Significance of the Early Archean seafloor hydrothermal alteration as a CO_2 sink

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Hydrothermally altered basalts from the Marble Bar area in the Pilbara Craton have been investigated in order to elucidate geological and geochemical characteristics of the Early Archean (~3.46Ga) seafloor hydrothermal alteration. The basalts, composed mainly of pillow lavas, are overlain by hydrothermal bedded cherts and are crosscut by massive black/gray silica veins that are considered as hydrothermal feeders (Kato and Nakamura, 2003). Basalts in the vicinity of the bedded cherts and silica veins have been subjected to strong hydrothermal alteration.

The altered basalts are characterized by the alteration mineral assemblage of K-mica + quartz + chlorite +/- carbonate minerals, indicating that the basalts were altered by the hydrothermal solution with high CO_2 fugacity and K^+ concentration. The whole-rock chemical compositions of the least altered samples are essentially similar to that of modern mid-ocean ridge basalt except for highly mobile elements (e.g., K_2O, Rb, Ba, Sr). Compared to the least altered samples, other altered samples are enriched in CO_2, K_2O, Rb, Ba due to the presence of carbonate minerals and K-mica, and are depleted in Na_2O, reflecting the disappearance of plagioclase. The d13C values of the carbonate minerals in the carbontized basalts are close to zero permil, indicating that the carbonate carbon is of seawater origin. Elemental concentrations and relationship of CO_2 and CaO show that the CO_2 in the carbonatized basalts was substantially retaind as $CaCO_3$ and there was essentially neither gain nor loss of Ca during the carbonatization. These suggest that CO_2 in the circulating seawater was trapped by using Ca contained in the oceanic crust.

Based on our geological and geochemical results, 3.46Ga carbon flux sunk into the oceanic crust by hydrothermal alteration is estimated to be comparable to the present total carbon flux by carbonate precipitation and carbon burial (Berner, 1989; 1991). This suggests that the carbonatization of oceanic crust by the seafloor hydrothermal activity played an important role as a CO_2 sink in the Early Archean atmosphere and ocean.