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Oxygen isotope composition of the seas through the ages

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Discussions about seawater changed with acceptance of plate tectonics. Former paradigm that seawater composition reflected accumulation of salt followed by reverse weathering had to be modified to include seawater interactions with the seafloor, subduction and its participation in the growth of continents. I demonstrated (1971) that such processes set and buffer δO of seawater to its current value. Low temperature weathering on land and shallow parts of the ocean crust that enrich the products in ^{18}O but strip it from the hydrosphere are balanced by addition of ^{18}O by high temperature alteration at mid-ocean ridges where ^{18}O is removed from the altered crust but added to seawater. “Black Smokers” show high temperature alteration of the ocean crust is prevalent at about 350 C. At that temperature the $\delta^{18}O$ partitioning of the ensemble of alteration minerals in the altered basalt and water is approximately 6‰, setting a “buffer” on the $\delta^{18}O$ of seawater itself to 0+/- 2 ‰ for all times plate tectonics operated. This appears incompatible with secular trend of decreasing $\delta^{18}O$ in sediments with age. However, no secular $\delta^{18}O$ trend is seen in ophiolites nor VMS ore deposits. If at least part of the sediment and fossil δ^{18}O records are real, then the debate remains if the $\delta^{18}O$ of seawater was not “buffered” or environmental temperatures were unexpectedly higher in the past? Recent, very detailed, as well as averaged, examination of $\delta^{18}O$ carbonates and phosphates in the sedimentary record both show for the whole of Phanerozoic and late Proterozoic a constant δ^{18}O of seawater near 0 ‰. Clumped isotope studies on carbonates and “triple oxygen” all indicate a $\delta^{18}O$ Phanerozoic ocean near 0 ‰. The debate on the $\delta^{18}O$ of Phanerozoic seawater is over, we have to accept and explain surprises in the climate record.

The $\delta^{18}O$ of the Archean ocean is not as certain. Recent studies give contradictory deductions of either a higher or lower $\delta^{18}O$ than in the Phanerozoic. Resolution is needed to better understand the Earth’s earliest environment and life, the onset of modern plate tectonics, growth and emergence of continents and perhaps the Hadean ocean.

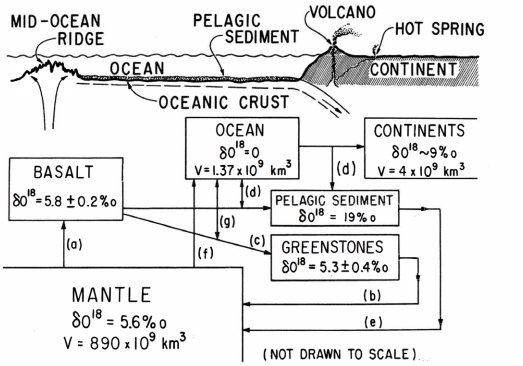

Fig.7.--Schematic diagram of sea floor spreading and block diagram of processes affecting the $\delta^{18}O$ of the ocean. See text for details.
From: Muehlenbachs, Karlis. "Oxygen isotope studies of rocks from mid-ocean ridges." PhD Thesis, University of Chicago, 1971