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Archean phosphorous cycle operated by submarine hydrothermal and biological processes

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Archean phosphorous cycles have been debated in last decades. on the other hand, it has been uncertain concerning about the source and speciation of phosphorous and sink mechanisms in the cycles. Geochemical and mineralogical studies were performed on Archean submarine volcanic rocks and banded iron formations from Pilbara (3.4 Ga), Barberton (3.2 Ga) and Abitibi and Wawa (2.7 Ga). The examined basalts and rhyolites were suffered from submarine hydrothermal alteration and seafloor CO_2 metasomatism. They contained various secondary apatite and monazite with extremely rare phosphides. This observation and thermodynamic calculations indicate that phosphate was a dominant specie in the migrating fluids, rather than reduced phosphorous species. Altered volcanic rocks are in general depleted in phosphorous concentrations. These findings suggest that Archean oceanic crusts behaved as the source of phosphorous in the global phosphorous cycle.

The some BIFs (3.2 Ga and 2.7 Ga) were found to be rich in phosphate (up to 0.8 wt%), accompanied with occurrences of large sulfur-bearing apatite. Such high phosphorous concentrations and apatite chemistry cannot be caused by adsorption-enrichment model by Fe-(hydro) oxides. Close association of P enrichments and organic matter in the examined samples suggest the P accumulation in BIFs through sedimentary organic matter. Those results indicate that microbial processes had a significant role to sink phosphate on Archean sea floor.