Coupling isotope labeling with compound specific stable isotope analysis of microbial biomarkers

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The vast number of high molecular substances in soil and their specific degradation pathways all end up in a reasonable small number of low molecular substances (LMWOS). Thus, the transformation and fate of LMWOS is one of the most important processes in biogeochemical cycles. These transformations are mainly controlled by microbial utilization and thus coupling the fate of LMWOS with their use by microbes is one of the tasks in the elucidation of C transformations and cycles.

Therefore we performed field experiments including application of dual-labeled and uniformly or position-specifically labeled amino acids. The microbial utilization was measured by means of ^{13}C- and ^{15}N-analysis of microbial biomass with the chloroform-fumigation-extraction method. A more specific look on the utilization of individual amino acids or C positions by distinct microbial groups was gained by the ^{13}C-PLFA approach.

Comparison of ^{13}C- and ^{15}N-incorporation revealed, that for a well N-supplied microbial community (C:N~6) of a grassland ecosystem appr. 50% of the amino acid N is mineralized by the microbes, whereas the remaining amino acids were incorporated into the microbial biomass. Incorporation of amino acid C into microbial biomass was highest for osmotrophic, prokaryotic groups. Position-specific labeling showed that highly oxidized groups are preferentially degraded, whereas more reduced C positions showed higher incorporation into the microbial biomass.

Our results show, that the combination of labelling with compound specific isotope analysis of microbial biomarkers opens a new way to investigate the microbial transformations of LMWOS in soil. Especially investigating the utilization of individual C atoms by microbial groups allows conclusions about the mechanisms and kinetics of microbial substrate utilization and the interactions between these groups. This will improve our understanding of soil carbon fluxes.

Control of biomineral formation during microbial Fe(III) reduction by local Fe^{2+} gradients – A multiscale approach

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The identity of minerals formed as a consequence of microbial iron(III) reduction is a function of geochemical conditions and microbial metabolic activity. While geochemical conditions set a thermodynamic framework for biomineralization, the microbial cells can influence the mineralization product by providing templates for mineral nucleation, localization of mineral precipitation, production of electron shuttles and changing the rate of Fe(III) reduction. Local Fe(II):Fe(III) ratios are known to be a key parameter for the transformation of Fe(III) minerals such as ferrihydrite to either dissolved Fe^{2+}, Fe(II) minerals (siderite), Fe(II)/Fe(III) minerals (green rust or magnetite) or other Fe(III) minerals (goethite).

We showed that under identical total concentrations of Fe(III) minerals, the geometry of the experimental setup significantly affected the local geochemistry, iron reduction rates and mineralogy of the reduction products in experiments with the iron-reducing strain *Shewanella oneidensis* MR-1. In these setups, the bacteria reduced 2.5 to 15 mM ferrihydrite with lactate as electron donor in glass tubes that were stored either horizontally or vertically.

In all setups with >7.5 mM ferrihydrite, magnetite formation was observed probably due to a high Fe(III):Fe(II) ratio present during ferrihydrite reduction. At lower concentrations of ferrihydrite, no magnetite but rather dissolved Fe^{2+} and/or siderite were formed in horizontally incubated tubes. However, in vertically incubated tubes magnetite was formed even at ferrihydrite concentrations as low as 2.5 mM. Probably ferrihydrite accumulation at the bottom of vertically incubated culture tubes also led to high Fe(III):Fe(II) ratios allowing magnetite to form. A multiscale approach combining bulk analysis with high resolution geochemical measurements and confocal laser scanning microscopy allowed us to characterize the microenvironments, localize cells at the mineral-solution interface and correlate geochemical data to mineral identification by XRD and Mössbauer spectroscopy.