TEM ANALYSYS OF FEO-RICH OLIVINES IN KABA: IMPLICATIONS FOR UNDERSTANDING THE ROLE OF FLUIDS IN CV CHONDRITES

E. Dobrică, J. L. Maxwell, and A. N. Krot, Hawai'i Institute of Geophysics & Planetology, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA (dobrica@hawaii.edu).

Introduction: In order to understand the effects of the earliest stages of hydrothermal alteration and fluid-assisted metamorphism on the matrices of CV_{OxB} chondrites, we have investigated the fine-grained matrix of Kaba (CV3.1) using multiple electron microscope techniques. According to previous studies, Kaba has experienced a moderate degree of alteration and minor thermal metamorphism resulting in the formation of secondary ferrous olivine (Fa_{50-100}) through fluid-assisted metasomatic alteration at 200–300°C [e.g., 1-2]. The matrix of this meteorite contains both fine-grained ferroan olivine ($(Fe,Mg)_2SiO_4$, $Fa_{\sim 50}$) associated with nearly pure, euhedral, coarse-grained fayalite (Fe_2SiO_4, Fa_{90-100}) [1]. The formation of pure fayalite olivine during hydrothermal alteration has been demonstrated to be viable based on hydrothermal experiments [3]. However, no ferroan olivine was formed during similar experiments, although it has been demonstrated to be thermodynamically viable based on the calculations [4-5]. This study aims to understand the hydrothermal alteration and fluid-assisted metamorphic growth of ferroan olivine associated with nearly pure fayalite on the parent bodies of CV chondrites through a detailed analysis of the mineralogy, texture, chemical composition, and crystallography. The research has important implications for understanding the chemical reactions and the role of fluids in the fluid-assisted metamorphism that affected the matrices of CV chondrites.

Samples and Methods: We selected a region that contains both ferroan olivine and nearly pure fayalite for the focused ion beam/transmission electron microscopy (FIB/TEM) study (Fig. 1a). The electron transparent section was prepared using the Helios 660 dual-beam focused ion beam SEM (FIB-SEM) instrument at the University of Hawai'i at Mānoa and examined by transmission electron microscopy (TEM) using the JEOL NEOARM 200CF at the University of New Mexico.

Results and discussion: Our detailed TEM study shows the presence of coarse-grained, zoned, euhedral olivine (2 × 7 µm in size) associated with fine-grained, elongated, ferroan olivine (20-90 nm in length and 10-20 nm in width, Fig. 1). The coarse-grained olivine has a ferroan olivine (Fa_{20}) core and FeO-rich rim (Fa_{74}, Fig. 1b). A diffuse compositional boundary is observed between the core and the rim. The groundmass of this FIB section is largely composed of elongated, ferroan olivine (Fa_{43-58}, avg. Fa_{50}), associated with sulfide and magnetite with Al-rich rims (Fig. 1c).

Our observations are in agreement with [6], suggesting that the coarse- and fine-grained olivines in Kaba form both through diffusion/replacement (i.e., zoned, coarse-grained olivine) and precipitation (i.e., fine-grained olivine groundmass) mechanisms. The mineral texture of these olivines indicates the pseudomorphic replacement of forsteritic olivine by FeO-rich olivines, which requires extensive mobilization of Mg. This Mg-rich fluid will subsequently precipitate as ferroan olivine in the fine-grained matrix. Additionally, we show that an Al-rich fluid circulated through the CV parent body after the precipitation of ferroan olivines considering that the Al-rich rims are only present on the rims of magnetite and sulfides and are lacking at the contact between ferroan olivine and magnetite (Fig. 1c). Alumina is one of the least soluble major rock-forming elements in H_2O. However, the complete leaching of chondrule mesostasis and the transport and reprecipitation of the Al-rich rims around the secondary phases clearly demonstrates that alumina was remarkably mobile in Kaba.

References: [1] Brearley A.J. and Krot A.N. (2013). In *Metasomatism and the chemical transformation of rock: The role of fluids in terrestrial and extraterrestrial processes*, Springer. pp. 659–789. [2] Krot A.N. et al. (2019) *Geochim. Cosmochim. Acta* 246, 419–435. [3] Dobrică E. et al. (2022) *Meteorit. Planet. Sci.* 57, 381–391. [4] Maxwell J.L. et al. (2022) *53rd LPSC*, Abstract #2404. [5] Zolotov M.Y. et al. (2006) *Meteorit. Planet. Sci.* 41, 1775-1796. [6] Krot A.N. et al. (2004) *Antarct. Meteorite Res.* 17, 153-171.

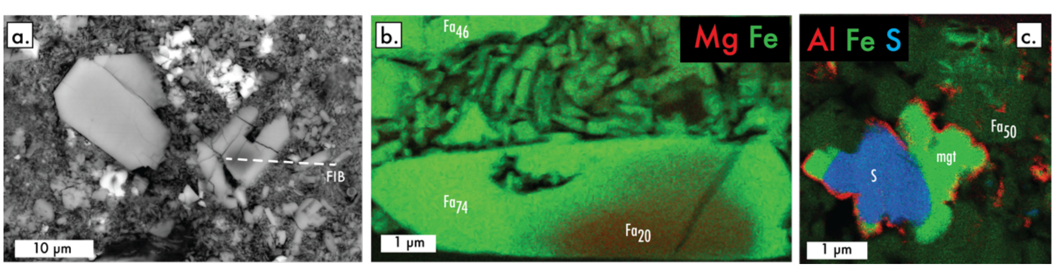

Figure 1. a) Backscattered electron micrograph showing the presence of euhedral nearly pure fayalite and zoned olivine from the Kaba matrix. One FIB section was prepared at the boundary between the zoned olivine and the fine-grained matrix containing nanometric ferromagnesian olivines. b) EDS/TEM map showing the Mg (red) and Fe (green) distribution in the zoned olivine. c) EDS/TEM map of the association of magnetite (mgt) and sulfide (S) in the fine-grained material identified in the FIB section. An Al-rich (red) rim was identified around the magnetite and sulfide.