

Geochemistry is a powerful tool applicable to all sorts of investigations, from hydrocarbon exploration to environmental protection. **Christopher Vane, Simon Chenery, David Jones** (BGS) and **Chris Richardson** (University of Wales, Bangor) outline a selection of projects in which geochemical techniques are being used in innovative ways.

# Geochemistry in the marine realm

What is the correct balance between environmental protection and resource requirements? This is one of the central questions to be answered by modern geology. Here, four projects are described in which sophisticated geochemical techniques are applied in the offshore realm to environmental and resource supply problems by BGS staff in order to provide high quality, objective advice.

## Source of Faroe Islands hydrocarbons

As the demand for oil grows and current reserves become depleted, so the need for new oil discoveries increases. Trace hydrocarbons in the form of oils and waxes in the onshore and offshore basalts of the



Danish Geological Survey (GEUS)

*Micro oil seeps have been found on the Faroe Islands (Vagar Island shown).*

Faroe Islands were first discovered in 1997 and indicate that source rocks may lie beneath. Offshore exploration models have inferred that the source rocks were Middle and Upper Jurassic in age, like those which generated oil accumulations west of the Shetland Islands. However, information from East Greenland and the North Sea indicates that source rocks may be present at a number of intervals ranging in age from Devonian to Paleocene. In collaboration with the Danish Geological Survey and Geolab Nor, we are characterising the Faroese hydrocarbon system by combining detailed organic geochemical evaluations of oil seeps from East Greenland, shallow sea-bed cores from around the Faroese sector and core from the British sector of the North Atlantic. We are examining the chemical properties of oil extracts to establish whether there is one or more oil family, what kinds of source rocks they are derived from, and how deeply the source rocks were buried when migration began. We will also be using biological marker compounds (chemical 'fossils'), carbon isotope ratios of individual compounds, and porphyrin analyses to establish

whether the oils and source rocks are genetically connected.

## Endocrine disruptors

Endocrine disrupting compounds (EDCs) are a diverse group of substances that have an ability to mimic or antagonise the effects of endogenous hormones in humans as well as animals.

## Estuarine contamination

Estuaries are the principal zones of sediment transfer between fluvial and marine systems and provide habitats for many organisms. They form sinks for sediment moving downstream, alongshore or landwards and for contaminants from both terrestrial and marine sources. Variable hydraulic conditions lead to complex sedimentation processes. These are compounded by activities and events upstream, dredging, port and industrial development along their shores, or operations and natural processes in the coastal zone, including global climatic change. Contaminants may be buried and in storage, undergoing remobilisation, or being deposited. Their distribution may be influenced also by the activities of living things. Contaminants must be distinguished

With the Marine Biological Association, we are examining how biological effects of EDCs in estuaries are modified by natural environmental conditions. A critical first step is to characterise the partitioning of potent EDCs such as 17- $\alpha$  ethinyloestradiol (the main component of the oral contraceptive pill) in sediment and water. We are carrying out experiments to determine the role of salinity, pH, and sediment characteristics on this partition coefficient. We are also studying bioaccumulation and loss in EDCs in the mollusc *Scrobicularia plana*. This will help us to determine the relative importance of sediments and water as assimilation pathways for oestrogens and xenoestrogens and to establish the level of reproductive impairment. The potential consequences of endocrine disruption for estuarine benthic mollusc populations will be tested in the field at the Severn and Plymouth Sound estuaries where we will determine the concentration of EDCs in water, sediments and *Scrobicularia*.

**Mussel shells: miniature tape-recorders of environmental change**

Scientists from the BGS and University of Wales, Bangor (UWB) are studying the chemical composition of dated bands and lines in mussel shells. Such shells contain a



*Analysing estuarine sediments for endocrine disruptors using gas chromatography-mass-spectrometry-mass spectrometry (GC/MS/MS).*

record of their growth history in the form of tidal bands and annual lines that can be observed under the microscope. These lines and bands are analogous to tree rings, representing seasonal changes in growth and periods when the mussels are exposed at low tide. They are miniature in situ 'tape-recorders' collecting a running commentary of environmental changes in their surroundings, recording predator

attacks and the activities of humans, such as trawling and the dumping of contaminated waste. We have used laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to determine the chemical composition of growth lines and bands in mussel shells collected from selected environments. By analysing individual bands less than 100 micrometres wide, we have revealed microscopic changes in their chemical composition. For instance, we have shown that 30–40 year old shells of the horse mussel (*Modiolus modiolus*) contain a record of the dumping of waste contaminated with heavy metals (copper, zinc and lead) in the North Sea during the mid 1970s. More recently, the ratios of barium to calcium and magnesium to calcium in the tidal bands of brown mussel shells (*Perna perna*) collected from a region of upwelling off the South African coast have recorded dramatic fortnightly lunar spring-neap changes in the temperature of the upwelled sea-water. Our current research is focusing on the long-lived bivalve *Arctica islandica*, to see whether their shells contain information on past activities of the oil and gas industries in the North Sea.

from natural geochemical variations linked to geology and geological processes. Knowledge of the baseline geochemistry of estuarine sediments and the distribution of contaminants, coupled with an understanding of the processes that influence their distribution are, therefore, important in many aspects of estuarine management. Such management might include land-use planning, harbour maintenance, fisheries, marine aggregate extraction, coastal defence, conservation or recreational activities. Knowledge of contaminant levels in estuaries is fundamental to the UK's obligations under international treaties, such as OSPAR, which require the separation of natural

background and anthropogenic inputs. We plan to carry out systematic geochemical surveys of the major UK estuaries and work on the Mersey Estuary is almost complete. The current focus is on the Clyde Estuary, where studies are being undertaken in collaboration with Glasgow City Council and the Scottish Environment Protection Agency.



*Geochemical sampling of the Clyde Estuary.*

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