On the margins

Much of the world's remaining oil and gas reserves are found where deep oceans meet continental shelves – the ocean margins. **Alick Leslie** describes how scientists can help industry understand these little-known regions.

The UK economy has benefited enormously from North Sea oil. What happens when it runs dry? NERC's £4.8 million Ocean Margins LINK programme, a unique collaboration between scientists and industry, has gone some way to addressing this question.

The programme, which started in 2000, draws to a close in 2007, but it is already providing benefits to the UK economy through improved predictions of oil and gas reserves, innovative approaches to finding and using other energy sources below the seabed, including methane hydrates, and a better understanding of the deep-sea environment including hazards on the seabed. From the outset, we involved industry in the direction of the programme. Industry collaborators have provided matching funding for the research projects, ensuring that the results would be put to best use. This led to us grouping the research into three themes, described simply as deep processes, shallow processes and fluid flow.

Deep down …

Beneath our feet here in the UK lies 30-35 kilometres of continental crust, before you reach a more fluid layer of rock called the mantle. Below the oceans the crust is much thinner, around six kilometres thick.

Study of the boundaries between continental and oceanic crust tells us how an ocean begins to form, but there are places where stretching in the continent did not develop into an ocean. In these places stretching caused the continental crust to thin and sink but not part. Examples of this kind of feature are the Rockall Trough to the west of the UK and also parts of the North Sea. In these regions of thinned continental crust we find sediment accumulating on the seabed filling the depression, eventually creating sedimentary basins that may produce the conditions for oil and gas to collect. Understanding the nature of the boundary and the surrounding crust can therefore help in predicting how the crust behaves during the split (see diagram) and where basins might be found on thinned continental crust.

A team led from Cambridge and Liverpool universities used information taken from satellites as well as data taken in the field to work out the thickness of the Earth's crust, providing independent verification of the location of ocean margins to the north and west of the UK. The UK oil industry immediately made use of this technique in their search for oil and gas in the

More information:
www.nerc.ac.uk/research/programmes/oceanmargins

region. But this is transferable technology, and oil prospectors in the Gulf of Mexico have not been slow to adopt it too (see box).

Heading south of Mexico, along the Atlantic coast, you will eventually reach the mouth of the Amazon. A team from Oxford University investigated the influence of sediment from the Amazon on the ocean margin. They found that the vast weight of sediment has actually buckled the crust in the area, forming a wedge on the continental margin. This work has also produced unexpected benefits – the images of the sediments and crust have also identified boundaries between water types in the ocean, providing information on ocean circulation for scientists to study.

Scratching the surface …

Understanding the structure of the whole crust is one thing, but you also need to know about the beds of rock where we find the oil and gas. These beds must be porous and thick: sandstone is ideal. At the University of Bristol, researchers looked at sandstone beds in northern Italy, formed millions of years ago from sediment flowing down slopes into the deep ocean. In the laboratory, a team at Leeds and Imperial College, London, have created a model channel and watched a sediment flow as it moves through the channel, round the bends. Unexpectedly, they found that the forces that control fluid motion in seafloor channels are quite different to those forces found in rivers on land, and cause flow in seafloor channels to rotate in the opposite direction to rivers – changing the position of sediment deposits. With this knowledge we can produce more accurate predictions of sedimentary deposits. The team's model predicts where the sediment will stay within a channel and form a porous bed, an extremely useful tool for industry, (see 'Down by the river', on page 26).

To the south-west of the UK, researchers have used high quality images of the seabed to identify the hazards associated with slope failure, to create a map of the region showing such geohazards. This hazard assessment is invaluable to communications companies running cables across the Atlantic, and can also be applied to areas of oil exploration.

Go with the flow …

So we know the structure of the crust, we know the location of porous rocks. Now we need to find out how the oil and gas get in. Understanding how fluid flows through rocks is a central part of exploration. For this we need to know how porous the rocks are and also how hot they are – circulation of fluids is commonly driven by differences in temperature.

At Leeds University, a team created a computer model of a basin filled by sediment and then looked at the way fluids such as water or oil flow through the beds. Across at Nottingham University, a revolutionary technique for 'fingerprinting' oil residues allows geologists to match the oil found in a reservoir with remnants within the original source rock, a vital tool to plot how and where a fluid goes as it moves through a basin.

Pushing the margins – future work …

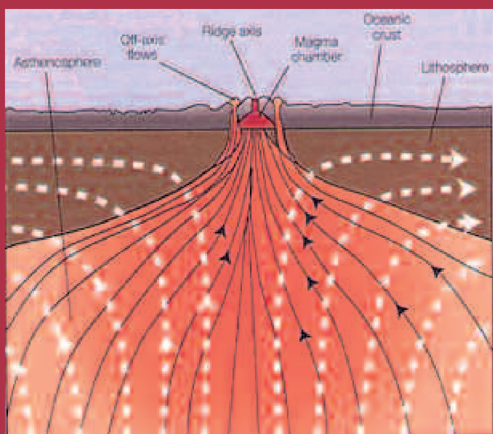
The programme has forged close links with the telecommunications, and oil and gas industries. We have worked with these industries to develop new techniques for locating oil and gas reserves and also improve their understanding of the ocean floor and marine hazards. The programme may now be winding up, but we will continue to build on these links. Several companies have started on the basis of research, and most of the projects have generated further funding for ongoing research work.

Old problems, new solutions

The Ocean Margin LINK programme tackled one of the biggest problems facing the oil and gas industry. In the last 65 million years widespread volcanic activity in the northern Atlantic has left a thick layer of basalt covering large regions of the Atlantic seafloor. Conventional techniques used to locate oil and gas reserves at ocean margins cannot 'see' through this layer of basalt to locate new reservoirs. An additional problem is that current software fails to model accurately the stretching, subsidence and thermal history of these rifted continental margins.

The Ocean Margins programme addressed both these issues with the Integrated Seismic Imaging and Modelling of Margins (iSIMM) project. From this the team developed a commercial model that is such a large improvement on existing techniques it is already in use by the hydrocarbon industry.

For more information: www.badleys.co.uk/isimm-public



Materials flow from deep within the Earth upwards towards the mid-ocean ridge, then outwards causing the ocean to expand. The iSIMM team is modelling this process.

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