Geochemical studies on the mobilization of phosphorus during seawater/rock interaction of Miocene lava flows in the *Hokuroku* district in Akita, Japan

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The phosphorus is an essential element for biological activity. On the other hand, the phosphorus cycle on the modern surface Earth is often controversial. Many reseachers consider that oceanic crusts scavenge phosphorus by seawater/rock interaction. However, this idea is not supported by global data, in particular fersic submarine lava flows. Thus, the purpose of this study is set to examine phosphorus behavior during seawater/rock interaction of submarine rhyolite. The samples are collected from ca.12 Ma submarine rhyolite lavas which erupted on the seafloor of ancient Japan Sea in the *Hokuroku* basin. The collected samples were categorized into less and extensively altered samples. The less altered samples recorded the simple seawater/lava interaction, and extensively altered samples represent altered rocks by high-temperature submarine hydrothermal fluids. Primary igneous apatite is observed in phenocrysts, such as quartz, plagioclase, magnetite, ilmenite, and zircon. Secondary phosphate minerals are observed in vein, chalcedony in plagioclase pseudomorphs, and Fe-bearing minerals. Secondary phosphate includes 10-100 μm-sized apatite, monazite, and xenotime. Variety of secondary phosphates were found in extensively altered rhyolite, including euhedral and anhedral apatite, monazite, xenotime, corkite, and hinsdalite. In addition, hydrothermal formation of sulfur-bearing apatite was confirmed in plagioclase pseudomorph, groundmass, and altered minerals. Systematic chemical analyses on less altered rhyolite indicate the enrichment of phosphorus in unaltered rocks, followed by extensive phosphorus loss in heavily altered rocks. Therefore, it is concluded that rhyolite can supply phosphorus in ocean water by advanced seawater/rock interaction. Coupling of the initial enrichment and rapid loss of phosphorus in submarine fersic rocks may be important when considering ancient and modern chemoautotrophic vent communities, because our results imply that Kuroko-type venting fluids were rich in phosphorus and could support the benethic ecosystems. This new knowledge is different from a popular hypothesis that oceanic igneous rocks are sink of marine phosphorus.

Keywords: phosphate mineral, seafloor alteration, hydrothermal alteration, apatite

