

Global carbon cycle ~3.5 billion years ago: A clue to solving the present-day climate problem due to elevated atmospheric CO₂

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Understanding global carbon cycle in the Early Archean (~3.5 Ga) Earth may provide us a clue to solving the climate problem caused by elevated atmospheric CO₂ in the modern Earth, because the atmospheric CO₂ in the Early Archean is considered to have been much greater than today (e.g., Kasting, 1993; Ohmoto et al., 2004). In order to unravel the global carbon cycle in the Early Archean, hydrothermally altered basaltic rocks exposed near Marble Bar, eastern Pilbara Craton, have been studied. Carbonate minerals in the carbonatized basalt include calcite, ankerite, and siderite, whereas calcite is quite dominant. The $\delta^{13}\text{C}$ values of the carbonate minerals are mostly close to zero and within the range of marine carbonate, indicating that the carbonate minerals were formed by seafloor hydrothermal alteration and that carbonate carbon in the altered basalt was derived from seawater. Bulk-rock chemical composition of the basalts is essentially similar to that of mid-ocean ridge basalt (MORB). Significant enrichment of CO₂ is recognized in the basalt due to the ubiquitous presence of carbonate minerals. However, there was essentially neither gain nor loss of CaO, strongly suggesting that the CO₂ in the hydrothermal fluid (seawater) was trapped by using Ca originally contained in the basalt. The carbon flux into the Early Archean oceanic crust by the seafloor hydrothermal alteration is estimated to be 3.8×10^{13} mol/yr, based on the average carbon content of altered oceanic crust of 1.4×10^{-3} mol/g, the alteration depth of 500 m, and the spreading rate of 1.8×10^{11} cm²/yr. This flux is equivalent to or larger than the present-day total carbon flux. It is concluded that the seafloor hydrothermal carbonatization played the most dominant role as a sink of atmospheric and oceanic CO₂ in the Early Archean. This type of geologic process (sinking of CO₂ into the oceanic crust through the hydrothermal alteration) does not operate pervasively in the modern ocean system, because the level of atmospheric and oceanic CO₂ is not so high to promote the hydrothermal carbonatization for the oceanic crust.