Links between tectonics and life, 4.0 to 2.3 Ga and the rise of oxygen

M.E. BARLEY[1*],

[1] School of Earth and Environment, The University of Western Australia, Crawley, Western Australia, 6009, Australia (correspondence: mark.barley@uwa.edu.au)

Earth is the only planet in our solar system with a bimodal topographic distribution crucial for the evolution of complex life. The tectonic records of the Archean to Paleoproterozoic (4.0 to 2.3 Ga) terranes indicate a link between evolving global tectonics with the formation of stable continents, increased subaerial volcanism and increased orogenic mountain building and the rise of atmospheric oxygen on Earth ~2.4 billion years ago. The first 2 stable cratons formed between 3.0 and 2.9 Ga after the first unambiguous evidence for plate tectonics. The Neoarchean record started at 2.8 Ga involving the possible break of a single pre-existing continent and the most prodigious period of generation and preservation of juvenile continental crust during a period of mantle plume breakout (2.72 to 2.65 Ga). During this period many cratons formed and aggregated into larger cratons and continents. Lower sea levels between 2.65 and 2.55 Ga were followed by a second (~2.51 to 2.45 Ga) period of plume breakout. Although oxygenic photosynthetic bacteria are thought to have evolved by 2.7 Ga or 2.5 Ga, the irreversible rise of atmospheric oxygen appears to have occured between 2.48 and 2.32 Ga suggesting a dynamic linkage and interaction of both sources and sinks of oxygen. Increased subaerial volcanism [1] and reduced temperature of magmatism (less komatiites) after 2.65 Ga helped cyanobacteria and also resulted in a decline of methane helping oxygen strat to rise [2]. There is growing evidence the long time the rise took involves interaction between cyanobacteria and oxygen using acid rock drainage bacteria from 2.48 Ga [3] as well as the rise of iron in the ocean using oxygen to form the bigest banded iron formations (BIFs). The 2.4 Ga break in tectonics and decline of BIFs helped the cyanobacteria and volcanic gasses with the rise of oxygen.

References.

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Chlorine isotope geochemistry of Icelandic geothermal waters

JAIME D. BARNES[1] AND ANDRI STEFÁNSSON[2]

[1]Department of Geological Sciences, University of Texas, Austin, Texas, USA jdbarnes@jsg.utexas.edu (* presenting author)

[2]Institute of Earth Sciences, University of Iceland, Reykajavik, Iceland, as@hi.is

The chlorine isotope composition of several geothermal systems in Iceland were determined in order to evaluate possible chlorine stable isotope fractionation in geothermal systems. The geothermal systems studied exhibit a range of temperatures (~38°C to >300°C) and pH (6 to 9.5). Chlorine concentrations range from ~5 to ~200 ppm. $\delta^{37}Cl$ values for all samples are near 0‰ (range = -0.3 to +0.3‰; error = +/- 0.2‰).

The source for the chlorine in the analyzed systems is commonly hypothesized to be from magmatic degassing or from leaching of host basalt during water-rock interaction. The $\delta^{37}Cl$ values are consistent with either of these hypotheses based on the near 0‰ value for the upper mantle and MORB glasses [1].

No large isotopic shifts due to fractionation are observed in these samples. These results are in agreement with previous experimental work on chlorine isotope fractionation between coexisting vapor and liquid in the system H2O–NaCl at 400°C and 450°C which show $\Delta^{37}Cl_{vapor-liquid}$ = 0 +/- 0.2‰ [2]. However, large Cl isotope fractionation has been observed in a few high-temperature (>100°C) and highly acidic volcanic fumaroles in Central America. ^{37}Cl preferentially partitions into the vapor phase as HCl resulting in extreme positive $\delta^{37}Cl$ values (~ +4 to +12‰) in acidic geothermal systems [3]. Further work will focus on acidic Icelandic geothermal systems in which Cl^- is hosted as HCl in order to explore the full range of $\delta^{37}Cl$ values in geothermal systems.

These results show that Cl stable isotopes act as a conservative tracer in neutral to slightly basic geothermal sytems regardless of phase separation; thereby, making Cl isotopes an excellent tracer of chloride sources in neutral systems.

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