RELATIONSHIP BETWEEN IRON VALENCE STATES OF SERPENTINE IN CM CHONDRITES AND THEIR AQUEOUS ALTERATION DEGREES.

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The 0.6-0.7 μm absorption band observed for C-type asteroids is caused by the presence of Fe^{3+} in phyllosilicates [1]. Because Fe-bearing phyllosilicates, especially serpentine, are the most dominant product of aqueous alteration in the most abundant carbonaceous chondrites, CM chondrites [e.g., 2,3], it is important to understand the crystal chemistry of serpentine in CM chondrites to better understand spectral features of C-type asteroids. CM chondrites show variable degrees of aqueous alteration [4,5], which should be related to iron valences in serpentine. It is predicted that the $Fe^{3+}/\Sigma Fe$ ratios of serpentine in CM chondrites decrease as alteration proceeds by Si and Fe^{3+} substitutions from end-member cronstedtite to serpentine [4], which should be apparent in the absorption intensity of the 0.6-0.7 μm band from C-type asteroids. In fact, the JAXA Hayabusa 2 target (C-type asteroid: 1993 JU3) exhibits heterogeneous spectral features (0.7 μm absorption band disappears by rotation) [6].

From these points of view, we have analyzed iron valences of matrix serpentine in several CM chondrites which span the entire observed range of aqueous alteration using Synchrotron Radiation X-ray Absorption Near-Edge Structure (SR-XANES). In this abstract we discuss the relationship between obtained $Fe^{3+}/\Sigma Fe$ ratios and alteration degrees by adding new data to our previous studies [7,8].

We have so far analyzed Murray, Nogoya, ALH 84029 [7], Murchison, Cold Bokkeveld and a clast of CM1 lithology within Tagish Lake (thin section KN1) [8], and we newly analyzed Kivesvaara (Table 1). The SR-XANES analyses were performed at BL-4A of the Photon Factory (PF), KEK in Tsukuba, Japan. The beam size was *ca*. 6 x 5 μm. We used kaersutite amphibole for the Fe^{2+} and Fe^{3+} standards whose $Fe^{3+}/\Sigma Fe$ ratios were determined by wet chemistry [9], and estimated the $Fe^{3+}/\Sigma Fe$ ratio of CM serpentine by a linear relationship between the centroid energy position of XANES Fe K pre-edge spectra and the $Fe^{3+}/\Sigma Fe$ ratio (±10% error).

In our previous study, we did not observe clear difference between $Fe^{3+}/\Sigma Fe$ ratios of serpentine and alteration degree, although we analyzed samples showing a wide range of aqueous alteration [7,8]. We saw only limited ranges of $Fe^{3+}/\Sigma Fe$ ratios of serpentine, showing mostly Fe^{3+}-rich compositions (Table 1). Our newly-obtained $Fe^{3+}/\Sigma Fe$ ratios of serpentine in Kivesvaara is ~0.9-1 for intermediate Mg-Fe serpentine, but Mg-rich serpentine clearly has a lower $Fe^{3+}/\Sigma Fe$ ratio of ~0.5. Because Kivesvaara is a minimally altered sample among CM chondrites studied, we expect that its $Fe^{3+}/\Sigma Fe$ ratio in serpentine is the most Fe^{3+}-rich. However, we again found no correlation between $Fe^{3+}/\Sigma Fe$ ratios of serpentine and alteration degree [7,8].

We suggest that the analyzed serpentine contains submicron Fe oxide or oxyhydroxide phases that affect XANES spectra in some samples. For example, the original serpentine compositions in heavily-weathered samples were heterogeneous (Fe^{2+}-rich), but terrestrial oxidation has made much of the Fe^{2+} into Fe^{3+} to form nano-phase ferrihydrite [3]. In contrast, minimally weathered samples contain small amounts of Mg-Fe anhydrous silicates (Fe^{2+}-rich) with Fe^{3+}-rich serpentine. Probably, smaller spatial resolution may be required for iron valence analysis of CM serpentine [10].

Table 1. Alteration degrees and $Fe^{3+}/\Sigma Fe$ ratios of serpentine in CM chondrites using SR-XANES.

Sample	Alteration index[4]	Petrographic type[5]	$Fe^{3+}/\Sigma Fe$ (Mg-rich)	$Fe^{3+}/\Sigma Fe$ (Intermediate)	$Fe^{3+}/\Sigma Fe$ (Fe-rich)
Kivesvaara	-	2.5	0.5	0.90-1.0	-
Murchison[7]	1.57	2.5	0.82-0.84	-	0.81
Murray[6]	1.43	2.4/2.5	0.87-0.88	-	0.76-0.88
Nogoya[6]	1.03	2.2	0.82-0.84	0.85-0.90	0.75-0.79
Cold Bokkeveld[7]	0.97	2.2	0.80	0.83	0.84
ALH84029[6]	-	-	0.87-0.94	-	0.18-0.73
Tagish Lake (KN1)[7]	-	1	0.80-0.82	-	0.78

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