The Ocean Continent Connection: Consequences of the Stable Isotopic Composition of the Ocean and the Onset of Plate Tectonics

ROBERT T. GREGORY[1]

[1]Department of Earth Sciences, SMU, Dallas, TX 75275-0395; bgregory@smu.edu

The oxygen and hydrogen isotope compositions of the ocean are proxies for plate tectonicsn [1,2,3] and ocean volume [4], repsectively. The main control on the oxygen isotope composition of the ocean is the competition between exchange with the mantle of the Earth through mid-ocean ridge hydrothermal circulation and the continental chemical weathering flux delivered to the ocean through rivers [1]. Water loss from the surface of the Earth results from two major processes: loss at the top of the atmosphere by photodissociation of water and hydrogen escape or water loss to the mantle by subduction. Both of these processes tend to enrich the residual ocean in deuterium. The rock record indicates that the hydrogen and oxygen isotopic composition of the ocean has remained near a quasi-steady state over Earth history. The constancy of the ranges in δD values of igneous, metamorphic and sedimentary rocks of any age [4] suggest that the volumetric set point for the ocean was achieved sometime in the early Archean or before. Time constants for changing the D/H ratio of the ocean are comparable to the age of the Earth. Similarly, the constancy of the range of $\delta^{18}O$ values of altered metapillow laveas of any age [2.3] indicates that seawater reached steady-state sometime in first 0.5 Gyr of Earth history consistent with perturbation half-lives <100 Myr for plate tectonic processes and therefore indicating an early onset of plate tectonics. Ocean volume coupled with seafloor spreading and the time constants [6] for mechanical erosion of topography (10 Myr scales) provide a mechanism for controlling the thickness of the continental crust which always evolves towards steady state elevation near sea level. This seems to occur when typical continental crust achieves a thickness of 35-40 km [7] independent of age.

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