Reconstructing the O isotope composition of Precambrian oceans

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The surface conditions on the early Earth have remained a topic of great controversies for decades, since the ~10-15‰ increase of oxygen isotope compositions ($\delta^{18}O$) measured in sedimentary cherts from *ca*. 3.5 Gyr ago to the present-day [1-3] can be accounted for if Archean oceans were characterised either by $\delta^{18}O$ values ~10-15‰ lower compared to today [4-5], or by temperatures ~50-70 °C higher than today [2-3]. Because $\delta^{18}O_{chert}$ is related to the $\delta^{18}O$ of the precipitating fluid and to the temperature *T*, it is not possible to derive both *T* and $\delta^{18}O_{fluid}$ without setting one of these two parameters. Warm Archean oceans imply a near constant $\delta^{18}O_{seawater}$ through geological times, and are consistent with other proxies, such as Si isotopes in cherts [6] or O isotopes in serpentine in early-Archean ophiolite rocks [7]. On the other hand, the proposed existence of Archean-Proterozoic glaciations [8-9] suggests the occurrence of cold surface conditions on the Earth during the Precambrian, which is consistent with a Sun much fainter than today [4-5].

Each of these scenarios have key implications for understanding the conditions that promoted the appearance of life on the Earth ~3.5 Gyr ago. Early-life remnants preserved in cherts can potentially provide us with an independent way of constraining $\delta^{18}O_{seawater}$, as the $\delta^{18}O$ of organic matter (OM) is primarily controlled by the composition of coeval water, while being insensitive to temperature [10]. We have measured $\delta^{18}O_{OM}$ on kerogen residues isolated from 0.4-3.4 Ga cherts using our newly developed ion probe protocol [11]. We show that $\delta^{18}O_{OM}$ of almost all the ~1.5-3.4 Ga samples are fairly homogeneous, corresponding to $\delta^{18}O_{seawater}$ estimates of ~0±5‰. Thus, our results support the hypothesis that Archean oceans were *ca*. 50-70 °C warmer than today.

Acknowledgments: This research is supported by the ERC Grant No. 290861 – PaleoNanoLife.

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