AQUEOUS ALTERATION, 'SERPENTINIZATION' AND THE CM-C2ung-CI CONNECTION BY PSD-XRD

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Introduction: At the scale of Transmission Electron Microscopy (TEM), meteoritic serpentines appear similar to terrestrial. By Position Sensitive Detector X-ray Diffraction (PSD-XRD), the apparent degree of stacking disorder exceeds terrestrial serpentines. In IR spectra the 3µm absorption feature of meteoritic serpentines is also unlike terrestrial standards [1]. Meteoritic serpentines also show Al enrichment relative to terrestrial [eg. 2]. Serpentine structure intimately relates to composition, which is controlled by the anhydrous pre-cursor. A key difference between terrestrial rocks involved in serpentinization, and meteorites, is the presence of glassy mesostasis in the latter. In carbonaceous chondrites the bulk of Al is not contained in CAI [3], the low abundance of Al bearing crystalline phases requires that mesostasis is an important Al sink. We studied 0.2g samples of a suite of CM, C2ung and CI meteorites. XRD patterns reveal the effect that Al from mesostasis has on the bulk rock during hydration: a process that explains the dissimilarity of meteoritic and terrestrial serpentines. We expand the model of [4] to include mesostasis and account for aqueous alteration of all components.

Results: We concur with [4] that alteration progresses through crystalline phases in order of decreasing Fe content. In our model, mesostasis alters rapidly, providing Al (+ Na,Ca,Si) to fluid. In the early stages of alteration, influx of Al causes growth of single chlorite layers on Mg-rich serpentine [5], as seen by TEM in even the least altered CMs [2]. Si available to fluid increases as alteration progresses [cf. 4], and in the presence of Al (from mesostasis/CAI/augite) saponite preferentially forms. Even at low abundances, chlorite and saponite inhibit growth of serpentine, disrupt repetition of layers (promoting disorder) and yield apparent Al enrichments. In Mg-rich serpentines (eg. lizardite), coupled substitutions of Al for Mg and Si at the octahedral and tetrahedral sites, reduces the misfit in lateral dimensions between the (larger) octahedral and (smaller) tetrahedral sheets and promotes flat layer structures [6]. Recrystallisation of Fe-rich serpentines results in loss of Fe to fluid, relative Mg enrichment and promotes curved layers [6]. These competing recrystallisation styles further increase disorder. Fe lost from serpentine during recrystallisation is incorporated in magnetite/sulphide/oxide.

The extent of the recrystallisation of serpentine and the abundance of saponite increases in the order: typical CM - unusual CM (eg. Essebi) - C2ung (eg. WIS91600) - CI. Magnetite, sulphide and oxide abundances trend similarly. Interpreted through our model, the mineralogy of these groups could be connected by varying degrees of aqueous alteration. Bulk chemical differences would then reflect heterogeneous anhydrous precursors – an often alluded to hypothesis that we are testing.

References: [1] Beck P. et al. 2010. *Geochimica et Cosmochimica Acta,* in press. [2] Lauretta D.S. et al. 2000. *Geochimica et Cosmochimica Acta* 64:3263-3273 [3] Hezel D.C. et al. 2008. *Meteoritics & Planetary Science* 43:1879-1894. [4] Tomeoka K. et al. 1989. *Proc. NIPR Symp. Antarct. Met.* 2:221–234. [5] Cressey G. et al. 2008. *Min. Mag.* 72:817-825. [6] Howard K.T. et al. 2009. *Geochimica et Cosmochimica Acta* 73:4576-4589.