SEAWATER ISOTOPE RECORDS, CRUSTAL EVOLUTION, TECTONICS, GLACIATIONS AND ATMOSPHERIC EVOLUTION. S. B. Jacobsen, J. Wills and Q. Yin, Department of Earth and Planetary Sciences, Harvard University, (20 Oxford Street, Cambridge, MA 02138; jacobsen@neodymium.harvard.edu).

The Sr, Nd, Os and C isotopic records of ancient seawater may be used to address questions relating to the evolution of the Earth's crust, oceans and atmosphere and sedimentary cycling. Simple first order models to interpret these records provide insight into the application of these isotope records as potential proxies for crustal evolution, climate change, etc.

Large variations in ε_{Nd} are often found between various ocean basins through time, due to the short residence time of Nd in seawater. Smaller variations are found within single basins. The ε_{Nd} value of an ocean in general reflects whether it is predominantly surrounded by active (high ε_{Nd}) versus passive continental margins (low ε_{Nd}). The global average seawater ε_{Nd} curve exhibits large fluctuations. The present Nd budget of the oceans is dominated by the river water flux (continental sources), while the mid-ocean ridge hydrothermal water Nd flux contributes about 1% of the total Nd input to the oceans. Thus, the Nd isotopic variation in seawater is primarily due to changes in the Nd-isotopic composition of the continental flux and is therefore a proxy for the mean age of the continental mass flux to the oceans.

Changes in $^{87}Sr/^{86}Sr$ of seawater are primarily controlled by changes in the river water flux (the erosional flux) of Sr from the continents and the hydrothermal flux of Sr through ocean ridges, as well as changes in the isotopic composition of these fluxes. The Sr isotope mass balance, Nd and Sr isotopic variations in river waters, and the seawater Sr and Nd isotope curves can be used to constrain the river water flux of Sr. Since the global dissolved flux of Sr in rivers is proportional to the global erosion rate, the river water flux of Sr is a proxy of erosion rates through time. We note that this does not necessarily imply that $^{87}Sr/^{86}Sr$ in seawater is a proxy for erosion rates. Most likely the $^{87}Sr/^{86}Sr$ of seawater is a function of both varying erosion rates as well as changes in the $^{87}Sr/^{86}Sr$ of the river flux. Model results indicate three distinct episodes of high global continental erosion rates due to uplift caused by continental collision at ~0 Ma, ~0.4 Ga and ~0.6 Ga ago. There is, in general, only a limited correlation between the Sr isotope curve and high vs. low erosional fluxes. The processes operating during the Vendian and Cambrian periods resulted in the largest change observed in $^{87}Sr/^{86}Sr$ of seawater at any time during Earth history. While ice ages mark both the Neoproterozoic and Cenozoic, different stratigraphic relationships between the strong increase in $^{87}Sr/^{86}Sr$ and continental glaciation indicate that uplift-driven models proposed to explain Cenozoic climatic change cannot account for Neoproterozoic ice ages.

The variation of $\delta^{13}C$ of seawater (and marine carbonates) over timescales of crustal recycling is controlled both by changes in the global organic C erosion rate and by changes in the rate of C burial. Coupling the Sr and C cycles, it can be shown that the burial rate of organic C shows a simple relationship to overall erosion rates and secular variations in $\delta^{13}C$ in seawater. This provides the basis for obtaining changes in erosion and organic C burial rates as a function of time based on the Sr-, C-, and Nd-isotopic records of seawater. It is thus possible to have relatively low $\delta^{13}C$ values (+1 to +2) in marine carbonates during periods of high organic carbon burial if the erosion rate is very high. We note that the $\delta^{13}C_{carb}$ is not a proxy for organic carbon burial rates while estimates of organic carbon burial rates from both Sr and C isotope records are more likely to reflect real global variations in organic carbon burial rates. In the latest Proterozoic high erosion rates contributed to a significant increase in the burial rate of organic C at ~575 Ma which, coupled with lower fluxes of reducing hydrothermal fluids, most likely gave rise to a large increase in O_2 in the atmosphere after the Varanger glaciation.

Compared with Nd isotopes, the Os isotope record in seawater indicates a relatively uniform isotopic composition, reflecting a much longer ocean residence time for Os than for Nd. The data obtained for river water suspended loads show a strong negative correlation between Os and Nd isotopic composition, a natural consequence of the extraction of the crust from the mantle. This correlation allows us to model the Os isotope record with that of other isotopic records. The Os isotopic record to some extent mimics the Sr isotopic record. High carbon burial rates produced (at various times) a black shale reservoir. This reservoir may affect $^{187}Os/^{188}Os$ of the continental input of Os to the oceans. The relationship between ε_{Nd} and $^{187}Os/^{188}Os$ in the suspended loads and mantle samples may indicate that currently eroding continental crust recorded in suspended loads may be less radiogenic in terms of Os, perhaps due to a hidden radiogenic sink such as black shales.