THE VALENCE OF IRON IN CM CHONDRITE SERPENTINE AS MEASURED BY SYNCHROTRON XANES. T. Mikouchi1, M. Zolensky2, W. Satake1, L. Le1, 1Dept. of Earth and Planetary Science, University of Tokyo, Hongo, Tokyo 113-0033, Japan (mikouchi@eps.s.u-tokyo.ac.jp), 2Astromaterials Research and Exploration Science, KT, NASA Johnson Space Center, Houston, TX 77058, USA, 3Jacobs ESCG, Houston, TX 77058, USA.

Introduction: Fe-bearing phyllosilicates are the dominant product of aqueous alteration in carbonaceous chondrites, and serpentine is the most abundant phyllosilicate in CM2 chondrites that are the most abundant carbonaceous chondrite [e.g., 1, 2]. Browning et al. [3] predicted that Fe3+/ΣFe ratios of serpentine in CM chondrites should change with progressive alteration. They proposed that progressive CM alteration is best monitored by evaluating the progress of Si and Fe3+ substitutions that necessarily attend the transition from end-member cronstedtite to serpentine. Their proposed Mineralologic Alteration Index, 2(Fe3+)/2(Si), was intended to highlight and utilize the relevant exchange information in the stoichiometric phyllosilicate formulas based upon the coupled substitution of 2(Fe3+, Al) = Si + (Mg, Fe2+) in serpentine. The value of this ratio increases as alteration proceeds.

The presence of Fe3+ in phyllosilicates is also important for the presence of the 0.6-0.7 μm absorption band in reflectance spectroscopy of C-type asteroids that are targets of the JAXA Hayabusa 2 and NASA OSIRIS-REx sample return missions [4]. In particular, the Hayabusa 2 target asteroid (1993 JU3) exhibits heterogeneous spectral features (0.7 μm absorption band disappears by rotation) [5] that may be related to differing degrees of aqueous alteration.

We always wanted to directly test Browning’s prediction through actual measurements of the Fe3+ content of serpentine at the micron scale appropriate to EPMA analyses (Zega et al. [6] have measured it at much finer scale), and this test can now be made using Synchrotron Radiation X-ray Absorption Near-Edge Structure (SR-XANES). Thus, we have recently begun investigation with CMs that span a large portion of the range of observed aqueous alteration, and we first analyzed Murray, Nogoya, and ALH 84029 by SR-XANES [7]. However, we did not find clear correlation between Fe3+/ΣFe ratios of serpentine and their alteration degrees [7]. We thus analyzed serpentine in three more CMs and here report their Fe3+/ΣFe ratios in comparison with our previous results.

Samples and Methods: In order to analyze more variable CM samples in terms of alteration degree, this time we selected Murchison (minimum alteration), Cold Bokkeveld (heavy alteration), and a clast of CM1 lithology within Tagish Lake thin section KN1 (complete alteration) – all falls. We located typical serpen-
Bokkeveld: 1.03) [3], and CM1 lithology of Tagish Lake shows even more extensive aqueous alteration [9]. The intensity of pre-edge peaks are also similar among three samples (Fig. 2), and are not so high, suggesting only small amounts of tetrahedrally-coordinated Fe [10]. These results are basically similar to our previous study analyzing Murray, Nogoya and ALH 84029 [7], although Beck et al. [11] reported a trend related to both Fe$^{3+}$/ΣFe ratio and pre-edge peak intensity among seven CMs they studied using a similar XANES technique. Among the six samples we analyzed so far, Fe-rich serpentine in ALH 84029 is the only example suggesting clear enrichment of Fe$^{2+}$ [7].

There are at least two explanations for the observed similar high Fe$^{3+}$/ΣFe ratios of six CM chondrites. One is that the analyzed serpentine contains submicron grains of Fe$^{3+}$-bearing phases and the SR-XANES beam size was not small enough to exclude them. This may be related to terrestrial weathering. Even if the original serpentine compositions were heterogeneous, terrestrial oxidation has made much of the Fe$^{2+}$ into Fe$^{3+}$, and the now excess iron forms nanophase ferrhydrite [2]. The other explanation is that the oxidation state of iron does not vary with alteration degree against our expectation. At present it is hard to say which is more likely.

The electron microprobe analyses of serpentine suggest that the iron in serpentine is dominantly present as Fe$^{2+}$ in all CM samples [3] although our XANES analysis suggests that most Fe is present as Fe$^{3+}$. Preparation of appropriate serpentine standards may reduce this discrepancy by the better calibration of the analyses. However, their identical pre-edge positions (Fig. 2) show that they have identical relative Fe$^{3+}$/ΣFe ratios although the absolute Fe$^{3+}$/ΣFe ratio may be varied by the standards. It will be also necessary to analyze many more CMs (e.g., CM1 lithology in Kaidun and the minimally altered CM Kivesvaara) to see whether the trend is really absent or not.