

## Rapid climate fluctuations during the penultimate deglaciation

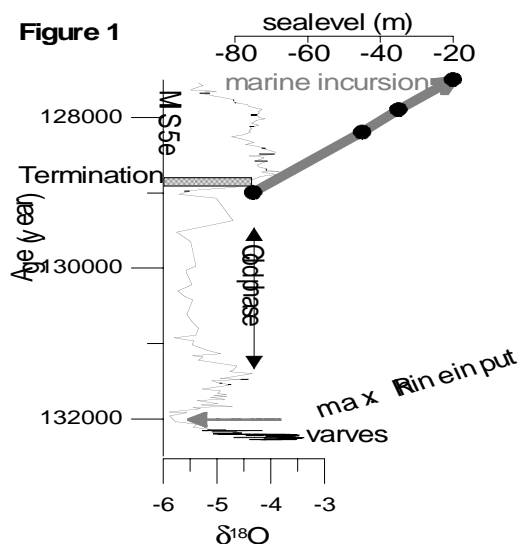
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The oxygen isotope record from the Holland Lake deposits, The Netherlands, shows rapid climate fluctuations at the end of the Saalian glacial (Figure 1). The large lake (~5000 km<sup>2</sup>) formed after melting of the glacier tongues belonging to the maximum ice-sheet extent in western Europe (Drenthe stage: ~135 ka). The  $\delta^{18}\text{O}$  climate record covers the period from the disappearance of the land-ice sheet in this area, up to the Eemian sea level rise (Marine Isotope Stage 5e). Salient features in the record are the varved layers at the base of the sequence, which allow reconstruction of a floating time scale which is anchored to the MIS 6/5 termination at 129 ka. Rhine river input into the lake increases at ~132 ka due to melting of remaining dead-ice fields and a general warming of the climate.



Abrupt drainage of the lake (at ~131.5 ka) coincides with a drop in the  $\delta^{18}\text{O}$ , and suggests a sudden change to much colder and drier conditions. These conditions lasted for ~2 kyr, and changed rapidly towards a milder climate at ~129.5 ka. The onset of the Eemian, as reflected in the pollen record, is exactly mimicked in the  $\delta^{18}\text{O}$  increase. The rapid rise of sea level in this region coincides with a  $\delta^{18}\text{O}$  plateau at -4 ‰.

## Abiotic vs. microbial reduction of uranium (VI)

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Reduction of U(VI) to U(IV) is associated with the precipitation of insoluble uranium phases under environmental conditions. Thus, U-reduction plays a major role in the formation of low temperature uranium ore deposits and is of great importance for the risk assessment of radioactive waste repositories. Diffusion of U(VI) across the sediment-water interface of suboxic sediments and subsequent reduction is the largest single sink in the global ocean budget of this element.

A causal connection between microbial activity and U-reduction is widely accepted. However, it is still uncertain whether U-reduction occurs predominantly abiotically or enzymatically. In our research we are focussing on the competition between two potential pathways for U-reduction under iron reducing conditions, namely dissimilatory U-reduction and surface catalysed U-reduction by ferrous iron produced by dissimilatory iron reduction.

In order to systematically investigate the interplay of the two pathways a model system was used, which was composed of nanoparticulate hematite and *Shewanella putrefaciens* 200R, a facultative anaerobe bacterium capable of growing with Fe(III) as well as U(VI) as sole terminal electron acceptor.

Adding bacteria, hematite, and U(VI) together resulted in the production of ferrous iron due to iron respiration and a decrease in U(VI) concentration with time. U-reduction was comparable to that observed in sterile controls, to which ferrous iron was added. U-reduction was less in experiments without hematite available for iron reduction or surface catalysis. This indicates that abiotic, surface catalysed reduction of U(VI) by ferrous iron dominated under the experimental conditions.

Addition of bicarbonate inhibited the abiotic reduction of U(VI) in sterile controls but also the enzymatic reduction in the experiments without hematite. The inhibitory effect of bicarbonate is consistent with the formation of strong dissolved U(VI)-carbonate complexes. However, in batch experiments with both hematite and bacteria, the inhibitory effect of bicarbonate addition was only noticeable during the first 24 hours of the experiment. After 5 days, lower U(VI) concentrations were measured than in experiments without bicarbonate addition. Furthermore formation of magnetite was observed. This led us to the conclusion that magnetite might be trapping uranium in these experiments. Lack of extractable U(IV) support this conclusion. Additionally, the U(VI) concentration did not increase when the suspensions were exposed to oxygen for 24 h, while a complete reoxidation of uranium was observed in the samples without hematite.