Palagonitization of basalt glass in the flanks of mid-ocean ridges: Implications for the bioenergetics of oceanic intracrustal ecosystems

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When basalt glass is exposed to oxygenated aqueous solutions, rims of palagonite form along fractures at the expense of glass. The flanks of mid-ocean ridges are the largest reservoir of basalt glass on Earth, and the flow of oxygenated seawater fluxed through these flanks is $>10^{16}$ kg/yr. Hence, a large amount of palagonite forms in this setting, but palagonitization is kinetically sluggish at the prevailing temperatures of < 25 °C, theorytically allowing chemolithoautotrophic microbes to catalyze oxidation reactions for catabolic energy gain.

While the energy sources fuelling this putative microbial life in basalt are unknown, it has been suggested that steady-state Fe oxidation in ridge flanks can support a microbial biomass production on the order of 10^{11} g C per year. Most of the Fe oxidation takes place within the first 10 Myrs of ridge flank evolution, but it is uncertain which energy sources chemolithoautotrophs may use in older crust.

We present geochemical data on whole rock powders and highly oxidized palagonite rinds from drill cores, obtained during IODP Expedition 336 on the western flank of the Mid-Atlantic Ridge 23°N.

Radioactive elements are enriched in the palagonite relative to the fresh glass, reaching concentrations where radiolytic production of molecular hydrogen (H_2) may be a significant energy source. We hypothesize that bioenergetics in ridge flank habitats undergo a transition in the principal energy carrier fuelling carbon fixation from Fe oxidation in very young crust to H_2 consumption in old crust. We argue that thick rinds of palagonite in old crust protect the remaining fresh glass from alteration and thwart the oxidation of ferrous iron in the glass. These palagonite rinds have accumulated enough U and K to release nanomolal quantities of H_2 per year. Unless the H_2 is swept away by rapid fluid flow (i.e. in young flanks), it may easily accumulate to levels high enough to support chemolithoautotrophic life.