At the rock face of mid-oceanic geology

ROV Technology

Smoking may damage your health

At 407°, the water from the hydrothermal vent is no longer a fluid. Picture courtesy of Marum

In mid-2006, the Quest 5 ROV from Schilling Robotics played an instrumental rôle in a major multinational research deep sea project investigating seafloor spreading. A highlight of the project was a special thermometer probe held by the ROV, which measured an astounding 407 degC in the deep sea.

The work was carried out as part of Meteor Cruise 68 project, along the Mid-Atlantic ridge at 5° south. At the study area, the African and South American plates diverge at a rate of about 4cm/yr. Magma therefore lies very close to the ocean floor and heats the sea water, which circulates through cracks in the sea bed. A common geomorphological feature of this spreading ridge are hydrothermal vents, more colloquially known as *black smokers*. The previous record temperatures around hydrothermal vents was in the Pacific, with temperatures of 402 degC being measured.

'This increase of the record by 5 degC is significant, as 407 degC at 3000m water depth marks the critical temperature at which water is no longer a fluid but reaches the state of *critical vapour*,' said cruise leader Andrea Koschinsky from the International University of Bremen. 'In this state, water has different chemical and physical properties, meaning that it leaches materials differently from the surrounding bedrock. The resulting super-hot solutions spewing from the black smoker are markedly different because of this.'

These conditions are very severe and demonstrate the ruggedness of the Quest 5 ROV as an all-round workhorse. The Quest 5 system is rated to work in 4000m water depths. It is 2.9m in length and has a width and height of 1.7m. It weighs 2,450 kg. It moves by the use of seven 11-kW DC electric ring thrusters (4 horizontal, 3 vertical) which give it a forward bollard pull of 544 kgf. It has a 250 kg payload capacity.

Sea floor

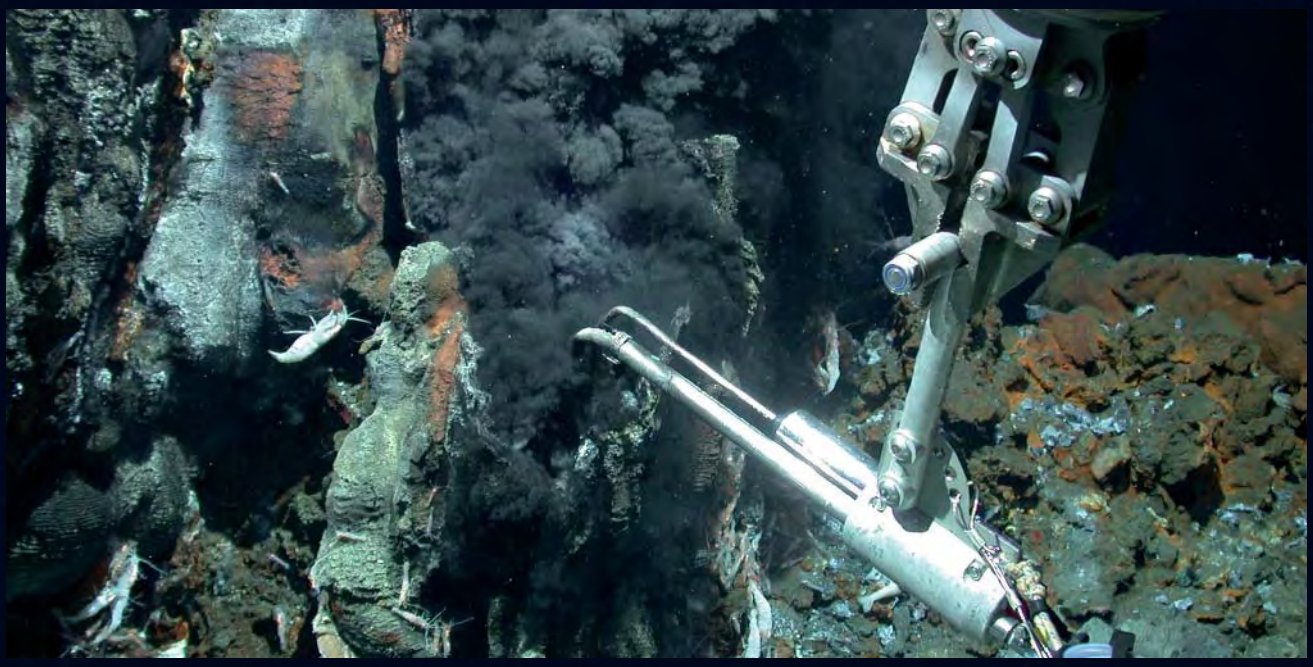
The ambient temperature at the sea floor in this depth is around 2-3 degC. All devices working there need to withstand both enormous pressures and the aggressive salt water. Hot vents

The black heat of technology

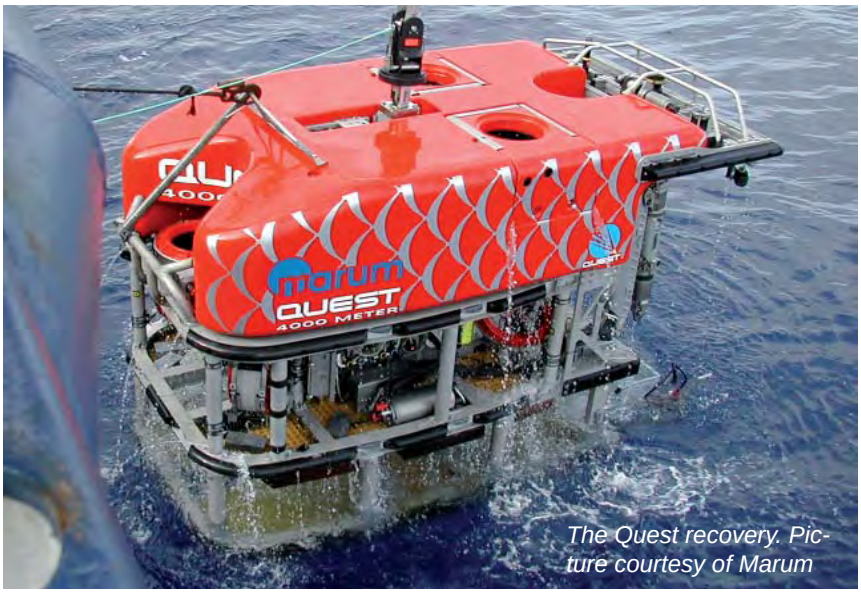
The design of the temperature probe itself was a major feat of engineering.

'If a device is supposed to work in these conditions, it needs to be extremely tough,' said Hans-Hermann Gennerich of Bremen University. 'The thermometer has to be very thin in order to transmit the heat easily, so the final measurement can be arrived at quickly. It also has to mechanically stable and fabricated from materials able to withstand the rigorous demands put on it. Tubes made from titanium for example, could withstand pressure, acid and heat, but would be too soft. The inside of the hollow probe would have the same pressure as at the surface. Outside however, the water would push down at around 300 kg/cm^2 – about the same as if a truck drove over it. The thin part of the probe that is pushed into the fluid, therefore, is made from a special steel. This is necessary because a lot of the additives that harden steel make it more susceptible to corrosion by salt and acids, and the corrosiveness is aggravated by the extreme heat.

Another factor was isolating the electrical cables. Even Teflon, which normally serves well, evaporates at 270 degC. Therefore, a thin meshwork from glass fibres were used. Soldered connections likewise do not work, because the tin-solder would just melt.'



Measuring inside the black smoker Picture courtesy of Marum



The Quest recovery. Picture courtesy of Marum

at the black smokers exacerbate the problem – they emit extremely hot, acidic flumes out of their metre-high stacks.

'The temperature profile is particularly interesting,' said senior field service engineer Greg Engemann at Schilling Robotics. 'Seawater is a very effective coolant, so the temperature drops from 407 degC to the ambient 3 degC in a remarkably short distance. This allows the ROV to get much nearer to the smoker than one might think.'

An important part of the work programme required of the ROV, was putting a titanium sampling tube or thermometer into the hydrothermal vent, using its two manipulators, the Orion 7PE and the RigMaster, to hold

Launching the Quest ROV . Picture courtesy of Marum

'Abe' : Wood's Hole Oceanographic Institution's versatile deep sea vehicle. Picture courtesy of WHOI

the devices. The sea floor around the vents was undulating and precipitous, so the ROV had to continually hover. This however was assisted by the automatic 'StationKeep' system – a kind of three dimensional subsea dynamic positioning to keep it in a stable attitude.

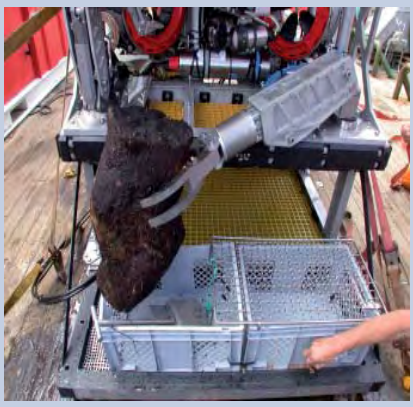
'One thing that was quite surprising was the currents at those ocean depths,' continued Greg Engemann. 'In one operation, it was necessary to insert a sampling tube into the smoker for up to 45 mins. If this was even temporarily moved, it would essentially dilute the reading with sea water and affect the veracity of the results.'

'Even though the smoker was approached from one side, we found that more than once, the plume of 'smoke' moved 90^{o} because of the current, occluding camera visibility and requiring the ROV to move away.'

The Extreme Team

The Meteor expedition M68/1 was carried out from April 27 to June 2, 2006, to explore the correlation between volcanism, water circulation inside and above the sea floor and hydrothermal vent organism communities. In addition to the super-hot vent, it also discovered other, to date uncharted hot deep-sea wells.

This work was facilitated by combining the abilities of the autonomous deep-sea vehicle 'ABE', which was specially developed by Woods Hole Oceanographic Institution for locating hot vents, along with the Marum's Quest ROV at the the University of Bremen.


Let's give the Quest a big hand

Participants in the Meteor Cruise 68/1 were from the Marum, the universities of Bremen, Hamburg, Kiel, Munster and Otago (New Zealand), the IUB, the Leibniz Institute of Marine Sciences, the Max-Planck-Institute for Marine Biology in Bremen, the National Oceanographic Institution in Great Britain and the Woods Hole Oceanographic Institution in the USA.