

Electrical conductivity associated with dissimilatory iron reduction: Do biofilms decrease resistivity?

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Dissimilatory iron reducing bacteria like *Shewanella* and *Geobacter* play an important role in the global iron cycle. However, the geochemical data necessary to calculate field scale rates of iron reduction are expensive and difficult to obtain. Recently, signals from electrical resistivity, induced polarization and self potential methods have been associated with zones of increased biogeochemical activity. We present data from batch experiments in the laboratory that suggest a geochemical reaction rate is obtainable by measuring changes in electrical conductivity. Geophysical and geochemical reaction rates were within 25% of each other. However, in some cases, the clear link between electrical conductivity and geochemical changes may be obscured by the presence of bacteria. Laboratory data from flow-through reactors reveal a 3 fold increase in electrical conductivity (0.02 S/m – 0.06 S/m) after 11 weeks that cannot be explained by changes in geochemistry. We model the electrical conductivity data using percolation theory to describe the presence and growth of an electrically conductive biofilm on mineral surfaces. Microbial biofilms must be between 5 and 75 times more conductive than the surrounding fluid to account for the measured increase in electrical conductivity. We also present preliminary data from electrochemical experiments that demonstrate a 3 order of magnitude increase in electrical conductance as biofilms form on graphite electrodes.

Mechanism and timing of Pb transport from subducted oceanic crust and sediment to the mantle source of arc lavas

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New high-precision (double-spike) Pb isotope analyses of lavas from the northern Tonga Arc are used to examine the source of Pb in these samples, and the relative timing of Pb addition from the subducting oceanic crust and subducting sediment. Lavas from the northern Tonga islands of Tafahi and Niuatoputapu have distinctive, radiogenic Pb isotope compositions, which are inherited from the basaltic crust of the subducting Louisville Seamount Chain on the Pacific Plate. The subducted oceanic plate and the overlying upper mantle beneath northern Tonga therefore have very different Pb isotope compositions, allowing the proportion of Pb derived from both of these sources, and from subducting sediment to be estimated for the first time. We show that between 42% and 90% of the Pb in northern Tonga lavas is derived from the subducting oceanic crust. The dominant process of transfer of mantle Pb to the crust at subduction zones is therefore dehydration of subducted oceanic crust. Oceanic crust is subducting at the northern end of the Tonga Trench at a rate of 0.24 m/y, and contains on average about 0.5 ppm Pb. Assuming that the magma production rate at the Tonga Arc is 0.13×10^6 kg/y/m, mass balance calculations show that the Pb flux from the subducting oceanic crust into the arc crust corresponds to complete Pb removal from the uppermost 114 to 244 m of the subducting oceanic crust, or up to 3.5% Pb removal from the entire 7 km thickness of oceanic crust. In the latter case, a 'subduction processing' signal would not easily be identified in the Pb/Nd ratio of the oceanic crust that is recycled into the deeper mantle.

The orientation of the Pb isotope arrays constrain the relative timing of Pb addition from these different sources, and show that sediment Pb must be mixed with the upper mantle before Pb from the subducted oceanic crust is added by fluids. Together with existing U-series and ¹⁰Be data for Tonga-Kermadec lavas, this observation places strong constraints on the physical processes responsible for fluid-soluble element transfer from mantle to crust in subduction zones.