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Origin of life: Mechanism of leaking Earth; Fate of cooling Earth

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Supply of nutrients is essential to bear life. To enable a nutrient supply, a landmass must appear above sea level, because continental crust (landmass) is nutrient-enriched. Through weathering, erosion, and transportation of nutrient-enriched rocks, particles are eventually fined to a sufficient size for life to ingest. The emergence of a landmass is caused by a drop in sea level. Here, the cause of sea level change through time is discussed.

Mechanism of change of ocean thickness through time

In the early 2 Ga, after the birth of the ocean, the surface ocean thickness increased through the degassing of a water-rich magma generated from a primordial mantle,. This is a theoretical speculation based on the geologic constraints. From the Archean to the Proterozoic Earth, mantle potential temperature was 200-150K higher than that of today. The subduction-zone geotherm, as documented by P-T conditions of regional metamorphic belts, prohibits water transportation into the mantle through the subduction of hydrated slabs.

Since the Archean, OIBs, such as komatiites and picrites, are enriched in H2O and CO2, as well as MORBs with minor water and CO2, all of which tend to increase the ocean volume through time. On the other hand, the volume of the ocean never reaches sufficient size to bury all of the continents in the Precambrian. Presumably, the maximum thickness of the ocean would have been less than 1km.

Subduction of ocean water and hydrated oceanic slabs began at the onset of the Phanerozoic, as discussed below. About 700-600 Ma ago, the ocean thickness started to decrease, with the reduction of about 600 m until now through the fluctuations in the balance between output versus input of water into the mantle.

Phase diagrams of MORB + H2O and peridotite + H2O indicate that the ocean level would decrease though subduction of hydrated oceanic slabs if the top of the descending slab changes to temperatures lower than 600oC at Moho depth of 30km through time from hot Archean mantle to the present. The subduction zone geotherm along the surface of the descending slab turns to generate blueschist-facies rocks if it crosses the high-temperature corner of the blueschist facies in a P-T space defining the subduction zone geotherm and passing to the point at 10kb, 600oC. A plot of the P-T conditions of the regional metamorphic belts over the world since the Archean shows that the first appearance of blueschist was ca. 700Ma, and the subduction zone rapidly cooled at the onset of Phanerozoic. The temperature of Moho depth was higher than 600oC before 700Ma, but rapidly cooled below 600oC, thereafter, and down to 200oC at present. This suggests that the initiation of return-flow of seawater into the mantle began in the Latest Proterozoic, as estimated by the phase diagrams. The observed drop in sea-level clearly supports the idea, and the proposed sea-level-change curve shows that ca. 600m thick ocean has been removed from the surface into the mantle, at the 410-660km depth transition zone, which has a capability to store about 5 times of the total mass water of surface oceans.

The sea-level fluctuation of plus minus 300m in the Phanerozoic could be explained by the glacial/non-glacial periods, as well as the partial mantle overturn when high-temperature and fertile lower mantle materials catastrophically replaced the upper mantle, such as during the Cretaceous (120-85Ma), a major period of magmatic-driven activity. Another pulse was during the mid-Paleozoic, when huge batholith belts were formed similar to the Cretaceous pulse. If the rate of decreasing ocean volume continues over the next 1.0-1.5 b.y., the Earth will finally dry up, which will mark the end of life.