roughly triangular field. One interpretation of this field is that the apices of the triangle are three 'end-member' geochemical components in the mantle. Assigning a mechanism of origin to these end-members is a subject of much debate. Point A is the source composition of most ocean-ridge basalts, and is depleted in those elements that preferentially have been transferred into the continental crust. Points B and C are often attributed to the influence, respectively, of old continental crust and basaltic oceanic crust injected back into the mantle by plate subduction. Mixing between these end-members then produces erupted lavas with isotopic compositions within the triangular field.

With some assumptions, the observed isotopic variation can be used to infer the relative ages of the end-member components. As the decay half-life of ^{235}U is less than one-sixth of the age of the Earth, most of the ^{235}U originally present has decayed away. Consequently, large variations in $^{207}Pb/^{204}Pb$ (giving steep slopes in the diagram) correspond to ancient variations in U/Pb whereas recent fractionation of U from Pb will be incapable of producing large changes in $^{207}Pb/^{204}Pb$. Thus, the isotopic distinction between ocean-ridge basalts, which generally plot close to point A on the figure, and those ocean-island basalts plotting near point B reflects source regions that have maintained distinct U/Pb ratios for over 2.5 billion years. Neither source region, however, is required to have been present in the mantle for this long. For example, sediments eroded from continents will carry with them the old mean age of the continents even though their reintroduction to the mantle may have occurred fairly recently through plate subduction.

At least two different mechanisms, with distinct consequences for the age of mantle geochemical heterogeneity, can explain the origin of the basalts that appear near point C in the figure. If the source of C-type lavas was derived from the source of ocean-ridge basalts (point A), the slope of the line connecting A and C corresponds to a fractionation age of 1.7 billion years. On the other hand, if the C-type source were generated from sources like those at point B, then significantly less time is required to generate the observed Pb isotope characteristics. If done in a short time, however, the large increase in $^{206}Pb/^{204}Pb$ from B to C would indicate a dramatic increase in U/Pb ratio in the C-type source, so dramatic that most workers favour the 1.7-billion-year interpretation for the age of source C.

The study of Class *et al.* provides a new approach for deciding between these alternatives. In the ocean basins are several long volcanic chains believed to be formed as crustal plates move over stationary plumes of hot material rising from the deep mantle. Class *et al.* reasoned that if the composition of the plume supplying the volcanism associated with one chain remained constant over the 100 million years or more that volcanism persists, examination of the isotopic changes along the chain, in basalts of widely varying age, could directly provide the parent–daughter ratios in the plume.

Their study of Pb isotope data for the basalts of the Ninetyeast Ridge, which connects the 117-million-year-old basalts of eastern India to the recent volcanism of Heard Island in the southern Indian Ocean, shows that $^{206}Pb/^{204}Pb$ increases significantly in going from old to young basalts along the chain. With the exception of the oldest basalts, $^{207}Pb/^{204}Pb$ is nearly invariant in the samples from this ridge (see figure). The conventional explanation for such a data array is that it represents mixing between a point on the A–B join with one on the A–C join. Hence, the line would have no age significance. Class *et al.*, however, argue that this array represents radiogenic increase of ^{206}Pb in the plume source over the 114-million-year history recorded by these basalts. To create the observed variation, Class *et al.* calculate that a U/Pb ratio of about 0.5 is required in the plume. This is indeed large compared with the values of about 0.1 typical of the ocean-ridge basalt source.

From this observation, Class *et al.* conclude that the geochemical fractionation responsible for producing the high $^{206}Pb/^{204}Pb$ component in the Ninetyeast Ridge plume happened not more than a few hundred million years ago. The process most likely to create high U/Pb in the plume source is partial melting near the Earth's surface. A common model for mantle plumes, however, has them forming as hot 'balloons' from a thermal boundary layer at the core–mantle boundary. If Class *et al.* are right, the young inferred age of the Ninetyeast Ridge plume source requires either a shallow plume source, or an unexpectedly rapid route for surface material to get to the core–mantle boundary and back again. A young plume age also contradicts the now long-held assumption that geochemical heterogeneity in the convecting mantle can be preserved for billions of years. Instead, the argument suggests a well-stirred mantle that takes on the disguise of old age by subduction of the ancient materials of the cold, convectively stagnant continental crust and upper mantle. □

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DAEDALUS

Textile topology

TEXTILE fabrics, says Daedalus, are one of the cleverest of inventions. The fibres are held together only by friction, yet the structure keeps its integrity. Even a knitted garment, which in principle consists of a single fibre knotted into an intricate two-dimensional manifold, holds together well despite its flexibility. Its one disadvantage is that it is hard to repair. Once a hole has worn in it, it must be crudely patched or discarded.

Daedalus now plans to get round this problem. Imagine, he says, a knitted garment made of one single fibre; and imagine that the knitting process returns to its origin so that the two ends of the fibre are adjacent. Fuse the ends together with a smooth, knotless join. The garment is now knitted from a single endless loop. This loop can then circulate round the garment, simply by traversing along its own length. The garment will retain its shape. But an area of high wear will be steadily renewed by the arrival of new fibre; the worn fibre will move away and be dispersed into less heavily abraded areas. Instead of developing a hole, the garment will wear evenly over its entire surface. After an amazingly long life, it will finally fall to pieces.

DREADCO fibre technologists are now elaborating this notion. They are devising a fibre with many tiny barbs, so that it can move easily in one direction, but cannot go back. The random slippage at any fibre junction now becomes directional. Daedalus hopes that the natural movements of the wearer will induce the circular fibre to travel round its loop, slowly but steadily. But to speed things up, he is inventing a special cleaning fluid with exactly the same surface-energy as the fibre. This eliminates friction from its many crossing-points. By submerging the garment in this fluid and subjecting it to ultrasonic vibro-cleaning, the loop is made to circulate at high speed, distributing and dispersing the accumulated wear.

DREADCO's knitted-loop garments should sell like hot cakes. The economical will value their sheer endurance. The fashionable will love their changing appearance. For the pattern printed on the fabric will slowly shimmer and disperse as the loop winds around, displacing its various elements. At unpredictable intervals it will reappear, upside-down, backwards, or in still stranger topological transformations. At every wearing, a knitted-loop garment will renew its novelty. David Jones