The Synchrotron Environment

The brilliant beamlines of the Australian Synchrotron are finding a host of environmental applications, from studying the chemistry of the upper atmosphere to developing better catalysts for hydrogen production.

Detecting and precisely locating specific atoms and molecules is one of the things synchrotrons do best. That makes them very useful for many environmental applications.

The Australian Synchrotron's microspectroscopy beamline, for instance, can be used as a probe to map where elements occur, from phosphorus and sulfur to metals such as iron, zinc and copper. The infrared beamline can track all sorts of organic and inorganic compounds, and the far infrared beamline – one of only three operating worldwide – is great for analysing the gaseous molecules of the atmosphere. Soft X-rays can analyse chemical bonds and probe how elements are linked into soil.

Plankton Trace the Cycle of Climate Change

Phytoplankton are the foundation for the ocean's food chains. They may also play a role in long-term climate regulation.

These tiny plant-like aquatic organisms absorb about 65 billion tonnes of carbon dioxide per year as they use the Sun's energy to turn carbon dioxide into sugars. So if anything were to reduce their numbers or activity, it could potentially have a big impact on the amount of carbon dioxide in the atmosphere, and hence global warming.

That's why Phil Heraud and his team from Monash University are studying how environmental factors such as temperature, UV light and CO_2 affect the biochemistry of phytoplankton. Using the Australian Synchrotron, he is exploring how they react to changes in the availability of nitrogen and phosphorus.

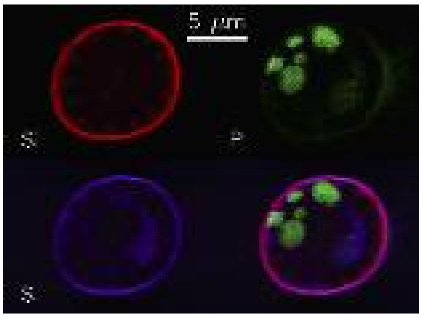
The infrared beamline allows the team to observe biochemical changes directly in a liquid flow cell. "The beamline can provide a direct indication of the presence of lipids, proteins and nucleic acids in cells, and hence how they are reacting to different environmental conditions," says beamline scientist Mark Tobin. "It can reveal what compounds are present and where they are in the cell."

Phytoplankton also featured in a synchrotron investigation into phosphorus distribution in the oceans. Phosphorus is an essential nutrient for phytoplankton.

Two Australian Synchrotron scientists, David Paterson and Martin de Jonge, used the microspectroscopy beamline at the Advanced Photon Source in Chicago to show what happens to the phosphorus (stored as phosphate polymer) in diatoms and other phytoplankton. In a paper published recently in *Science* the research team reported that as phytoplankton die and decay, the polyphosphate drops down to the seabed where it is gradually transformed into stable calcium phosphate minerals such as apatite. It can remain there for decades, out of reach of growing marine organisms.

"The microspectroscopy beam is effectively an X-ray nanoprobe capable of resolving structures less than a ten-thousandth of a millimetre (100 nanometres) in diameter. That's about one-hundredth the width of a single-cell organism like a diatom," Paterson says. "We can map the distribution of phosphorus and other trace elements and identify their chemical forms at concentrations well below one part per million."

Microspectroscopy has also found wide use in studying the movement and chemistry of toxic metals in the soil, and how ferns and other plants can accumulate them. The microspectroscopy beamline at the Australian Synchrotron is in the final stages of installation, and will be operating early next year.



Synchrotron light is revealing the location of elements in individual plankton. This image shows silicon, phosphorus and sulfur inside the diatom *Cyclotella*.

Image taken at the Advanced Photon Source by M. de Jonge *et al.*

Clay Barriers Bottle Up Landfill

Clay mineralogist Will Gates of Monash University Civil Engineering has been studying clays for more than 20 years. He's particularly interested in bentonite, a kind of soft rock made mostly of clay minerals. Bentonite is used in geosynthetic containment barriers at municipal landfill and industrial waste sites to prevent heavy metals and other toxic compounds from leaching out.

The geosynthetic barriers, of which Australia is a major supplier, are constructed like a sandwich of felt and woven plastic filled with highly processed clay. "The more we understand the structure of the clay minerals in bentonite, the better we can improve its capabilities to retain more hazardous materials under wider conditions," says Gates.

The soft X-ray beamline at the Australian Synchrotron has become an essential tool in his studies. It provides valuable information on the naturally occurring metals as well as the trapped contaminants in the clay.

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