Furthermore, many of the data suffer from a fundamental ambiguity of interpretation, as there are two contrasting rheological models which can generate identical or nearly identical motions at the Earth's surface[6] (see figure). In the first, the thick-elastic-lithosphere model, the depth of fault slippage, D, is much less than the thickness, H, of the elastic lithosphere, and transient and steady inter-event motions are caused by episodic and uniform aseismic fault slip beneath the rupture plane. In contrast, for the thin-elastic-lithosphere model, $D \approx H$ and it is transient and steady ductile flow in the viscoelastic substrate that generates the inter-event movement patterns. This ambiguity is not always acknowledged or fully appreciated in the published literature, and individual researchers often employ one model without rationalizing their choice.

The general problem here is the absence of independent constraints on mid- and lower-crustal rheology appropriate to the timescales of event recurrence (usually hundreds to thousands of years). In this regard the Icelandic data set may have a distinct advantage. Electrical resistivity measurements quoted by Foulger *et al.* suggest a ductile rheology for the mid-to-lower crust, and effective viscosities inferred from post-rifting surface movements during 1987–90 are broadly consistent with those based on modelling by post-glacial rebound in Iceland. Nonetheless, doubts remain, as the depth resolution of surface measurements is generally crude, and it seems entirely possible that a model including post-event aseismic dike opening in the mid-crust could reproduce the observed displacement field and yet not significantly violate the other geophysical constraints.

Cycles

Of course the mid-crust could also flow at timescales longer than those which are directly relevant to seismic or volcanic eruption cycles. However, the potential merit of geodetic observations is to constrain the minimum value of the effective viscosity of the mid-crust. If post-event relaxation occurs on timescales of decades to centuries, and if this relaxation were due to crustal flow, then effective viscosities would be less than about 10^{20} Pa s, a value sufficiently low to decouple the tectonics of the brittle upper crust from the steady flow of the ductile lower lithosphere.

Another common limitation of inter-event deformation data is the difficulty of clearly distinguishing post-event transient movements from steady (uniform rate) long-term motions. For example, the Icelandic data cover only a short, 3-year interval about 10 years after the rifting episode which is alleged (reasonably) to be responsible for the observed high rates of post-rift transient deformation. However, there are as yet no data demonstrating either a temporal decline in strain rate or the expected migration of the strain rate field. Indeed, but for a small number of relatively complete post-earthquake geodetic data sets from Japan, the evolution of postseismic transient deformation is poorly documented, and even for the best constrained of the Japanese case studies there is room for several alternative views[9].

Declines

The general problem is that although there is convincing evidence for short-term (1 year or less) postseismic transient movements which are plausibly related to accelerated aseismic slip immediately down-dip of the earthquake rupture plane, supporting evidence for declines in strain rate over decades or longer is more elusive, and it is these latter movements that may indicate ductile flow in the mid- or lower crust. Again, the Icelandic data appear to have a distinct advantage, as the maximum relative displacement rate during 1987–90, about 40 mm yr^{-1}, looks as though it significantly exceeds the steady-state spreading rate of 19 mm yr^{-1} across the Mid-Atlantic Ridge in Iceland, supporting the authors' interpretation of their data in terms of transient motion.

These results point to clear ways in which new geodetic measurements can contribute to improving understanding of lithospheric rheology and the processes occurring beneath the brittle upper crust. Careful tracking of the spatial and temporal evolution of the strain-rate field following major earthquakes and episodes of dike injection would be especially valuable. The versatility and relative ease of surveying with the satellite-based Global Positioning System[10] makes it well-suited for this purpose, both through the establishment of new geodetic networks in the source region of major events and through resurvey of existing nets, which in many active regions date back 100 years or more. □

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RÉSUMÉ

Paternity pursuit

ENGAGING in the astronomical equivalent of an identity parade, P. J. Mouginis-Mark *et al.* have tried to track down the parentage of the SNC family of meteorites, comprising shergottites, nakhlites and Chassigny (*J. geophys. Res.* **97**, 10213–10225; 1992). The consensus is that the SNC meteorites are all chips off the martian block, probably ablated in a single planetary impact. But could the scar left behind be recognized? From the meteorites' petrology, the authors narrowed the search to the Tharsis volcanic region of Mars. Using mug shots of craters from the Viking mission, they found nine likely culprits, each of which is young (less than 180 million years old) and large enough (over 10 km across) to supply material that is still arriving at Earth. But none fully fits the description, and the authors are, as they say, continuing with their enquiries.

Strong stuff

THE marine worm, *Phragmatopoma*, ranks high among nature's builders for the economy and ingenuity with which it constructs its communal labyrinth, made of what appears to be masonry. J. H. Waite *et al.* (*Biochemistry* **31**, 5733–5738; 1992) have isolated the precursors — the unset cement — of one component of the composite (particles of debris caught from the circulating water make the other). Two proteins are abundant in the creature's thorax, each characterized by a repeating amino-acid motif in which 3,4-dihydroxyphenylalanine is prominent. This catechol is enzymically converted into quinone, which crosslinks the protein chains and probably attaches them to the substratum. The mortar outclasses man-made counterparts in that it bonds to unprepared and wet surfaces, is not choosey about the filler material, and functions at low mortar/filler ratios. Not bad for a mere worm.

Mirror image

A NEW twist is given to Berry's phase by researchers at Caltech (M. Segev *et al. Phys. Rev. Lett.* **69**, 590–592; 1992). The quantum record of a particle's history, Berry's phase is a phase angle which changes as the particle's environment is altered. Once the environment is brought back to its orginal state, the phase can be measured by comparison with a reference particle; in practice this is typically done interferometrically using beams of photons or neutrons. The usual picture of the phase rotating is made manifest in the new work, in which the image of a cross is passed through a many-mirrored periscope. The emerging image it turns out, is rotated by an angle equal to the sum of the phases acquired on each reflection.