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Two modes of terrestrial phosphide formation

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Abstract

In anorthite-diopside-tridymite paralava of the Hatrurim Complex, Daba-Siwaqa, Jordan, phosphides from two facies environments were found. Large xenomorphic phosphide aggregates, presented by minerals of the barringerite-transjordanite series, murashkoite and zuktamrurite, were noted at the intimate contact of the paralava with the host rocks. Moreover, the contact facies of the paralava, composed of large diopside crystals up to 1 cm in size and cemented by hydrosilicates, zeolites, and calcite, are enriched in phosphides. In the contact facies, it was possible to observe pseudomorphs of barringerite and murashkoite after fish bones and inclusions of minute needle-like barringerite crystals in diopside with morphological manifestations of the simultaneous crystallization of these minerals. In the central part of the weakly altered paralava with abundant amygdules, two nodules containing ore minerals were detected. In the first nodule, barringerite and schreibersite were found; the second contained nickelphosphide. In this paper we discuss the hypothesis that phosphides at the contact facies of the paralava formed as a result of reducing carbothermal reactions with the participation of thermally altered and graphitized fish-bone remains as a source of carbon and phosphorus and oxidized pyrite framboids as an iron source: $Fe_2O_3 + 3C = 2Fe(lq) + 3CO(g)$, $2Ca_5(PO_4)_3F + {}^{14}C = 3P_2(g) + {}^{14}CO(g) + 10Cao + F_2(g)$ and $nFe(lq) + ½P_2(g) = Fe_nP$, where n = ½, 1, 2, 3. The process of phosphide formation during hot paralava injection, the temperature of which exceeded 1400 °C, into previously altered host rocks with contamination of material containing bone remains, took place in a small volume in a kinetic mode, which led to the preservation of the primary form of bone remains when they were replaced by phosphides. The formation of phosphides in the central part of the paralava occurred with the participation of gases that transported phosphorus reduced as a result of carbothermal reactions. The phosphorous was absorbed by drops of metal or sulfide melt, which led to the formation of phosphides.

Keywords: Terrestrial phosphides, barringerite, murashkoite, zuktamrurite, paralava, genesis, Hatrurim Complex, Daba Siwaqa, Jordan