Exploration of the sea bed in deep water is a technically demanding operation. **Michael Wilson** describes how the BGS is continuing to rise to the challenge.

Drilling at sea

Over the past 30 years our Marine Operations Unit has worked successfully on many scientific and commercial projects worldwide, from the Arctic to Antarctic, and the North Sea to the South Pacific. During this time we have gained a wealth of knowledge, experience and expertise in the development and operation of some of the world's most advanced and successful sea-bed sampling tools.

The BGS has successfully developed and operated a range of subsea equipment enabling the collection of samples for geological site surveys and ground-truthing seismic data. With ever-increasing requirements from the scientific and commercial communities we have endeavoured to maintain our position at the forefront of sampling technology. We currently possess two methods for recovery of sea-bed cores: remote sea-bed rigs deployable from ships of opportunity and wireline technology used from drillships.

New BGS fifteen-metre sea-bed drill.

Remote sea-bed rigs are self-contained drill systems, controlled from the surface. They are lowered on an umbilical cable that provides combined control, communications, power and hoist capability. The current winch enables the rigs to be deployed to a maximum water depth of 2000 m. These drills can be used in lieu of expensive drillships in areas where simple ground truthing of a hard sea bed is sufficient. They are also able in many cases to provide a 'first look' in areas that are too remote or inaccessible for conventional drillships, such as the Arctic or Antarctic.

The first of the current remote rockdrills developed was the five-metre rockdrill (RD1). Work commenced in 1982 to replace our first operational drill, the one-metre midi-drill with a larger and deeper diving system. The development used the frame design of our own six-metre vibrocorer, designed to recover cores of soft and unconsolidated sediment, which uses a one-ton weight and vibrator motor mounted at the top of a core barrel.

The resulting design created a single-shot, bottom-drive, rotary rockdrill with five-metre penetration. It also has a vibrocoring option and is capable of drilling in water depths of 2000 m.

Development has been continuous, as technologies have improved. For example:

Five-metre rockdrill in Antarctica.

- 2000 — new control software and PC-based subsea electronics upgrade
- 2002 — addition of a camera allowed a snapshot of the sea bed to be transmitted to the surface
- 2004 — use of fibre optics in the umbilical cable allowed transmission of real-time video, affording geologists and drill operators a greater chance of landing on more favourable sample sites
- 2005 — replacement of subsea electrical connectors.

With over 1500 rock cores recovered, this drill has proved itself as probably the most successful remote sea-bed rockdrill in the world.

The next evolution in sampling for us is our 15 m multibarrelled rockdrill (RD2), which uses mining and remote operated vehicle (ROV) technology. Following

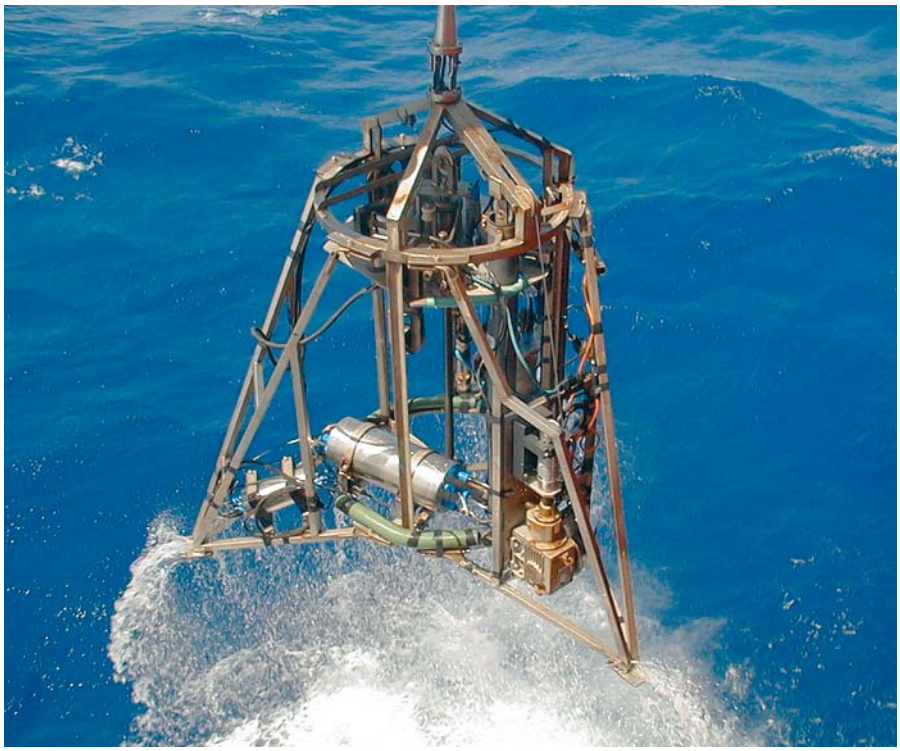
trials in the Firth of Forth the drill will be in service in early to mid 2006. This drill has been created to increase our coring capability and address limitations of the single-shot drills. Single-shot drills contain one drill barrel, which may be stopped during drilling by a fault in the rock, if this occurs the drill is then usually unable to continue the borehole and must be recovered to the ship.

Our multibarrel system has the advantage of having ten 1.5 metre core barrels, which in normal operation will be used in succession to penetrate to 15 m. If a jam occurs, the core barrel can be retracted and replaced with a fresh barrel without the rig returning to the ship. This drill will be capable of working in a water depth of 3000 m (though it will be limited to 2000 m with our current winch).

The orientated rockdrill is our deepest diving drill and has recovered core from 3950 m. It has dived to 4500 m but, unfortunately, the geologists could not find us any hard rock to sample, so we only managed to bring back pictures. It is unique in the world as it allows the core's orientation to be referenced to a compass heading thereby allowing paleomagnetic analysis of the recovered core.

We hope, subject to funding, to upgrade this drill to extend its maximum working depth from 4500 m to 5500 m. This will involve the replacement of the stainless steel electronics bottles rated to 4500 m by titanium ones rated for 5500 m due to the winch cables' weight limitations.

Where the depth of the borehole is beyond the remote drill rig's capability, a drillship using wireline core retrieval techniques is used. This method is more expensive but it offers the ability to sample hundreds of metres below the sea bed. It combines techniques using oilfield drillstrings deployed from drillships, mining and geotechnical coring tools, and the proven technology of wireline retrieval. We have developed and continually upgraded a suite of coring tools, and interchangeable inner core barrels that have proven themselves on many projects, the most recent of which was the ground-breaking Arctic Coring Operation (ACEX) in 2004.



BGS one-metre orientated drill.

With wireline, an inner core barrel is dropped down (under free fall) the centre of the drillstring through the drill fluid. Once at the bottom it locks in place. When the coring operation to fill the inner core barrel is complete, a retrieval tool is lowered down the drillstring on a wire (hence wireline). The tool captures and locks on to the top of the core barrel and on retraction of the tool the mechanism holding the core barrel in place is unlocked, allowing it to be pulled back to the surface. The advantage of this method is that different inner core barrels can be used to cope with varying geology.

The current inner core barrels options available are:

- piston core barrel for soft formations
- push core barrel for soft to firm and non-cohesive formations
- push core rotating barrel for firm and non-cohesive formations
- non-rotating inner core barrel for consolidated soils and rock formations
- multipurpose insert rod, allowing sensors to be carried down the drillstring or a drill bit to be placed at the core opening for drilling with no core collection.

The subsea coring equipment was primarily developed for our regional offshore geological mapping, but over time it has also been deployed for many clients including:

- Bristol University, sampling around Montserrat for volcanic dome-collapse material
- British Antarctic Survey
- De Beers Marine South Africa
- Danish Geological Survey
- Integrated Ocean Drilling Program (IODP) in the Arctic (ACEX)
- STATOIL North Sea
- IFM GEOMAR University of Kiel (working off Costa Rica)
- University of Freiberg (working off Papua New Guinea)
- Straits of Gibraltar Bridge/Tunnel Project for SEGECSA
- various oil companies and the BGS/PIP Rockall Consortia for deep water stratigraphical research.

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