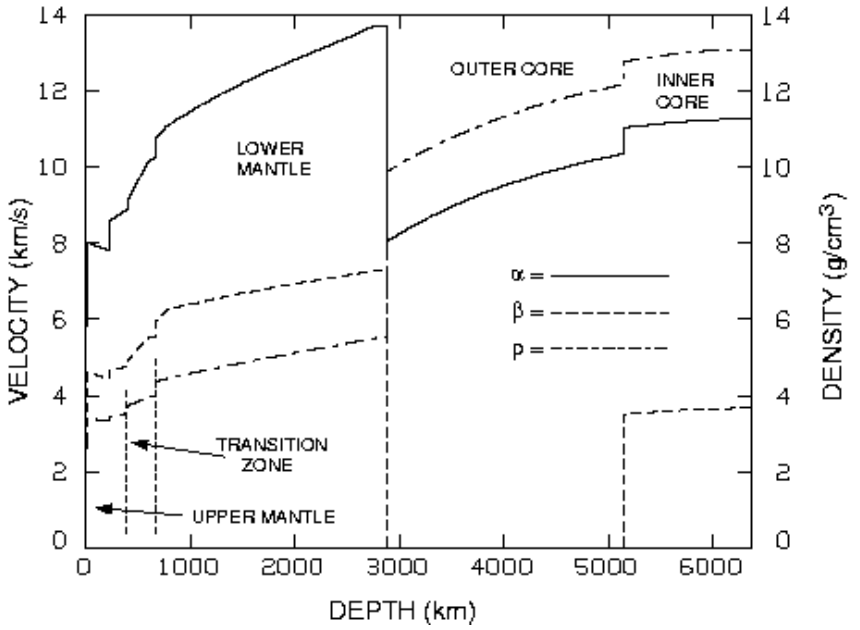
4.3 THE CORE: CURRENT PREJUDICES

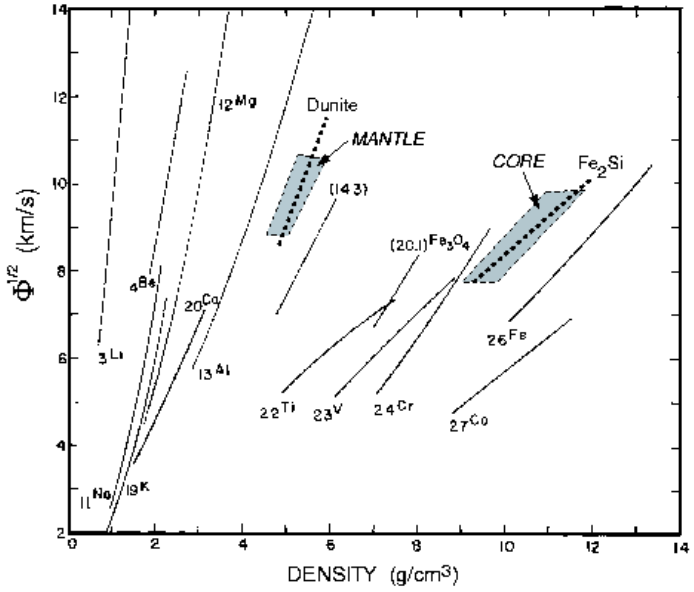
Given the size of the earth's core, we don't know that much about it-but we ought to say something!

Facts: there are significant velocity and density changes even if the details are unclear at the transitions.



The dramatic changes in physical properties at the CMB strongly suggest a major compositional change rather than a phase change. The core is thought to be primarily iron for a number of reasons:

1) High pressure experiments suggest a relationship between mean atomic number, density, and $\sqrt{\frac{K}{\rho}}$ (called bulk sound velocity - P wave velocity for zero rigidity material) It is clear that the mantle and core must be very different with the core close in composition to iron.



2) Iron is the only heavy element found in volume in meteorites and the solar system.

3) the earth's magnetic field is thought to be generated in the core by fluid motions - it is to hot to be a permanent magnet. Iron is the only suitable material.

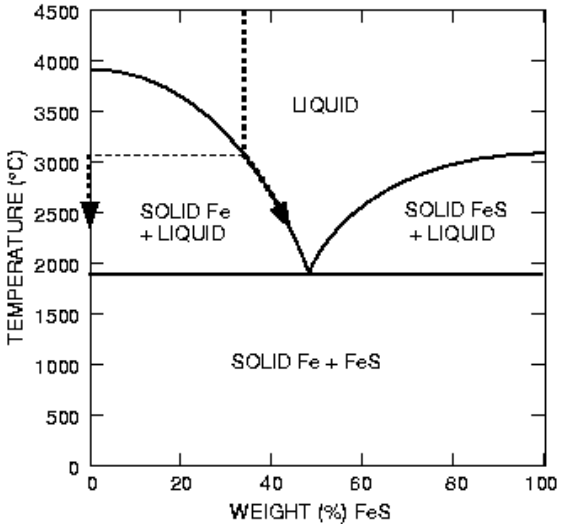
But-the data show the core is lighter (less dense) than it would be if it were pure iron. In meteorites, some nickel (Ni) is found with the iron so the core is probably Fe-Ni, but Ni is heavier than iron! The core must thus be mostly Fe, some NI and an unknown light element.

A number of light elements have been proposed - silicon and sulphur are the most popular but others are possible.

4.4 THE INNER CORE

In contrast to the outer core, the inner core is *denser* than pure iron, so it is thought to be iron-nickel without a light element. Thus it is chemically different from the outer core, as well as being solid rather than liquid.

WHY? One possible explanation for the differences can be obtained from the chemistry of the Fe-FeS system at high temperature and pressure.



The phase diagram is extrapolated from the laboratory.

-pure iron (Fe) melts at ~4000°

-pure FeS melts at ~3000°

-BUT about 45% FeS (~16% S) mixture melts at a much lower temperature ~1800 °

(this temperature is called a *eutectic* temperature: material melts into a solid of the same composition : the *eutectic composition*)

If it were not at the eutectic - start off with a liquid that is 33% FeS at a temperature of 4000 ° and this cools. Eventually it hits the phase boundary, at this point solid Fe starts to freeze out. As the Fe freezes out of the melt the melt becomes richer in FeS. With continued cooling we get a solid Fe material and a liquid FeS melt. The material melts into a solid and liquid of different composition!

This *may* be what is happening in the core-so the inner Fe core is growing with time as the core cools. It is thought that the nickel would go preferentially with the iron into the inner core.

If so (model only!), we can say:

Outer core: 30% earth's mass: fluid ~12 % S, 86 % Fe, 2% Ni

Inner core: 2% earth's mass: ~80 % Fe, 20% Ni

These numbers are subject to change without notice!

How did it get there? We'll see that current theories of planetary formation assume the earth heated up to the melting point of iron which sank to form the core. If so, the inner core is a result of the slow cooling of the original core.