Lowermost mantle becomes more complicated

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The lower mantle resides at a depth between 660 km to nearly 2,900 km inside the earth and consists of 56% of Earth's total volume. It is believed to consist of three minerals: bridgmanite, ((Mg,Fe)SiO_3), ferropericlase ((CaMg) O); and calcium-silicate perovskite ($CaSiO_3$). Bridgmanite is believed to be the major component.[1]

Importance of lower mantle to the Flood

The properties of the lower mantle are important since models of its viscosity, temperature, density, and composition would impact several aspects of any Flood model, such as vertical tectonics, catastrophic plate tectonics (CPT), estimates of seismic velocities, seismic tomography interpretations, and others. Some of the issues involve the interpretations of what are called Large Low Shear Velocity Provinces (LLSVPs) and ultralow-velocity zones (ULVZs).

LLSVPs and ULVZs

LLSVPs consist of two regions of low shear wave velocity in the lowermost mantle as detected by seismic tomography (figure 1). They are located under Africa and the western Atlantic (named Tuzo) and over much of the equatorial Pacific Ocean (named Jason). LLSVPs are surrounded by regions of higher seismic velocity. They cover about 30% of the lowermost mantle above the core-mantle boundary (CMB) and are believed to extend upward around 1,000 km.[2] They have been consistently detected for many years by numerous tomographic observations, so they are very likely real features. It is interesting that the LLSVPs mostly straddle the equator and are antipodal to each other. Seismic S-wave (shear-wave) velocities are 2% less and P-wave (primary wave) velocities are 0.5% less, respectively, than the average of lowermost mantle velocities[2] with lateral and vertical heterogenicity.

Seismic waves are affected by both pressure and temperature differences. If seismic velocity is entirely caused by temperature differences, every S-velocity decrease of 1% equates to a temperature increase of 200°C.[2] And if the LLSVPs are entirely thermal, they would be buoyant, which is one reason why secular scientists believe that the LLSVPs are mostly or entirely chemical differences providing higher density.[3,4] Thus, LLSVPs are believed to have remained above the CMB for hundreds of millions of years.

However, in the CPT model, they may be hotter lower mantle blobs pushed to these locations by cold subduction slabs 4,500 years ago during the Flood.[5] Then, there may not have been enough time for the hotter blobs to rise appreciably, but they still could have been the cause of 'mantle plumes' that would explain 'hot spots'.

However, the cause and properties of LLSVPs are still unknown.[6] The bulk sound velocity is probably 0.5–1.0% higher in LLSVPs than average,[7] which suggests that the reduced seismic velocities are not all due to higher temperature.

ULVZs are much smaller than LLSVPs in area, believed to be only 5–25 km thick, and reside on top of the CMB.[8] They have S-wave and P-wave reductions of 5–50% and 5–25%, respectively, giving much lower wave velocities than LLSVPs! Their distribution is patchy on the CMB and are generally associated with LLSVPs (figure 1).[9] The cause of ULVZs is unknown, but suggestions include partial melts, a different composition of lowermost mantle minerals, strong heating from the core, ultra-dense subduction remnants, etc.[6]

Secular scientists suggest LLSVPs and ULVZs could be primordial, caused by differences in the precise chemistry of mantle minerals, caused by the sinking of a 'magma ocean', caused by heat from the core, or as a result of subduction.

A new mineral phase discovered in a super-deep diamond

Researchers had previously assumed that calcium-silicate perovskite, which has been investigated at room temperature and mantle pressures, was in its tetragonal configuration in the lower mantle. It shows great strength against deformation.[10] Just recently, researchers discovered a new phase of calcium-silicate perovskite in a 'super-deep' diamond from South Africa that they estimate formed 200–1,000 km deep in the earth.[11] Such diamonds sometimes also contain other lower mantle minerals. After forming at depth, these diamonds are carried rapidly to the surface in narrow explosive diatremes, also called kimberlite pipes.

The particular structure of calcium-silicate perovskite in the diamond is cubic and is considered a new lower mantle mineral. It is called davemaoite, named after Ho-kwang 'Dave' Mao, a prominent Chinese researcher who made many pioneering discoveries

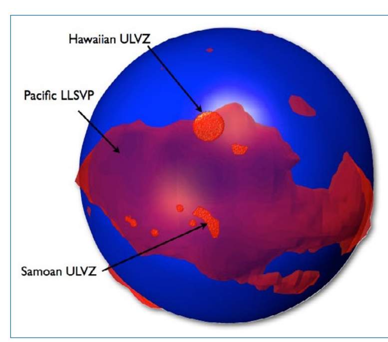

Figure 1. Graphic of structures on the core of the earth (blue). The Pacific LLSVP is shown in red with the smaller, thinner, ULVZs shown in bright red.

in high-pressure geophysics and geochemistry. The cubic form is highly unstable at the earth's surface, which is why it was previously unknown. Davemaoite is likely the mineral that represents calcium-silicate perovskite throughout the lower mantle and would make up 5–7% of the lower mantle.[12]

Davemaoite surprisingly 'soft'

The properties of davemaoite were discovered when researchers put calcium-silicate perovskite in a diamond anvil press under a pressure equivalent to a 1,200 km depth and heated it to 1,150°K.[10,13] They not only formed the cubic structure, but also were able to deform the crystal and analyze its properties. The bulk modulus (its resistance to compression) and viscosity of davemaoite turned out to be significantly lower than bridgmanite and ferropericlase. The degree of 'softness' depended upon the precise composition, since davemaoite can have minor component impurities of other elements as well as the radioactive elements uranium, thorium, and potassium.[14]

The possible significance of davemaoite

Because of the relative softness of davemaoite, researchers hypothesize that it may explain low seismic velocities in the uppermost lower mantle, as well as other properties of LLSVPs and ULVZs.[13,14] They also consider that the mineral may have a role in the subduction process, including the separation of the crust and upper mantle lithosphere subducted into the lower mantle.[13] This separation is believed to occur because the oceanic crust becomes denser due to more significant phase changes than those taking place in the subducted uppermost mantle. They suggest that the crust becomes the denser LLSVPs and/or ULVZs and the uppermost mantle remains as the high seismic velocity regions surrounding the LLSVPs. However, the subducted slab is only 100 km thick to begin with, making thick LLSVPs and ULVSs still difficult to explain.

Davemaoite also provides evidence that recycled ocean crust may partially explain the sometimes-perplexing geochemical diversity of ocean island basalts.[13] However, other scientists point out that the ocean crust is only 6–10 km thick of which only 23% is believed to transform to davemaoite.[11] This is way too small a volume for subducted slabs to explain the huge volume of LLSVPs, although it may explain the small volume of ULVZs.[10]

Many variables associated with the lowermost mantle

Much of what is believed about the lowermost mantle is speculative and the discovery of davemaoite adds to that. The problem is that the exact chemical makeup of mantle minerals is quite variable and depends on factors like the heat flow across the CMB, the amount of iron, the electronic configuration of iron that changes with mantle depth, whether the iron is in the ferrous or ferric ionic state, the amount of aluminum and other elements, the existence of a unique phase change to post-perovskite, etc.[1,6,15–17] Such variables can have large effects on viscosity, density, thermal conductivity, seismic wave velocities, and other properties. For instance, if the amount of Al_2O_3 increases 10% in the mantle, it would account for the entire 2% decrease in S-velocity in LLSVPs.[2] Thus, it is still unknown whether the LLSVPs and ULVZs represent temperature changes, compositional changes, a little water,[18] melt, or combinations of any two or more.

Flood implications

Davemoaite and other lower mantle mineral characteristics have several possible Flood model implications. Davemaoite could relate to the dynamics of convergent plate margins.[13] Mantle viscosity is likely much lower than secular scientists assume, which would allow more rapid vertical and/or horizontal tectonics in a Flood model. Both the upper mantle,[19] and now locally the lower mantle, can have much lower viscosity than expected. Davemaoite could also possibly explain low seismic velocity zones in the uppermost lower mantle, as well as the LLSVPs and ULVZs, as at least partly due to composition.[13] Radioactive elements have been assumed to exist predominantly in continental crust and the upper mantle, but they could also exist in davemaoite in the deep mantle. This could have implications for accelerated radiometric decay in the mantle.

The many variables associated with mantle need to be understood better in any secular or Flood model. The fact that the higher velocity zones at the edges of LLSVPs do not line up with presently active subduction zones is an issue that needs better explanation by the advocates for CPT. This is why the high velocity zones are said to be due to 'ancient subduction zones'.[20] But the question is, just how ancient? Creation geophysicists would argue these may have formed just 4,500 years ago. And it is possible they formed early in the Flood year in subduction zones that are presently inactive. More research on this topic is still needed.

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