Vicky Wong

Exploring the deep ocean

Discovering hydrothermal vents

There are not many places left on Earth which have not been explored. Humans have been to the top of the highest mountains and to every continent. But under the sea it is another matter. We know a very limited amount about the depths of the oceans and the creatures that live there.

The oceans are extremely deep in parts. The deepest known area is the Mariana Trench in the Pacific Ocean. This has been measured to be over 10 km deep, although some measurements suggest it may be more than 11 km deep. The pressure exerted at these depths is over 1000 times atmospheric pressure at sea level. We might imagine that the seabed is flat or gently sloping, but the longest mountain range on the planet is under the Atlantic Ocean.

Exploring the depths

Exploring in this environment is not a straightforward matter. For those who dive as a hobby, 30 m is the deepest recommended; specialist diving suits help withstand the pressure to 600 m. Deep sea submersible research vessels are required to dive anywhere deep enough for exploration of the ocean depths.

The two Mir research vessels can be used to depths of 6 km which allows them to reach 98% of the ocean floor. This allows scientists to observe the deep sea through multiple view ports, video records, instrument placement, sample collecting, and environmental monitoring. They have manipulator arms which allow them to collect samples. By contrast, Jason is a remote operated research vessel, so the scientists stay on board the ship and control it from there.

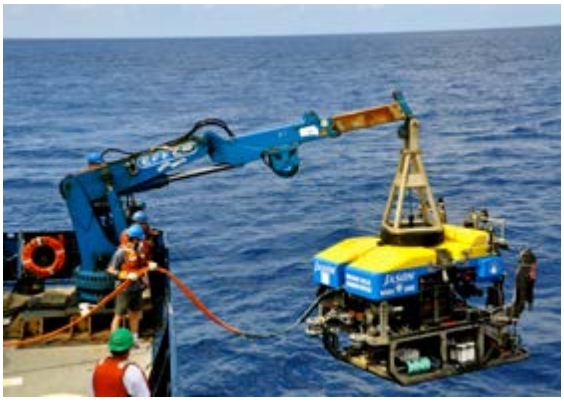
Dark discoveries

In the late 1970s, scientists using deep sea vessels found vents on the ocean floor which were gushing out hot water. These hydrothermal (hot water) vents form along mid-ocean ridges. A mid-ocean ridge is where the Earth's tectonic plates are moving apart, usually at a rate of about 6-18 cm a year. Magma wells up from below forming new crust. Cold ocean water in some places seeps through cracks in the sea floor to hot spots below, where it is heated and then forced back out. While inside the Earth's crust many minerals are dissolved in the hot water.

Sometimes in very hot vents the emerging water turns black forming what is known as a black smoker. These contain dissolved sulfides (sulfur compounds) of metals such as iron and copper. These instantly precipitate out of solution when they come into contact with the cold surrounding water and form tall chimneys.

The Mir explorer can reach 6000 m and carry three passengers.

The Mariana trench is deeper than Mt Everest is high; Everest is 8.8 km.



Jason is a remotely operated deep sea vessel.

The photo on pages 10-11 shows a black smoker hydrothermal vent along the Juan de Fuca Ridge in the Pacific Ocean.

Deep on the Pacific seabed, scientific instruments monitor a black smoker vent encrusted with tube worms.

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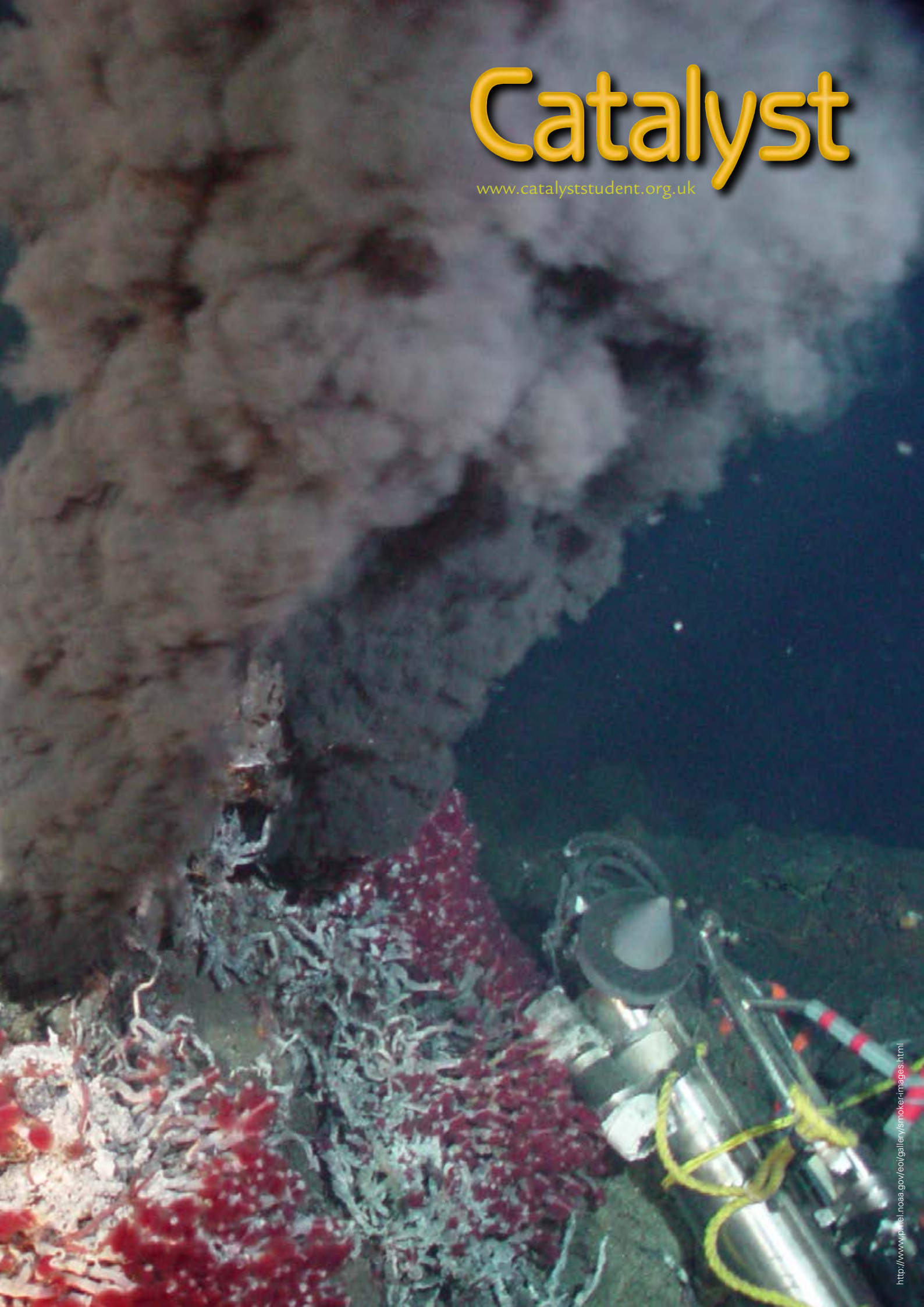

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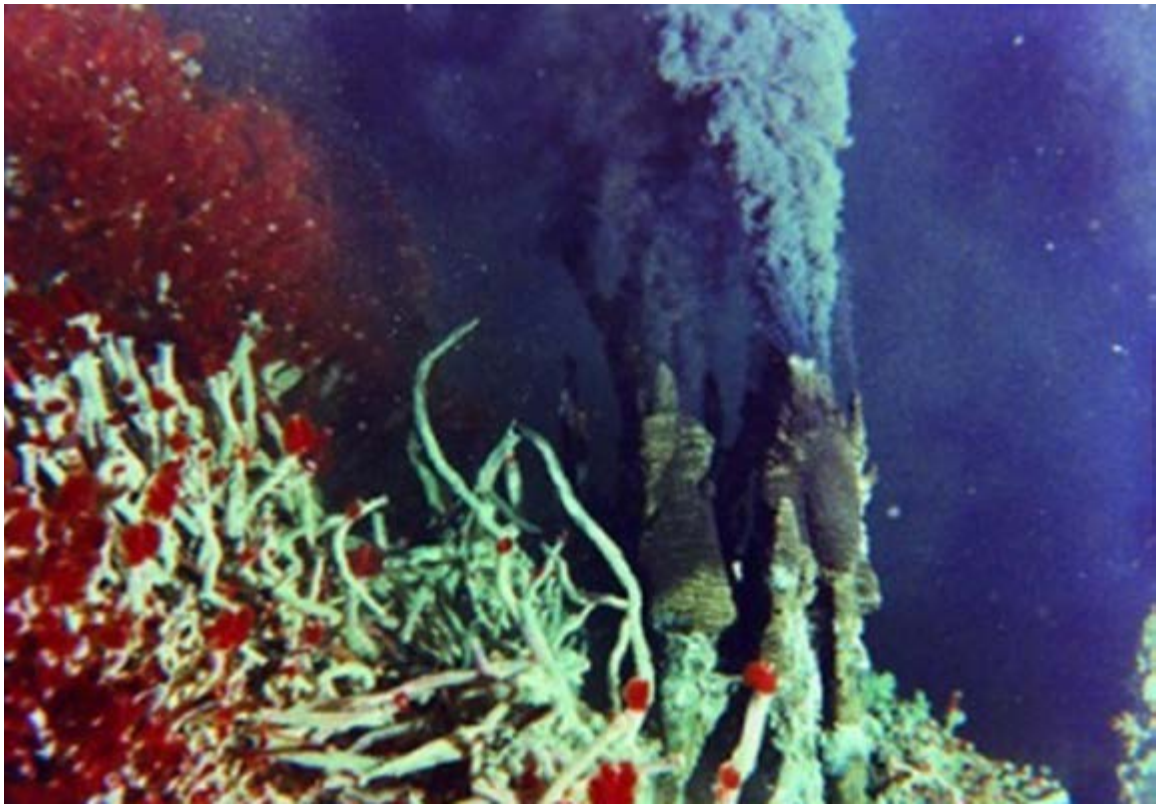


Giant tube worms next to a black smoker

In the deep mid-ocean

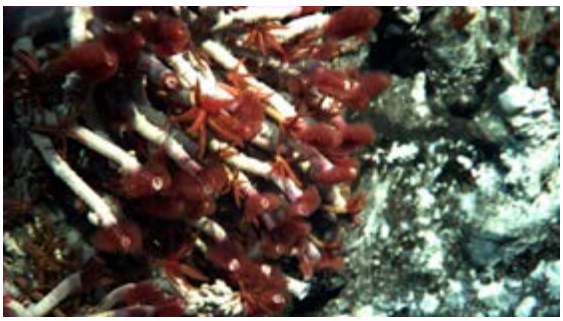
The presence of hydrothermal vents had been predicted by an increasing understanding of plate tectonics, but they had never been seen before. This was exciting enough, but the scientists found that the area around the vents was full of extraordinary and unexpected life.

Up to this point it had been assumed that all life on Earth was dependent on photosynthesis from plants and energy from the Sun. Food chains all ultimately led back to plants and the Sun. But these life forms and food chains were different. It was far too deep for light from the surface to penetrate so they could not be using photosynthesis.

The food chain starts with bacteria living in and around the vents which extract their energy from hydrogen sulfide (HS) and other molecules in the water, giving out the element sulfur as a by-product as plants give out oxygen. Where plants use photosynthesis, these bacteria use chemosynthesis. Just like plants, the bacteria use this energy to build sugars out of carbon dioxide and water. The sugars then provide the fuel and raw material for the rest of the microbe's activities.

Up the food chain

These deep-sea bacteria form the base of a varied food chain that includes shrimps, tube worms, clams, fish, crabs, and octopi. All of these animals must be adapted to endure the extreme environment of the vents – complete darkness; water temperatures ranging from 2°C (in ambient seawater) to about 400°C (at the vent openings); pressures hundreds of times that at sea level; and high concentrations of sulfides and other noxious chemicals.



Tube worms are often found near hydrothermal vents. They do not eat but contain bacteria which provide them with all they need. They never leave their tubes which provide protection from the extreme environment.

The chemistry from these organisms is of great interest. One of the enzymes from heat-loving microbes is used in DNA fingerprinting and other uses are almost certain to follow.

The image on pages 10-11 shows a black smoker hydrothermal vent. Around the base is a colony of tube worms. There are two instruments which have been placed there by scientists. One is a hydrophone to record the sound of the vent; the other a probe to monitor some of the chemistry of the water.

The ocean floor remains largely unexplored – the last great frontier for discovery on Earth.

Vicky Wong is Chemistry editor of Catalyst. All photos courtesy NOAA.

Look here!

To find out more about exploring the deep sea: *http://tinyurl.com/ntmadtu*