Ring of fire

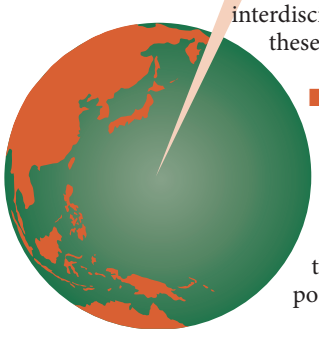
Verena Tunnicliffe, Robert W. Embley and their colleagues sank their remotely operated vehicle into a boiling pool of molten sulphur in their vigour to sample the deep ocean floor.

What was the objective of the work?

The 'Submarine Ring of Fire' programme was funded by the NOAA Ocean Exploration programme; the Mariana Volcanic Arc promised to be a fruitful target — only a few submarine volcanoes were well mapped and only a handful actually visited. Between 2003 and 2006, we mapped the arc with seafloor sonar systems and water column instrument packages. We discovered some extraordinary sites during the dives of remotely operated vehicles (ROV) to twelve volcanoes. These included an underwater erupting volcano, liquid carbon dioxide emerging from lava flows, bubbling liquid sulphur lakes at 44 times the atmospheric pressure, and an extraordinary array of exotic biology adapted to extreme conditions. In 2006, we targeted the carbon-dioxide-rich northwest Eifuku volcano for further study of the mussels.

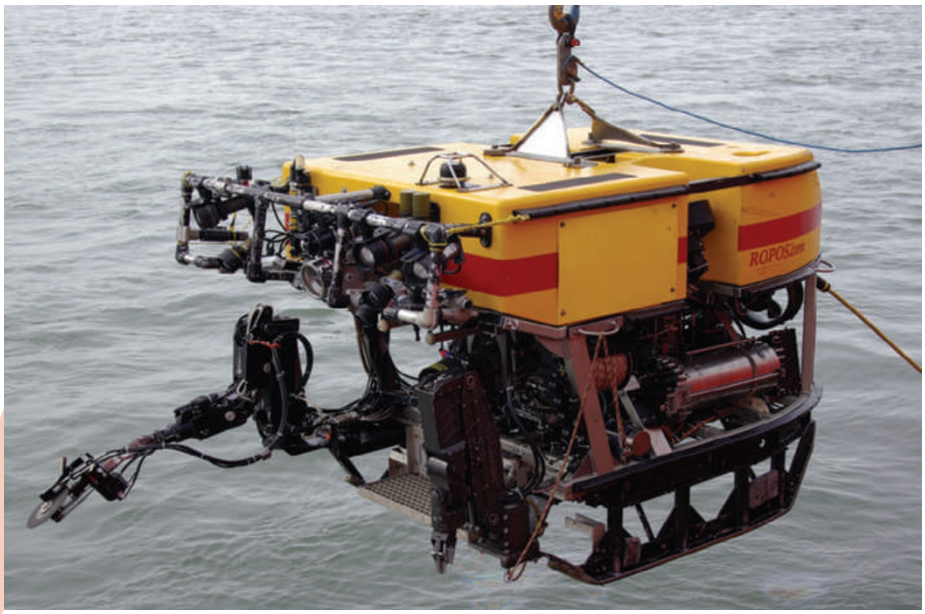
How did you collect your samples?

We used deep-sea submersibles to collect samples at hot vents and volcanoes. In this case, we used two ROVs designed for scientific studies — *ROPOS* (from the Canadian Scientific Submersible Facility) and *Jason-II* (from Woods Hole Oceanographic Institution) — which were lowered on fibre-optic cables from a surface ship. Dedicated operators piloted the ROVs using seafloor navigation linked to the maps we provided. Considerable training is needed to use force-feedback manipulators to sample. Imagine using a remote arm to place a sample hose into a 2-cm-wide vent opening, or to collect delicate shells using only a two-dimensional video stream to see. In the 'control van' on the ship's deck, the science team gathered behind the pilots, directing the dive, collecting imagery and logging observations and samples. It is a shared experience, made all the richer by the interdisciplinary teams on these cruises.



Did you encounter any dangerous situations?

Dangerous situations are the mark of poor planning or inattention. Ultimately, the ship's captain can overrule zealous scientists in the event of hazards (such as the typhoon that was chasing us). We used ROVs to study these volcanoes because some settings are too dangerous for manned submersibles. On the volcano adjacent to northwest Eifuku, we encountered boiling pools of molten sulphur at 175 °C. In our preoccupation, we did not realise that the bottom of the ROV had broken through the crust and was embedded in the congealing sulphur; eventually, the ship pulled it free. The pilots made the scientists chip the sticking mess off the ROV — a definite low point of the cruise.



ROVing the sea floor. A remotely operated vehicle (ROV) is carefully lowered into the water on its way to exploring the secrets of the Mariana arc.

What was the highlight of the expedition?

The fact that the ocean can still hold so many surprises was astonishing, even to a team of seasoned deep-sea scientists. In January 2009, President George W. Bush created the Mariana Trench Marine National Monument, which includes a large swath of the deep ocean trench, a large area surrounding the three northern islands and the summits of 22 submarine volcanoes including the northwest Eifuku volcano. Our work along the arc helped to provide the rationale to appreciate and protect an extraordinary geological setting with associated chemical and biological wonders.

Did you learn anything new about yourselves?

We learnt that we love the process of discovery. The uncertainty of exploration is not for everyone — our team excels in adapting and exploiting new opportunities. As we saw more of the human effects on the oceans, we also considered how to contribute more to awareness of and solutions to anthropogenic ocean change. Without a better understanding of the physical and biological systems along the Mariana arc, virtually unknown before the Submarine Ring of Fire Ocean Exploration programme, there would have been far less information to make informed decisions about the extent and coverage of the new monument.

This is the Backstory to the work by Verena Tunnicliffe and colleagues, published on page 344 of this issue.