Enhanced nutrient consumption in the glacial Antarctic

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Productivity in surface waters leads to the sequestration of carbon dioxide (CO_2) in the deep ocean, a process known as the ocean's "biological pump." The Antarctic Zone of the Southern Ocean represents the major "leak" in this pump. Nutrient- and CO_2-rich waters are brought to the surface, allowing CO_2 to outgas. The scarcity of iron and/or light reduces phytoplankton productivity, leaving some of the major nutrients (nitrate, phosphate) unused. Those "preformed" nutrients are subducted into the subsurface without re-sequestering CO_2 into the deep ocean, introducing a degree of inefficiency to the global biological pump. To explain lower glacial atmospheric CO_2, it has been suggested that there was a decrease in the exchange between polar surface water and ocean interior, described as "polar ocean stratification." This physical change would have, in itself, reduced the outgassing of CO_2, and it may have increased the fraction of nutrients utilized in Antarctic surface ocean, rendering the region a more efficient part of the global biological pump. The first efforts to reconstruct nitrate utilization in the Antarctic measured nitrogen (N) isotopes on bulk sediment, but this can be biased by diagenesis and/or allochthonous N input. Subsequent studies measured the N isotopes encapsulated in diatom frustules ($\delta^{15}N_{db}$), which carry the pristine signal, but results have varied. Here, we report a consistent increase in $\delta^{15}N_{db}$ into the last two glacial periods, with abrupt decreases during the subsequent deglaciations. In contrast, the descent from interglacial to glacial conditions was more gradual/stepwise, reminiscent of the general atmospheric CO_2 pattern. The first major $\delta^{15}N_{db}$ increase into the last ice age occurred at the MIS 5e/5d transition, coincident with the major decline in Antarctic temperature and the first 40 ppm step in ice age CO_2 decline. In addition to our analysis of the total biogenic opal <100 µm, we analyzed the $\delta^{15}N_{db}$ of two distinct diatom species assemblages. Their $\delta^{15}N_{db}$ values are offset by roughly 1‰ but show the same trends through time. This rules out the possibility that the glacial-interglacial $\delta^{15}N_{db}$ changes measured on the total diatom community are caused by changing diatom species composition, a concern that had been raised previously.

Noble gas radionuclides in Yellowstone geothermal gases

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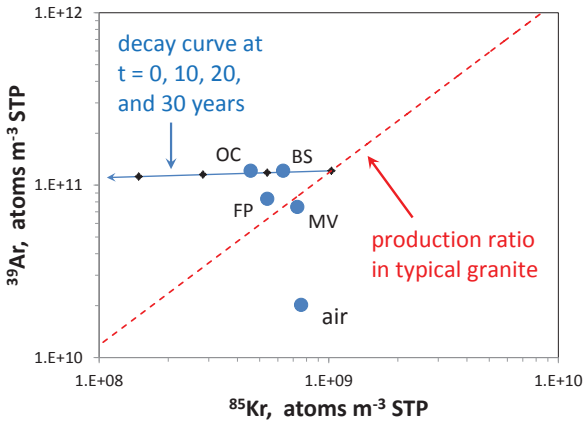
We collected and analyzed noble gas radionuclides (^{39}Ar, half-life = 269 yr; ^{81}Kr, half-life = 229,000 yr; ^{85}Kr, half-life = 10.8 yr) in gases from four geothermal features at Yellowstone National Park (Beryl Spring, Frying Pan Spring, Ojo Caliente Spring, and Mud Volcano). In the field, condensation of water vapor and chemical stripping of CO_2 were done to reduce the samples to manageable volumes which were compressed into gas cylinders. Separations of Kr and Ar from gas samples were performed by existing methods [1,2]. Kr radionuclides were measured by atom-trap trace analysis at Argonne using ATTA-3 [3], and ^{39}Ar was measured by low-level counting at Bern [2].

Isotopic abundances of ^{39}Ar in all four samples were 4 to 6 times higher than atmospheric, indicating substantial contributions from subsurface nucleogenic production, as reported earlier [4]. ^{81}Kr isotopic abundances were not significantly different from atmospheric. ^{85}Kr isotopic abundances were 0.55 to 0.96 times atmospheric, possibly indicating contributions from recent groundwater recharge (≤ 10 yr) and/or contributions of both ^{39}Ar and ^{85}Kr from subsurface production at a ratio typical of that in granitic rock (see Figure).



[1] Yokochi et al (2008) *Anal. Chem.* **80**, 8688-8693.
[2] Forster & Loosli (1989) In: *Isotopes of Noble Gases as Tracers in Environmental Studies*, IAEA, Vienna.
[3] Jiang et al. (2012) manuscript in review.
[4] Purtschert et al. (2009) Goldschmidt abstract, Davos.