PHOSPHATE FLUX FROM OCEANIC CRUST TO THE ARCHEAN OCEANS: EVIDENCE FROM THE 3.46 GA APEX BASALT, AUSTRALIA

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The phosphorous (P) cycle on early Earth is poorly understood. Considering the abundance of submarine volcanism, we have hypothesized that oceanic crust was the most important P reservoir; P in basalts was delivered into oceans by high-temperature submarine hydrothermal fluids. To examine this hypothesis, we have conducted mineralogical and geochemical studies of the 3.46 Ga Apex Basalt in ABDP #1 core from Eastern Pilbara.

The Apex Basalt in the core is 70 m long, which can be divided into three zones. Zone A (top 10 m section) is the least altered zone, containing actinolite, epidote, albite and chlorite with low chemical index of alteration (CIA) values (0.42-0.44). P_2O_5 contents in this zone are 0.10±0.01 wt%. Euhedral apatite crystals (10 to 50 µm in diameter) in this zone represent the primary igneous phosphates in the Apex Basalt. Zone B (middle 30 m section) is extensively chloritized. Zone C (lower 30 m section) contains chlorite, K-mica and sulfides with siderite. CIA values of both zones range from 0.76 to 0.99, suggesting intense hydrothermal alteration. Most parts of zones B and C exhibit depletions of P_2O_5 (0.01±0.01 wt%), but minor enrichments of P (0.06±0.01 wt%), occurring as secondary apatite (<5 µm in diameter), xenotime (YPO4, <30 µm in diameter), and belrinite ($AlPO_4$, <50 µm in diameter), are found in zones B and C. Similar relationship between P depletions and CIAs are found in a large number of outcrop samples of the Apex Basalt investigated by Nakamura & Kato (2004).

Examinations of geochemical profiles of the DSDP/ODP drill cores (Holes 504B, 735B and 801B) indicate that P was leached out locally, but large scale leaching from oceanic basalts is ambiguous. Hence, we suggest that leaching of P from oceanic basalts by submarine hydrothermal fluids was more significant in the Archean than today; intense submarine hydrothermal activities could have supplied most of P in the Archean oceans. Submarine hydrothermal environments would have been important sites for biological activity on early Earth, if the exposed land masses had been very limited as postulated by many researchers.