

**REPRODUCTION OF PHYLLOSILICATE TEXTURES IN CM2 CHONDRITES DURING EXPERIMENTAL HYDRATION OF AMORPHOUS SILICATE SMOKES.** L. J. Chizmadia<sup>1,2</sup>, <sup>1</sup>NASA Astrobiology Institute, Institute for Astronomy, University of Hawai'i, Honolulu, HI 96822 lchiz@ifa.hawaii.edu, <sup>2</sup>Hawai'i Institute for Geophysics and Planetology, University of Hawai'i, Honolulu, HI 96822.

**Introduction:** For over 20 years, Nuth and his colleagues have been synthesizing amorphous non-stoichiometric silicate smokes [1]. These smokes have metastable eutectic compositions and have similar infrared spectra as the materials observed in circumstellar and cometary dust [1]. These smokes are composed of chains of rounded amorphous particles 10-50 nm in size [2,3].

Amorphous silicate materials have been reported in the matrices of several primitive carbonaceous chondrites (e.g. CM2 Murchison, CO3 ALHA77307, the ungrouped chondrite Acfer094, CM2 Y-791198, the anomalous chondrite Tagish Lake and several CR2 chondrites) [4-10]. Those in the fine-grained rims of Y-791198 are similar to aggregate IDPs in terms of textures and mineralogy [7].

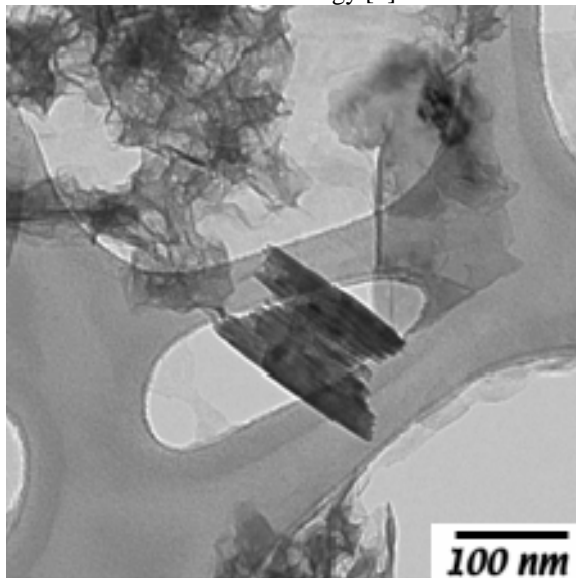


Figure 1: TEM image of a well-developed phyllosilicate crystal grown in amorphous Mg silicate smoke exposed to distilled H<sub>2</sub>O at ~22°C for 56 days.

In order to test the hypothesis that materials similar to the above smokes could have been incorporated into the fine-grained materials of chondritic meteorites, several hydration experiments were undertaken which resulted in the formation of phyllosilicates in the Mg-silicate smoke after as little as three days (Fig. 1) and mats of phyllosilicates (Fig. 2) after a few months of contact with water [11-12]. However, the Fe-silicate smoke showed no textural evidence of hydration after 6 months of contact [11-12]. Annealing experiments showed that the Mg-

silicate smoke anneal into 200-250nm sized crystals at 1000-1100 K in up to 30 hours [1,2]. The Fe-silicate smoke required higher temperatures (~1300 K) to anneal in the same time scale as the Mg smoke [1]. Perhaps the higher temperatures are required for the hydration of the Fe-silicates. Could the presence of the Mg-silicate smoke aids in the hydration of the Fe-silicate smoke?

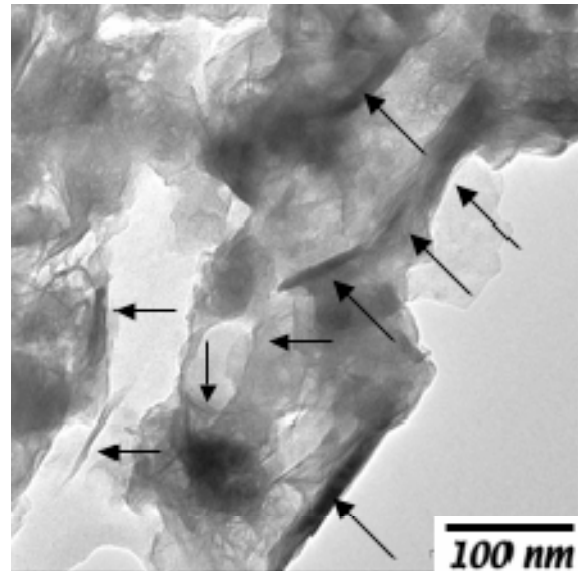


Figure 2: TEM image of randomly-oriented phyllosilicates grown in amorphous Mg silicate smoke exposed to distilled H<sub>2</sub>O at ~22°C for 168 days.

**Methods:** Mg-Si-O smoke created at 800K in October 2003 and Fe-Si-O smoke created at 500K in September 2003 were acquired from Joe Nuth's laboratory in the summer of 2005. These smokes were mechanically mixed in three Mg:Fe ratios: 2:1, 1:1, and 1:2. Two batches of experiments were done at two experimental temperatures (~25°C and ~5°C), one of each composition. Approximately 1.5 mg of amorphous silicate smoke mixture was sealed in a 1.5 mL centrifuge tube and left at the experimental temperature. A 250 mL bottle of distilled H<sub>2</sub>O was also left at temperature. 72 hours later, 1.5 μL of distilled H<sub>2</sub>O at temperature was added to each tube. At the appropriate time step, the tubes were filled with 100% ethanol at the same temperature as the smokes in order to stop any hydration reactions. Preliminary experiments with the Mg silicate smoke showed that the ethanol successfully prevented any

further reaction for at least 3 months. In preparation for TEM characterization, each tube was placed in an ultrasonic bath to disperse the altered smoke into suspension in the ethanol. A 0.5  $\mu\text{L}$  drop of this suspension was applied to 200 mesh Cu TEM grids with lacey formvar and characterized with the EFTEM at the Biological Electron Microscopy Facility at the University of Hawai'i, using an acceleration voltage of 100 kV and an emission current of 8-10  $\mu\text{A}$ .

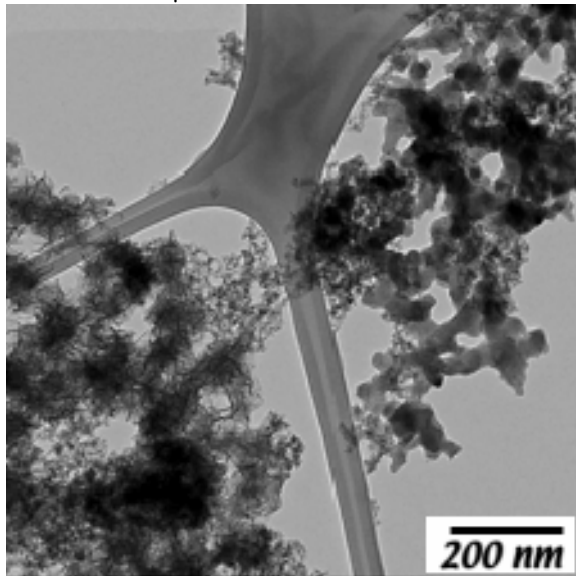


Figure 3: TEM image of incipient hydration of Mg+Fe silicate smokes (Mg:Fe ratio 1:2) exposed to distilled  $\text{H}_2\text{O}$  at  $\sim 22^\circ\text{C}$  for 1 day.

**Results:** The initial steps of hydration show that the Mg-silicate smoke alter preferentially to the Fe-silicate smoke. However, the presence of Fe-smoke retards the hydration of the Mg-smoke proportionally to the ratio of the two compositions. For example, the Mg-smoke in the 2:1 ratio mixture forms a gel by Day #1, whereas in the 1:2 ratio mixture, the particles in the Mg-smoke are just beginning to inflate. Figure 3 shows the two compositions in contact with each other and cleared the Fe-smoke (upper right) has retained its particular nature while the Mg-smoke (lower left) is showing the beginning of inflation. The denser areas in the Mg-smoke are the remnants of the individual particles.

The rate at which the Fe-smoke shows textural evidence of hydration is dependent on the Mg:Fe ratio. The 2:1 ratio mixture shows the Fe-smoke turning into a gel by the end of the first week, the 1:1 ratio mixture takes an additional week and the 1:2 ratio mixture requires 2 months (Fig. 4). In addition, the 2:1 ratio mixture contains phyllosilicates after 1

month of contact with  $\text{H}_2\text{O}$ , while the 1:1 ratio mixture requires 2 months and the 1:2 ratio mixture does not contain crystals after 2 months of hydration.

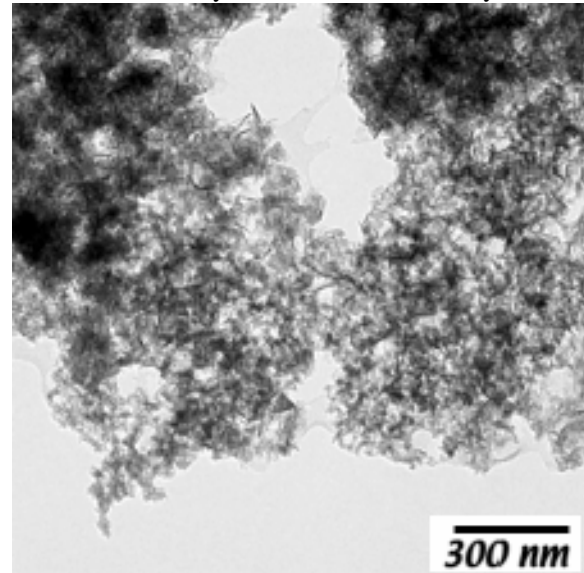


Figure 4: TEM image of further hydration of Mg+Fe silicate smokes (Mg:Fe ratio 1:2) exposed to distilled  $\text{H}_2\text{O}$  at  $\sim 22^\circ\text{C}$  for 56 days.

**Discussion:** The dependence of the hydration reaction of the Fe-silicate smoke on the Mg:Fe ratio is consistent with the hypothesis that a thermodynamic barrier exists and, with heat, the activation energy of hydration can be overcome. Alternatively, the presence of Mg may be what is needed. Mg in solution may substitute into certain sites, allowing the Fe-smoke to rearrange its structure into the gel phase. Future work will include a series of hydration experiments using  $\text{MgCl}_2$  in solution to test if the mechanism of hydration depends on the presence of Mg in solution in aid hydration.

**References:** [1] Nuth J. A. et al. (2002) *Meteoritics & Planet. Sci.*, 37, 1579-1590. [2] Rietmeijer F. J. M. et al. (1986) *Icarus* 66, 211-222. [3] Fabian D. et al. (2000) *Astron. Astrophys.*, 364, 282-292. [4] Barber D. J. (1981) *GCA*, 45, 945-970. [5] Brearley A. J. (1993) *GCA*, 57, 1521-1550. [6] Greshake A. (1998) *GCA*, 61, 437-452. [7] Chizmadia L. J. and Brearley A. J. (2003) *LPSC XXXIV*, Abstract#1419. [8] Greshake A. et al. (2005) *Meteoritics & Planet. Sci.*, 40, 1413-1431. [9] Abreu N. M. and Brearley A. J. (2005) *LPSC XXXVI*, Abstract #1826. [10] Abreu N. M. and Brearley A. J. (2006) *LPSC XXXVII*, Abstract #2395. [11] Chizmadia L. J. et al. (2006) *LPSC XXXVII*, Abstract #2187. [12] Chizmadia L. J. and Nuth J. A. (2006) *Meteoritics & Planet. Sci.* 41, 5166.