Accordingly, prevailing biogeographical hypotheses of European isolation[2–4] seem to be at least partly a product of incomplete fossil sampling, a factor that has bedevilled biogeographical investigations of many dinosaur groups[6]. For example, several recently discovered Asian dinosaurs — brachiosaurid[7] and diplodocid[8] sauropods, a ceratosaurian theropod[9], and a centrosaurine ceratopsian[10] — have altered the accepted biogeography of the groups to which they belong.

Ősi *et al.*[1] go even further. Because *Ajkaceratops* is very similar in some features to the bagaceratopsids (Fig. 1), a small group of horned dinosaurs previously known only from the Late Cretaceous of Asia, they suggest that *Ajkaceratops* or its immediate ancestors reached Europe during the early Late Cretaceous by 'island-hopping' across the Tethys Ocean, a prehistoric ocean lying between the southern and northern continents. Taking into account the previous discovery of some teeth from a leptoceratopsid (another type of Late Cretaceous coronosaurian) from the Late Cretaceous of Sweden, the authors propose that there were two independent dispersal events from Asia to Europe during the Late Cretaceous.

This might well be true. But biogeographical hypotheses are strongly influenced by phylogenetic hypotheses: when the evolutionary relationships of a group are not well understood, the associated biogeographical conclusions are not entirely reliable. For now, this reservation applies to the hypothesis of a double Asia-to-Europe dispersal proposed by the authors[1].

The affinity of *Ajkaceratops* with Asian bagaceratopsids is supported by some minor features from a limited anatomical region of the animal. However, if complete specimens of *Ajkaceratops* exhibit a combination of anatomical features seen in different groups, which is not unusual among dinosaurs, the systematic position of *Ajkaceratops* might have to be reconsidered. Furthermore, the position of the Swedish coronosaur among the North-American-dominated Leptoceratopsidae is even more ambiguous. Ősi and colleagues' Asia-to-Europe hypothesis is thus supported by the available data, but cannot be described as a firm conclusion. More complete specimens of *Ajkaceratops* and the Swedish leptoceratopsid are needed to securely reconstruct their systematic positions, and to evaluate the Asia-to-Europe dispersal hypothesis.

Because Europe is considered to be a biogeographical buffer between the Southern and Northern Hemispheres[11], it plays an essential part in reconstructing global biogeographical patterns during the Late Cretaceous. The discovery of *Ajkaceratops* may mark the beginning of a better understanding of the Late Cretaceous fauna of Europe, and ultimately of the Late Cretaceous biogeography of the planet as a whole. ■

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EARTH SCIENCE

Our planet's internal weakness

James A. Van Orman

The influence of the region where the lower mantle meets the core extends to Earth's surface. A computational study of mineral properties shows one way forward in understanding this enigmatic zone.

Earth's mantle is composed of solid rock, but on geological timescales it behaves as a sticky liquid. Just as in ordinary liquids, hotter material tends to rise and colder material to sink. The bottom of the mantle is hotter than the top, and the resulting convective flow leads to plate tectonics, earthquakes and volcanism. But unlike ordinary liquids, the mantle's resistance to flow varies with depth owing to changes in temperature, pressure and mineralogy. How these flow properties vary is largely unknown, because it is difficult to carry out the appropriate laboratory experiments at the extreme conditions of the deep mantle. Ammann *et al.* (page 462 of this issue[1]) have used first-principles physics at the atomic level to suggest that a change in mineral structure in the region just above the core will cause it to flow much more easily — be weaker — than the materials above.

The bottom layer of the mantle, known to geophysicists as D′′ (D double-prime), has a key role in mantle convection, as it is the region where heat is transferred up from the core. This layer is also the probable birthplace of mantle plumes, thin zones of upwelling rock that underlie volcanic centres such as Hawaii. Plumes are notoriously difficult to track by geophysical means, and much of our understanding of their behaviour relies on geodynamic simulations. The strongly enhanced flow in D′′ suggested by Ammann and colleagues will undoubtedly change our picture of plume development. It may also help to explain the complicated and enigmatic structures of the D′′ region that have been revealed by seismology[2].

Mantle convection occurs through the gradual deformation of minerals at the microscopic scale. The most direct pathway to information on the flow properties of mantle minerals is to apply a well-defined stress to a sample and to measure the resulting rate of plastic deformation. This experimental approach is not yet viable under conditions relevant to the deepest parts of Earth's mantle, although significant progress towards this goal has been made recently[3].

A second approach is to investigate the fundamental rate-limiting step in plastic deformation — the hopping of atoms from site to site through diffusion within the mineral. If the diffusion rates of the constituent atoms are known, the flow properties of the material can be estimated on the basis of established theoretical relations. Diffusion rates in the deep-mantle minerals magnesium silicate perovskite ($MgSiO_3$ perovskite) and periclase (magnesium oxide) have been determined experimentally at the pressures and temperatures reached in the middle of the mantle, but such experiments are beyond present capabilities under deeper mantle conditions. Thus, no experimental data exist on the plastic rheology of the recently discovered post-perovskite[4] phase of $MgSiO_3$, the high-pressure mineral that probably predominates in the D′′ region.

Ammann and co-authors[1] used methods based on a quantum-mechanical approach known as density functional theory to estimate atomic diffusion rates in all of the major deep-mantle minerals, including post-perovskite. The calculations necessarily involve some important approximations. But similar methods accurately predict a wide range of mineral properties under deep-mantle conditions[5], and the results of Ammann *et al.* are in reasonable agreement with diffusion data for $MgSiO_3$ perovskite and periclase. Ammann *et al.* found that the diffusion properties of post-perovskite are highly dependent on direction, with Mg and Si diffusion rates in one crystallographic orientation, <100>, being several orders of magnitude faster than in orthogonal directions.

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Such strong diffusional anisotropy is not observed in other deep-mantle minerals, and it introduces some ambiguity in modelling the rheology of D″. Post-perovskite could be either stronger or weaker than perovskite depending on how it deforms — whether by 'diffusion creep', in which case the slow direction dominates, or by 'dislocation creep', in which the faster direction may control the rate of deformation. Diffusion creep cannot easily explain the anisotropic behaviour of seismic waves observed[2] in D″. Thus, it seems likely that dislocation creep is the main mode of deformation, and that the transition to post-perovskite results in a substantial reduction in resistance to flow. This interpretation is broadly consistent with geophysical estimates of the mantle's viscosity profile[6], but suggests that D″ is much weaker than previously thought.

Ammann and colleagues[1] also propose a mechanism for generating the sharp reflection of seismic waves that is observed at the upper boundary of D″. Although the mineralogical transformation from perovskite to post-perovskite may be gradual[7], an abrupt transition in rheology might occur when a critical fraction of the new mineral is produced. A shift from perovskite-dominated diffusion creep to post-perovskite-dominated dislocation creep may lead to a shift from an isotropic mineral fabric above D″ to a textured one in which the mineral grains have a high degree of crystallographic alignment. The increase in the speed with which waves travel in the textured material may be sufficient to reflect seismic waves at this rheological transition.

Clearly, much work remains to be done to provide a more complete picture of the rheology of deep-mantle materials. Deformation processes in minerals with strong diffusion anisotropy need to be better understood, as do the effects of chemical impurities. Ultimately, technical developments should permit well-controlled diffusion and deformation experiments at the conditions relevant to D″. But for now, sophisticated computations such as those performed by Ammann and colleagues are leading the way. ■

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CANCER

A wolf in wolf's clothing

Douglas R. Green

Paradoxically, the CD95 receptor, a potent inducer of apoptotic cell death, is expressed on most tumour cells. Surprisingly, it turns out to be an important promoter of various cancers.

For more than two decades, CD95 — also known as Fas and APO-1 — has been considered a killer, the *capo di tutti capi* of death receptors in the tumour-necrosis-factor receptor family. Interaction of this cell-surface receptor with its ligand, CD95L, or with activating antibodies induces rapid apoptotic death in many cell types, and injection of such ligands or antibodies into animals results in liver destruction and death. Moreover, deletion or mutation of CD95 causes an immune-related disease due to loss of apoptosis. In many cells, even when apoptosis is blocked, CD95 induces necrotic cell death through a different signalling pathway. So the idea that CD95 actually promotes cancer — which is generally characterized by decreased rather than increased cell death — seems ridiculous. But on page 492 of this issue, Chen and colleagues[1] provide overwhelming evidence that this is indeed the case, a finding that is tantamount to a paradigm shift.

The authors use various human tumour-cell lines, primary cancer cell lines and mouse models of spontaneous and damage-induced cancer to show that reducing or abolishing CD95 compromises tumour growth without causing cell death. Furthermore, they find that tumour-derived CD95L is necessary for tumour promotion, presumably acting in a cell-intrinsic (autocrine) way. Their conclusion, that CD95L–CD95 signalling is generally important for the generation and maintenance of cancers, is therefore compelling.

Hints that CD95 has non-apoptotic functions have surfaced repeatedly in the past. (Sometimes, however, a viewpoint becomes so ingrained in our collective scientific consciousness that alternatives go unheeded.) For example, previous work has shown that activation of CD95 has a co-stimulatory effect with antigen-receptor signalling in T lymphocytes,

50 & 100 YEARS AGO

NATURE

50 YEARS AGO

Since Morrison and Cocconi published the suggestion that there might be advanced societies elsewhere in the Galaxy ... beaming transmissions to us on a frequency of 1,420 Mc./s, Drake has described equipment under construction to look for such transmissions ... Would not this other more advanced society ... be doing what we ourselves are now discussing and are on the point of doing, probably during this century, namely, sending probes to nearby stars ... For this reason we might better devote our efforts to scrutinizing our solar system for signs of probes sent here by our more advanced neighbours.

From *Nature* 28 May 1960.

100 YEARS AGO

In the *Cairo Scientific Journal* for February Mr. Harold Sheridan gives an account of that curious musical instrument, the *rabába*, which was introduced into Europe by the Crusaders, and, with a slight modification of the original name, is now known as the rebeck. It has certainly been evolved from the one-string lyre of the early monuments, the single string twanged with the finger developing into the present double-stringed instrument played with a rude bow and provided with a body. Even in its present state it is a most primitive instrument, made up in the rudest way out of a long iron nail, a cocoa-nut, a few strands of horse-hair (that of the living animal being most in request), a piece of fish-skin, and sundry pieces of wood. The last are coarsely glued together, and the body is made of half the cocoa-nut, over which a piece of moist skin — that of the Nilotic fish known as the *bayad* — is tied tightly until it dries. The tone is regulated by incisions made in the body ... The *rabába* is thus of considerable interest as marking an early stage in the evolution of the modern violin.

From *Nature* 26 May 1910.

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