OXYGEN IOSTOPE SYSTEMATICS IN EQUILIBRATED ORDINARY CHONDRITES: COMPARISON TO ITOKAWA PARTICLES.

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Introduction: High precision SIMS oxygen isotope analyses of Itokawa particles and equilibrated ordinary chondrites (EOCs) indicate that Itokawa particles are very similar to LL5-LL6 chondrites [1]. These results also show that high-Ca pyroxene (hpx) and plagioclase (pl) are in oxygen isotope equilibrium at metamorphic temperatures (~800˚C). However, olivine (ol) and low-Ca pyroxene (lpx) data show small isotope fractionations ($\Delta^{18}O_{lpx\text{-}ol} \leq 0.5‰$) that are not consistent with hpx-pl data. To follow-up these data, we have reported systematic SIMS study of four silicate minerals (ol, lpx, hpx, pl) in 11 EOCs that cover all petrologic types (4-6) and groups (H, L, LL) including a shocked L6 (S4) and a LL6 regolith breccia [2]. Here we summarize results from [2] and compare to those of Itokawa particles from [1].

Oxygen Isotope Systematics in EOCs: The $\delta^{18}O$ and $\delta^{17}O$ of individual minerals are more homogeneous with increasing petrologic type. Ol and lpx data in type 4s show a large variation similar to those of chondrules in LL3 [3]. In unshocked type 6s, individual minerals are homogeneous in $\delta^{18}O$ and $\delta^{17}O$ at the precision of SIMS analyses (≤0.3‰ and ≤0.5‰ in 2SD, respectively). The $\delta^{18}O$ values distribute in the order of ol~hpx < lpx <pl, similar to [1]. In type 5s, the shocked L6, and the LL6 regolith breccia, $\delta^{18}O$ in individual minerals are more variable than unshocked type 6s (typically 0.5-1‰ in 2SD).

In type 5s, the isotope fractionations $\Delta^{18}O_{pl\text{-}hpx}$ between adjacent hpx and pl (≤ 100 μm) are nearly constant within a meteorite, suggesting that they are locally in isotope equilibrium. The $\Delta^{18}O_{pl\text{-}hpx}$ values in types 5-6 EOCs indicate equilibrium temperatures (T_{eq}) of 600-1000˚C. In most of these samples, $\Delta^{18}O_{lpx\text{-}ol}$ values are small (≤0.5‰) and not consistent with respective hpx-pl data. Only in Tuxtuac (LL5), both mineral pairs (ol-lpx and hpx-pl) provide consistent high T_{eq} of ~1000˚C. If the oxygen isotope diffusion rate in ol is slower than other minerals, then isotope equilibrium between ol and other minerals will occur only at high temperatures (≥1000˚C), and lpx-hpx-pl would be re-equilibrated at lower temperatures during slow cooling in the parent asteroids.

Comparison to Itokawa particles: [1] reported the 2SD of $\delta^{18}O$ values to be 0.7‰ in ol from Itokawa particles, which is comparable to type 5 EOCs [2]. Thus, Itokawa particles are similar to LL5 than LL6, or may be related to regolith on the asteroid surface.

References: [1] Nakashima D. et al. 2013. *Earth and Planetary Science Letters* 379:127-136. [2] McDougal D. et al. 2015. 46th Lunar & Planetary Science Conference. Abstract #1598. [3] Kita N. T. et al. 2010. *Geochimica et Cosmochimca Acta* 74:6610-6635.