SECONDARY FAYALITE, HEDENBERGITE, AND MAGNETITE IN THE CO3.0–3.1 CARBONACEOUS CHONDRITES Y-81020, EET 90043, AND MAC 88107. A. N. Krot*, P. Doyle, and K. Nagashima. HIGP/SOEST, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA. *sasha@higp.hawaii.edu

Introduction: Ferroan olivine ($Fa_{50–100}$) is one of the major minerals in matrices of type 3 ordinary (H, L, LL), R and carbonaceous (CV, CK, CO) chondrites which experienced low degrees of aqueous alteration and mild thermal metamorphism. Matrix ferroan olivine is absent in extensively aqueously altered carbonaceous chondrites (CI1, CM1–2, and CR2), in unaltered and unmetamorphosed carbonaceous chondrites (Acfer 094, CR3), and in the reduced enstatite (EH, EL) and K chondrites. In aqueously-altered and the least metamorphosed CVs (Kaba, Mokoia, A-881317, Vigarano, and MET 00430), nearly pure fayalite coexists with magnetite, Fe,Ni-sulfides, salite-hedenbergite ($Fs_{10–50}Wo_{45–50}$) pyroxenes, and phyllosilicates [1]. The mineralogy, petrography, O and Mn-Cr isotope systematics of the CV fayalite [2–5], and thermodynamic analysis [1, 6] indicate that fayalite formed during aqueous alteration at low water/rock ratio (0.1–0.2) and elevated temperatures (100–300°C). Subsequent thermal metamorphism resulted in Fe-Mg exchange in fayalite and formation of more magnesian olivine (up to $Fa_{\sim 50}$). Here we describe the mineralogy and petrography of the fayalite-magnetite-hedenbergite-sulfide paragenesis in Y-81020, EET 90043, and MAC 88107 chondrites, classified as CO3.05 [7], CM/CO3.1-like [8], and magnetite-rich CO3 [9], respectively. Oxygen and Mn-Cr isotope systematics of fayalite in MAC 88107 are reported in [10] and [11], respectively. Isotope studies of magnetite and fayalite in EET 90043 and Y-81020 are in progress.

Results: In the CO chondrites studied, fayalite-bearing assemblages are found in matrices, fine-grained rims, around chondrule fragments, and inside chondrules.

(*i*) In the matrix, fayalite occurs as isolated euhedral and subhedral grains, 1–60 μm in size, often containing inclusions of magnetite (Fig. 1a). The abundance and sizes of the fayalite grains increases from Y-81020 to EET 90043 to MAC 88017. Hedenbergite occurs as anhedral grains and concentrically-zoned nodules up to 50 μm in diameter (Fig. 1a). In addition, in the matrix of MAC 88107, fayalite, hedenbergite, magnetite, and Fe,Ni-sulfides form coarse-grained intergrowths [8, 10].

(*ii*) In the fine-grained rims around type I chondrules, fayalite, magnetite, hedenbergite, and Fe,Ni-sulfides occur as veins that start at the peripheries of host chondrules (often at the opaque nodules), crosscut the rims and terminate at the boundary with fine-grained rims around neighboring chondrules (Fig. 1b; see also [8]). The veins are common in MAC 88107 and EET 90043, but are rare in Y-81020.

(*iii*) Fayalite±hedenbergite±magnetite overgrowths on ferromagnesian olivines of type I and type II chondrule fragments (Figs. 1c,d). The overgrowths contain nearly pure fayalite ($Fa_{98–100}$) that typically shows no evidence for Fe-Mg exchange. Occasionally, some of the fayalite overgrowths have a wide range of fayalite content ($Fa_{70–100}$) suggesting a post-crystallization Fe-Mg exchange with the host olivine and/or with magnesium-bearing fluid.

(*iv*) Fayalite-magnetite assemblages associated with altered opaque nodules inside type I chondrules are found only in EET 90043 (Figs. 1e,f). The nodules are replaced by magnetite, containing small inclusions of phosphates, chromite, and Fe,Ni-sulfides, and often surrounded by a compositionally pure, massive magnetite. Fayalite preferentially replaces compositionally pure, massive magnetite (Fig. 1f). Chondrule mesostasis is replaced by phyllosilicates and partially leached out. Magnesian olivine phenocrysts in contact with fayalite are partly replaced by ferroan olivine ($Fa_{60–80}$).

Conclusions: We infer that fayalite, hedenbergite, and magnetite in Y-81020, EET 90043, and MAC 88107 resulted from an aqueous alteration of the CO chondrite parent asteroid. The similar occurrences and mineral assemblages of secondary fayalite are found in aqueously altered and weakly metamorphosed CV chondrites [1–6]. These observations suggest that aqueous alteration of the CO and CV chondrite parent asteroids occurred under similar physic-chemical conditions. Oxygen and Mn-Cr isotope systematics of the fayalite-bearing assemblages in these meteorites can provide constraints on the sources of water in their parent asteroids and the timing of alteration [10–12].

References: [1] Krot A.N. et al. 1998. *Meteorit. Planet. Sci.* 33:1065–1085. [2] Hutcheon I.D. et al. 1998. *Science* 282:1865–1867. [3] Choi B.-G. et al. 2000. *Meteorit. Planet. Sci.* 35:1239–1248. [4] Hua X. et al. (2005) *Geochim. Cosmochim. Acta* 69:1333–1348. [5] Jogo K. et al. 2009. *Eearth Planet. Sci. Lett.* 287:320–328. [6] Zolotov M.Y. et al. 2006. *Meteorit. Planet. Sci.* 41:1775–1796. [7] Grossman J.N. & Rubin A.E. 2005. *Meteorit. Planet. Sci.* 40:87–122. [8] Krot A.N. et al. (2000) *Meteorit. Planet. Sci.* 35:1365–1387. [9] Choe W.H. et al. 2010. *Meteorit. Planet. Sci.* 45:531–554. [10] Krot A.N. & Nagashima K. (2012) *Meteorit. Planet. Sci.* 47*(Suppl.)*:#5338. [11] Doyle P. et al. (2013) *Lunar Planet. Sci.* XLIV:this issue. [12] Choi B.-G. & Wasson J.T. 2008. *Meteorit. Planet. Sci.* 42*(Suppl.)*:#5272.

Fig. 1. Backscattered electron images of different textural occurrences of the fayalite (fa) – hedenbergite (hed) –magnetite (mgt) paragenesis in EET 90043 and Y-81020. a – Subhedral fayalite and magnetite grains and anhedral hedenbergite grains and nodules in the hydrated fine-grained matrix. b – Fayalite veins crosscutting a fine-grained rim (FGR) around a porphyritic olivine (ol) – pyroxene (px) chondrule (CHD) fragment. c, d – Fayalite overgrowing olivine of type I and type II chondrule fragments. e, f – Fayalite and magnetite inside a porphyritic olivine-pyroxene chondrule. Chondrule olivine phenocrysts ($Fa_{2–5}$) are partly replaced by ferroan olivine ($Fa_{45–57}$); the original boundaries of the grains are indicated by arrows. Yellow numbers and red dots correspond to fayalite contents and locations of EPMA analyses of chondrule olivine and secondary fayalite. Chondrule mesostasis (alt mes) is heavily-altered.