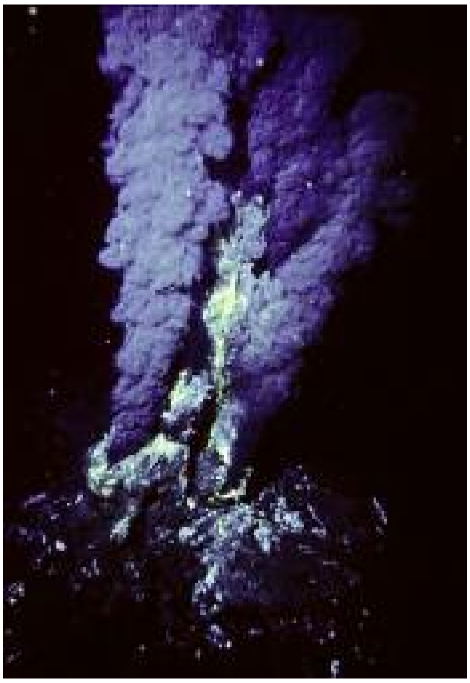
Revealing the Mysteries of the Earth's Crust



A deep-sea "black smoker" hydrothermal vent releasing hot (>400˚C) metal-rich fluids deep in the ocean. The hydrothermal cell developed by Joël Brugger and his group allows them to reproduce these conditions on a synchrotron beamline.

It might seem at first glance to be one of the simpler techniques performed at the Australian Synchrotron, but X-ray absorption spectroscopy requires a beamline that is very finely tuned. The technique measures the amount of X-rays absorbed by a sample while scanning a selected range of X-ray energies. The result is information on what elements are present and in what chemical form, what their local environment is and how they are bonded. The technique is only available at synchrotrons.

The beamline can analyse all elements heavier than calcium.

Although the technique is simple in concept, beamline scientist Chris Glover says that setting up the beamline poses major challenges. "Because the experiment is effectively performed by the beamline itself, the X-ray beam has to be tuned reliably and smoothly." No amount of clever data analysis can compensate for a poor quality X-ray beam.

The beamline also has to be designed to dissipate several kilowatts of X-ray power in its optics. Chris' beamline is in the final stages of commissioning and will become available in the latter half of 2008. "We've already got a significant number of proposals from groups keen to use the beamline," he says.

Deep in the Earth's crust, metals come out of solution to form ores. Over billions of years this process has provided the materials on which the $40 billion Australian mining industry depends. ARC (Australian Research Council) Professorial Fellow Joël Brugger of the University of Adelaide is using X-ray absorption spectroscopy to study how it happens.

The conditions under which metal deposition occurs are extreme – up to 600°C and 1000 times atmospheric pressure with highly acidic and caustic water. So Brugger works on samples constrained in hydrothermal chambers made of glassy carbon with beryllium windows to allow the synchrotron X-rays through.

The absorption patterns provide information on how much of a particular metal dissolves and how quickly, and the form in which it ends up. Brugger is using that information to develop computer models that predict where metals will dissolve and where they will come out of solution. Eventually these models will help mining companies determine the best prospects for mineral deposits. .

"At the moment there is only one beamline in the world set up to do this work, at the European Synchrotron Radiation Facility in Grenoble in France, and I only have access to it for about 1 week a year," Brugger says. The Australian Synchrotron beamline should double or triple that access time, and allow Brugger and others to generate novel techniques geared to Australia's vast economic interest in metals.

Most of us don't think much about what happens to drugs after we swallow them or they are injected, but Peter Lay of the University of Sydney's School of Chemistry does. He recognises that how drugs interact with digestive juices, blood and living cells is critical to their function. He's using synchrotron radiation to study what happens.

Many pharmaceuticals and dietary supplements consist of compounds that contain metals. These are ideal subjects for using X-ray absorption spectroscopy to study them from the site of administration all the way until they reach and interact with their target tissues. Lay is following the fate of chromium, vanadium and molybdenum in diabetes drugs and supplements, ruthenium in anticancer preparations, and gallium used in radio pharmacology and cancer therapy.

"There's always the question of how what we see in the laboratory relates to what happens in a living organism," he says. "In a complex biological medium, X-ray absorption spectroscopy allows us to tune into the metal we are interested in. There is no other technique that will allow you to study all the oxidation states and how they are bound and change in biological fluids, cells and tissues."

So far Lay has been using synchrotrons in Japan and the US, but he's looking forward to working at the Australian Synchrotron because it will get over the complex problem of having to gain approval from authorities and airlines to carry certain biological and chemical samples abroad. It will also enable him to use living cells cultured at the facility.

Visit www.synchrotron.org.au for more information.