EXPLORING THE RELATIONSHIP BETWEEN FE:SI AND SMOKE:WATER RATIOS DURING AQUEOUS ALTERATION OF AMORPHOUS FE-SILICATE SMOKES.

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Introduction: Amorphous silicate materials have been observed in numerous primitive carbonaceous chondrites, e.g. the CR2 chondrites GRA95229, GRA06100, MET00426 and QUE99177; the CM2 chondrites Y-791198 and Murchison; the CO3 chondrite ALHA77307; and the ungrouped chondrites, Tagish Lake and Acfer 094 [1-8]. In fact, those chondrites containing the highest abundances of pre-solar grains also hold some of the highest concentrations of amorphous silicates [1-8]. Electron microprobe studies of the CM2 chondrites, Y-791198 and ALHA81002, indicate that their amorphous silicates have non-stoichiometric elemental relationships [9]. These meteorites with the highest quantities of amorphous silicates may represent some of the most pristine samples of our early solar nebula, with the least amount of modification [10-11].

[12] has created amorphous silicates through vapor-deposition which have similar infrared reflectance spectra as materials observed in circumstellar disks and in cometary tails. Therefore, these "smokes" are the best analogs available for experimental studies in understand nebular and asteroidal processes such as aqueous alteration and thermal annealing [13-16]. In fact, currently, these smokes are the only freely available amorphous silicates, of variable compositions.

Last year, we reported results for a series of hydration experiments involving Fe-silicate smokes and found that the solutions become quite acidic. This effort is an attempt to better understand the complex hydration reactions of the Fe silicate smokes. We investigated the Fe:Si ratio in addition to further exploring the smoke:water ratio.

Analytical Methods: These experiments involve three separate smokes, each with a different Fe:Si ratio. In order of decreasing Fe:Si ratio: Fall 2009, October 2003, and September 2003. The smoke:water ratios investigated in this study were: 40mg to 4mL, 40mg to 2mL and 20mg to 2mL. The smoke-water solutions were open to the atmosphere during measurements.

The pH and temperature of the solution for experimental run was measured with an OakTron pH Testr30 meter, every 10 seconds for 30 minutes, from the moment the distilled water was added to the smoke. Room temperature was monitored with a separate thermometer, calibrated to the OakTron meter; any changes were recorded with a resolution of 10 seconds.

Results: Overall, with decreasing Fe:Si ratios, the solution acheives less acidic pH values. Generally speaking, the higher smoke:water ratios yield more acidic values. Also, the absolute amout of distilled water also seems to have an effect, independent of the water:smoke ratio; more water results in more alkaline pH values (40mg:4mL vs. 20mg:2mL). This is consistent with the priliminary results we reported last year.

pH-Time Series. For all the Fe:Si compositions, the pH starts at or above neutral and drops to acidic values within the few couple of minutes. The minimum pH values of 3.9 were achieved by the Fall 2009 Fe-silicate smokes (Fig. 1) which have the highest Fe:Si ratio. In addition, the 40mg:2mL ratios usually provide the lowest pH values for each given composition (Figs. 1-3). Most of the trials continue to decrease in pH after 30 minutes of reaction, with the exception of the 40mg:2mL group from September 2003 which drop to their lowest pH values at approximately 30 minutes and then rise slightly with continued reaction (Fig. 1).

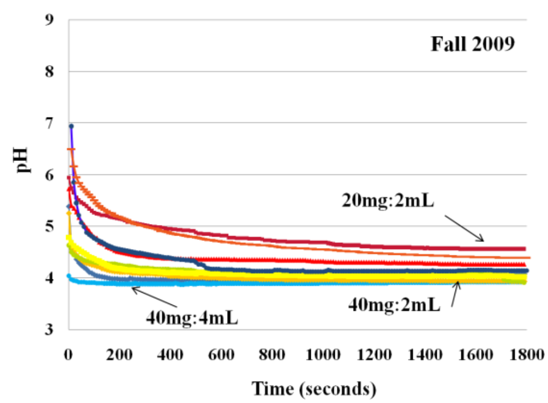

Figure 1. pH-time series plot of the high Fe:Si smokes created in Fall 2009: the blue points show data for 40mg:4mL, the red points show data for 20mg:2mL and the yellow-green points show data for 40mg:2mL.

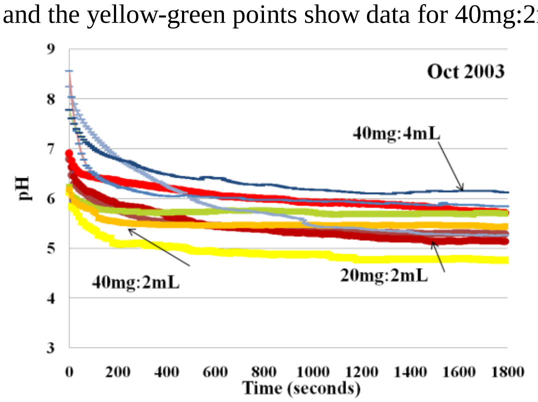

Figure 2. pH-time series plot of the medium Fe:Si smokes created in October 2003, with the same color coding as above.

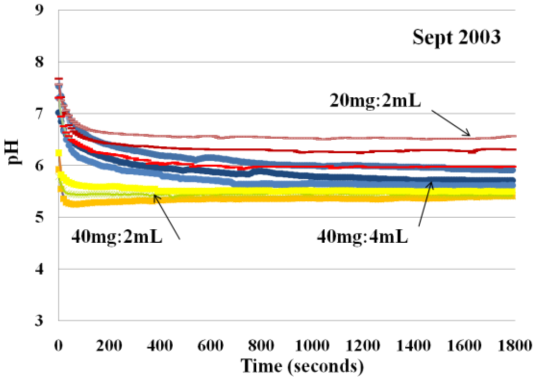

Figure 3. pH-time series plot of the low Fe:Si smokes created in September 2003, with the same color coding as the two previous figures.

Temperature-Time Series. The temperature profiles for hydration of Fe-silicate smokes are complex. Generally speaking, the temperatures rise initially after the addition of distilled water and then continue to increase gently (Figs. 4-6). However, some reactions level off and others decrese in temperature after their initial peak. It is difficult to determine whether these reactions are exothermic or endothermic due to their complex behavior and their relationship with room temperatures. Overall, the 40mg:4mL batches tend to achieve some of the highest temperatures while the 40mg:2mL batches tend to be lower. However, there are clear exceptions in the Fall 2009 data (Fig. 6).

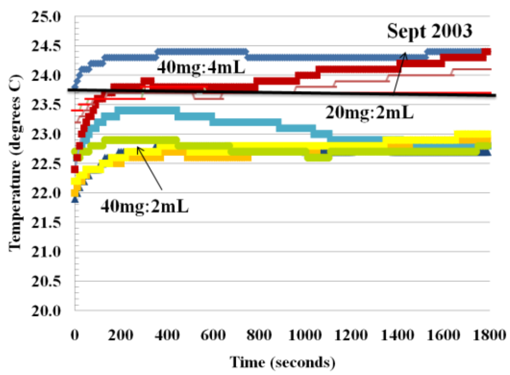

Figure 4. Temperature-time series data for the high Fe:Si smokes created in the Fall 2009, with the same color coding as the previous figures. The bold horizontal line is the average room temperature during these experiments.

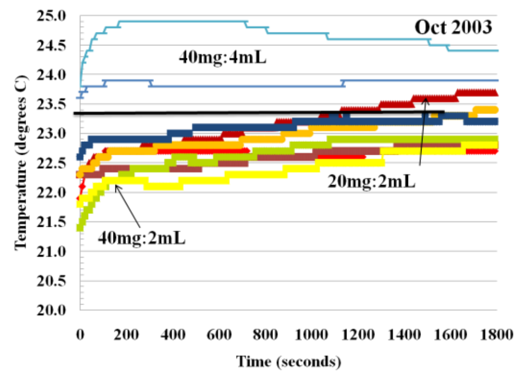

Figure 5. Temperature-time series data for the high Fe:Si smokes created in October 2003, with the same color coding as the previous figures. The bold horizontal line is the average room temperature during these experiments.

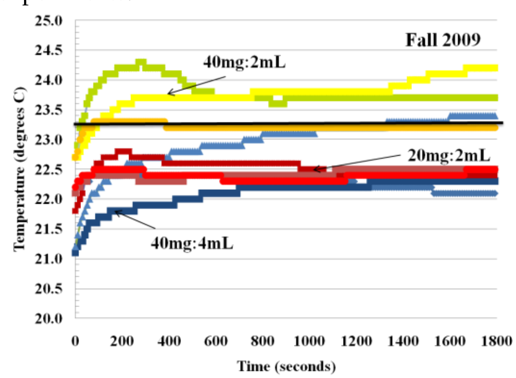

Figure 6. Temperature-time series data for the high Fe:Si smokes created in September 2003, with the same color coding as the previous figures. The bold horizontal line is the average room temperature during these experiments.

References: [1] Abreu N. M. and Brearley A. J. (2005) *LPSC XXXVI*, Abs #1826. [2] Abreu N. M. and Brearley A. J. (2008) *LPSC XXXIX*, Abs#1391. [3] Abreu N. M. and Brearley A. J. (2006) *LPSC XXXVII*, Abs #2395. [4] Barber D. J. (1981) *GCA*, 45, 945-970. [5] Chizmadia L. J. and Brearley A. J. (2008) *GCA*, 72, 602. [6] Brearley A. J. (1993) *GCA*, 57 1521-1550. [7] Greshake A. et al. (2005) *Meteoritics & Planet.Sci*,, 40, 1413-1431. [8] Greshake A. (1998) *GCA*, 61, 437-452. [9] Chizmadia L. J. and Brearley A. J. (2003) *LPSCXXXIV*, Abs#1419. [10] Grady M. M. and Wright I. (2006) *MESSII* 3-18. [11] Brearley A. J. (2006) *MESSII* 584-624. [12] Nuth J. A. et al. (2002) *Meteoritics & Planet. Sci*, 37, 1579-1590. [13] Abreu N. M. and Nuth J. A. (2010) *LPSC XVI* Abs#1533. [14] Chizmadia and Nuth (2006) *Meteoritics & Planet.Sci.*, 41, A5166. [15] Abreu N. M. et al. (2010) *Meteoritics & Planet. Sci.* 45 Abs#5203 A5. [16] Chizmadia L. J. (2007) *LPSC XXXVIII*, Abstract #1338.