On the significance of sharp interfaces on nanometer scale in oscillatory zoned minerals

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Oscillatory zoning in minerals is the self-evident record of a dynamical growth process and is common in many different geological environments. Theories and models about the origin of oscillatory zoning are numerous, with a notable emphasis on zoning in plagioclase. For many minerals the compositional variation is described as an asymmetric "saw-tooth pattern" whereby the wavelength and the amplitude can differ widely within one crystal as well as between minerals of various systems. Many studies also show that the compositional variation between the zones is bimodally bounded, i.e. that the zoning varies between two stable or gradually varying compositions. A short-wavelength zoning of <1 to 5 µm is commonly described for various minerals which is right at or even beyond the resolution limit of the applied micro-analytical techniques. Only very few studies have addressed oscillatory zoning on nanometer scale and the nature/microstructure of the compositional interfaces (Reeder et al. 1990, Pollok et al. 2001).

The exact pattern of compositional variation in oscillatory zoned crystals is of considerable interest in reference to the proposed kinetic (mostly non-linear) crystal growth models. These models assume a boundary layer at the crystal-melt/solution interface which were often combined with various growth kinetics and/or non-ideal behaviour of the growing solid-solution. The oscillatory numerical solutions of the non-linear equations commonly predict an at least partly continuous change in composition on a typically not well constrained length scale.

In this study we present nanometer scale microstructural and analytical results on oscillatory zoned plagioclase, grandite garnet and barite-celestite using analytical transmission electron microscopy (ATEM). The plagioclase and grandite garnet samples are of natural occurrence (magmatic and hydrothermal, respectively) whereas the barite-celestite crystals have been grown experimentally (Putnis et al. 1992). Intracrystalline diffusion which could decrease any sharp compositional gradients generated during crystal growth can be ruled out for these samples. The results will be discussed in respect to the proposed growth models with a special emphasis on the significance of sharp compositional interfaces at nanometer scale.

Tracing microbial activity in a contaminated aquifer at the field scale using ^{13}C-labeling of bacterial fatty acids

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Stable isotope analysis of phospholipid-derived fatty acids (PLFA) is used to trace bacterial assimilation of organic carbon in microbial communities. The labeling of biomarker PLFA allows the identification of specific microbial populations involved in the metabolism of particular substrates, supplemented in a ^{13}C-labeled form. The aim of this study was to investigate the feasibility of ^{13}C-labeling of PLFA and produced dissolved inorganic carbon (DIC) in an aquifer during a field-scale experiment.

We performed a single-well "push-pull" test in a monitoring well located in the denitrifying zone of a petroleum-hydrocarbon-contaminated aquifer in Studen, Switzerland. Anoxic test solution was prepared from 500 l of groundwater with addition of Br^- as a conservative tracer, NO_3^-, and acetate (50% [2-^{13}C]-labeled). At 4, 23 and 46h after injection, 1000 l of test solution/groundwater mixture were sequentially extracted from the same well. During injection and extraction phases we measured Br^-, NO_3^- and acetate concentrations, characterized the microbial community structure by PLFA and fluorescent in situ hybridization (FISH) analyses, and determined $^{13}C/^{12}C$ ratios in DIC and PLFA.

Computed first order rate coefficients were 0.63±0.08 d^{-1} for NO_3^- and 0.70±0.05 d^{-1} for acetate consumption. Significant ^{13}C-incorporation in DIC and PLFA was detected as early as 4 h after injection. After 46 h, we measured ^{13}C-enrichments of up to 5614 ‰ in certain PLFA, and up to 59.8 ‰ in the DIC. Profiles of enriched PLFA and FISH analysis suggested the presence of active denitrifiers.

Our results demonstrate the applicability of ^{13}C-labeling of PLFA and DIC in combination with FISH to link microbial structure and activities at the field scale during a push-pull test.