

Crustal accretion on mid-ocean ridges revealed through volatile concentrations in olivine-hosted melt inclusions

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We present volatile (H₂O, CO₂, Cl, S, and F) and major element data from melt inclusions in olivines found in crustal xenoliths and crystal clots from the fast-spreading East Pacific Rise to determine the depths of crystallization on mid-ocean ridges (MOR). The melt inclusions are generally, more primitive compared to the host glasses, with MgO concentrations ranging from 7.5 to 11.5 wt% and 6.6 to 8.4 wt%, respectively. Vapor saturation pressures calculated from equilibrium CO₂-H₂O concentrations suggest crystallization depths ranging from the crust-mantle transition (~6 km bsf) to above the seismically imaged, shallow melt lens (~600 m bsf). Minimum pressures estimates indicate that most of the melt inclusions (~70%) cluster between 1 and 2.5 km, consistent with crystallization in the shallow melt lens. However, the remaining melt inclusions show minimum equilibration pressures deeper than 2.5 km, implying that olivine crystallization beneath fast-spreading centers is not limited to the shallow melt lens.

Vapor-saturation pressures are also used to determine how volatile and major element concentrations vary with depth in the ocean crust. In general, volatile concentrations are much more variable in the upper 4 km of crust compared to the lower crust. For instance, Cl concentrations in melt inclusions formed in the upper crust range from 10 to 66 ppm, compared to only 42 to 51 ppm in melt inclusions formed deeper in the crust. This may result from higher degrees of fractional crystallization and/or increased fluid-rock interaction in the shallow crust. Major elements show no systematic variations with depth; however, more evolved olivines (Fo <86) are restricted to pressures within the shallow crust.

Several models have been proposed for crustal accretion beneath MORs (e.g., gabbro glacier or stacked sills), however there is no consensus on how the lower crust is formed at MORs or the depths over which crystallization occurs. Our volatile data imply that crystallization on fast-spreading ridges occurs throughout the crust, favoring models of in-situ crystallization or stacked sills and is inconsistent with a purely top-down, gabbro glacier model for lower crustal accretion on fast-spreading MORs.

A role of plant biomass-derived black carbon in electron transfer processes?

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Recent work by Roden *et al.* [1] has provided strong evidence for a role of aromatic compounds in providing solid-state electron shuttles for electron transfer between bacteria and metal oxide surfaces. Historically, such materials are considered to be part of operationally defined "humic" substances [2] and are thought to result from "humification", i.e., from processes of secondary synthesis in the course of organic matter decomposition. However, there is increasing evidence that soils and sediments are subject to large imports of aromatic carbon on a global scale [3,4] through vegetation fires and additions of industrial black carbon. Future additions of aromatic carbon to soils are expected to rise in the wake of the evolving "Biochar" movement [5].

Up to one fifth of oxygen-containing functional groups on industrial black carbon can have quinonic functionality [6], and a number of studies suggest that quinone functionalities within natural organic matter can be a suitable electron transfer mediator for iron bioreduction and contaminant degradation [7]. It has been determined that the efficiency of quinone redox mediators is controlled by their reduction potential, stability towards side reactions and kinetic reactivity in electron transfer reactions [7].

Here we take a first step towards identifying a potential role of plant biomass-derived black carbon in generating aromatic compounds with the ability to serve as electron transfer media. Titrations and spectroscopic information were used to test the hypothesis that redox potentials of chars vary as a function of quinone group abundance. Grass and wood chars generated across a range of heat treatment temperatures [8] allowed us to represent the varying amounts of oxygenated surface groups known to occur in natural chars.

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