perpendicular to the fibre axis.

Unfortunately, there are still many uncertainties in the interpretation of such measurements. In the first place, the angle between the absorption and emission dipoles is not known, though it is believed to be small in the rhodamine dyes. A more serious limitation is that the orientation of the dipole(s) relative to the long axis of the myosin head is unknown. Also, the polarization signals show that there is large variation in the angles made between the dipoles and the fibre axis, and this may have many causes: a proportion of the heads being randomly oriented (perhaps not attached to actin); there being two or more populations of heads with different orientations; and the fluorophore being capable of limited rotation relative to the myosin to which it is attached.

A different kind of difficulty is that the movements appear to be rather small, totalling not more than about 3° of tilt with a release of 3.5 nanometres per half-sarcomere. Of this 3.5 nm, some will have been lost in the compliance of the filaments because the original tension is not completely recovered during the working stroke, so the relative movement of thick relative to thin filaments in each overlap zone was probably about 3.0 nm. However, the effective length of the crank is probably between 10 and 20 nm, so the movement corresponding to 3° is about 0.5–1 nm. Of this, about two thirds would be simultaneous with the length change and one third accompanies the subsequent recovery of tension. As regards the elastic part of the response, which is simultaneous with the length change, this is not a difficulty: it is often assumed that much of the compliance lies in other parts of the myosin molecule (for example, the S2 neck region), and there is now much evidence[10–12] that about half of the instantaneous compliance resides in the filaments, not in the crossbridges. As regards the working stroke itself, about two thirds of the initial tension drop was recovered during this phase, so if there had been no active tilt of the crossbridges, the elastic change would have dropped to one third, while in fact there was further movement in the same direction; the tilt attributable to the working stroke is the difference, namely up to 2° or so.

It has always seemed likely[4] that there is more than one component in the 'working stroke', so perhaps tilt of the myosin head is only one of these. Alternatively, the dipole axis may not be perpendicular to the axis about which tilt occurs, so that only a part of the tilt is registered by the changes in polarization, or there may be flexure between the tilt axis and the attachment of the fluorophore.

The interesting observation that the direction of the polarization response is reversed when the fibre is put into rigor implies that the mean tilt of the myosin heads is on the opposite side of the perpendicular to the fibre axis, in agreement with the electron microscope observation that first suggested tilting of the heads[2].

In any case, this is a most encouraging start of a new approach to the central problem of muscle contraction, and all muscle physiologists will look forward to its development. □

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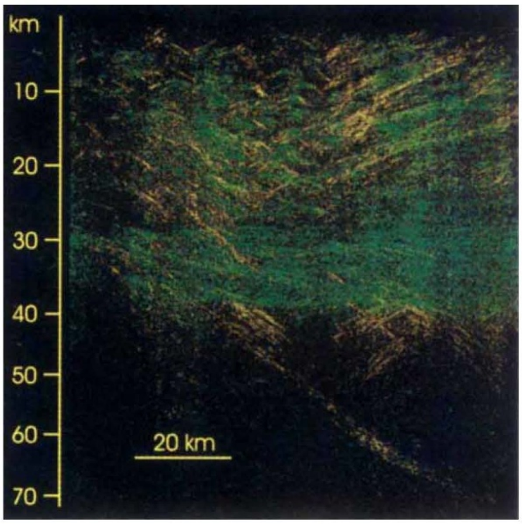
EARTH HISTORY

Reflections on plate tectonics

THE Earth today is a well regimented planet, with its surface divided into a small number of lithospheric 'plates' that slide as coherent masses over the mantle beneath. New oceanic lithosphere is formed at spreading ridges, cools and thickens, and disappears back into the mantle at deep-sea trenches; the result is a rather efficient escape mechanism for the Earth's internal heat. But this isn't the only way for a planet to organize its affairs. In particular, it has been suggested that the hot early Earth may have favoured a more chaotic tectonic style — for example, with small blocks of lithosphere foundering incoherently into the mantle, instead of the subduction process that we see at trenches today.

Uniformitarians everywhere will accordingly take heart from the seismic cross-section shown here, obtained by Calvert *et al.* from a 2.7-billion-year-old terrain in Canada's Superior Province and discussed on pages 670–674 of this issue. The steeply dipping seismic reflections (yellow) that extend to 65 km depth mark a shear zone along which oceanic crust was thrust down into the mantle (the unreflective region below about 40 km). This region of the Superior Province had already been identified as a collision zone from its surface geology; the seismic profile now suggests that this collision followed the disappearance of an ocean basin, by a process indistinguishable from modern-day subduction.



The seismic data reveal another modern feature of this Archaean terrain: the presence of a strongly reflective lower crust (sub-horizontal green lines between 30 and 40 km depth). The absence of this feature in previous seismic images of Archaean terrains has led to suggestions that Archaean continental crust might have formed in a different manner from its more recent counterparts. Now it seems that in at least some of these other terrains an originally reflective signature in the lower crust may have been lost by subsequent modification — perhaps due to a heating episode.

The new results extend the evidence for modern-style plate tectonics back into the Archaean aeon — the earliest subdivision of Earth history — beating by 800 million years the previous record of 1.9 billion years, held by a collision zone in the Proterozoic Baltic shield. How much further back might it go? Terrains older than 3.5 billion years are now known from several continents, and the oldest intact rocks date back to almost 4.0 billion years, so there is scope for yet another significant leap backwards. Laura Garwin

Laura Garwin is Physical Sciences Editor of Nature.