Origin and dynamics of Fe- and Mn-crusts in the sediments of Lake Baikal

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The setting

Iron-manganese crusts were studied at six regions of Lake Baikal. They exhibit different sedimentation rates ranging from 0.8 mm yr^{-1} at the Selenga Delta down to about 0.2 mm yr^{-1} at Academician Ridge. Enriched Fe-Mn layers were found at the sediment-water interface at the Selenga Delta, and the Southern and Central Basins. In the North Basin of Lake Baikal and at Academician Ridge buried layers with very high concentrations of Fe- and Mn oxides were found.

The analysis

We measured pore-water profiles with dialysis plates and whole-core squeezing. From these date we obtained estimates of diffusive Fe^{2+} and Mn^{2+} fluxes into the enriched layers. By comparing the actual fluxes on the accumulated amount of Fe and Mn oxides in the layers we obtained estimates of the in-situ accumulation time of the enriched layers. These values could then be compared with the average sediment age calculated from published sedimentation rates at the different sites.

Results

Both methods yield similar estimates for the dynamics of Fe-Mn-crust formation in the sediments of Lake Baikal. Table 1 compares the accumulation time t_{acc} with the age in the enriched layer t_{age} calculated from the Mn data for different characteristic sites.

Site (core no.)	t_{acc} [years]	t_{age} [years]
Selenga Delta (core 94-08)	30	80
Southern Baikal (94-02)	80	50
Central Baikal (94-09)	390	170
Northern Baikal (94-10)	2200	680
Academician Ridge (94-11)	8100	5000

There is a good correlation between the penetration depth of oxygen into the sediment and the depth and extension of the enriched layers. They can therefore be considered as redox fronts. The crusts are enriched with Fe and Mn by factors of 10-100 compared with background levels in deeper sediment layers. Recently we have shown that P and As were strongly enriched in the Fe-fraction of these layers, while Mo and Cd preferentially accumulated in the Mn fraction (Müller et al. 2002).

Reference

Müller B., Granina L., Schaller T., Ulrich A. and Wehrli B. (2002) *Environ. Sci. Technol.* **36**, 411-420.

Studies of Archaean prokaryotic mat ecology, Belingwe Belt, Zimbabwe

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Detailed study of biological material in Archaean formations from the 2.7Ga Belingwe Greenstone Belt, Zimbabwe, has led to reconstructions of early microbial ecology. The work has been based on petrographic study of sedimentary facies, and on high resolution stable isotope analysis by CF-IRMS.

Sulphur and carbon analyses have been carried out on two very carbon- and sulphur-rich black shales of the Manjeri formation from three different drill cores. The overall results show remarkable isotopic heterogeneities. The range of $\delta^{13}C_{reduced}$ from -34.8 to -6.5‰, in samples with up to 18% carbon, indicates the signature of both rubisco and methanogenic archaea. Anoxygenic photosynthesis may also be recorded. In the S-isotope record on the same samples the large isotopic range within small distances (the largest spread in sulphur fractionation yet measured in an Archaean sequence) appears to record both sulphate reduction and sulphide oxidation parts of a sulphuretum cycle ($\delta^{34}S$ from -23.7‰ to +16.7‰). These rocks are the freshest Archaean biogenic material yet found and the isotopic diversity obtained can only be explained as the accidentally preserved products of microbial consortia.

This study has been extended by analysing also the carbonate and reduced carbon on different stromatolitic formations from the Belingwe Greenstone Belt and the 3.0Ga Steep Rock Group (Canada). The values obtained shows well established photosynthetic processes. Some results from the 3.5Ga Barberton Greenstone Belt, South Africa (collaboration with J. Kramer and C. Siebert), are also presented. Carbon isotopic compositions are around –20‰, might imply organic processes, and $\delta^{34}S$ measured are in a narrow range between 0 and +2‰.

The isotopic and sedimentary facies analyses identify microbial consortia and map out the procaryotic Archaean ecosystem at 2.7Ga. Microbial mat consortia depend both on photosynthetic and non-photosynthetic processes. The results imply that hyperthermophile communities are of considerable antiquity, though it is not possible yet to show that they preceded photosynthesis. They also show a well established biological sulphur cycle. The extended study on earlier formations indicates that any microbial processes which were occurring at 2.7Ga might have been different in Early Archaean.