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Apatite in brachinites: Insights into thermal history and halogen evolution

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Abstract

Apatite is an important petrogenetic indicator in extraterrestrial materials. Here, we report the mineralogical features of apatite and associated phases in three brachinites Northwest Africa (NWA) 4969, NWA 10637, and NWA 11756. Two types of apatite are observed: intergranular apatite and apatite inclusion within chromite and silicate minerals. The intergranular chlorapatite is enclosed by or penetrated by irregular porous merrillite, indicating chlorapatite replacement by merrillite. The intergranular chlorapatite is closely associated with a fine-grained pyroxene-troilite intergrowth along olivine grain boundaries, which is a sulfidization product of olivine. High-Ca pyroxene is observed as a constituent phase in the intergrowth for the first time. The apatite inclusions are either monomineralic or closely associated with subhedral-euhedral pore-free merrillite. In NWA 4969, the apatite inclusions show a large compositional variation from chlorapatite to fluorapatite and are systematically more F-rich than intergranular apatite; while the apatite inclusions in NWA 10637 and NWA 11756 are chlorapatite. Most of the two apatite types in brachinites contain oriented tiny or acicular chromite grains, suggesting the exsolution of chromite from apatite. We propose that apatite replacement by merrillite, formation of pyroxene-troilite intergrowth, and exsolution of chromite in apatite were caused by a shock-induced, transient heating event (~930–1000 °C) on the brachinite parent body. This heating event resulted in halogen devolatilization during replacement of the intergranular apatite by merrillite, which probably disturbed the Mn-Cr isotopic system in brachinites as well. We also propose that the apatite inclusions could be a residual precursor material of the brachinites.

Keywords: Apatite, merrillite, halogen, replacement, sulfidization, exsolution, brachinite; Experimental Halogens in Honor of Jim Webster