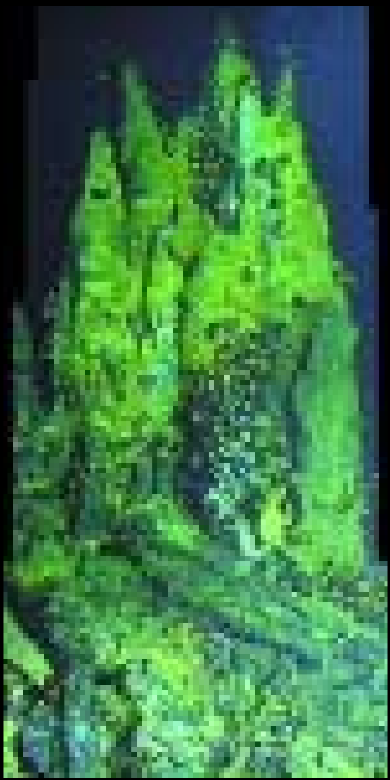

These CSIRO images of mineral columns have been pieced together from photos taken using a submersible called the 'Shinkai', owned by the Japanese company JAMSTEC.

Above: A large edifice formed of coalesced 'beehive chimneys', three to four metres high, showing the brown and white coating of bacterial mats on which baseball-sized snails are grazing.

Right: A close up view of pencil-like branching tubes at the side of a large chimney.

Above: A three-metre-high, recently deceased chimney complex, mostly abandoned by fauna.

Bismarck bugs raise hopes of **greener mining**

A team of CSIRO scientists has embarked on a pioneering search of active volcanic vents on the seabed of the Bismarck Sea, north of Papua New Guinea. If the mission proves a success, it will foster new ways of making Australia's $37 billion mineral export industry cleaner, greener, safer and more competitive.

The biologists and mineral researchers sailed from Cairns aboard the CSIRO research vessel *Franklin* in April. They're on the hunt for 'hyperthermophiles', microbes endowed with the natural ability to process minerals at high temperatures. The team, an international collaboration that includes researchers from CSIRO Molecular Science, Marine Research, and Land and Water, is led by Dr Ray Binns of CSIRO Exploration and Mining, who discovered the hot spring sites and associated mineral deposits in 1991. CSIRO is also working with Papua New Guinean authorities to ensure the protection of their scientific and commercial interests. The Geological Survey of Papua New Guinea, is represented on the cruise.

The search is being conducted in an eerie landscape of smoking undersea chimneys that pump mineral fluids from deep in the Earth's mantle into the surrounding ocean. These shattered mineral columns, which resemble ancient ruins, are cloaked in snow-white carpets of bacteria and organic hydrates: compounds that exist only under the extreme pressures of the deep sea.

The minerals form when hot spring fluids, at temperatures of 300–400°C, mix with colder seawater. The microbes live right where the superheated fluid meets the sea, at temperatures up to 110°C and pressures of about 150 atmospheres.

The goal is to find particular microbes that can be used to process minerals on dry land, and so develop more efficient and cleaner ways to extract metals from ores. These deep sea microbes could enable Australia's miners to exploit lower grade ore deposits, extract metals more cheaply, clean up waste streams and may even improve mine safety.

The microbes, which are comprised of bacteria and archaea, probably represent the types of communities that were Earth's most ancient life forms. They can grow at the most extreme temperatures known to support life.

As a rule, vent microorganisms, or 'hyperthermophiles', grow fastest at temperatures between 80°C and 100°C. About 60 new species of hyperthermophiles have been discovered since these types of communities were first encountered in the late 1970s in a tectonically active area north of the Galapagos Islands.

Examination of DNA in the microbial 'mats' and 'clouds' associated with vents, and direct microscopic examination of the morphology of the cells in these communities, has shown that researchers have uncovered just a tiny fraction of the microorganisms in these environments.

Most of the vent organisms discovered so far are anaerobic; they grow in the absence of oxygen, gaining their energy by using sulfur or nitrate to oxidise the reductive gases (such as hydrogen) that erupt from the earth.

Hyperthermophiles are not only scientific curiosities. Because they grow at extreme temperatures, their enzymes are highly temperature-stable, which makes them attractive for biotechnological exploitation.

A possible application for vent hyper-thermophiles stems from their ability to oxidise and leach metals from mineral sulfide ores. Microbes are used in the minerals processing industry to leach sulfide ores to recover copper, nickel, zinc and cobalt, and to pre-treat ores prior to gold extraction.

For high-grade ores, these microbial extraction processes are conducted in tanks at temperatures ranging from 28°C to 50°C. For low-grade ores, the process takes place in heaps in which the temperature is not controlled, but where it can reach as high as 80°C. At higher temperatures, however, a more rapid microbially-driven process would allow an increase in the rate of metal recovery.

One of the hopes of the research cruise is that new hyperthermophiles will be discovered that leach mineral sulfide ores in the 80°C to 100°C range, and cultivated to improve the economics of biomining. A great advantage of biomining is that it can have less impact on the environment than traditional minerals processing.

The ingredients for success are there: high temperature vents – rich in mineral sulfides such as chalcopyrite – covered in bacterial mats and erupt clouds of particles laden with microbes. The art will lie in teasing out the desired organisms from the microorganisms that inhabit the vent areas.

Echoes of **the deep**

DURING a three-part voyage extending through April and May, scientists aboard the CSIRO research vessel *Southern Surveyor* are evaluating tools and techniques to efficiently map and classify large areas of deep seabed.

They are building up detailed images of the ocean floor using an instrument called a swath mapper: an acoustic system that fires pulses of sound at the seabed and records the complex echoes that return, generating fine-scale maps of seabed texture and topography. Contrasting areas are then target-sampled with a range of other instruments (including cameras and sediment grabs) to 'ground-truth' the maps.

The mapping and sampling, which is taking place off the south-east coast of Australia, is part of a rapid assessment program funded by the National Oceans Office and CSIRO. The program will assist the development of regional plans for managing Australia's vast marine territory, as specified under Australia's National Oceans Policy.

Australia is one of the first countries to adopt a national Oceans Policy recognising the responsibility to understand, manage and conserve marine territories.

More information about National Oceans Policy is available on the World Wide Web at www.environment.gov.au/marine/ocepoly. The CSIRO Marine Research home page is at www.marine.csiro.au, or contact the communication unit on (03) 6232 5222.

It is known that deep-sea microbes can survive the trip to the surface and can be grown under laboratory conditions. If this is done successfully, researchers led by Dr Martin Houchin of CSIRO Minerals will be able to determine whether the microbes can be used in large-scale mining operations on land. Ultimately, such undersea deposits themselves may be mined for their riches, although probably with a focus on inactive vents, rather than those still supporting the unique life forms.

In the geological time scale, active hydrothermal deposits are short-lived, ore-forming processes. It is therefore likely that many more such deposits have stopped 'smoking' and are now cold and devoid of the chemical conditions required to support hyperthermophiles and other fauna.

While there is evidence that vent communities are resilient and can repopulate new fields as they arise, dead mineral fields may be the preferred mining targets if further study indicates mining may pose a risk to the ecology. Indeed, a secondary purpose of the cruise is to identify a geophysical signature for the deposits that will assist in locating fields of 'dead' hydrothermal vents.

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