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Geochemical behavior during the alteration of plateau basalts and its significance for the global carbon cycle

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Global warming induced by the increase in atmospheric CO2 concentration is one of the most serious problems as to the earth's surface environment. Atmospheric CO2 level is dominantly controlled by the balance between source and sink of carbon. So, it is important to unrabel sources and sinks of carbon for understanding the fluctuation of atmospheric CO2 in the Earth's history and furthermore for predicting future atmospheric CO2 level.

Volcanism is one of the major sources of CO2 into the atmosphere-ocean system. Especially, submarine volcanism at mid-ocean ridges (MOR) where new oceanic crust is produced represents more than 60% of the total volume of lavas erupted at the Earth's surface and releases huge amount of CO2. However recently, it has been demonstrated that carbon is fixed as calcium carbonate minerals (CaCO3) in oceanic crustal rocks and veins during hydrothermal alteration (Alt and Teagle, 1999). Alt and Teagle (1999) estimated the carbon budget for altered ocean crust based on whole-rock CO2 contents and showed that the sink of CO2 into oceanic crust is greater than the source of CO2 (total outgassing rate from newly-formed oceanic crust). It should be kept in mind, however, that the origin of calcium in the CaCO3 is still uncertain, and there are two potential mechanisms; reworking of calcium carbonates in overlying sediments and leaching from calcium silicates in oceanic crust. If calcium carbonates in the altered oceanic crust is merely reworked from overlying sediments, the carbonate precipitation is not virtually counted as a CO2 sink (Tajika and Matsui, 1992). On the other hand, if Ca in the calcium carbonates is derived from calcium silicates in oceanic crust, CO2 in the atmosphere and ocean can be fixed into oceanic crust. Consequently, calcium release from oceanic crust during hydrothermal alteration plays an important role as a potential sink of CO2.

Hotspot volcanism is also one of the major volcanism on the Earth's surface, although it is though to be volumetrically minor at present. However, recent studies demonstrated that hotspot volcanism produced huge volumes of magma and emitted enormous amount of CO2 episodically in the past (Larson, 1991). By analogous with the formation of oceanic crust, it may be possible that carbon is fixed into seamounts and plateaus formed by hotspot volcanism. In this study we present geochemical data on basement basalts drilled during Ocean Drilling Program (ODP) Leg 130 on the Ontong Java Plateau which is the largest oceanic plateau in the world, and determine whether or not the hotspot volcanism plays a role as a net CO2 sink in the atmosphere-ocean system.

Whole-rock chemical compositions show there is a negative correlation between CaO content and loss on ignition (LOI) value which is a proxy of degree of the alteration, suggesting the altered basalts are depleted in CaO. However, the average amount of Ca-depletion from the altered oceanic plateau basalts is estimated to be 0.3 wt.% which is five times less than that from the altered oceanic crust (Muta et al., 2005). In addition, LOI values decrease significantly as depth increases, indicating that only the outer part of the huge plateau is affected by the alteration. This means the significance of the oceanic plateau as a CO2 sink is relatively less than that of oceanic crust. Therefore, it is very likely that CO2 degassing rate from the hotspot volcanism is greater than the carbon budget fixed into the oceanic plateau, suggesting that hotspot volcanism is much more important than MOR volcanism as a major CO2 source to the atmosphere-ocean system in the long Earth's history.