HOW DID THE GROWTH OF CONTINENTS INFLUENCE THE CHEMICAL AND ISOTOPIC EVOLUTION OF PRECAMBRIAN OCEANS? Y. Goddéris[1], J. Veizer[2], and L. M. François[1], [1]LPAP-University of Liège, 5, avenue de Cointe, 4000 Liège, Belgium (godderis@astro.ulg.ac.be; francois@astro.ulg.ac.be), [2]Department of Earth Sciences, University of Ottawa, Ottawa K1N6N5, Canada, and Institut für Geologie, Ruhr Universität, 44780 Bochum, Germany (veizer@geol.uottawa.ca).

A numerical model that couples carbon-sulfur-strontium and atmospheric oxygen cycles is used here to explore the impact of continental growth on the long term (≥ 10^8 years) evolution of the isotopic composition of seawater [1]. Three growth scenario are tested: "big bang"" generation of continents shortly after the accretion of the Earth [2], and two more gradual scenarios, with a major growth episode around the Archean-Proterozoic boundary [3] [4]. The corresponding $^{87}Sr/^{86}Sr$, $\delta^{34}S$ and $\delta^{13}C$ of seawater, and the sizes of the respective crustal sedimentary reservoirs, are calculated for each scenario, and compared to the available data. The gradual continental growth scenarios yield a better fit to the existing $^{87}Sr/^{86}Sr$ and $\delta^{34}S$ isotope data for ancient seawater than does the "big bang" model. These scenarios also generate a progressive oxygenation of the ocean/atmosphere system, with a large pO_2 rise coincident with (and due to) the major continental growth event around the Archean-Proterozoic transition, in accord with the geologic record that indicates a major oxidation event in the early Proterozoic. The advancing oxygenation of the planetary exogenic system may therefore be a consequence of tectonic evolution, rather than of biological innovations, such as the photosystem 2. The latter may have predated considerably the impact of oxygenation visible in the geologic record. The model also generates a strong climatic cooling around the Archean-Proterozoic transition, coincident with the first glaciation of global extent in the early Proterozoic.

Seawater δ^{13}C: The model also calculates the evolution of seawater $\delta^{13}C$. We show that a critical factor of the ocean-atmosphere-sedimentary ^{13}C cycle is the opening of this cycle to the mantle through the mid-oceanic ridge degassing over all the Earth history. Under the post-Early Proterozoic oxygenated conditions, only carbonates in close equilibrium with seawater return to the mantle at subduction zones, since there is only negligible accumulation of organic light carbon on the pelagic seafloor. This pushes the $\delta^{13}C$ of seawater towards equilibrium with mantle value (~-5 ‰) in a few hundred millions of years. This discrepancy with data can be solved if the MOR degassing became negligible after Archean times, but this is not in agreement with estimates of present day MOR degassing. We illustrate this problem with various model simulations. There is a strong need for a process able to remove or isolate light organic carbon from the ocean-atmosphere-sedimentary system.

Seawater δ^{18}O: The calculated seawater $\delta^{18}O$ shows little fluctuations over the Earth history, in disagreement with the experimental record, at least for the Phanerozoic [5]. This inhibition is due to the links existing between ^{18}O and the carbon-alkalinity cycles [1], rather than to possible steady-state of the present-day ^{18}O cycle [6]. Focusing now only on the Phanerozoic (where reliable data exist [5]), we explore the possible range of fluctuations of the $\delta^{18}O$ compatible with a realistic carbon-alkalinity cycle in the ocean-atmosphere-sediments system. We show that fluctuations of about 2 to 3 ‰ are conceivable over the Paleozoic times, and compatible, at least qualitatively, with the simultaneous increase in observed seawater $\delta^{13}C$.

References:

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