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Hydrothermal alteration experiments of amorphous silicates: effect of organic-inorganic interaction.

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Most of carbonaceous chondrites with primitive chemical compositions have experienced aqueous alteration in their parent bodies. In order to understand the formation of minerals during the aqueous alteration process, we have previously carried out hydrothermal alteration experiments using Fe-free amorphous silicates with CI chondritic composition [1]. That study showed that saponite, serpentine, calcite and a relatively small amount of aragonite are formed from amorphous silicates and de-ionized water. This study focuses on the organic-inorganic interaction upon aqueous alteration of chondrites, since carbonaceous chondrite contains large amounts of organic compounds (~2%) [2] that could have been involved to formation of some minerals, such as carbonates.

The glass of the system, $\text{SiO}_2\text{-MgO-Al}_2\text{O}_3\text{-CaO-Na}_2\text{O}$, with the CI chondrite chemical composition was used. Three major elements, Fe, Ni and S, were excluded from the system for simplicity to avoid the change of the redox states. The glass sample was ground to make micron-scale powders. Two kinds of amino acids, glycine and alanine, were used as the analogue of whole organic matter in the carbonaceous chondrites. The ratio of alanine to glycine is 2.56:1.00, based on that in the GRA95229 which is weakly altered CR chondrite [3]. Silicates (100 mg), amino acids (23 mg) and de-ionized water (0.1 or 0.5 ml) were placed in Teflon vessels so that water to rock mass ratios were 1.0 and 5.0, sealed with stainless jacket, and were heated in an electric furnace at 150°C for 1, 2, 4 and 8 weeks under water saturated vapor pressures (approximately 3.0 bars). After heating experiments, vessels were rapidly cooled to room temperature in water. Solid products were recovered from solutions and dried in vacuum at room temperature. Parts (~80 mg) of solid materials were extracted with hot Milli-Q water for 24 hrs. The water extracts were analyzed with high-performance liquid chromatography (HPLC) to quantify the concentrations of amino acids. Solid products were analyzed with powder X-ray diffractometer (XRD).

In the XRD patterns of all the samples obtained from the hydrothermal experiments with different heating times, two major phyllosilicates, serpentine and saponite were identified. Aragonite, minor phase in CM chondrite, was also formed in all the experiments. However, calcite was not formed. The concentrations of alanine and glycine decreased with increasing time of heating, which is consistent with the trend of amino acid concentrations in aqueous-altered carbonaceous chondrites. On the other hand, the ratio of alanine to glycine decreased with increasing time of heating. This is a reverse trend to that of carbonaceous chondrites.

[1] Noguchi et al. (2011) 42th LPSC, abstract #1789

[2] Pizzarello et al. (2006) Meteorites and the Early Solar System II. 625-651

[3] Martians et al. (2007) Meteoritics and Planetary Science 42, 2125-2136

Keywords: carbonaceous chondrites, aqueous alteration process