creasing depth). Crudely speaking, the rate of melt generation in a volume of rock is proportional to the vertical component of its velocity within the zone of extensive melting, which extends down to a few tens of kilometres depth. The width of upwelling is expected to be comparable to the depth. Therefore if melt ascends vertically to the surface, the zone of igneous activity is expected to be tens of kilometres wider than it is. Either the zone of upwelling is narrow or the magma must be able to move, in a lateral direction, into the axial region.

The papers by Blackman *et al.*[2] and Ildefonse *et al.*[3] both provide data directly related to this problem. The first discusses large long-term strains that produce fabric (ordered orientation of mineral grains) in the upwelling mantle beneath ridges. The second relates to the instantaneous stress field that determines the orientations of dikes in the mantle.

Blackman and colleagues[2] studied the travel times from distant earthquakes to an array of seismic stations on the sea floor near the Mid-Atlantic Ridge axis, and found that P-waves (primary waves, which are compressional and locally propagate upwards from great depths) arrived early at the ridge axis. This observation cannot be explained by the thermal structure of the ridge axis because the hot rocks have lower seismic velocities. Instead the authors propose that the mantle in the upwelling zone is anisotropic. This hypothesis is based on the well known observation that the oceanic lithosphere is anisotropic with the seismically fast direction horizontal and perpendicular to the ridge axis. Basically, olivine crystals (the chief mineral in the upper mantle) are anisotropic. Their fast direction is aligned in the transport direction within the plane of shear when the rock becomes rigid at the base of the lithosphere. The transport direction within the plane of shear is nearly vertical in the upwelling rock. The width of the vertical-fast anisotropic region — a few tens of kilometres — thus establishes that the upwelling region is much wider than the zone of igneous activity.

Ildefonse *et al.*[3] take a different tack, studying rocks in Oman that were once oceanic mantle. They have discovered an isolated upwelling region that was not subsequently deformed by horizontal shear at the base of the lithosphere and have deduced the orientations that the dikes (tabular, igneous intrusions) had in the upwelling region. Vertical dikes in the plane of the ridge axis, horizontal sills and some vertical 'A–C' dikes perpendicular to the ridge axis were mapped. These intrusions appear to have formed a network of molten channels that may have helped carry magma to the ridge axis. However, it is still not conclusive that such dikes (rather than porous flow through the partially molten mantle) are the dominant path that carries magma to the axial zone.

The mechanics of how several orientations of dikes coexist are not fully evident. Dikes are expected to intrude perpendicular to the axis of least compressive stress. This axis is roughly horizontal and perpendicular to the ridge at shallow depths where the lithosphere is being stretched. Ildefonse *et al.* propose two mechanisms that may act together to produce the horizontal sills and the A–C dikes. The first involves the excess pressure of the magma itself. This pressure often exceeds lithostatic pressure in the Earth — magma can rise to produce high volcanoes. Intrusion of a thick dike makes the stress more compressive in the direction perpendicular to the dike and may eventually cause the least compressive stress to lie along another axis, leading to a second set of dikes perpendicular to the first. Their second mechanism involves transient failure of the lithospheric lid either by crustal faulting or crustal dike intrusion which increases horizontal tension in the underlying mantle. The 'normal' asthenospheric stress field associated with mantle flow is present at other times. Ildefonse *et al.* call the alternate inflation of dikes in different orientations 'breathing'.

One aspect of this second explanation constrains the geometry of upwelling. For the typical least compressive stress to be vertical, either the strain rate in the vertical direction $\dot{\varepsilon}_z = \partial v_z/\partial z$ must be positive or the upwelling velocity must increase with shallower depths. The total volume flux per length of ridge axis of mantle material upwelling at a given depth clearly decreases upwards, reaching zero at the base of the crust. For upwelling velocity to increase upwards, the width of the upwelling region must decrease faster than the total volume flux.

Until now, models of the upwelling beneath ridge axes have by necessity been mixtures of elegant physics, based on simple assumptions, and qualitative observations of exposed mantle rocks. Blackman and colleagues' seismic study now indicates that the upwelling region can be sensed remotely, and the field study by Ildefonse and co-workers indicates that careful observations of dikes and fabric can constrain both transient and long-term processes in the upwelling. Both studies doubtless hold further implications, yet to be fully explored, for how ridges work. □

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1. Dietz, R. S. *Nature* **190**, 854–857 (1961).
2. Blackman, D. K., Orcutt, J. A., Forsyth, D. W. & Kendall, J.-M. *Nature* **366**, 675–677 (1993).
3. Ildefonse, B., Nicolas, A. & Boudier, F. *Nature* **366**, 673–675 (1993).

DAEDALUS

Home brewing

ALCOHOL is a treacherous friend. Many people value its mood-expanding qualities; but the heavy drinker risks serious medical trouble. Curiously enough, even the strictest teetotaller is exposed to alcohol, for it is naturally generated in the mammalian gut. The main culprit is the gut bacterium *Sarcina ventriculi*, which releases up to 30 g of alcohol a day into our intestines — equivalent to three 'standard drinks' such as glasses of wine or half pints of beer. We don't notice, because the liver mops up this small steady flow very efficiently. Nonetheless, we are all imperceptibly drunk all the time.

Dedicated alcoholics will be indignant at this wasted resource: for there is no point whatever in being imperceptibly drunk. Furthermore, the recommended safe daily alcohol intake for men is 30 g a day (women, with their less efficient livers, should keep below 20 g a day). Pooling internal and external sources, therefore, men can safely handle 60 g a day, and women 50 g. So, says Daedalus, if our internal source could be eliminated, men could safely drink six standard drinks a day, and women five drinks: a much more cheerful prospect. For by taking this dosage in a few large slugs rather than wasting it as a dribble, it could all be used to establish a period of worthwhile intoxication.

So DREADCO's biochemists are seeking a selective antibiotic to eliminate *Sarcina ventriculi* and other internal brewers from our guts. Already pilot compounds are being tested on experimental animals. They are making kittens noticeably less kittenish than usual, and guinea pigs less gormless — Daedalus suspects that these creatures are usually a bit drunk on their natural internal fermentations. Once perfected, 'Soberinsides' will be widely welcomed. Alcohol lovers will be able to double their consumption before hitting the medically prudent limits. Breweries and wine merchants will be able to sell twice as much before being accused of threatening the health of the community. Best of all, Soberinsides will bring new sharpness to our sober mental processes. For by eliminating the steady mental sabotage of internal fermentation, it will clear away the slight unnoticed alcoholic haze which now clouds our minds from birth to death. It will give all of us a calm clarity of thought, a keenness of insight and acuity of inference, equivalent perhaps to 10 or 20 extra points of IQ. Soberinsides will expand our mental life two ways: both reducing the perils of being really drunk, and allowing us for the first time to be really sober.

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