

IN SITU GROWTH OF FAYALITE AND HEDENBERGITE IN THE UNGROUPED CARBONACEOUS CHONDRITE MAC88107. A.N. Krot¹, M. I. Petaev², A. J. Brearley³, G. W. Kallemeyn⁴, D. W. G. Sears⁵, P. H. Benoit⁵, I. D. Hutcheon⁶, and K. Keil¹. ¹Hawai'i Institute of Geophysics & Planetology, SOEST, University of Hawai'i, Honolulu HI, USA (sasha@pgd.hawaii.edu); ²Harvard-Smithsonian Center for Astrophysics, Cambridge MA, USA; ³Earth and Planetary Sciences, University of New Mexico, Albuquerque NM, USA; ⁴Department of Chemistry, Faculty of Science, Tokyo, Japan; ⁵Department of Chemistry & Biochemistry, University of Arkansas, Fayetteville, AR 72701, USA; ⁶Lawrence Livermore National Laboratory, Livermore CA, USA.

Introduction: MAC88107 is petrographically similar to CM chondrites [1, 2], but has a bulk composition and induced thermoluminescence glow curve closer to the CO chondrites [3, 4]. Based on the Zn/Mn and Al/Mn abundance ratios which fall in the hiatus between CM and CO chondrites, Kallemeyn [4] concluded that MAC88107 is an ungrouped carbonaceous chondrite. Based on the observed phyllosilicate assemblage (intergrowths of saponite and serpentine similar to those in CI chondrites), lack of tochilinite, and abundance of matrix olivine, Zolensky et al. [5] inferred that MAC88107 experienced non-pervasive aqueous alteration to a maximum temperature of ~150°C. Here, we describe a previously unknown secondary mineralization in MAC88107, which includes fayalite (Fe₂SiO₄) and hedenbergite (CaFeSi₂O₆).

Results: The MAC88107 meteorite (thin section 50) is virtually unbrecciated; most chondrules, chondrule fragments and Ca-Al-rich inclusions are surrounded by continuous fine-grained rims; matrix material outside the rims is minor. These textures are similar to the "primary accretionary textures" previously described in CM chondrites [6]. Although chondrule mesostases in MAC88107 are extensively replaced by phyllosilicates and most of the metal-sulfide nodules are oxidized to magnetite and Ni-bearing sulfides, olivine and pyroxene phenocrysts experienced only a minor degree alteration. Fayalite and hedenbergite are observed in several textural occurrences which are similar to those in the oxidized CV3 chondrites Kaba and Mokoia [7, 8], but are finer-grained and less abundant. In contrast to Kaba and Mokoia, andradite and salite-ferrosalite pyroxenes are absent in MAC88107.

Fine-grained rims around chondrules are commonly crosscut by Fe-rich veins composed of fayalite (~Fa₉₀₋₁₀₀, 0.6-0.9 wt.% MnO), hedenbergite (~Fs₅₀Wo₅₀, 0.2-0.4 wt.% MnO), and compositionally pure magnetite (Fe₃O₄). Fayalite and hedenbergite are closely intergrown and contain inclusions of magnetite. We infer that fayalite and hedenbergite in veins formed contemporaneously by replacement of magnetite. Fine-grained rims crosscut by veins also contain relatively coarse-grained (3-5 μm) fayalites that

replace opaque nodules composed of magnetite and sulfides.

The veins typically start from the opaque nodules which are peripheral to the host chondrules and contain abundant submicron inclusions of chromite, Caphosphates, and Ni-bearing sulfides. The veins crosscut chondrule rims and either terminate at the boundaries with the neighboring fine-grained rims or extend as thin discontinuous layers between these rims. The largest subhedral grains of fayalite and hedenbergite (10-15 μm) are commonly observed in the porous regions within the inter-rim layers. Some of these fayalites overgrow isolated forsteritic (Fa₁₋₅) and fayalitic (Fa₂₀₋₄₀) olivine grains. The compositional profiles across the fayalite-host olivine boundaries show no evidence for Fe-Mg interdiffusion, suggesting that fayalite formed at low temperatures.

Conclusions: Based on our petrographic and mineralogical observations, we suggest that formation of fayalite and hedenbergite in MAC88107 took place *in situ* during low-temperature aqueous alteration. We infer that magnetite formed by oxidation of metal during an early stage of alteration by the H₂O-bearing fluid: 3Fe(s) + 4H₂O(g) = Fe₃O₄(s) + 4H₂(g) and/or 6Fe(s) + 4H₂O(aq) + 6H⁺(aq) = Fe₃O₄(s) + 3Fe²⁺(aq) + 7H₂(g). The reactions between an aqueous solution and anhydrous silicates resulted in replacement of the former by Mg-rich, Ca-poor phyllosilicates, release of Si, Ca, and Mn in the solution and formation of fayalite and hedenbergite: 2Fe₃O₄(s) + 3SiO₂(aq) + 2H₂(g) = 3Fe₂SiO₄(s) + 2H₂O(g); Fe₃O₄(s) + 6SiO₂(aq) + 3Ca²⁺(aq) + 2H₂O(aq) = 3CaFeSi₂O₆(s) + 2H₂(g); Fe²⁺(aq) + Ca²⁺(aq) + 2SiO₂(aq) + 2H₂O(aq) = CaFeSi₂O₆(s) + 2H₂(g); 2Fe²⁺(aq) + SiO₂(aq) + 2H₂O(aq) = Fe₂SiO₄(s) + 2H₂(g). In order to constrain the time of fayalite formation in MAC88107, we are currently attempting to study its ⁵³Mn-⁵³Cr isotope systematics by ion probe. The absence of andradite in MAC88107 suggests that the alteration occurred at lower temperatures (~120-220°C) and/or under more reduced conditions than that of the oxidized CV3 chondrites Kaba and Mokoia [7, 9]. The TL data are consistent with this scenario.

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