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Conditions of aqueous alteration of C-type asteroids deduced from mineralogy and oxygen isotope ratios of CM chondrite G
Conditions of aqueous alteration of C-type asteroids estimated from oxygen isotope ratios of carbonate in CM chondrites

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CM chondrites have undergone prevailed aqueous alteration that changed mineralogical and isotope signatures of water-bearing C-type asteroids (Zolensky and McSween,1998; Clayton and Mayeda 1984). In the present study, we studied a CM chondrite GRA06172 that has never been studied in detail in order to estimate the degree and the conditions of aqueous alteration occurred on a meteorite parent body. A polished section was observed by a SEM/EDS and analyzed by an EPMA/ WDS. A small piece (200 microns in size) of matrix was analyzed by synchrotron radiation X-ray diffraction to identify minerals, since matrix minerals are too small to identify by using a scanning electron microscope.

SEM observations suggest that approximately half of the meteorite consists of primary rocks (Metzler et al., 1992) where chondrules were mantled by thick fine-grained rims and aggregates of PCPs occur on the rims. The other half is clastic matrix that was produced by fragmentation of the primary rock. This observation indicates that the meteorite is a breccia. Mesostasis glasses in both type-I and ?II chondrules are aqueously altered but most of anhydrous silicates such as olivine and low- and high-Ca pyroxenes are unaltered.

The results of the X-ray diffraction analysis indicate that matrix is composed mainly of serpentine and tochilinite, which suggests that matrix has undergone aqueous alteration. The presence of tochilinite limits the temperature experienced by this meteorite to be lower than 245C. (Gooding and Zolensky, 1992). In addition, sharp diffraction peaks from low-Ca pyroxene were detected. This indicates that some of anhydrous silicates survived aqueous alteration.

The EPMA analysis suggests that most of matrix composition fall within the area enclosed by composition PCP and two serpentine compositions on a Si-Mg-Fe ternary diagram as was reported in the McSween (1986). The average matrix composition changes with progressive alteration (McSween, 1986) and suggests that the degree of aqueous alteration experienced by GRA06172 is similar to or even higher than that for Murchison.

In addition, the mineralogical alteration index defined by Browning (1995) (when the number of oxygen of serpentine is nine ,the index is calculated by 2- (Fe3 + / (2-Si))) is approximately 0.65, which indicates that the meteorite altered to a degree higher than Murchison (1.57). Based on the CM chondrite classification scheme (CM2.6-2.0) defined by Rubin (2007), the average value of FeO/SiO2 in PCP (2.8) and mineralogical and other characteristics of the meteorite suggest that it is classified to CM2.5 that is the same as Murchison. These results suggest that the extent aqueous alteration on GRA06172 is intermediate similar to or slightly higher Murchison, although small gaps are present between estimations from different models (i. e., McSween, 1986 vs Rubin, 2007).

There are many carbonate with sizes up to 100 microns in the matrix. Oxygen isotope analysis of the carbonate and co-existing serpentine is in progress using SIMS at Tohoku University (CAMECA ims-6F) so as to estimate water temperature and water / rock ratio during aqueous alteration.

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