Hydrogenase enzyme assay for the quantification of microbial activity in subsurface environments

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The subsurface biosphere is the largest microbial ecosystem but very little is known about the microbially mediated processes that drive early diagenesis. Hydrogenase is an ubiquitous enzyme that catalyzes the interconversion of molecular hydrogen and/or water into protons and electrons. The protons are used for the synthesis of ATP, thereby coupling energy-generating metabolic processes to electron acceptors such as carbon dioxide or sulfate. It can therefore be used as a measure for total microbial activity as it targets a key metabolic compound rather than a specific turnover process.

Using a highly sensitive tritium assay we measured hydrogenase enzyme activity in the rather oligotrophic marine subsurface sediments of the Equatorial Pacific (EQP) and the organic-rich sedimens of Lake Van, a saline, alkaline lake in eastern Turkey.

At the EQP sites Hydrogenase activity could be detected throughout the most of the entire length of the cores down to depths of 15 to 35 meters below seafloor (mbsf). In contrary, the rather organic matter-rich Lake Van sediments exhibit measurable Hydrogenase activity only down to around 75 cm. Concomitant with the difference in organic matter content, hydrogen consumption rates are usually below 0.5 nmol H_2/g/min in EQP sediments, whereas they are around to 2 to 5 nmol H_2/g/min in Lake Van Sediments. At several EQP sites there appear to be small horizons of elevated Hydrogenase activity, indicating the location of redox fronts.

Additionally, we present enumerated microbial cell abundance in all samples in order to obtain per-cell turnover rates which allows a deeper insight into the energetics of subsurface ecosystems.

The effect of deep ocean stratification on pCO_2 and $\Delta^{14}C$

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Recently we have used the distribution of $\delta^{18}O$ in the deep Atlantic Ocean at the Last Glacial Maximum (LGM) to constrain the ratio of transport (psi) to vertical diffusion (kappa) in abyssal waters that flowed from around Antarctica (Lund, *et al*. 2011). This conservative tracer balance implies that psi/kappa was 8 times larger at the LGM as compared to today. As it is highly unlikely that the ocean overturning was eight times more vigorous at anytime in the past, we look to variations in kappa in the past to change this ratio. This large reduction in vertical mixing is akin to increased stratification in the LGM deep ocean.

In this work we use a 7-box ocean model to explore the consequences of deep stratification on the carbon budget of the ocean-atmosphere system. Toggweiler's 7-box model (Paleo, 1999) is modified slightly to allow explicit isolation of southern source water relative to a northern source overturning circulation. Mixing between these so called 'blue' and 'red' circulations is allowed at both the deep interface and in the Sub-Antarctic surface waters. Simulated increases in the ratio of psi/kappa lead to pCO_2 draw down, though this effect is largely due to the budget of preformed nutrients in the deep. An important sensitivity to the vertical rain ratio of organic to inorganic carbon arises in cases with deep stratification (lower kappa). Because organic matter is remineralized more in the shallow water column and carbonate in the deep, there is an important vertical stratification in the effect on pH. Preferential deposition of alkalinity in an isolated southern source water mass lowers pCO_2 in both closed and open system simulations. We will present the effects of deep stratification on both pCO_2 and the radiocarbon distribution in the past ocean.