# Heavy metal meets hard rock

Recovering an intact section of ocean crust has been an elusive goal of scientific ocean drilling for decades. **Damon Teagle** is one of the leaders of the international team who boldly went where no one had gone before.

In the late 1950s, in tandem with the nascent space race, a team of US scientists attempted to drill into the Earth's mantle. The endeavour, known as Project MoHole, failed. While the space race reached dizzy heights culminating in the moon landings in 1969, deep ocean drilling on this scale stagnated in a political quagmire and sampling a complete section of intact ocean crust remained a long unfulfilled ambition of scientists worldwide.

Over 50 years have passed since MoHole, named after the boundary between the Earth's crust and the mantle – the Mohoroviãiç Discontinuity or 'Moho'. In late 2005, the Integrated Ocean Drilling Program, funded by NERC in the UK, finally achieved one of Project MoHole's important milestones. Scientists onboard the US ship JOIDES Resolution drilled beneath the Pacific for six months to recover the first intact section of upper oceanic crust – the layer below the sediment that makes up the seafloor.

UK scientists have been pivotal in drilling this hole, which penetrates completely through the lavas that once erupted onto the ocean floor, down through the magma feeder dikes below, and into gabbros. These are coarse-grained rocks that slowly crystallise in magma chambers beneath the mid-ocean ridges. The gabbros cores provide new information on the processes that form the ocean crust and about the intensity of ocean floor geothermal activity that leads to spectacular black smoker chimneys – hot water vents, rich in minerals. Cores to this depth can also reveal insights into the hydrothermal consequences of adding very large amounts of red-hot, molten magma to the crust beneath the oceans.

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The Earth's crust varies in thickness. Beneath continental crust and mountain ranges it can extend 70 kilometres down, but beneath the oceans it is a more reasonable 7 kilometres on average. New crust forms at mid-ocean ridges and, through plate tectonics, it spreads out to cover 60 percent of our planet. We know all of the ocean crust formed within the past 200 million years but we have little knowledge of how it is actually constructed. One of the major


*Assembled scientists and operational staff celebrate recovery of a complete five metre core of gabbro. Damon Teagle is far left.*

*Before and after. The team went through 20 massive drill bits.*

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*'Drilling to gabbro in intact ocean crust'* Science *312:1016-1020. 19 May 2006.*

*Damon Teagle sailed on all three cruises, twice as Co-Chief Scientist, and was joined by two graduate students Roz Coggon and Chris Smith-Duque. Other UK scientists involved in this project include petrologists Sally Morgan based at the University of Leeds and John MacLennan based in Edinburgh and Cambridge. Also wire-line geophysical loggers Samantha Barr and Mark Reichow, from the University of Leicester.*

impediments to understanding the enormous volcanic processes at work has been our lack of access to continuous sections of ocean crust.

Previous drilling in the oceans has shown that mid-ocean ridge basalts are highly fractured, extremely hard, and very difficult to core. Doug Wilson of the University of California Santa Barbara devised a strategy to minimise these difficulties by identifying intact crust where gabbros would be closest to the surface. We targeted a region of the eastern Pacific Ocean that formed 15 million years ago during a period of superfast spreading on the East Pacific Rise. Superfast means more than 20 centimetres a year. When geologists fired acoustic waves into the crust to find out the structure of the site, the acoustic waves passed through a region deep beneath the sea floor much faster than scientists would normally expect. This led us to believe we were looking at magma chambers that had formed at shallower depths beneath these faster spreading ridges.

We positioned the ship over the site and started work. Drilling took over 140 days in water 3.6 kilometres deep. The hole is now over 1.6 kilometres in length. It took more than 20 massive hard rock drill bits but eventually we recovered the gabbros. At only 1.5 kilometres below the seafloor, it confirmed our predictions that magma chambers occur at very shallow levels in crust formed during fast spreading rates.

The gabbros we found have chemical compositions very similar to the overlying lavas. Models show that lavas erupted on the ocean floor are chemically distilled or 'fractionated' compared with lavas formed by the partial melting of the mantle. All the gabbros we sampled from the ocean floor were fractionated. Somewhere in the crust there are magma chambers where this fractionation must have taken place.

The size, location and geometry of these magma chambers are key to understanding how new crust forms at the mid-ocean ridges as well as helping understand what controls black smokers. Gabbros made up of the crystal residues from magmatic fractionation must be deeper than the bottom of our hole. These gabbros are now within reach and could be cored in a single future expedition to deepen the hole. Our proposal for a prompt return to this site has passed through the Integrated Ocean Drilling program's peer-review process and we await scheduling, hopefully early in the next phase of operations. ❖