appeared on 11th Aug 2008

Sneak peek at the earth’s core

A picture of El Dorado is slowly getting clearer, says S.Ananthanaryanan .

The progress of civilization has been remarkable. Since the first step away from primates, which may have been towards making better tools and certainly in the discovery of using fire, the way humankind has gained control over natural resources would have been incredible if it wasn’t there to see!

Agriculture, coal mining, roads and transport, the discovery of metals and metal-working, mining of mineral oil, the internal combustion engine, chemical engineering, aviation, nuclear power, computers… the list goes on. But now, progress itself seems to be using up sources both of energy as well as key raw materials, which may bring the great parade to a halt! It is in this context that the reserves trapped in the depths of the earth are seen as a storehouse that may help us get over the crisis. But while seismologists and scientists had hardly a lead on how to get a handle on this way out, ***Nature***, last week reported a step forward in the understanding of the earth’s internals.

Structure of the earth

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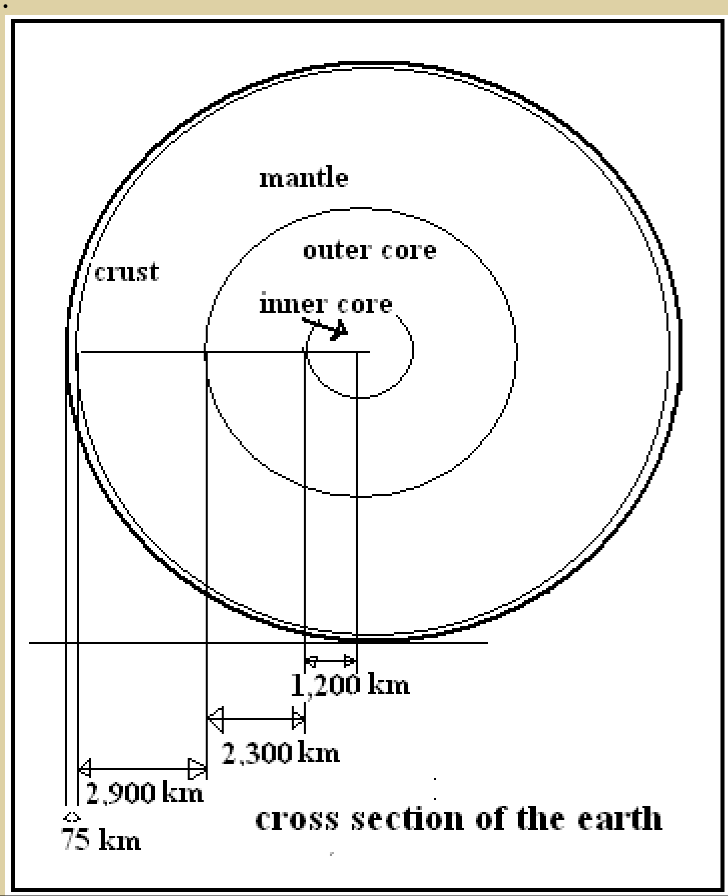


cross section of the earth

The layers of the earth as we go down from the surface are the ***crust***, the ***mantle*** and the ***core***. The crust is the outer layer and is about 75 km thick. This layer is where we have the continents and the body of the oceans. This layer is mainly aluminium silicates and it is rigid and reasonably fixed. Below the crust is the mantle, some 2,900 km thick and which contains much of the earth’s internal heat. The heat makes the mantle fluid, though a viscous fluid, and the earth’s crust could be said to ‘float’ on the mantle. Convective currents within the mantle are thought to be the drivers of ‘plate tectonics’ or the movement of the earth’s crust. The mantle consists of silicates of iron and magnesium

The next layer is the core – the liquid, outer core, some 2,300 km deep and the inner core, 1,200 km, down to the centre. The outer core is mainly nickel-iron alloy and the inner core is mostly iron. Because of the tremendous pressure, the inner core is solid, although it is as hot as the outer core.

Resources of the earth

All mining carried out on the earth so far is within the 'upper' crust or within a few kilometers. It would appear that the denser components of the earth, like the metals, sank to the bottom when the early earth was much hotter, while only lighter elements at the surface condensed to form the crust. The deposits of iron, nickel, and other metals we find in the crust are only accidental and minute in quantity, compared to what there is deeper down in the earth.

As we see, the mantle and the core are thousands of km across, and consist almost entirely of the most valuable minerals. If we could find a way to go down to get them, or a means of getting them up on the surface, the scope for new materials and structures would be limitless.

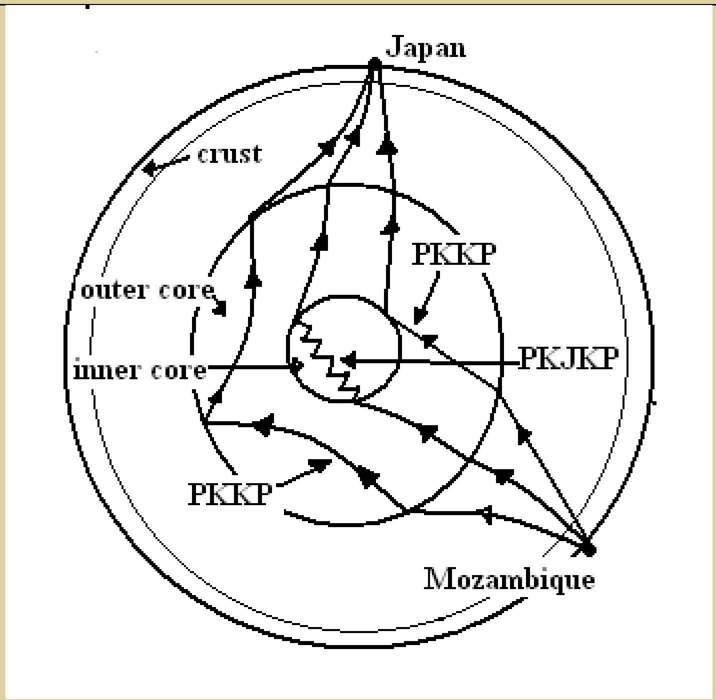
The earth's crust is also an excellent insulator and has locked in huge reserves of heat energy. All known coalfields and mineral oil deposits and even the nuclear energy sources would appear negligible if we could tap into the immense reservoir that is in the mantle. As the climate on the earth is mostly controlled by the radiant energy of the sun, tapping the earth's internal energy would not directly affect the ecology. In any case, it would be centuries before we could appreciably affect the reserve and by then the energy economics of mankind would certainly be vastly different.

How to get there

For all these possibilities, our knowledge of the core of the earth is scanty, derived from secondary evidence and is even speculative. The existence of the core itself was suggested from earthquake data only in 1906. And it was in 1940 that a solid iron core was proposed, based on the earth's magnetic field. Since then, seismic data of different kinds has been collected but observations of distortion of faint waves passing through the earth, which form the bases for conclusions, are not reliable for any clear mapping of the earth's interior.

The method is that whenever there is an earthquake, it creates elastic waves in the earth, something like sound waves when we clap our hands. Now, when these waves pass through the earth and are detected at different places, the timing and intensity of what is detected provides data on the strata that the waves have traversed. The waves would have different speeds through different media, which would bend the waves, like lenses do with light waves. Scientists use symbols **P**, **K** and **J** for the wave, the outer core and the inner core. A wave that passes right through the inner core and emerges, is then a **PKJKP** wave. Surface waves or waves that traverse the mantle are well known, but PKJKP waves are barely perceptible.

Another feature of waves is whether they are ***compression*** waves (like sound) or ***shear*** waves (like cracking a whip). Compression waves are faster and can pass through liquids, but not shear waves. The PKJKP waves that have been detected are the slower, shear waves, which is why we know the core must be solid.



The results reported by Dr Wookey and Dr Helffrich of The University of Bristol, UK, in the journal ***Nature*** are of a single event, a 7.0 magnitude earthquake in Mozambique, observed by a high sensitivity array of detectors, called ***Hi-Net***, in Japan. Mozambique is at 15˚ S and 35˚ E while Japan is at 35˚ N and 140˚ E. That puts an angle of 50˚, in the N-S and 105˚ in the E-W for the path of a signal from Mozambique to Japan, via the centre of the earth. This provides a good setting for analyses of different sorts of seismic waves.

The results of the observations of the compression and shear waves through the inner core suggest a change-over from the traditional picture of the core as being the same in all directions to one where the iron particles are packed in a particular, directional way. A model of iron forming a hexagon lattice with an axis perpendicular to the earth’s rotation leads to results that agree with observations and is step forward in understanding the structure of the earth’s core..