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Late-stage, high-temperature processesing in the Allende meteorite: Record from Ca,Fe-rich silicate rims around dark inclusions

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ABSTRACT

Secondary Ca,Fe-rich minerals (CFM; diopside-hedenbergite, andradite, wollastonite, kirschteinite) are widespread in the Allende carbonaceous chondrite. About 90 vol% of the total CaO content of the Allende matrix is concentrated in CFM. The conditions and environment (solar nebular or asteroidal) of this alteration are still matters of controversial scientific discussion. Here we present evidence for late-stage, high-temperature processes recorded in Ca,Fe-rich rims around Allende dark inclusions 3529 and IV-1 studied using scanning (SEM) and transmission electron microscopy (TEM), and electron probe microanalysis. The rims show a multilayered structure, with the outermost layer intergrown with the matrix olivines and chondrule fragments of the Allende host, indicative of in situ formation. The central portion of the rim around IV-1 contains several wollastonite polytypes (a polysynthetically twinned polytype of pseudowollastonite, wollastonite-2M, and wollastonite-1T) and an intergrowth of hedenbergite-PM (primitive monoclinic) and augite-hedenbergite$_{ss}$. These findings require temperatures above 1000 °C and fast cooling rates after formation of the central part of the rim. The close occurrences of three different polymorphs of wollastonite suggest that this process was highly localized and may have resulted from shock metamorphism.