The authors attempted to remove hydrogen from $C_{36}H_{36}$, using palladium-charcoal heated to 500 °C, but they were unsuccessful. Full dehydrogenation to give an all-carbon cage related to the fullerenes is, in any case, not expected as the bonding pattern in such a product seems almost certain to be unfavourable. The reverse process of reducing $C_{36}H_{36}$ in the presence of a platinum catalyst led to the aromatic rings being successively hydrogenated up to and including the formation of $C_{36}H_{60}$.

This synthesis is an important milestone in the continuing development of supramolecules incorporating three-dimensional cavities. The aim is to add to the range of synthetic strategies and precursor fragments, so opening the way to new families of cages enclosing cavities of various sizes and electronic nature. Molecules of this type — with tunable, hydrophobic interiors — widen the options for producing new classes of receptors. For example, they appear to offer very considerable potential for the selective capture of individual ions and molecules in a range of applications which includes pollution control. □

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CLIMATE CYCLES

Upset for Milankovitch theory

Wallace S. Broecker

ONE of the fundamental tenets of palaeoclimate modelling, the Milankovitch theory, is called into doubt by isotope analyses of a calcite vein, just reported in *Science* by Winograd and colleagues[1,2]. The theory, which is backed up by a compelling bank of evidence, suggests that the ice ages are driven by periodic variations in the Earth's orbit. But the timing of the ice ages determined, with unprecedented accuracy, in the new record cannot be reconciled with the planetary cyclicity.

The idea behind Milankovitch theory is that changes in the tilt of the Earth's rotation axis and in the point in the annual cycle of the Earth's closest approach to the Sun alter the way solar radiation forces the climate. An exceptionally good match exists between the peaks and troughs in the radiometrically dated ice-volume record and those expected from variations of summer insolation in the Northern Hemisphere mid- to high latitudes. Specifically, the oxygen isotope composition of shells of marine foraminifera has varied with the precession of the Earth's spin axis. Indeed, the magnitude of the climate changes so revealed were in direct proportion to the eccentricity of the Earth's orbit[3].

Winograd and colleagues' evidence also turns on oxygen isotope data, this time from vein calcite coating the hanging wall of an extensional fault at Devils Hole, an aquifer in southern Nevada. In 1988, the authors[4] published a date, 145,000 years, based on ^{234}U-^{230}Th dating for the end of the penultimate ice age (Termination II), marked by an increase in the ^{18}O to ^{16}O ratio, a change taken to mirror an increase in local precipitation. Although the date was only 17,000 years earlier than the previously accepted date of 128,000 years, if correct, this change is enough to bring the Milankovitch mechanism into serious doubt.

Not surprisingly, palaeoclimatologists refused to take this lying down. Because of the long traverse time between the source of the Devils Hole signal (the aquifer recharge zone) and the site of the recorder (at the aquifer exit) the validity of the match between the ^{18}O record for the Devils Hole calcite vein and that for marine foraminifera was doubted. A finite age was obtained for the outer surface of the Devils Hole calcite vein, bringing the ^{230}Th-^{234}U chronology into question. The accepted marine chronology was defended on the grounds of a 124,000-year ^{230}U-^{234}U age for coral reefs formed during the sea-level maximum of the last interglacial, providing a firm anchor point for the timescale. Nevertheless, no satisfactory alternative explanation for the Devils Hole record could be given.

Because of this, the publication of further results was eagerly awaited. The two new papers[1,2] provide additional evidence which undermines much of the earlier criticism. The ^{18}O record in Devils Hole has been extended back two more full climatic cycles to about 550,000 years. The match with the marine ^{18}O record remains strong[1], demonstrating that the oxygen isotope composition of Devils Hole calcite has changed in harmony with that in deep-sea foraminifera. Uranium series measurements made by mass spectrometry[2] verify and make more accurate the earlier chronology. Further, ^{234}U-^{238}U measurements on water currently upwelling in Devils Hole confirm the validity of the 60,000 year age for the outermost surface of the vein calcite. These measurements yield a completely

RÉSUMÉ

Dead good

LUBBER grasshoppers are not palatable — in laboratory experiments, 21 species of bird and lizard refused to eat them, vomited if they did or, in the case of one unfortunate meadowlark, died. But loggerhead shrikes in Florida can get round these formidable chemical defences (R. Yosel & D. W. Whitman *Evolut. Ecol.* **6**, 527–536; 1992). The birds often impale their prey on thorns or barbed wire, either as a food cache or in courtship. Now it seems that this behaviour has another function. Although shrikes cannot eat fresh lubbers, they will consume them after corpses have aged for a day or two (by which time, presumably, the toxins have lost their potency). In nature, as in human affairs, no defence is perfect.

Growing stronger

IN the quest for ever stronger materials, F. T. Wallenburger and P. C. Nordine have developed a way of growing boron fibres that rival commercial carbon and silicon fibres in strength (*Mater. Lett.* **14**, 198–202; 1992). Until now, no reliable method had been found to do this (except for growing the boron around a filamentary tungsten substrate, which left the product too thick for its optimum material properties). But Wallenburger and Nordine have succeeded in growing fibres just 6 μm across and up to 2 m long by irradiating and dissociating high-pressure diborane (B_2H_6) gas, in hydrogen, with tightly focused laser light. At first the laser spot is kept aimed at a simple substrate surface; but once the boron growth has been nucleated, the substrate is drawn away as fast as the filament grows, at around 0.5 mm a second. That may seem slow, but only single-crystal silicon carbide whiskers have a higher tensile strength and they can be grown to only a few millimetres long.

Skin deep

IN a dazzling paper published in 1902 Rudyard Kipling sketched out his *Just So* hypothesis of how the rhinoceros got his skin. The aims of R. E. Shadwick and colleagues (*Proc. R. Soc.* B**337**, 419–428; 1992) are more modest. On the death of Duncan, a white rhino at Calgary zoo, they took skin samples and subjected them to structural and mechanical tests. It turns out that rhino skin, especially on the back and flanks (the areas most exposed during intraspecific fights), is not just thicker than that of other animals. Rather, it has properties intermediate between skin and tendon, making its strength, stiffness and work of fracture extremely high. The skin is comparatively easily torn which, say the authors, may provide a defensive advantage, in that in combat the result is more likely to be gashes than lethal punctures.