# Getting to the bottom of things

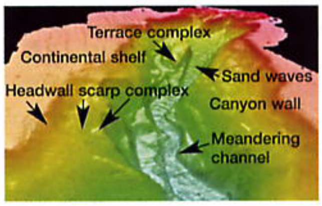
**It's as large as the Grand Canyon in the USA, lies just off the Californian coast, and has a river of sand snaking along its bottom. The speed at which this sediment is moving has surprised a team of earth scientists from the local university. So how are they unravelling the geological mysteries of the Monterey Canyon? Luke Hutson reports**

Using bathymetry, an imaging technique involving sound waves, a team from the California State University Monterey Bay, USA, is taking 'snapshots' of the vast submarine Monterey Canyon.

'Each image can be interpreted in terms of the landforms that are present,' says team leader Douglas Smith, 'just as a terrestrial geologist looks at a river valley and its terraces to infer a geological history.' Smith's team are also able to obtain a sequence of images, enabling them to detect small changes in topography occurring over time.

In their recent work, the team analysed changes over a 24-hour period and a six-month period. 'There was no detectable change in 24 hours, but the six-month time-frame showed a surprising level of activity and change,' says Smith.

The team's work is the first to use high-resolution bathymetry in the head – or 4km nearest to the coast – of Monterey Canyon.




**Deep and meaningful – an eastward view of Monterey Canyon, USA, 2km down the canyon from the shore (above). Shoals of fish can disturb the sonar imaging of the canyon (top). Image: Seafloor Mapping Lab at California State University Monterey Bay, USA**

The images have revealed a large field of sand dunes that, according to Smith, provides clues to canyon currents and sediment transport processes. 'The most important thing we learned about canyon evolution is that the rates of change are higher than we imagined, and that canyon enlargement may occur on time-scales of interest to human culture.'

### In-depth results

'We found that $10^5$ cubic metres of sediment was re-arranged in just six months in the small part of the canyon we observed,' says Smith. 'Although our results may only apply to canyons that head very close to shore, it is clear that a subset of modern canyons are evolving as we speak. Some may be eroding towards shore where their presence will be gradually more apparent.'

The sonar technique used by the team involves a trade-off between spatial resolution and the depth that can be targeted. 'We were able to acquire a series of bathymetric surveys at high enough spatial resolution to perform meaningful "raster subtractions" of bathymetric grids,' explains Smith. 'We subtracted depth grids to calculate volumetric changes in the canyon through time.'

### The scale of things

Smith and his team chose to evaluate smaller-scale geomorphic change and interpret the associated small-scale physical processes. 'We are currently restricted to depths of less than about 300m, but we are able to resolve features as small as several tens of centimetres in height. Each pixel in our processed data set of the sea floor is one metre square, and the average depth of each pixel is typically known to less than 0.5m.'

A real-time kinetic GPS system allows the team to know the ship-mounted instrument position to within a few centimetres throughout the cruise. There are, however, several technological challenges to obtaining the data. According to Smith, some can be minimised through planning, and others are accidental. 'Scheduling cruises during calm seas is sensible, and we use appropriate sensors and software to correct for the pitch, roll, and yaw of the ship.'

Despite the advantages of the best available technology, sound can be reflected back to the sensors from a variety of unintended targets. 'It is heartbreaking to process the data and find significant 'holes' in it where huge schools of fish or krill had blocked the sonar signal from reaching the seafloor,' says Smith.

### Future gains

The work of the Monterey team could make significant contributions to the study of both coastal erosion and tsunamis. One discovery in their recent paper is that the rock jetty, or groin, protecting the north side of Moss Landing Harbour terminates inside the shallowest part of the canyon head. Sand that would have otherwise moved southward along the coast past the canyon is now forced to enter the northern tributary of the canyon head. 'That sand is then forever lost from its potential benefits in the beaches and littoral zone processes,' explains Smith. 'Some of the beaches located far south of the canyon are sand starved, but we cannot yet clearly link the jetty's effect and the coastal erosion. A more novel aspect of coastal erosion is the observation from more recent (currently unpublished) surveys that the canyon appears to be gradually enlarging, extending its head shoreward.'

### Wave guide

Studies of the canyon could also yield insights into tsunamis, which can be generated by submarine landslides. 'We have imaged both ancient and very recent landslides along the walls of Monterey Canyon. We were very surprised to discover that a significant submarine landslide had actually occurred during our study, between two of our cruises.' According to Smith, this observation indicates that the canyon walls are locally unstable and that the risk of landslide-generated tsunamis may be underestimated along the central Californian coast.

Smith and his team hope to conduct surveys in other canyon heads along the Californian coastline to see whether their results are generally applicable.

For further information, see GSA (Geological Society of America) Bulletin, September/October 2005, Vol. 117, No. 9/10.

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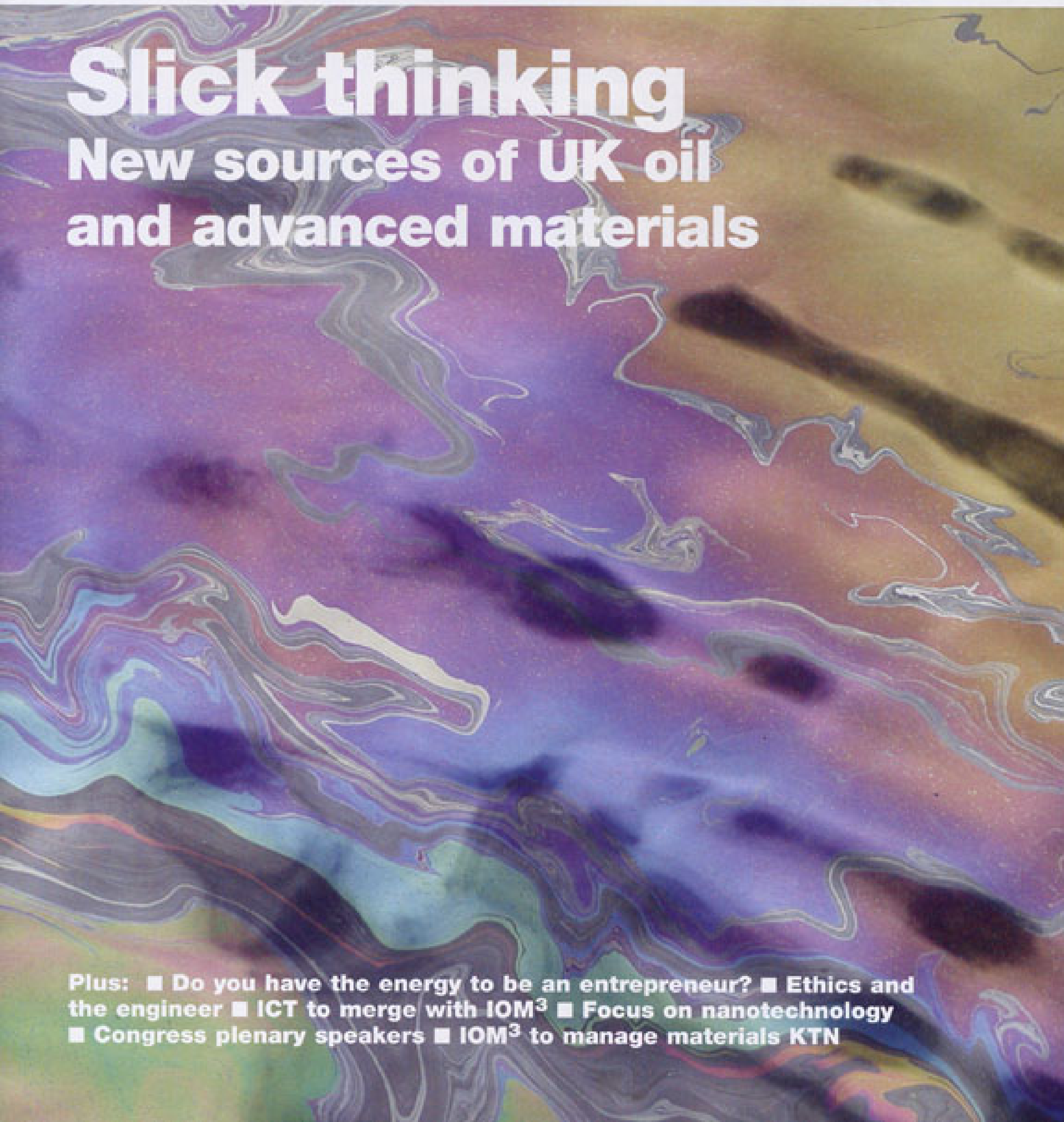

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