

Is the lower mantle dry?

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Since the theoretical synthesis of origin of solar planets by Safronov (1962, 1972) and Kyoto Group by Hayashi et al. (1985) explained our solar system was generated from solar nebula, most geologists have long believed that both solid Earth and ocean-atmosphere was born together at 4.567Ga. This model strongly affected whole mantle dynamics, and even origin of core due to the interpretation of ubiquitous occurrence of water and hydrogen. Yet, oxygen isotope of crust and mantle indicates the solid Earth must have formed from dry meteorite similar to enstatite chondrite, not from carbonaceous chondrite. On the other hand, D/H ratio of ocean-atmosphere of the Earth suggests the origin of ocean-atmosphere is carbonaceous chondrite. By these reasons, Maruyama and Ebisuzaki (2017) proposed ABEL model for the Earth explaining that the Earth was originally dry when solidified at 4.53Ga and bio-elements (oceanic and atmospheric component) were secondary accreted after 4.37Ga until 4.0Ga.

Following to the proposal of this new model, a series of revolutionary changes in classic concepts happened. One example of such changes is the understanding of lower mantle. ABEL model produced the idea that lower mantle is still dry. First of all, the primordial Earth's mantle must have been dry, not only the surface, but also in deep mantle. During the ABEL Bombardment by icy asteroids, volatiles must have been bombarded into only near the surface which was shallower than ca.100km in depth even in the case of 1,000km across asteroids. Because of high temperature over 10,000K by collision-heating, it is impossible to contain water in lower mantle and core.

By the initiation of plate tectonics, hydrated slabs can transport the surface water into deep mantle as hydrated silicates. However, surface water has not yet been transported below the 660km in depth which is the boundary between upper and lower mantle. Phase diagram of peridotite-water is now available which cover the whole range of mantle depth with increasing temperature. If the temperature of subducted slab is low enough below 1,200°C at 660km in depth, slab peridotite can transport water into deep mantle. But the tomography of 660km in depth never support the idea of leaking water into lower mantle due to the thickness of mantle transition zone (250km in average). In addition, known deepest earthquake is 682km in depth which occurred off Mariana trench. The cause of deep earthquake is dehydration embrittlement. Observed seismicity is only in the upper mantle, which seems to be consistent with the idea of dry lower mantle, indicating no hydrous silicates in the lower mantle.

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