Enhanced delivery of bioavailable Fe through glacial processes in Kongsfjorden, Svalbard

JEREMY D. OWENS[1*], LAURA M. WEHRMANN[1], ROBERT RAISWELL[2] AND TIMOTHY W. LYONS[1]

[1]University of California- Riverside, Riverside, CA, USA, jowens@student.ucr.edu, laura.wehrmann@ucr.edu, timothyl@ucr.edu (* presenting author)
[2]Leeds University, Leeds, UK, r.raiswell@earth.leeds.ac.uk

Primary production in large portions of the world's ocean is iron-limited, and the supply of bioavailable iron is not well understood. Only recently have glacially derived iron sources been considered a potential major contributor, particularly to high latitude regions. Past workers considered glacial iron to be non-bioavailable or non-reactive more generally. However, we now know that increased delivery of reactive iron to the ocean, as driven by enhanced glacial runoff, has the capacity to increase primary production and concomitant CO_2 uptake. Understanding the role of glaciers in the delivery of bioavailable iron to the ocean has become a priority, and the concentration and reactivity of glacial iron is likely controlled by chemical weathering processes tied to pyrite oxidation and bedrock type within the subglacial environment.

To better understand the factors controlling the delivery of bioavailable iron to glacial fjord environments, we sampled three proglacial streams in the Kongsfjorden region of Svalbard. The streams differed dramatically in the characters of their adjacent glaciers, in their suspended loads and the local bedrock. We quantified the amount of dissolved iron in the glacial meltwaters, determined the reactivity of the iron associated with the fine glacial flour of the streams, and constrained the iron properties of the source bedrock. Here, we present iron data (Fe_{Total}/Al and $Fe_{Highly\ Reactive}$/Fe_{Total}) from each sample type, along with riverine sulfate and bedrock sulfide isotope data ($\delta^{34}S$). The average dissolved iron concentrations varied from glacier to glacier between 4 ppb and 13 ppb, which is only 2 to 3 times higher than in seawater. However, highly reactive iron was enriched in the glacial flour samples at highly variable levels. The overarching suggestion is that the Kongsfjorden glacial systems could deposit large amounts of reactive iron into the fjords via the discharge of glacial flour. The three sampled meltwater streams have comparable and relatively stable pH (~8) coupled with $\delta^{34}S$ values of dissolved sulfate near +10‰, suggesting that the iron is from a source other than just pyrite oxidation. These initial data and specifically the observed variability indicate that bedrock type and other still unknown variables affecting diverse glacial processes control the delivery of bioavailable iron to the ocean in high latitude regions.

Modeling ocean acidification and de-oxygenation: Testing the linkage between large igneous province and Ocean Anoxic Event.

KAZUMI OZAKI [1*], EIICHI TAJIKA[2]

[1]University of Tokyo, Earth and Planetary Science, Tokyo, Japan, ozaki@eps.s.u-tokyo.ac.jp (* presenting author)
[2]University of Tokyo, Complexity Science and Engineering, Chiba-ken, Japan, tajika@k.u-tokyo.ac.jp

Recent geochemical data and chronology enable us to explore biogeochemical dynamics in geological past. The causal linkage between ocean anoxic events and activity of large igeneous provinces has been discussed based on the geochemical imformation, such as the rapid disturbances of osmium isotopic records or metal abundance anomalies before and during ocean anoxic events. It has been discussed that the abundance of nannoconid is rapidly decreased at the initiation of OAE1a, implying the oceanic acidification in sea surface environment. Considering the compensation mechanism of oceanic carbonate system, this must indicate drastic disturbances of Earth's surface environment.

We developed a new atmosphere-ocean biogeochemical cycle model in order to explore the biogeochemical consequences of the activity of large igneous province, and a systematic model sensitivity study is performed with respect to an injection scenario of CO_2 into the terrestrial environment. Examined characteristic timescale of the CO_2 injecation scenarios ranges from 100 year to several hundreds of thoushands of years and the total amount of injection ranges in three orders of magnitudes (0.01-10 EmolC).

Systematic examination shows that (1) the required CO_2 amount for the maximum carbon isotopic anomaly of +1 to 4 permil is approximately from 0.4 to 1.0 Emol (10^{18} mol), providing the theoretical requirements for the carbon isotopic anomaly accompanied with OAE2, and (2) such scenarios result in the global ocean de-oxygenation of approximately 40-80 % (depending on the degassing flux). Our simulation results also indicate that the rapid (less than 10 kyr) and drastic (greater than 100 TmolC/yr) CO_2 injection would be required to explain the strong acidification of sea surface waters and widespread carbonate gap. We conclude that the many characteristic features of OAEs can be explained by the short, rapid and frequent activity of large igneous province.