contacts between the granite and sediment is deflecting the heat.

The argument thus puts a question mark over the calculations of thermal conductivity, but these are difficult to budge. First, geophysical logs[3] indicated that the sediment — which is itself made of weathered granite — has 20 per cent porosity; and second, measurements of electrical conductivity show that the basement rock is twice as electrically resistive as the sediment. Only fresh water, filling the porosity in the sediment, is electrically conducting enough to explain the difference. The assumption of 20 per cent fresh water then brings the calculated thermal conductivity of the sediment well below that of the basement.

It thus appears that the heat flow around the oil well is complex, possibly suffering from local disturbances. The region is certainly geologically complex. The hole is in a mountain pass, and Ray Weldon of the US Geological Survey has shown from careful, skilful geological mapping[4] in the area that about 1 km of sediment has been eroded from the well site in the past million years. Calculations by Lachenbruch show that this amount of rapid erosion could cause some, but probably not all, of the anomalously high heat flow in the granite.

The question now is what is happening to heat flow, and the supposed high stress in the fault, even deeper than the 2 km presently drilled. Luckily, observations at those depths may soon be to hand. Some while ago, Mark Zoback proposed to drill a new 5 km hole at the site of the oil-company hole at a time when the 'heat flow anomaly' was the total absence of frictional heating.

Now, this deeper hole, to begin in 1987, seems even more imperative. Zoback will lead a team of 27 scientists from 7 universities and US Geological Survey in making geophysical and geochemical measurements in the hole, which is to be sponsored by the US National Science Foundation programme for the deep observtion and sampling of the Earth's continental crust (DOSECC).

The DOSECC programme will also receive core which will be made available for general study by scientists, in much the same fashion as the Ocean Drilling Program supplies its deep-sea cores. Only this deep work below the apparent 'disequilibrium zone' at the drill site seems likely to provide the deep measures of stress and heat flow near the San Andreas fault that are now required. □

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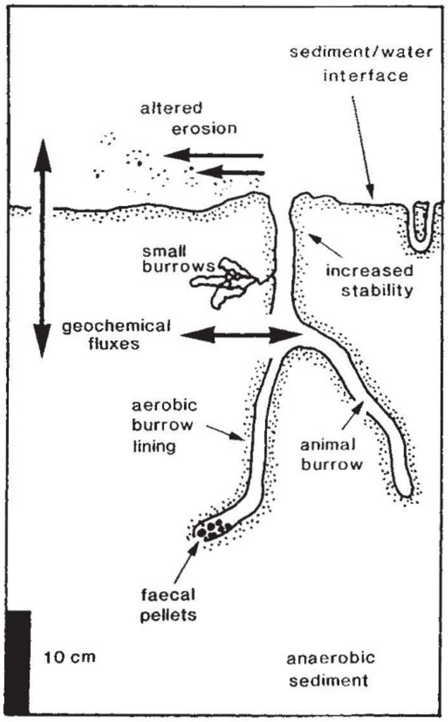
Marine biology

Biological activity and seabed sediment structure

from P.S. Meadows

THE top metre or so of all sediments in the sea contains a rich diversity of animals and microorganisms. Animal burrows can increase the surface area of the sediment–water interface by a thousand-fold or more, and microbial activity can cause sediments to become totally anoxic. Recent reports suggest these activities are an integral part of the sediment fabric, inhibiting sediment erosion and controlling the complex patterns of early sediment diagenesis and the first stages of oil formation[1,2]. Aller's[3] elegant experiments show that geochemical fluxes of inorganic ions can be dramatically altered by the presence of burrow structures, and highly significant chemical and microbiological changes have been described in shallow and deep sea sediments *in situ*[4,5]. The report by King on page 257 of this issue[6] of the inhibition of microbial activity in sediments by 2,4-dibromophenol (DBP) from the hemichordate *Saccoglossus kowalewskii* shows further the significance of biological activity on sediment structure.



S. kowalewskii secretes high concentrations of DBP in its mucus which then become incorporated into the lining of the animal's burrow. The burrow lining is aerobic because *S. kowalewskii* ventilates its burrow, whereas sediment nearby is anaerobic. Now King shows that DBP markedly inhibits aerobic microbial activity that would otherwise occur in the burrow lining, but has little effect on nearby anaerobic microbial activity. He therefore deduces that DBP is important in increasing the longevity of the mucus lining of the burrow wall, hence maintaining the integrity of burrows in the sediment. He also argues that the inhibition of aerobic microbial activity will lead to the deposition of iron oxyhydroxides — and these are indeed found in quantity in the burrow linings of this species.

These findings support further the key role of biological activity in the chemistry and physics of the top metre or so of marine sediments[7,8]. The general picture now emerging is of an interacting system between macrobenthic and meiobenthic animals burrowing in sediments, changes in microbial biomass and activity[9], and altered chemical and physical sediment properties (see figure).

Although this picture is emerging, we still know surprisingly little about marine sediments. *S. kowaleskii* lives in the relatively accessible intertidal regions, and the sediments that cover most of the seabed are documented only in the broadest outline. Little is known about the influence of bioturbation and microbial activity on sediment erosion and transport, and even less about their effects on geochemical fluxes in and across the sediment[7]. Adequate models need to be developed from Berner's[10] classic mathematical approach.

The potential significance of this work cannot be overemphasized. It is central to our understanding of such diverse aspects of sediments as the chemistry of early diagenesis and oil formation, and the control of sediment stability in harbours and estuaries and around man-made structures on the seabed. □

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