both Hayakawa[9] and Hillebrandt *et al.*[10] have considered giant explosive events in the centre. As mentioned above, Webber *et al.*[2] have proposed an elegant solution, based on the idea of associating the only two gamma-ray astronomy line measurements from that general region of the sky. According to these authors, the previously observed 0.511-MeV line could come from the annihilation of positrons emitted in the ^{26}Al–^{26}Mg decay, a process that is immediately followed by the emission of the 1.809-MeV photon bringing the ^{26}Mg to its ground state. In this model a significant part at least of the observed ^{26}Al would not be created from continuous diffuse nucleosynthesis in the disk, but rather from the special environment in the galactic centre.

What all these results clearly call for are better data, providing good spectral resolution as well as serious imaging for the gamma-ray sky. Cooled germanium detectors already provide a spectral resolution approaching 0.1 per cent around 1 MeV, as shown at least in part by the HEAO-3 experiments, and are currently improving. Imaging in gamma-ray astronomy is trickier, because of the physics of high-energy photon detection. True imaging (at the arc minute level, a minimum requirement for astronomical work) is possible with coded masks or 'multiple pinhole' collimators, but this has so far never been coupled with the high-resolution spectroscopy possible with germanium detectors. A mission combining the two, and with good sensitivity in a wide range, is currently being considered by the European Space Agency under the name of GRASP (Gamma-Ray Astronomy with Spectroscopy and Positioning) for launch on whatever carrier may be available in the early-to-mid 1990s.

Looking beyond nucleosynthesis, much new astronomical data would be revealed to a mission looking for the first time at gamma-ray sources with the same resolution as the historical imaging proportional counter on the Einstein Observatory: from the active galactic nucleus gamma-ray luminosity function, to new redshift measurements in the 0.511-MeV line, to a wealth of galactic problems such as accurate mapping of the ^{26}Al line. ☐

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Earth sciences

Composition of the inner core

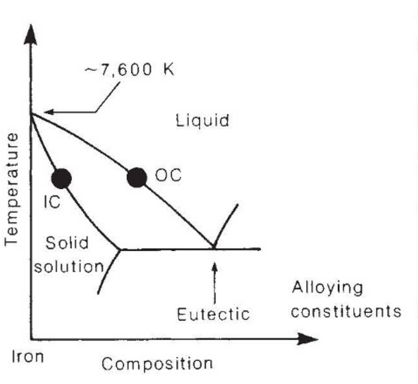
Raymond Jeanloz

THE inner core makes up only 0.7 per cent of the volume of the Earth. Despite its small size, this region is very important to our understanding of the planetary interior. In particular, current estimates of the temperature at the centre of the Earth; of the energy sources required to sustain the geomagnetic field; and of the core heat that is available to drive convection in the overlying mantle all rely on models of the chemical and physical state of the inner core. Thus, A. Jephcoat and P. Olson's re-analysis elsewhere in this issue (*Nature* **325**, 332–335; 1987) of the geophysical constraints on the composition of the inner core is of broad interest.

By comparing the seismologically determined density of the inner core with the latest measurements of iron and iron-sulphide densities at elevated pressures, Jephcoat and Olson conclude that some alloying constituent must be present in the solid inner core, as well as in the liquid outer core. This result is somewhat tentative because seismological constraints on the inner-core density are less certain than for other regions of the Earth. Also, the combined effects of temperature and pressure on the experimental measurements are still imperfectly known. Nevertheless, Jephcoat and Olson's conclusion is supported by the most recent shock-wave study on iron reported by J. M. Brown and R. G. McQueen (*J. geophys. Res.* **91**, 7485–7494; 1986). Although Brown and McQueen suggest that the inner core is pure iron, their analysis in fact shows that both the density and bulk sound velocity of iron are about 5 per cent higher than those of the inner core, when compared at the same pressures and temperatures (see Fig. 6 of their paper).

A possible phase diagram for the core alloy at the pressure of the boundary between the inner and outer core is shown in the figure. The coexisting solid (inner core) and liquid (outer core) compositions are shown in accord with Jephcoat and Olson's estimate that about half the alloying of iron is indicated by the inner-core density relative to that of the outer core. If this analysis is correct, it will be possible to combine further refinements of the seismological densities with high-pressure measurements (now in progress) on the melting relations of iron-rich alloys to identify the temperature at which the inner core and outer core compositions coexist. Because the inner core is sufficiently small to be essentially isothermal, such a determination of the temperature at the inner-core boundary is equivalent to measuring the temperature at the centre of the Earth.

The compositional separation between the inner core and outer core is also of interest to those modelling the dynamo that produces the geomagnetic field. One of the leading models for driving this dynamo is a compositionally induced convection of the outer core, whereby denser (more iron-rich) crystals freeze out of the less dense (more alloyed) outer-core liquid. The crystals thus sink towards the inner core, and in doing so induce the liquid motions that sustain the magnetic field. According to Jephcoat and Olson, however, the compositional and hence density difference between inner- and outer-core materials is substantially less than previously thought. In the light of their results, they suggest that the dynamo is sustained mainly by the alternative energy source of radioactive decay. Models of radioactive heating lead to the prediction of considerably higher fluxes from the core into the mantle than for the compositional dynamo. Hence, Jephcoat and Olson favour core heating as a significant source of energy for mantle convection and the resultant motion of crustal plates observed at the surface.



Possible phase diagram for the Earth's core at a pressure of 330 GPa. IC, inner core; OC, outer core.

Regardless of whether one fully accepts Jephcoat and Olson's conclusions, their timing is appropriate not only because it is the 50th anniversary of the discovery of the inner core, but also because very recent advances in seismology and in high-pressure experimentation have led to a resurgence of studies on the deepest region of our planet (see, for example, the December issue of *Geophysical Research Letters*). ☐

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