Secondary alteration of amoeboid olivine aggregates in the reduced and oxidized CV3 chondrites.

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The CV chondrites are subdivided into the oxidized Allende-like (CV^{oxA}), oxidized Bali-like (CV^{oxB}), and reduced (CV^{red}) subgroups [1]. In both oxidized subgroups, common secondary minerals in chondrules, CAIs, and matrices include magnetite, Ni-rich metal, Fe,Ni-sulfides, Ca,Fe-rich pyroxenes, and andradite. Phyllosilicates and fayalite are common in the CVoxB (e.g., Bali, Kaba, Mokoia), whereas secondary fayalitic olivine (Fa30-50), nepheline, and sodalite are observed largely in the CV^{oxA}, (e.g., Allende, ALH84028) [2,3]. Secondary minerals in the CV^{red} chondrites Efremovka and Leoville are similar to those in the CV^{oxA}, but much less abundant.

It has been suggested that the major chemical and mineralogical differences between the CV subgroups largely reflect their complex alteration [4]. In order to understand the alteration history of the CV chondrites, we performed mineralogical studies of Y-86009 which have a unique mineralogy. Especially, we have studied amoeboid olivine aggregates (AOAs) in Y-86009. Because AOAs in primitive chondrites are composed of fine-grained minerals that are easily modified during postcrystallization alteration, the mineralogy of AOAs can be used as a sensitive indicator of metamorphic or alteration processes.

AOAs in Y-86009 are irregularly-shaped objects, 50-750 micron in size, composed of forsteritic olivine, high-Ca pyroxene, anorthite and FeO-poor spinel. Forsteritic olivine typically shows enrichment in FeO along the cracks and grain boundaries. Anorthite is partly or completely replaced by fine-grained Al-rich phyllosilicates; nepheline is minor. Anhderal grains of hedenbergite occur along grain boundaries in direct contact with phyllosilicates. Euhedral fayalitic olivine grains (Fa63-71) overgrow forsterite and occasionally show inverse compositional zoning. Some forsterite grains are overgrown by euhedral pyroxene (Wo41En56Fs3, smaller than 10 micron in size) along the rim of AOAs. In some cases, enstatite (Wo5En94) occurs around the metal-magnetite nodules.

Based on our observations, it is likely that Y-86009 experienced hydrous alteration that resulted in formation of secondary phyllosilicates, magnetite, Fe-Ni-sulfides, fayalite, Ca-Fe-rich pyroxenes, and andradite These alteration features are similar to those in the CV^{oxB} chondrites Bali and Mokoia [5]. However, there are some important mineralogical differences as well. The common presence of anorthite in AOAs and rarity of Fa100 implies that the degree of aqueous alteration is lower than other CV^{oxB} chondrites. In addition, secondary fayalite in Kaba is rarely shows inverse compositionally zoning and approaches nearly pure fayalite. The presence of nepheline, sodalite and lath-shaped fayalitic olivine in matrix implies that Y-86009 also experienced higher temperature, and possibly more prolonged aqueous alteration than Kaba. We infer that Y-86009, like MET00430 [6], is intermediate between CV^{oxA}, and CV^{oxB}. Inverse chemical zoning of the individual ferrous olivines suggest the dissolution of ferrous olivine and precipitation of more forsteritic olivine from a fluid phase during the late-stage thermal metamorphism, and probably reflect fluctuations of fluid compositions on a local scale [5].

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