HRTEM STUDY OF THE MATRIX MINERALOGY OF THE LANCE CO(3) CHONDRITE: Lindsay P. Keller and Peter R. Buseck, Departments of Geology and Chemistry, Arizona State University, Tempe, AZ 85287.

Introduction. Phyllosilicates are known to be major constituents of CI and CM carbonaceous chondrites, but little is known about their occurrence and character in CO and CV carbonaceous chondrites. We have undertaken a study of the Ornans-type (CO) carbonaceous chondrites in order to understand more about the matrix mineralogy of carbonaceous chondrites and the processes responsible for the formation of matrix phases. We report here preliminary observations from a high-resolution transmission electron microscope (HRTEM) study of the matrix mineralogy of the Lance carbonaceous chondrite.

Previous studies using SEM/EMPA have shown that fayalitic olivine is the dominant mineral in Lance matrix [1,2,3]. Minor matrix phases in Lance include Ca-rich and Ca-poor clinopyroxene, metal, oxides, and phyllosilicates [1,2,3]. The identities of the phyllosilicates are poorly known, as is their relationship to the other matrix phases.

Observations. Much of the Fe-rich olivine (Fa_{40} to Fa_{50}) in Lance matrix is fine-grained (<0.1 to 10 μm in diameter) and fragmented with the smaller fragments altered to fibrous phyllosilicates and Fe-oxide/hydroxide. The phyllosilicate fibers are <20 to 100 Å in width and from 100 to 500 Å in length. High-resolution imaging shows (001) basal fringe spacings of 7 Å. In addition, rare fibers of phyllosilicate with 9 Å fringes also occur.

Fe-oxide/hydroxide is ubiquitous in Lance matrix. The material is very poorly crystalline, with selected-area electron diffraction (SAED) patterns containing only diffuse diffraction rings. Two SAED patterns are common, one with spacings of 2.45, 2.15, 1.99, and 1.41 Å, and another with spacings of 2.73 and 1.55 Å. These patterns are consistent with data on well-crystallized and poorly crystallized ferrihydrite (5Fe₂O₃·9H₂O) respectively [4]. The ferrihydrite is mixed intimately and pervasively with phyllosilicate, suggesting that both formed simultaneously during the alteration of olivine.

Energy dispersive x-ray spectrometry (EDS) analyses of altered areas were obtained using an analytical TEM. The fibers of phyllosilicate are too fine-grained to obtain precise compositional data for a single fiber; however, EDS spectra of altered areas indicate major Mg, Si, and Fe, and occasionally, minor Al. This observation is consistent with the results of Michel-Levy [1], who also observed major Fe, Mg, and Si in EDS spectra. Based upon our imaging and chemical data, we conclude that the phyllosilicate material is mostly serpentine. We do not have sufficient data to allow identification of the 9 Å phyllosilicate; it probably is talc or a smectite.

The alteration products are richer in Fe than matrix olivine. This result suggests that either Fe was added to the altered areas or Mg and Si were removed. A probable
source of additional Fe is the oxidation and removal of Fe from matrix metal, leaving the residual metal enriched in Ni. The fine-grained metal that occurs in Lance matrix is richer in Ni than the average value for Lance taenite determined by McSween [5]. A similar mechanism was proposed to explain the high Fe/Si ratio in Ornans matrix and the presence of high-Ni taenite in matrix [5].

Discussion. The matrix mineralogy of Lance is most similar to the matrix of the Mokoia CV3 chondrite. Both meteorites have Fe-rich olivine as the major matrix constituent. Additionally, both chondrites exhibit textures suggesting that olivine was partially altered to phyllosilicate. In Mokoia, Fe-rich olivines have sustained partial iddingsitization, a topotactic replacement of olivine by a mixture of smectite (saponite) and Fe-oxide [6,7]. In Lance, we observe that fayalitic olivine altered to ferrihydrite and serpentine. The formation of saponite in Mokoia is thought to be related to low-temperature deuteric alteration of olivine [7,8]. The presence of serpentine in Lance instead of saponite suggests that its alteration occurred at higher temperatures than the alteration of Mokoia. McSween [5] showed that coexisting taenite and kamacite in CO(3) chondrites record minimum equilibration temperatures of 400 to 450°C. This result places an upper limit to the temperature at which the alteration in Lance could have occurred.

Conclusions. Our TEM investigation of Lance matrix has revealed: 1) that the fine-grained Fe-rich olivine in the matrix has been partially altered to a mixture of ferrihydrite and phyllosilicates; this process involved both hydration and oxidation of the olivine; 2) while the alteration was pervasive, the alteration products are volumetrically small in quantity, suggesting a limited availability of fluid; 3) the composition of the alteration material is more Fe-rich than matrix olivine; either Mg and Si were removed from matrix, or Fe was added to matrix by the alteration of other Fe-rich phases (i.e., kamacite); 4) the alteration assemblage in Lance is similar to that in the Mokoia CV3 chondrite; however, the assemblage in Lance probably reflects a higher temperature of formation.

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