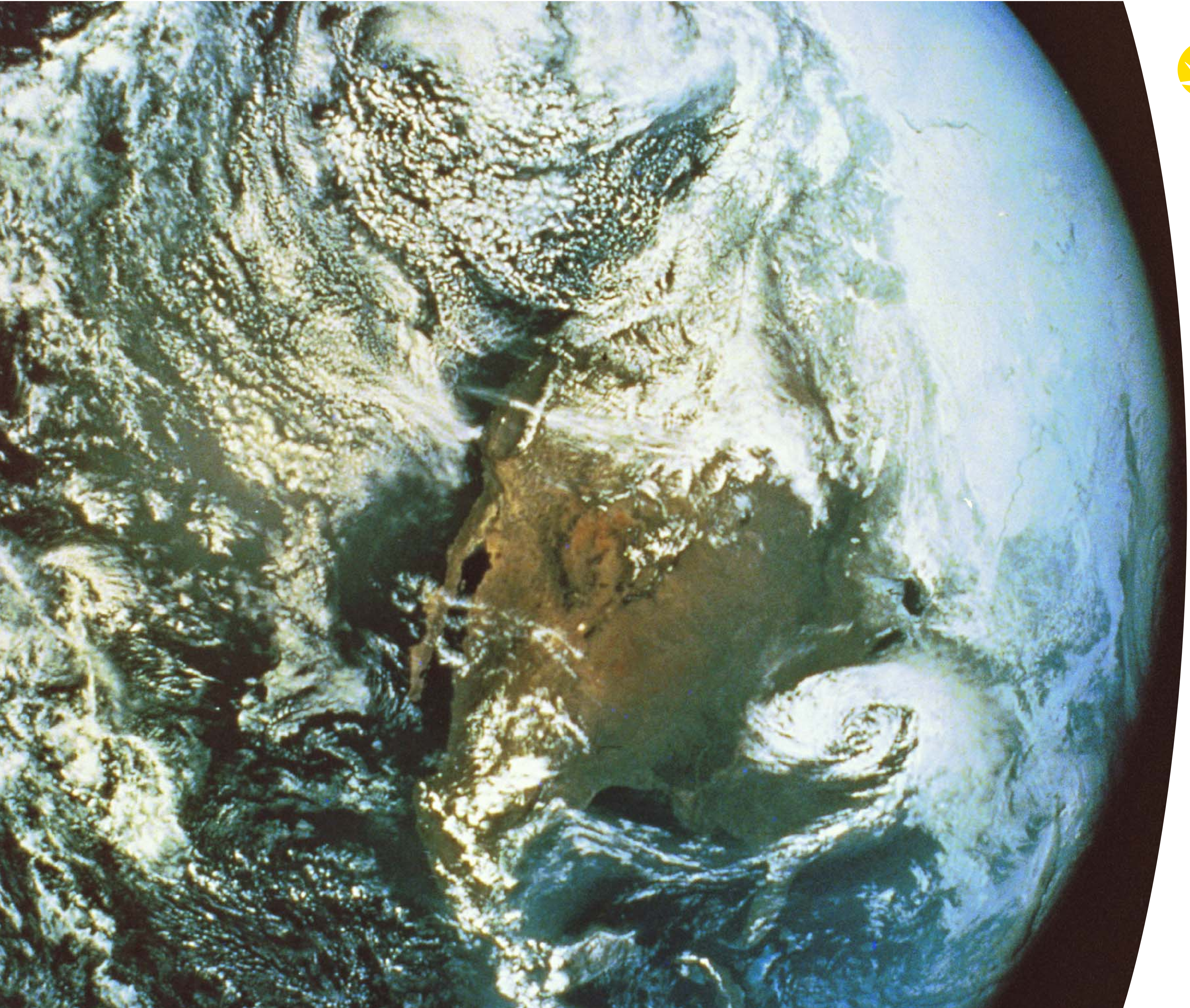

diamond

Light for Science

Environmental Studies

overview

A detailed understanding of environmental issues such as pollution and climate change is fundamental if we are to find long term solutions to the problems we currently face.

In addition, there is an increasing amount of statutory legislation relating to environmental impact, which all companies need to comply with.

The complexity of the issues means that companies working in the environmental sector often have expertise in a combination of areas, such as microbiology, geology and geochemistry, and use advanced analytical techniques to make real breakthroughs.

By harnessing the technical capabilities of the UK's new synchrotron facility, and the expert knowledge of the scientists based there, the environmental sector will be able to investigate solutions that will allow them to drive their businesses forward, and make real, high impact changes over the coming decades.

Diamond's first PhD student Lois Davidson is currently undertaking research on the transport of pollutants in ground waters. This work, looking at the particle size and growth of iron oxyhydroxide with and without the presence of heavy metal pollutants, is being carried out at other synchrotrons, but will transfer to Diamond in 2007.

Key Challenges

- **Nanoscale solutions**
  The environmental sector stands to benefit from the field of nanoscience and the discovery of novel materials with exploitable properties.
- **A helping hand from nature**
  Some living plants have the potential to clean up pollution thus offering a natural solution. High resolution X-rays can be used to follow small-scale, complex reactions answering questions that current laboratory techniques are unable to answer.
- **Complex assemblies**
  Intense, very high-energy X-rays can penetrate into complex sample assemblies giving detailed mapping of structural order or disorder, chemical fingerprint, or single crystal structure determination.

The Synchrotron Solution
The synchrotron offers experimental techniques that go beyond the capabilities of traditional laboratories.

Techniques
A range of techniques will be available for the study of rocks, soils, sediments, plant material, pollutants and radioactive waste. They include X-ray Spectroscopy, Microfocus X-ray fluorescence, absorption, and diffraction, Small angle x-ray scattering (SAXS), and Photo emission electron microscopy (PEEM).

Powder diffraction provides information regarding crystal phase identification, unit cell dimensions and material structure at the atomic level.

Beamlines: I18 Microfocus Spectroscopy, I20 X-ray spectroscopy, I22 Non-crystalline Diffraction, I06 Nanoscience, I11 High resolution powder diffraction
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case studies

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Light for Science

Environmental Studies

Arsenic poisoning

Action is needed to protect millions of people in Bangladesh, India, Nepal, Pakistan, Cambodia and Vietnam from suffering serious, debilitating arsenicosis as a result of the use of arsenic-rich groundwaters for drinking, cooking and irrigation.

Significant progress in understanding this arsenic contamination has been made recently using the Synchrotron Radiation Source (SRS) at Daresbury.

A team of researchers, led by Drs Dave Polya and Andrew Gault from the University of Manchester, used X-ray Absorption Spectroscopy (XAS) to monitor the chemical reactions occurring in aquifer samples and to identify changes in arsenic species.

Dr Polya explains, "We needed to be able to obtain XAS spectra from sediments with low concentrations of arsenic, so the SRS facility was vital to our work."

This XAS study was a key part of recently published work (Islam, FS, Gault, A et al., 2004, Nature, 430, 68) that provided the first direct evidence that metal reducing bacteria are implicated in the release of arsenic from the sediments in aquifers in Bengal. Dr Polya says, "It appears that the arsenic is locked up with iron (hydr)oxide grain coatings in the sediment. If the conditions are right, these bacteria dissolve the iron and ultimately this releases the arsenic."

Source: Dr Dave Polya

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De-toxing the environment

Major goals of environmental science include controlling the mobility of toxic elements in natural systems and waste depositories, and the remediation of contaminated soils, sediments, or surface waters.

Prof Alain Manceau, who heads up the team of Environmental Geochemistry at the Centre National de la Recherche Scientifique (CNRS) in Grenoble, says, "In order to meet our goals we need a fundamental understanding of the elemental composition, spatial distribution, and chemical form of trace elements in environmental nanoparticles".

Working at the Advanced Light Source (ALS) and the European Synchrotron Radiation Facility (ESRF), the team has developed the use of complementary x-ray techniques to identify zinc-containing compounds in contaminated French and Belgian soils located near smelters.

Prof Manceau adds, "Combining three analytical techniques (micro-SXRF-XRD-EXAFS) at the molecular scale of resolution offers unique access to the identification of trace metal species in natural and contaminated solid matrices. Remediation strategies depends not just on the concentration of the toxic metal but on its mobility in soil and water and its ease of uptake by plants, animals, and people, properties that depend on the chemical compounds containing the metal. Therefore, our results will help us to cure a number of environmental problems".

Source: Prof Alain Manceau
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