GLACIATION

A case of missing water

John T. Andrews

As the globe warmed and massive ice sheets melted at the end of the last ice age, sea level world-wide rose by around 120 metres[1]. The first 100 metres or so of the rise were accounted for by melting of ice sheets in the Northern Hemisphere[2] (18,000–7,000 years ago), leaving the last 25 metres or so to be supplied by the Antarctic ice sheets less than 9,000 years ago, or so it is assumed. But new measurements by Colhoun *et al.*, on page 316 of this issue[3], show that the Antarctic contributed at most 2.5 metres to sea level, and maybe as little as 0.5 metres.

Keeping track of the ice sheets and sea level could be a relatively straightforward matter were it not for the flexibility of the Earth's crust. But allowance has to be made for the flexure of the continental crust under the weight of the ice sheets and for depression of the sea floor as the mass of sea water increases, which leave a constantly shifting base line. For the Northern Hemisphere, the change in relative sea level has been tracked at many coastal sites, enabling, for example, Tushingham and Peltier to construct highly detailed histories[2] for the regression of the ice sheets and advance of the oceans for the end of the last ice age.

But in the Southern Hemisphere, matters are not so good. For Antarctica itself, only one relative sea level curve has been determined, and to constrain their model Tushingham and Peltier had to rely on data from New Zealand and other remote Pacific sites. So in spite of Antarctica's patent importance in these matters (its current ice sheets hold enough water to raise sea levels a further 60 metres), modellers have very little evidence to go on.

Colhoun *et al.* use the ages and elevations of raised beaches in the Ross Embayment and on Eastern Antarctica to develop their version of the deglaciation there. These are former beaches that, because of unloading of the ice sheets, have been raised up to tens of metres by the flexing crust. Although no single beach yields a relative sea level curve, collectively they offer an insight into the end of the last ice age.

The authors show that the retreat of the Antarctic ice sheets was already well underway 11,600 years ago, well before the 9,000 years previously imagined, and was completed by 6,000 years ago. (With a detailed calibration now available[4], it is possible to convert the radiocarbon dates of Colhoun *et al.* confidently into calendar years.) By comparison with the highest raised beaches (marine limits) in the Northern Hemisphere, those in Antarctica are relatively low — 30 metres, at most, above sea level. In Greenland, for example, elevations in excess of 80 metres are quite common[5]. It is with this contrast in mind that Colhoun *et al.* argue that the Antarctic ice sheets were thinner at the last glacial maximum than others believe. Otherwise the marine limits, with greater rebound of the crust, would have been raised higher.

The estimates are clearly controversial. They contradict, for example, interpretations of marine seismic and core data. But over the next three years, the West Antarctic Ice Sheet Project[6] (WAISP) may be able to verify them. The surprising conclusions, however, underline the difficulties in elaborating the details of glacial–interglacial history. Indeed, only recently Lambeck and Nakada tried to rewrite the story of the interglacial period immediately before the last ice age[7]. Although many have accepted that the sea level was 5 metres higher then than now, suggesting that either Greenland was entirely deglaciated or that the West Antarctic Ice Sheet had disintegrated, Lambeck and Nakada argue from analyses of raised coral reefs that the ocean volume was no different from today. Moreover, the warm period lasted from 135,000 to 120,000 years ago, spanning a considerably longer period than previously believed.

The bottom line of Colhoun and colleagues' paper, that Antarctica contributed only 0.5–2.5 metres to the post glacial sea-level rise, will surely be challenged. But if the authors are right, where did the 25 metres everyone seems to expect come from? The northeastern sector of the Laurentide Ice Sheet on North America, the Franklin/Innuitian Ice Sheet complex of the Canadian High Arctic or possible ice sheets across the Eurasian continental shelves might be implicated. But it is hard to believe they are the whole answer. □

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RÉSUMÉ

Nonproliferation theory

Physicists searching for the sixth quark, called top, may be encouraged by new calculations indicating that this is the last one that remains to be identified (Y. Iwasaki *et al. Phys. Rev. Lett.* **69**, 21–24; 1992). So far five types (or 'flavours') of quark are known — up, down, strange, charm and bottom. A sixth is confidently expected, if only because the first four make two matched pairs and a third pair would mirror the three members of the electron family. But are there any more? The new calculations look at what would happen to the interactions between the quarks using lattice quantum chromodynamics (dividing space into discrete points makes the number crunching tractable). With more than six flavours, it seems, the strong force would lose its most striking feature, confinement, and single quarks could be found in isolation. That would contradict all the evidence.

Skeletal skeleton

Aficionados of the cytoskeleton have always been preoccupied with defining the types of nexus between filamentous and other structural proteins — the shrouds and halyards of the cell, as they have been called — that prevail in different tissues. G. A. Porter *et al.* (*J. Cell Biol.* **117**, 997–1005; 1992) now report that in skeletal muscle the distributions of three sarcolemma-associated proteins are superimposed: dystrophin, muscle spectrin and vinculin occur in hoops around the I-bands and the M-lines of the contractile lattice and also in relatively sparse longitudinal strands. In dystrophic muscle the spectrin distribution is known to be unaffected, so the network does not depend on dystrophin. The suggestion is that the three proteins together form the system that couples the sarcolemma to the contractile machinery.

Gliding light

The discovery of fossil teeth of a species of flying lemur from Eocene rocks in Thailand casts doubt on the affinities of other fossils assigned to this enigmatic group, according to S. Ducrocq and colleagues (*Palaeontology* **35**, 373–380; 1992). The term 'flying lemur' is a misnomer: the animals neither fly (they glide) nor are they lemurs. The two extant species belong to a single genus, *Cynocephalus*, the sole representative of the Order Dermoptera; although reckoned to be allied to primates, their fossil record is sparse and ambiguous. The new fossil, *Dermotherium major* differs from all previous contenders in that its teeth are recognizably like those of *Cynocephalus*. Now that the fossil history of *bona fide* dermopterans goes back to the Eocene, the status of the several fossil groups assigned to the Order must be in question.