Interpretations of Uranium Mobility at 3.7 Ga

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The timings of the development of oxygenated environments and of the evolution of photosynthesis are crucial to the development of biomarkers for anoxic planets. Recently, evidence for the early (prior to 3.7 Ga) evolution of oxygenic photosynthesis was reported based on lead isotope measurements in ancient sediments (Rosing and Frei, 2004). The lead isotope ratios have been interpreted as a signal of uranium enrichment in organic-rich shales and the enrichment is claimed to be the result of uranium mobility. Since uranium is mobile under oxidized conditions, it has been argued that the presence of uranium mobility implies high levels of oxygen production prior to 3.7 Ga. Thus, it has been concluded that oxygenic photosynthesis must have been in place by this time. Here, we use simple thermodynamic to determine whether other conditions could have allowed for the observed uranium mobility. Our results show that uranium could have been mobilized by oxidation of the water column through H_2 drawdown by anaerobic bacteria (as opposed to O_2 production), particularly if the early Earth was above 70°C. Drawdown of H_2 increases the oxidation state of the water column through the following equilibrium reaction:

$$H_2 + _O_2 _ H_2O.$$

Our conclusion is that the presence of this uranium enrichment is consistent with the presence of either oxygenic photosynthesis or of H_2-consumption in a hot, CO_2-rich surface environment.

M.T. Rosing and R. Frei, U-rich Archaean sea-floor sediments from Greenland--indications of >3700 Ma oxygenic photosynthesis, Earth Planet. Sci. Lett. 6907, 1-8, 2003.