m shown after partial retraction of core barrel while attempting to restart.
Recovery 0.35m of rubbly core collected possibly at top.

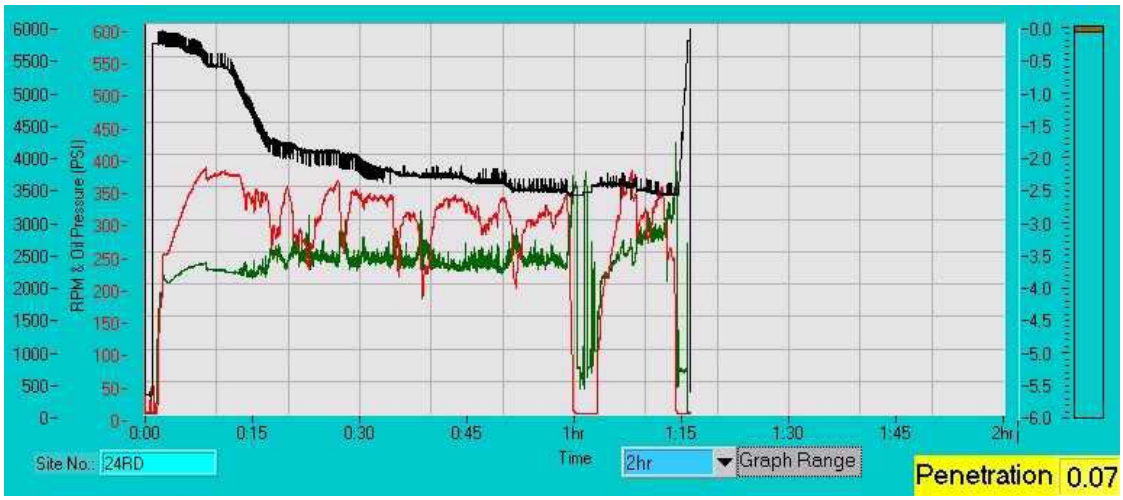
Site 23RD
Rig lying on a rubbly surface at an angle of 20 degrees to the vertical. A G9 matrix impregnated diamond bit used.
Penetration stepped, bit blocking. Stalled at 1.5m and little progress after. Final penetration of 1.63m. at another stall. Unable to restart. Penetration of 1.23m shown after partial retraction of core barrel.
Recovery 0.35m of rubbly core possibly from top.



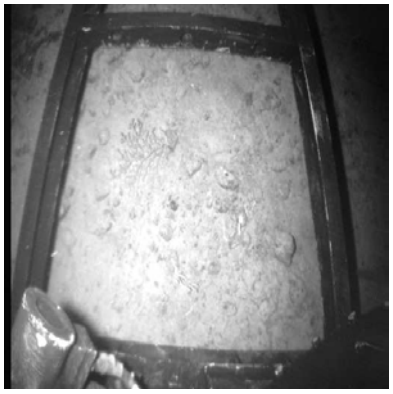




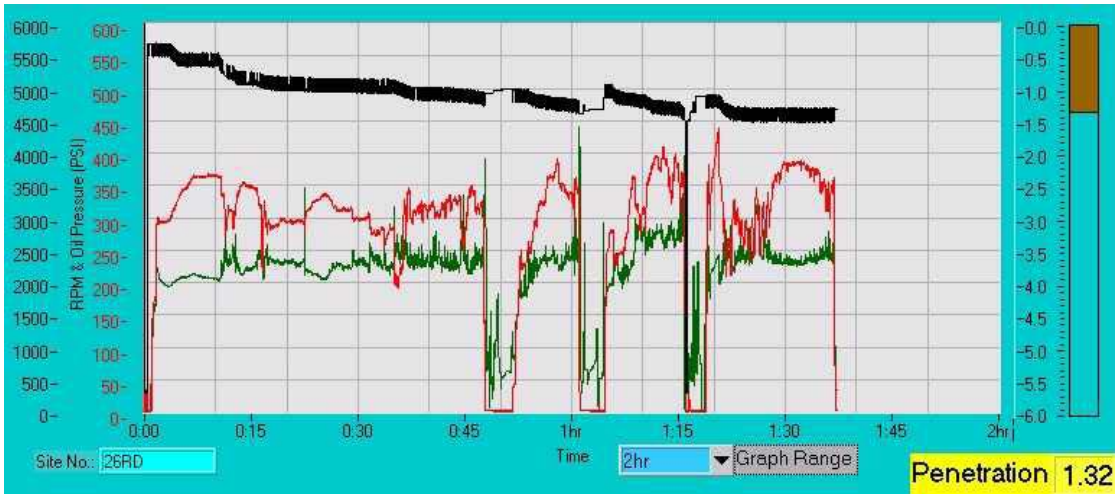
Series of seabed photos taken each time drill was landed to try to find the clamshell bed which was drilled on as site 24RD. Times are1215, 1244, 1254, 1303, 1305, 1311, 1347, 1409, 1437, 1747hrs.



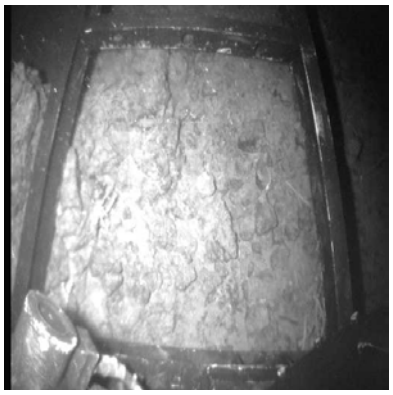
Site 24RD
Rig lying on seabed at an angle of 11 degrees to vertical. A G9 Matrix impregnated diamond bit used. Seabed is a mass of living clams. Penetration fast to 1.8m then slow with torque and variable (slower) to 2.6m where rotation stalls. Restart but no further penetration after 2.63m, bit blocked. Penetration indicated after retraction. Recovery 0.30m of rubbly core, possibly from 1.8m down.



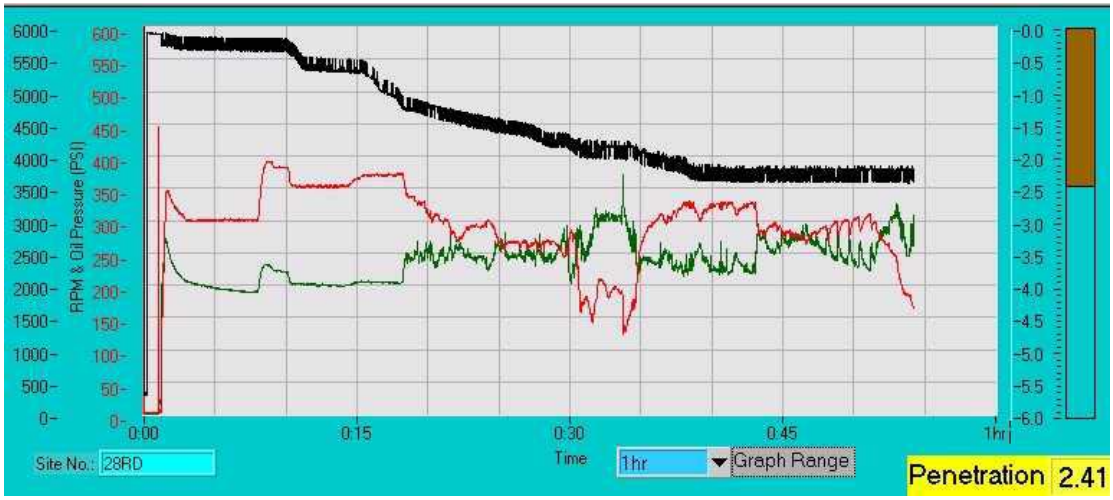
Site 25RD
Rig lying on seabed at an angle of 16 degrees to vertical. A G9 Matrix impregnated diamond bit used.
Penetration slow and stepped with little torque which becomes less as bit becomes blocked. No progress after 0.95m and stop coring. Penetration indicated after retraction.
Recovery 0.30m of rubbly core, probably all before 0.75m.

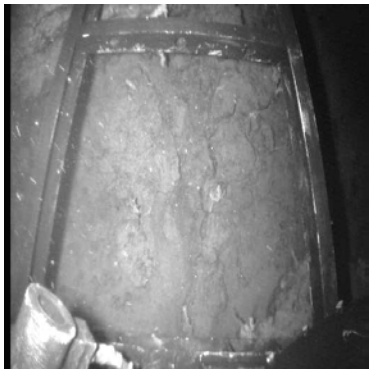


Site 26RD
Rig lying on seabed at an angle of 7 degrees to vertical. A G9 Matrix impregnated diamond bit used.
Penetration fast but stepped to 1.0m then slow with stalling and restarting indicating fractured material. Stop at 1.50m as no progress, bit blocked.
Penetration indicates top of curve thickness.
Recovery 0.30m of rubbly core, probably from 0.8-1.4m area.

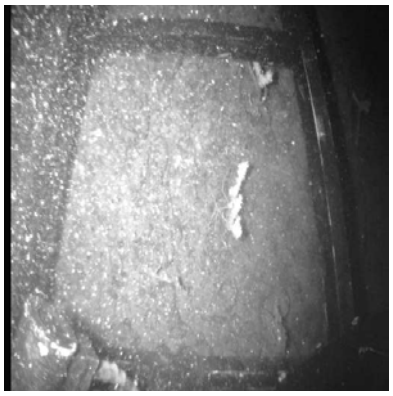


Site 27RD
Rig lying on seabed at an angle of 7 degrees to vertical. A G9 Matrix impregnated diamond bit used.
Penetration faster but stepped to 0.8m then slow with rpm and torque variation to 1.1m where no further progress and coring stopped, bit blocked.
Recovery 0.40m of rubbly core, probably from lower part of coring.

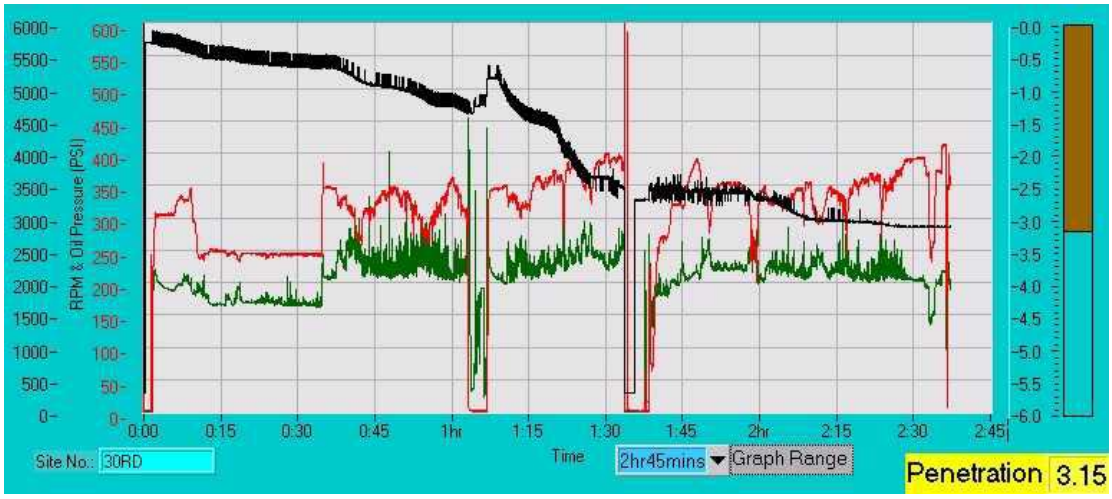


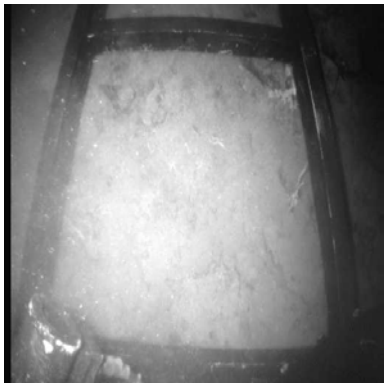


Site 28RD
Rig lying on seabed at an angle of 11 degrees to vertical. A G9 Matrix impregnated diamond bit used.
Penetration slow to start then fast but stepped to 1.3m then steady with varying torque to 2.4m where no further penetration, bit blocked.
Recovery 0.70m of fractured core, probably some from 'steps' at top, remainder from 1.25m to base.

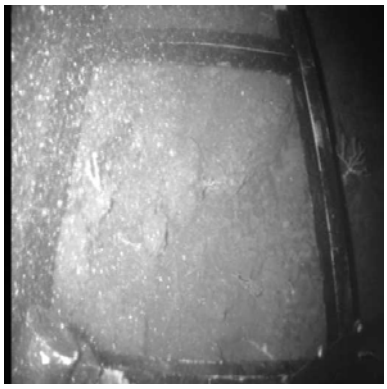


Site 29RD
Rig lying on seabed at an angle of 11 degrees to vertical. A G9 Matrix impregnated diamond bit used.
Penetration slow and stepped abruptly in top section then slow but steady. Torque and RPM not steady indicating difficult to keep rotating smoothly.
Penetration eventually stops - bit blocked.
Recovery 0.15m of core, most likely from lower part of coring.

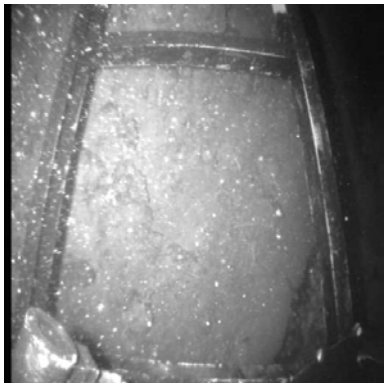




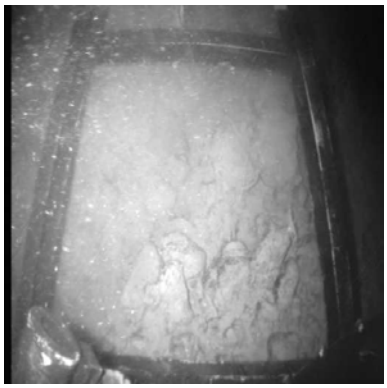
Site 30RD
Rig lying on seabed at an angle of 16 degrees to vertical. A G8 Matrix impregnated diamond bit used.
Penetration smooth but fast to 1.14m to rotation stall then fast again to 2.4m then slows and more torque RPM iteration with stalling to final penetration of 3.15m. at bit blockage.
Recovery 0.60m of rubbly core, probably from top and base of core run.



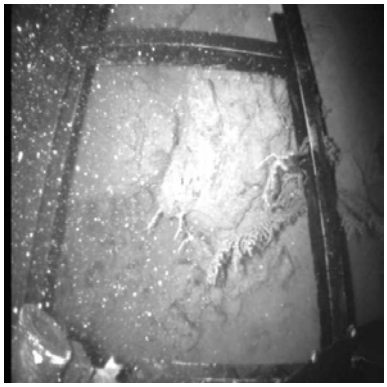
Site 37RD
Rig lying on seabed at an angle of 5 degrees to vertical. A G8 Matrix impregnated diamond bit used.
Penetration slow and stepped with little torque/RPM interaction until 0.8m, which continues to bit blocking at 1.22m penetration. Penetration indicated is top of graph line.
Recovery 0.30m of core, most likely from upper part of coring.



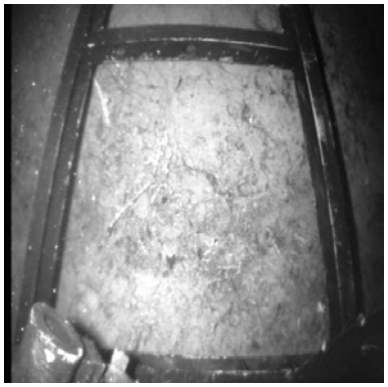
Site 38RD
Rig lying on seabed at an angle of 28 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration fast then faster and smooth with some matching torque/RPM. Stop penetration and coring at 4.45m as rig becomes unstable and rocking.
Recovery only scrapings of soft grey mush from core bit – from base of hole.



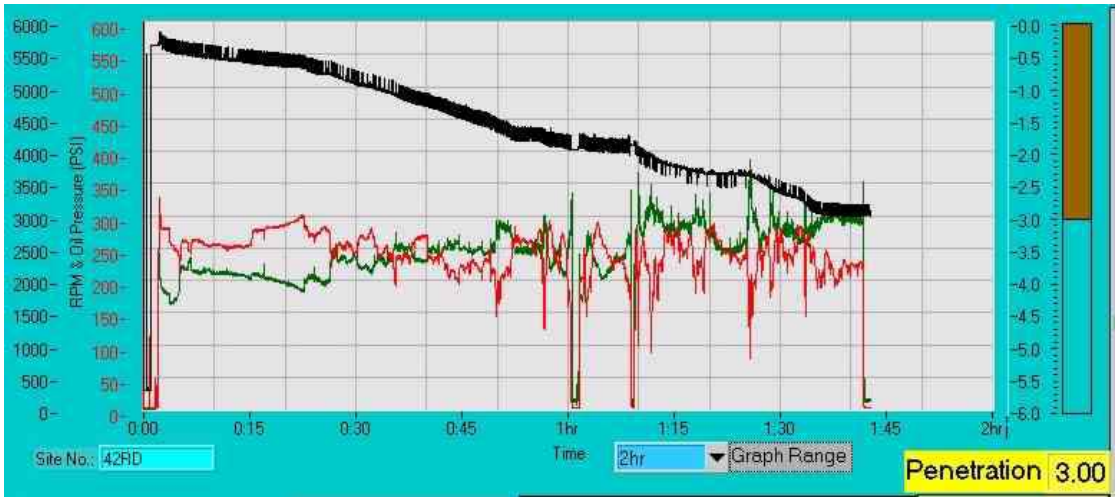
Site 39RD
Rig lying on seabed at an angle of 22 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration stepped, more steady after 1.0m to 1.7m where rotation stalls. Then speeds up again then bit appears to be blocking but have to stop as ship losing position. Torque and RPM curves match.
Recovery 0.40m of rubbly core, probably from throughout the coring

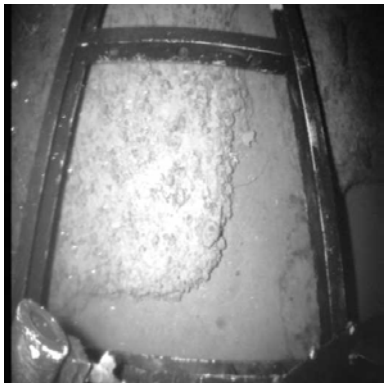


Site 40RD
Rig lying on seabed at an angle of 24 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration slower at top of coring then fast with little increase in torque/RPM. Flushing progressively decreased to zero for last 20cm to block bit and obtain bit sample at depth of 3.63m.
Recovery 0.40m, cored pebble at top and mush of cuttings from base. Paint sample of barrel also in case of contamination in analyses of this material.

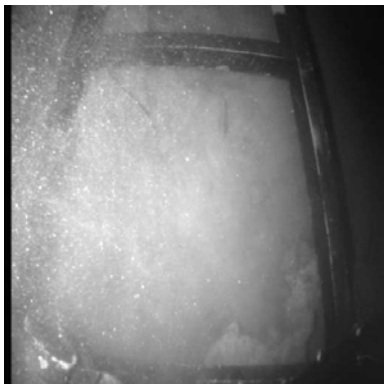


Site 41RD
Rig lying on seabed at an angle of 24 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration slow and stepped. Torque and RPM matching. Still penetrating at 1.03m when have to stop and retract as rig beginning to move on seabed.
Recovery 0.30m of rubbly core, probably from throughout the coring.

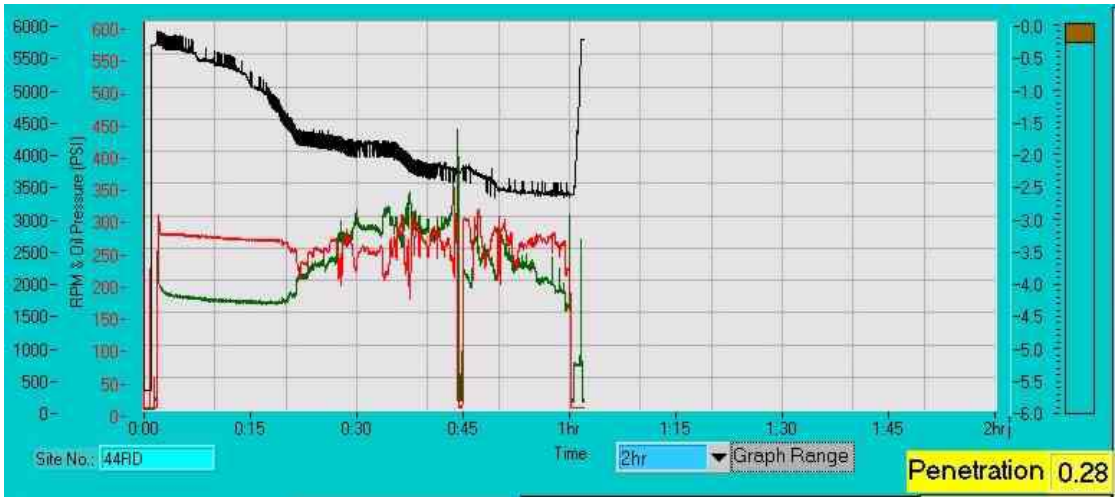


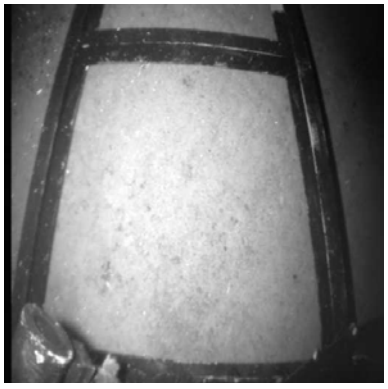


Site 42RD
Rig lying on seabed at an angle of 17 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration steady and smooth with matching torque and RPM. Some stalling but able to restart.
Eventually cease penetration, bit blocked at 3.0m. depth.
Recovery 1.5m of core, most likely from above 2m in the coring interval.

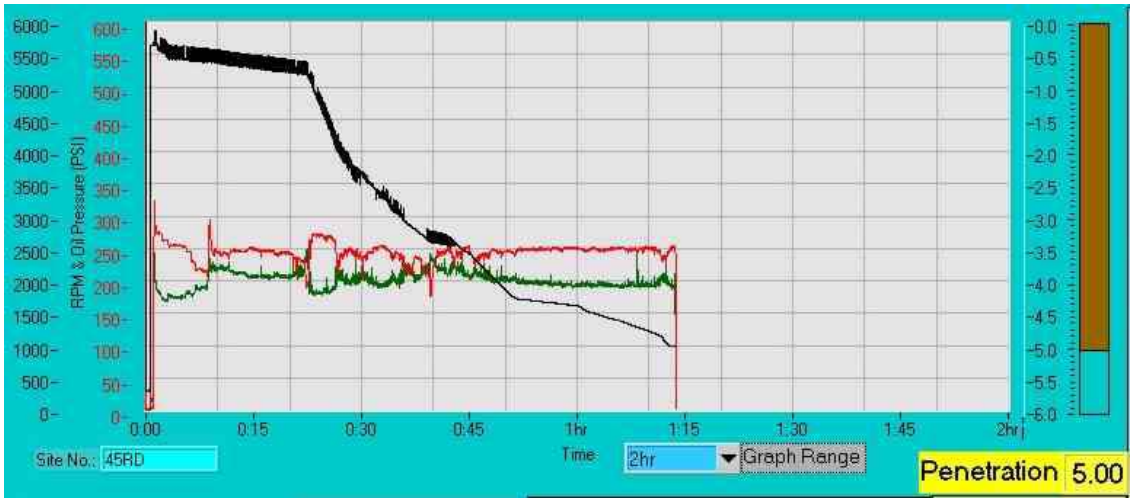


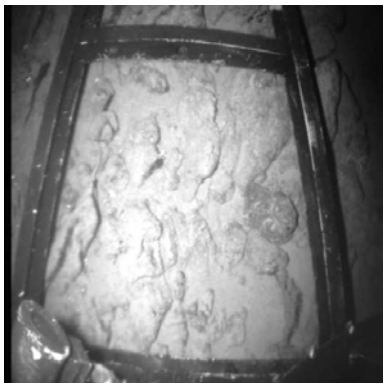
Site 43RD
Rig lying on seabed at an angle of 20 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration slower to start then fast with decreasing torque for increasing RPM at base. Penetration stops at 4.47m with indication of bit blocking.
Recovery 0.25m of core, most likely from top part of coring.



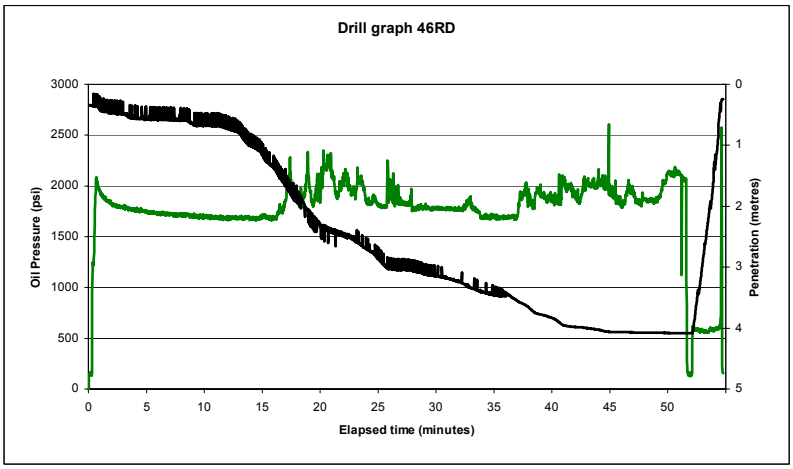


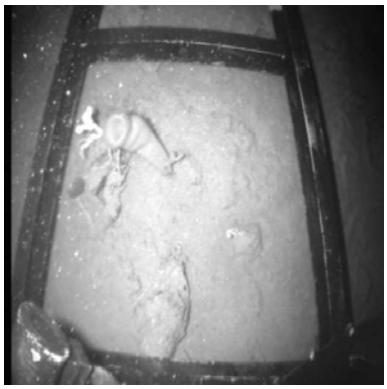
Site 44RD
Rig lying on seabed at an angle of 25 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration fast then slows with steps and increasing torque for roughly same RPM. Stalls at 2.36m but restart. Stop at 2.67m penetration as ship losing position. Penetration indicated on graph is during retraction.
Recovery 0.55m of core, most likely from top and base of core run.



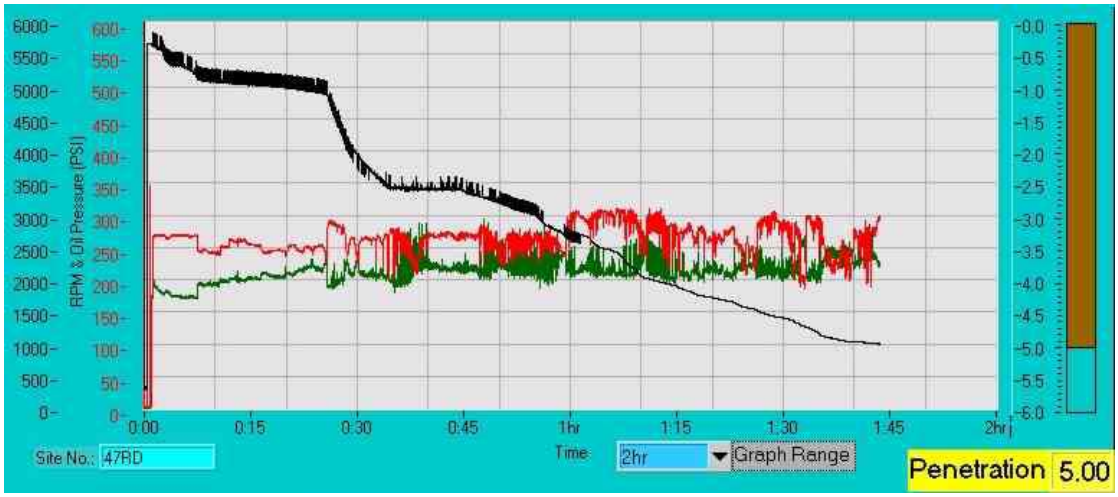


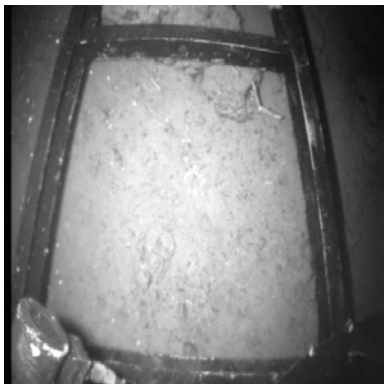
Site 45RD
Rig lying on seabed at an angle of 19 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration slower at start then fast and generally smooth with little torque to full penetration of 5m.
Recovery 0.30m of core, most likely from within the top 0.75m of coring.



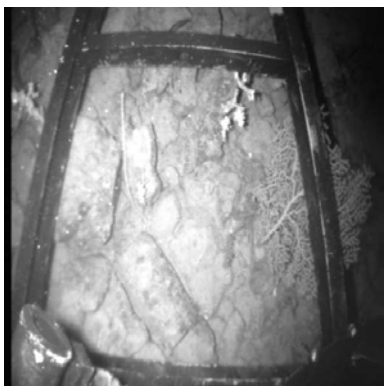


Site 46RD
Rig lying on seabed at an angle of 18 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration slow then fast then slows a little with increasing torque. No further penetration after 4.07m, bit probably blocked. Graph from logged data.
Recovery 0.55m of core, most likely from top and perhaps around 3-3.5m in core run.

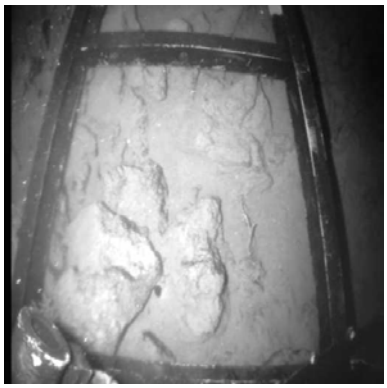




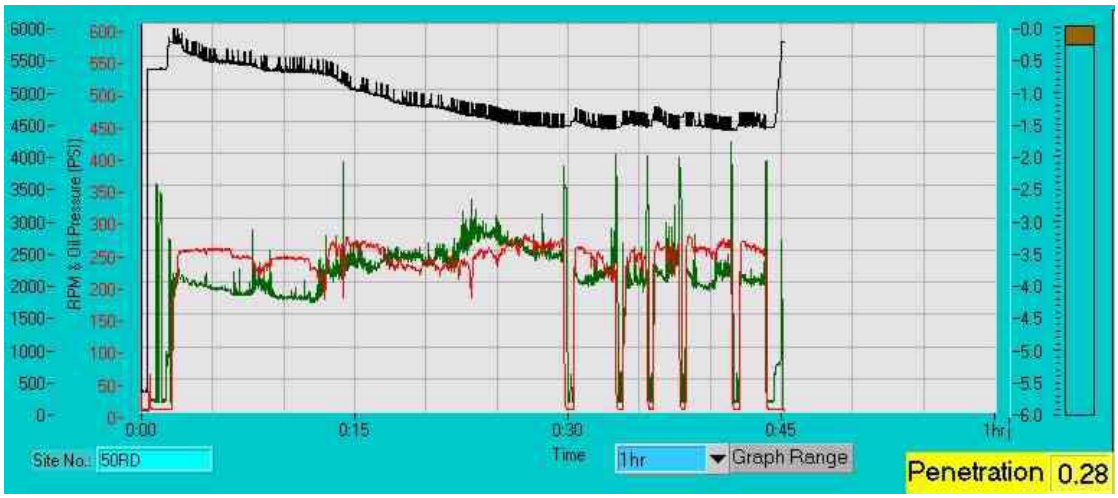
Site 47RD
Rig lying on seabed at an angle of 24 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration fast initially then slower then fast again and generally smooth with little torque to full penetration of 5m.
Recovery 0.27m of fractured core, most likely from within the top 1.1m of coring.

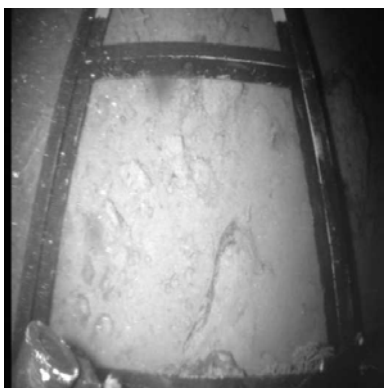


Site 48RD
Rig lying on seabed at an angle of 10 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration steady to 1.0m then slower and likely bit blocking with stalling and torquing. No further progress at 1.25m penetration.
Recovery 0.65m of fractured core, probably all from above 1m.coring depth.

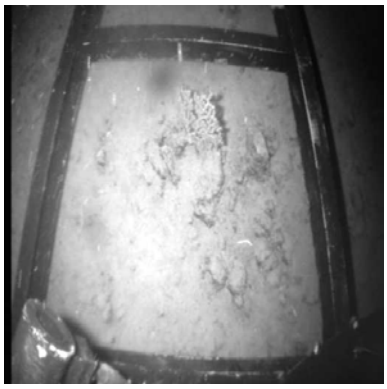


Site 49RD
Rig lying on seabed at an angle of 26 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration steady and slow to 0.8m then stepped to no further progress at 1.33m where bit blocked.
Recovery 0.55m of core, most likely from within the top 0.75m of coring.

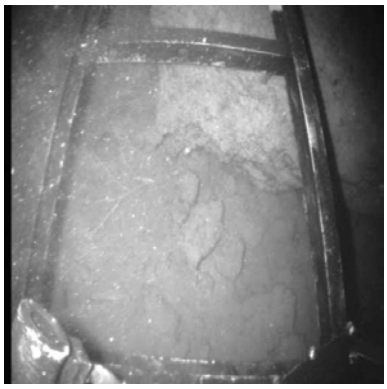




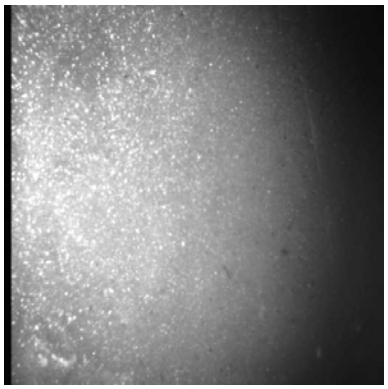
Site 50RD
Rig lying on seabed at an angle of 25 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration steady, slight variation and then slowing to continuous stalling at 1.64m so retract. Penetration indication shown on retract.
Recovery 0.25m of rubbly core most likely from within the top 0.75m of coring. Core barrel bent – hence torque build-up and RPM decrease.



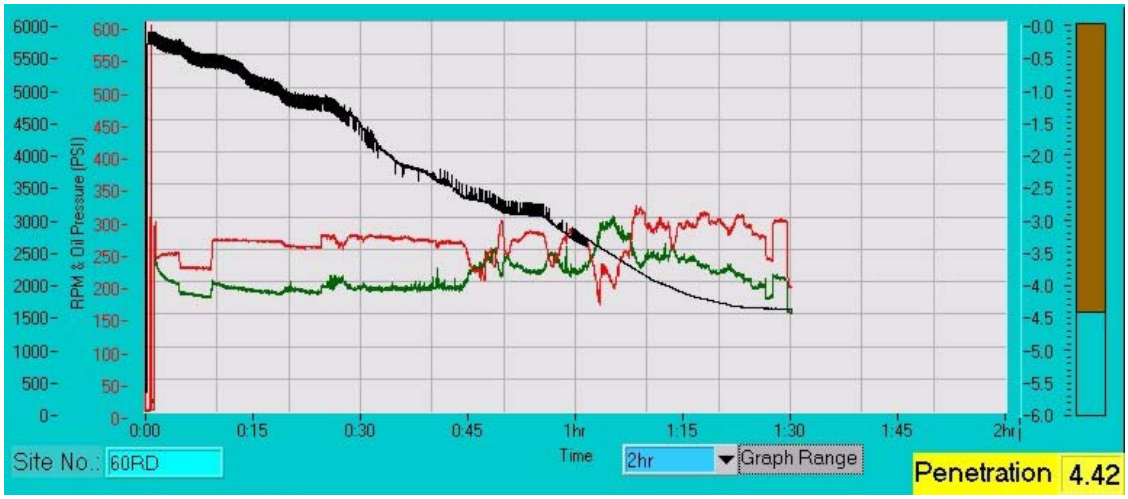
Site 51RD
Rig lying on seabed at an angle of 20 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration steady to 1.0m then steady but slower with probable bit blockage. Stop at 1.43m penetration, variation in bit weight or RPM makes no difference.
Recovery 0.30m of rubbly core, which could have come from the bottom below 1.0m coring depth.

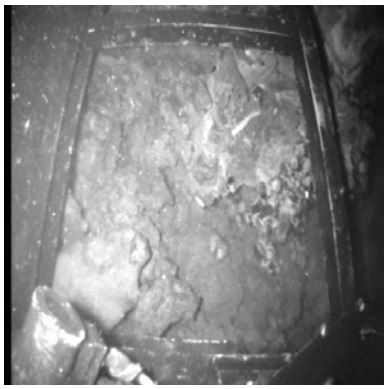


Site 52RD
Rig lying on rubbly seabed at an angle of 12 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration steady and fast with little torque to full penetration of 5m.
Recovery 0.0m with only some grey smearing on face of bit. All very soft/granular.



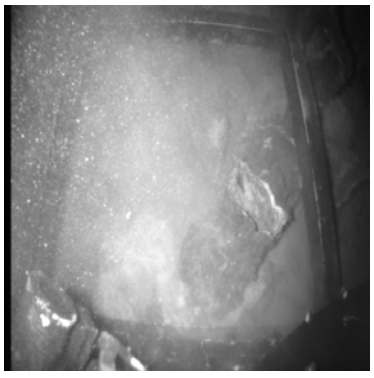
Site 57RD
Rig lying on seabed at an angle of 25 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration fast with two stops. No evidence of coring at any stage and no penetration and probable bit blockage at 1.46m. Drill tending to stall condition at end of core run.
Recovery 0.10m of pebbles, which could have come from the top of the core run.



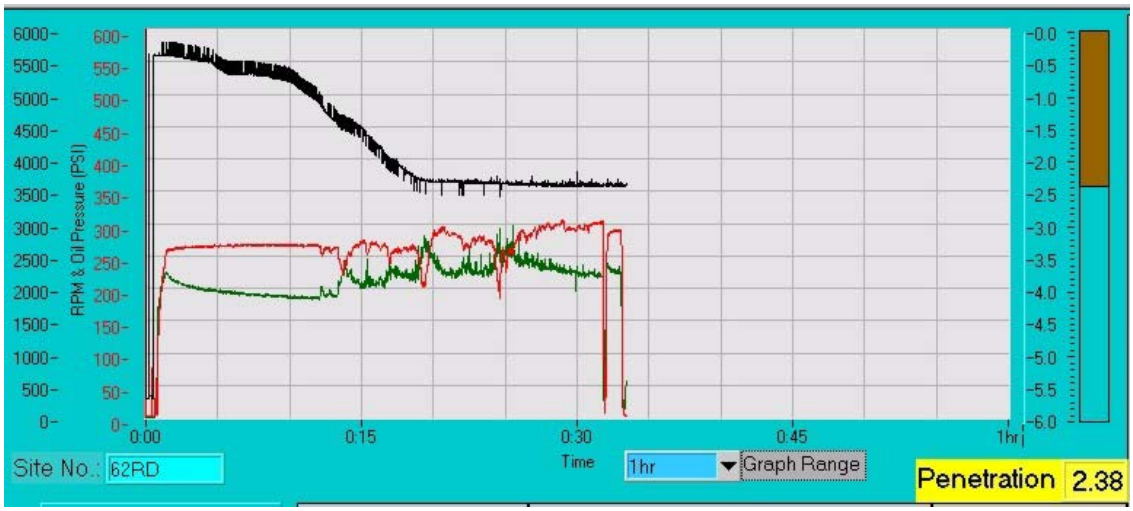


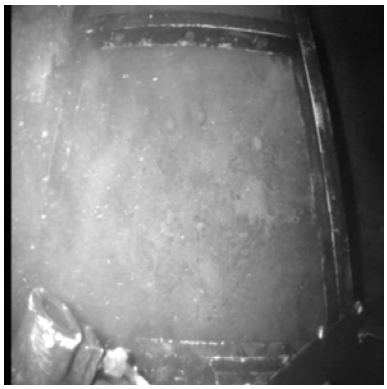
Site 60RD
Rig lying on seabed at an angle of 25 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration fast then slower throughout first 3.0m then fast to refusal and probable bit blocking at 4.42m penetration.
Recovery 0.9m of rubble and core, which has most likely come from above 3m. coring depth.

Two pre-land photos taken in area of site RD61 showing sulphide chimneys. The rig was not landed at either of those positions.

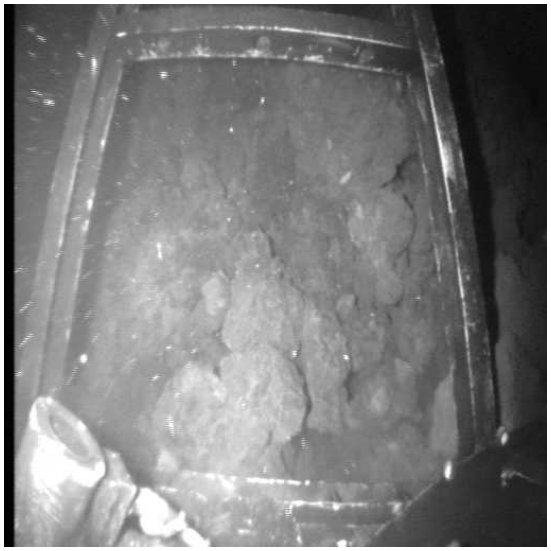


Site 61RD
Rig lying on seabed at an angle of 17 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration slow with little bit weight to 0.75m then faster to refusal at 2.77m where bit blocked off.
Recovery 1.4m of mineralised core, which could have come from the top 2m of coring depth.

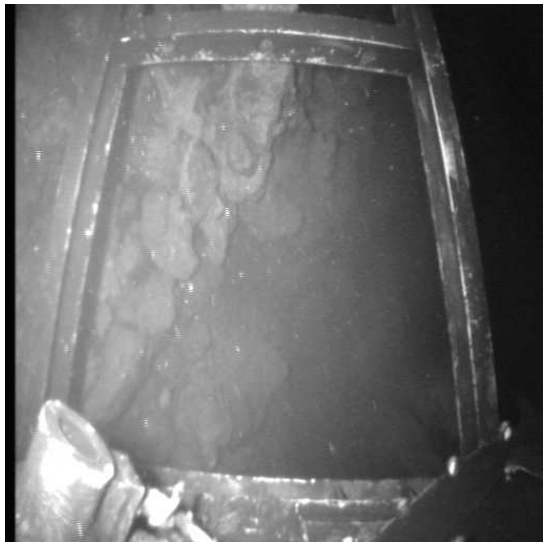




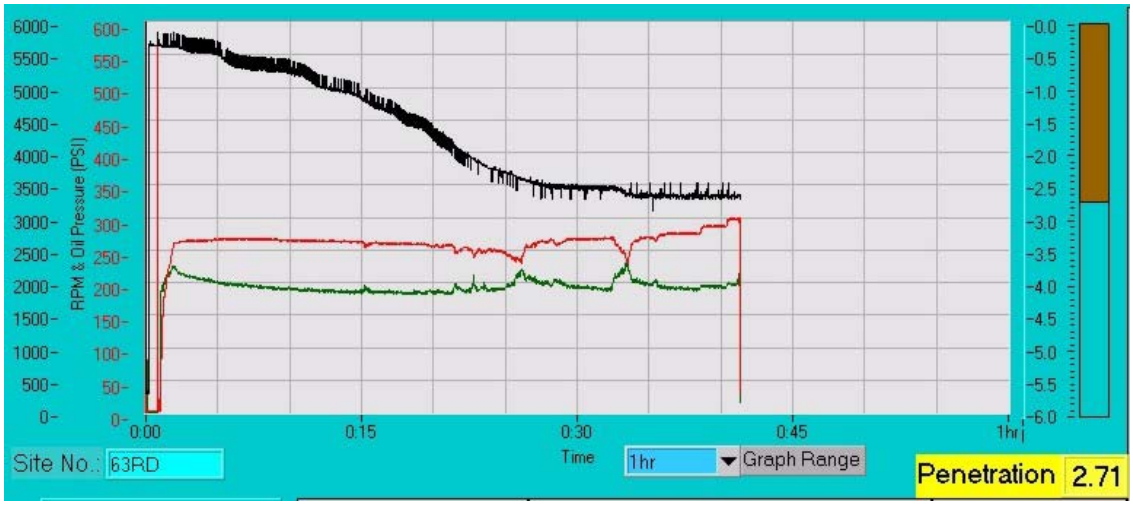
Site 62RD
Rig lying on seabed at an angle of 17 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration slow with one step to 0.7m then faster to 2.4m then slows to a stop with probable bit blockage at 2.43m penetration.
Recovery 0.35m of rubbly core which most likely came from the top 0.7m of coring depth.

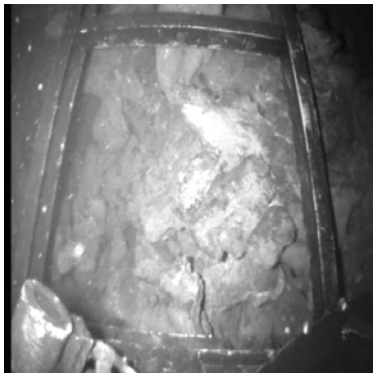


Pre land photo at Site RD63. Rig Landed on rubbly surface.

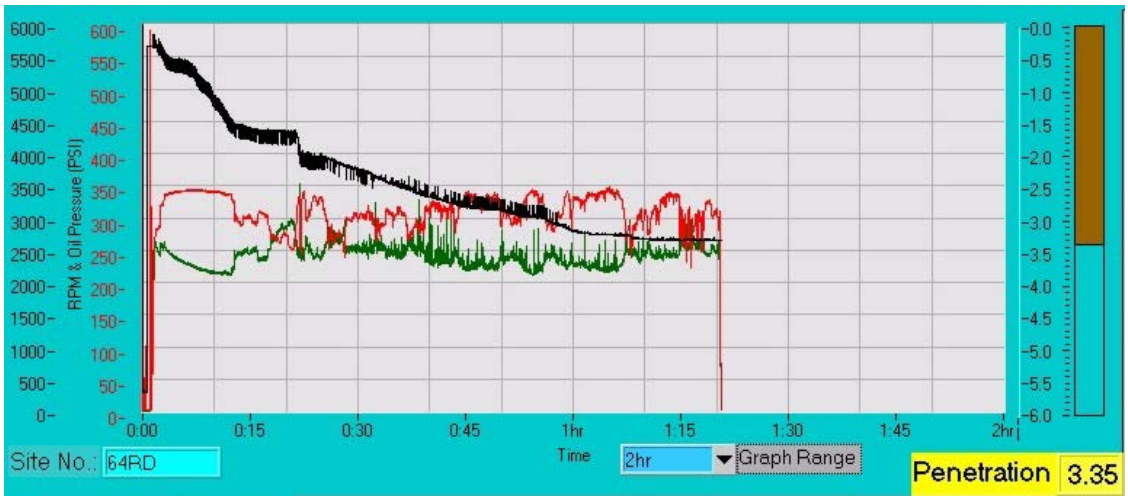


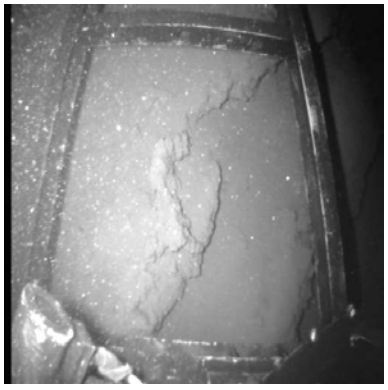
Pre land Photo at Site RD65, ? fallen over chimney, on slope. Rig did not land.



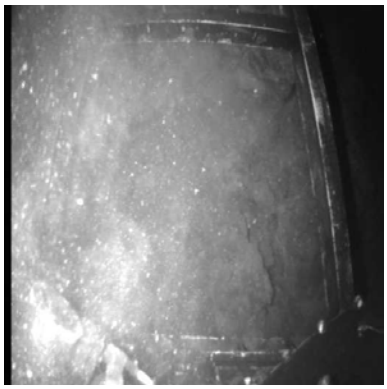


Site 63RD
Rig lying on seabed at an angle of 24 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration stepped to 1.0m then steady but faster to 2.5m and probable bit blockage. Stop at 2.71m penetration as no further progress.
Recovery 0.50m of rubbly, fractured core which most likely came from the top part of the coring depth.

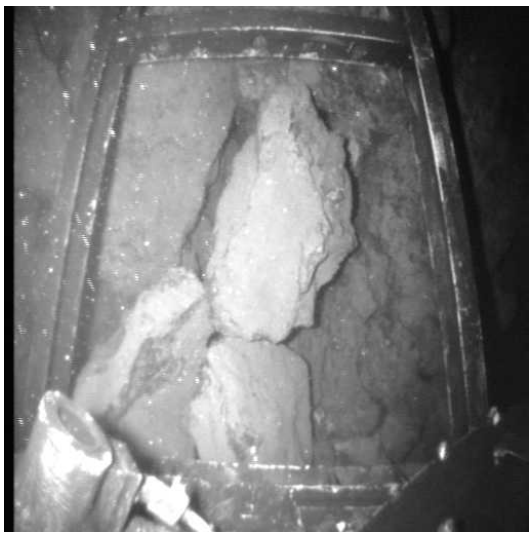




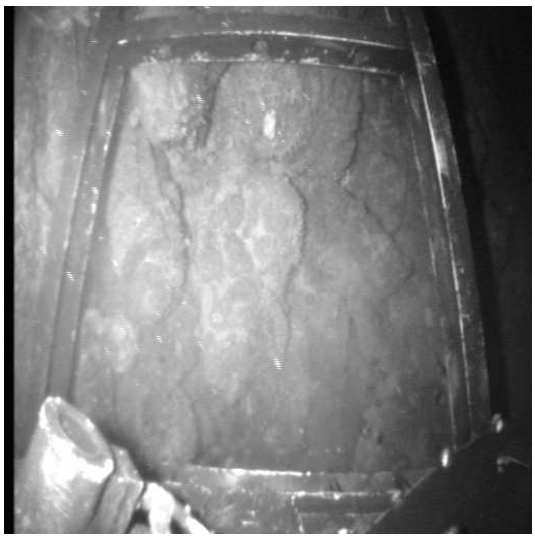
Site 64RD
Rig lying on seabed at an angle of 14 degrees to vertical. A G9 impregnated diamond bit used.
Penetration fast to step at 0.7m, fast again to step at 1.7m then slower, steady coring to probable bit blockage and refusal at 3.35m.
Recovery 2.2m of fractured, mineralised core, which probably came from the steps and bottom part of the coring run.



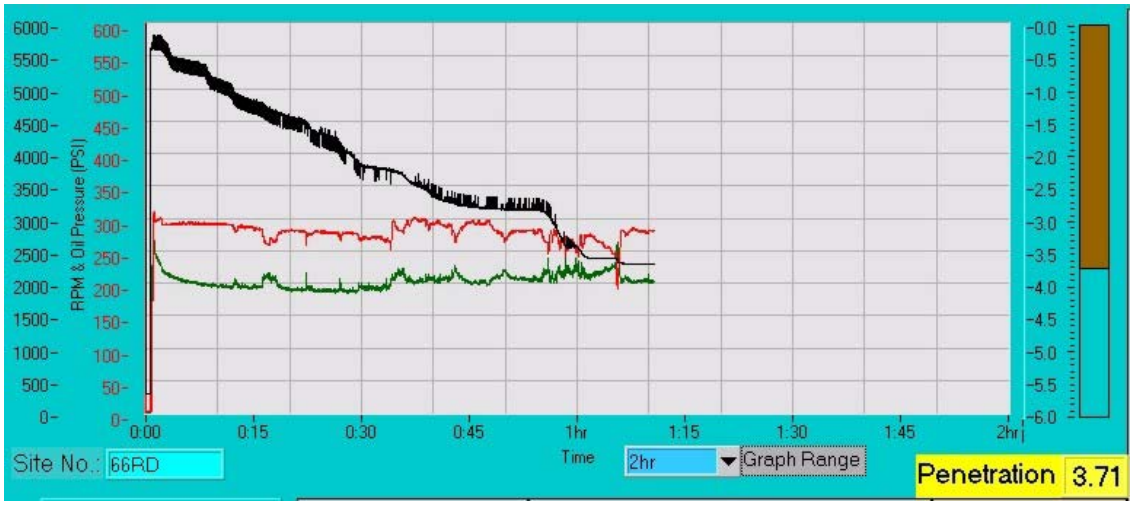
Site 65RD
Rig lying on seabed at an angle of 25 degrees to vertical. A G9 impregnated diamond bit used. Penetration variable to 1.0m then steadier and slower to 1.4m then steady but fast to refusal with probable bit blockage at 4.42m.
Recovery 0.40m of mineralised core which probably came from above 1.4m coring depth.

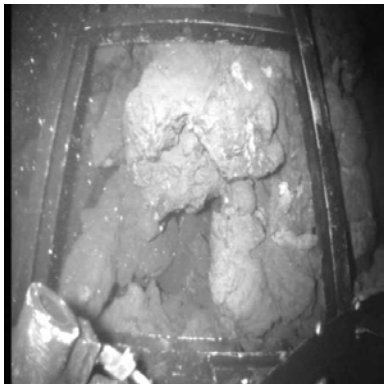


Pre land Photo at Site 66RD. Rig landed and operated on boulder field.

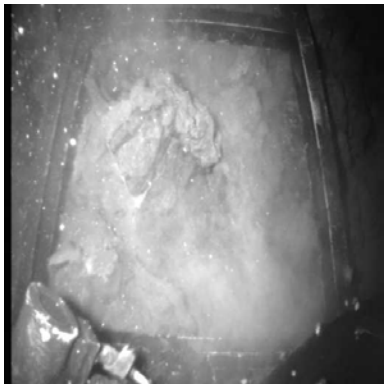


Pre land Photo at Site 69RD. Rig did not land on rough, sloping seabed.

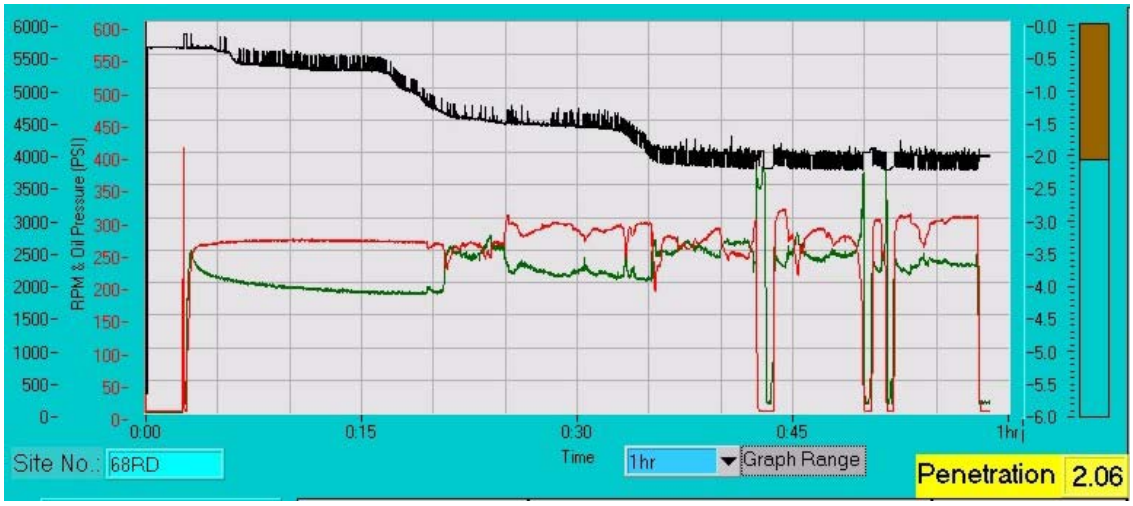


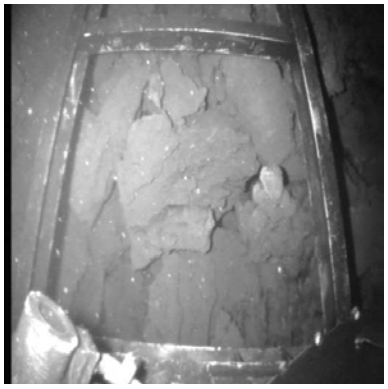


Site 66RD
Rig lying on seabed at an angle of 6 degrees to vertical. A G9 impregnated diamond bit used.
Penetration steady with minor blockages to 2.25m then slower to 2.8m the fast to bit blocking at 3.71m.
Recovery 0.80m of mineralised core, which could have been collected from throughout the core run above 2.8m depth.



Site 67RD
Rig lying on seabed at an angle of 8 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration steady with some bit blocking or harder areas to 2.2m then steady but faster to maximum penetration possible of 5.0m
Recovery 1.90m of fractured core which most probably came from above 2.5m coring depth.

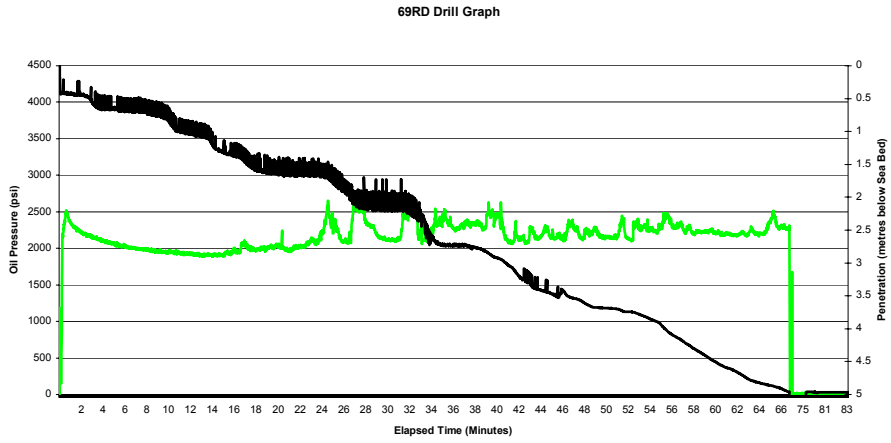


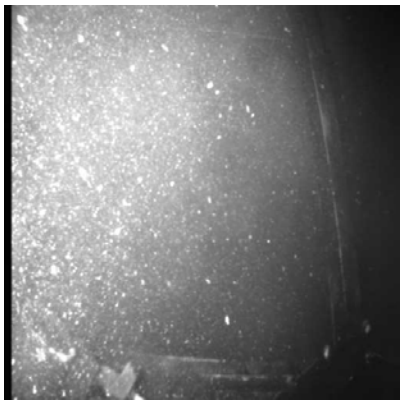


Site 68RD

Rig lying on seabed at an angle of 24 degrees to vertical. A stepped profile surface set diamond bit used.

Penetration in steps with periods of no progress probably due to bit blocking in between each. Final penetration 2.27m (base of graph curve) achieved after stalling and restarting twice. Bit may not be blocked. Recovery 0.42m of mineralised core, which could have come from anywhere in the core run.

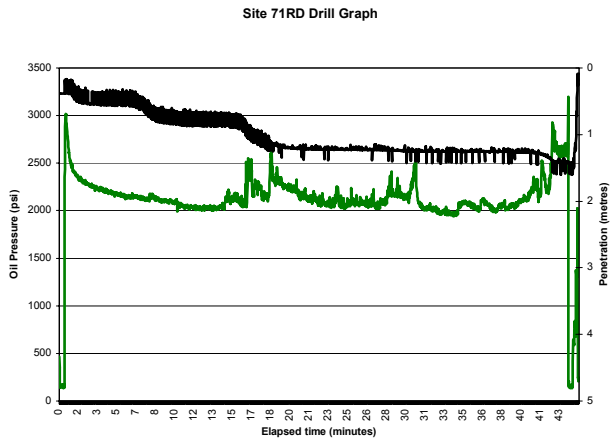


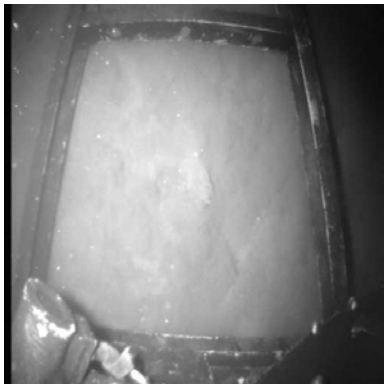


Site 69RD

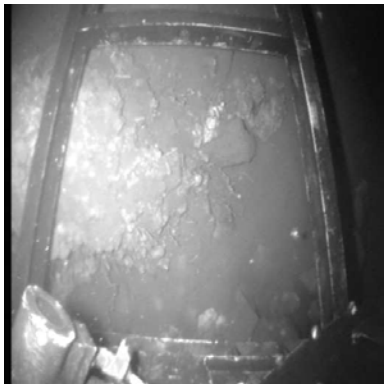
Rig lying on seabed at an angle of 21 degrees to vertical. A stepped profile surface set diamond bit used.

Penetration in steps with periods of no progress probably due to bit blocking in between each. Penetration of 4.96m achieved before electric trip cut all power to system. Unable to restart and pull out without retraction. Graph from log data). Recovery 2.2m of mineralised core, which could have come from anywhere in the core run.

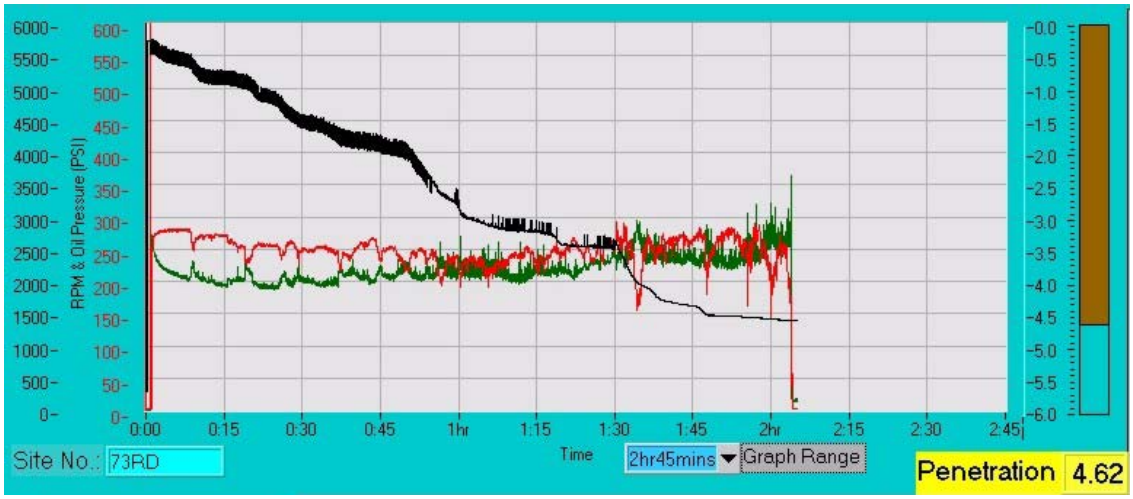


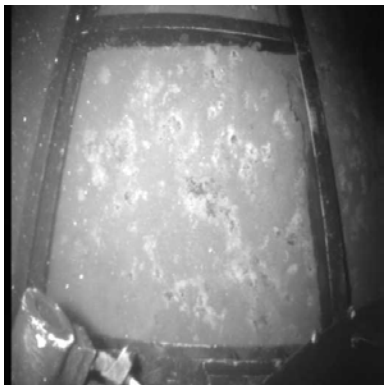


Site 71RD
Rig lying on seabed at an angle of 23 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration in fast/slow steps to 1.3m then rig tipped over, power tripped out and recovery made. Graph taken from data log.
Recovery 0.26m of fractured core, which could have come from anywhere in the core run.

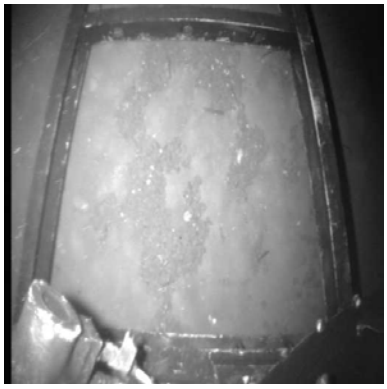


Site 72RD
Rig lying on seabed at an angle of 7 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration variable fast/slow and stepped to 1m indicating bit blocking and clearing. Then final bit blockage and no progress after 1.15m (base of graph line).
Recovery 0.17m of fractured core, which could have come from anywhere in the coring run.





Site 73RD
Rig on seabed at an angle of 21 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration steady but with bit blocking to 2.0m then faster but still with bit blocking to final penetration of 4.62m where torque increasing and RPM decreasing indicting possible hole stability problem.
Recovery 0.80m of fractured core, probably recovered from above 2.0m and between 3.0 & 3.5m coring depths.



Site 74RD
Rig lying on seabed at an angle of 12 degrees to vertical. A stepped profile surface set diamond bit used.
Penetration steady but fast after initial blockage or harder material until 3.0m then slower and refusal to progress, presumably with bit blocking, after 3.2m.
Recovery 0.25m of fractured core, which could have come from anywhere in the core run but most likely from the top or base.

Glossary

BGS - British Geological Survey

ODP – Ocean Drilling Programme

OFOS – Ocean Floor Observation System

PACMANUS – Papua New Guinea, Australia, Canada, Manus (Survey Area)

S.D.L. – Safe design Load

TU Freiberg – Freiberg University of Mining and Technology

TV Grab – Hydraulically operated mechanical grab with TV camera inside to observe target area

BGS Marine Operations and Engineering
2a Nivensknowe Road
Loanhead
Midlothian
EH20 9AU
Scotland

☎ +44 (0)131 448 2700
Fax +44(0)131 448 2545