Climate forcing by very large basaltic eruptions - Insight from oxygen isotopes of biogenic silica from the finely laminated diatomite of the Fur Formation, Denmark

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The sensitivity of oxygen isotope composition of biogenic minerals to the temperature of seawater invites investigation of possible climate change in periods of extensive volcanic activity by high-resolution studies of suitable stratigraphic sections. Here we present the initial results from a study of the oxygen isotope composition of finely laminated (<0.25 mm - 4 mm) diatomite deposited in direct contact with tephra layers within the Fur Formation, Denmark. More than 200 layers of volcanic tephra of predominantly basaltic composition are exposed in the Fur Formation (Mo-clay), Denmark. The tephra layers are associated with the explosive volcanism following the extensive flood basalt volcanism during continental break up in the North Atlantic.
Historic volcanic events have shown to affect average global temperatures significantly, e.g. 0.5-0.6℃ cooling following the Pinatubo eruption in 1990 and 1℃ drop in northern hemisphere average temperatures in 2-3 years following the Laki eruption in 1783-1784. The climatic effect of the volcanic eruptions associated with the Fur formation is expected to be significantly greater.

In a shallow ligated inland sea as the sea for deposition of the Mo-clay, it is assumed that temperature variations in the sea waters are reflected in the oxygen isotope composition of the diatom silica.
The temperature influence on the oxygen isotope fractionation during formation of the diatom silica is anticipated to give a difference in $\delta^{18}O_{diatom}$ of approx. 0.2 ‰(relative to SMOW) per 1℃ change of temperature with an uncertainty of the temperature coefficient of $\pm$0.05 ‰. However, quantitative paleoclimate applications are indeed limited by uncertainties about the nature and the magnitude of the temperature influence on the oxygen isotope fractionation during formation of the diatom silica.

The average sedimentation rate associated with the deposition of the Mo-clay is prudently estimated to 1 mm/decade. The finely laminated nature of the Mo-clay indicates high-frequency environmental change through time; however it is not believed to be annual rhytmites. This is rather interpreted as multiannual phenomena such as extraordinary external nutrient loading or upwelling of nutrient rich waters with following phytoplankton blooms as a result of tropical rainfall regimes associated with intense storms.
To ensure high resolution climate studies on this 55 Ma old formation a sampling protocol has been designed to enable sampling of layers down to less than 0.1 mm thick and a highly specialized separation protocol including chemical attack, sieving, heavy-liquid separation and ultra sound treatment has been designed to handle sample sizes of down to about 20 mg. Thus obtained samples are expected to represent a resolution of down to 1 year per sample.