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Venue: Meeting Room #486
Science Research Bldg. 1, 4th floor.
Ehime Univ.

Deep Earth melting and global water circulation. How can Earth maintain surface oceans?

Oceans on Earth are present as a result of dynamic equilibrium between degassing and regassing through the interaction with Earth's interior. We review mineral physics, geophysical, and geochemical studies related to the global water circulation and conclude that the water content has a peak in the mantle transition zone (MTZ) with a value of 0.1–1 wt% (with large regional variations). When water-rich MTZ materials are transported out of the MTZ, partial melting occurs. Vertical direction of melt migration is determined by the density contrast between the melts and coexisting minerals. Because a density change associated with a phase transformation occurs sharply for a solid but more gradually for a melt, melts formed above the phase transformation depth are generally heavier than solids, whereas melts formed below the transformation depth are lighter than solids. Consequently, hydrous melts formed either above or below the MTZ return to the MTZ, maintaining its high water content. However, the MTZ water content cannot increase without limit. The melt-solid density contrast above the 410 km depends on the temperature. In cooler regions, melting will occur only in the presence of very water-rich materials. Melts produced in these regions have high water content and hence can be buoyant above the 410 km, removing water from the MTZ. Consequently, cooler regions of melting act as a water valve to maintain the water content of the MTZ near its threshold level (~ 0.1–1.0 wt%). Mass-balance considerations explain the observed near-constant sea-level despite large fluctuations over Earth history. Observations suggesting deep-mantle melting are reviewed including the presence of low-velocity anomalies just above and below the MTZ and geochemical evidence for hydrous melts formed in the MTZ. However, the interpretation of long-term sea-level change and the role of deep mantle melting in the global water circulation are non-unique and alternative models are reviewed. Possible future directions of studies on the global water circulation are proposed including geodynamic modeling, mineral physics and observational studies, and studies integrating results from different disciplines.

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