A STRONG LINK BETWEEN ITOKAWA PARTICLES AND EQUILIBRATED LL CHONDRITES INFERRED FROM OXYGEN ISOTOPE RATIOS.

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Introduction: Silicate particles returned from asteroid Itokawa by the Hayabusa mission showed similarities of mineralogy, chemistry, and oxygen isotope ratios to those of LL4-6 chondrites [e.g., 1-3]. However, $\delta^{18}O$ values of the Itokawa particles are highly variable from +1.4‰ to +8.8‰ [2-3], which could suggest multiple origins of the particles. Yurimoto et al. [2] also mentioned the possibility that part of the $\delta^{18}O$ variation could be caused by SIMS instrumental mass fractionation relating to irregularities of the sample surface owing to the small size of the grains. Here we report new SIMS oxygen isotope analyses of 7 Itokawa particles using the IMS-1280 at WiscSIMS with precision of 0.3‰ (2SD). We re-analyzed 5 particles reported in [2], in addition to 2 new particles, using an indium mounting method that minimizes potential instrumental mass fractionation due to surface topography [4].

Results: Oxygen isotope data of the 7 Itokawa particles are distributed above the terrestrial fractionation line with indistinguishable $\Delta^{17}O$ ($=\delta^{17}O-0.52\times\delta^{18}O$) values of +1.34±0.36‰ (2SD; n=22), consistent with data from the previous analyses [2-3]. Values of $\delta^{18}O$ from olivine in the 7 Itokawa particles range from +3.9‰ to +5.1‰ (n=16), which are systematically higher than those (+1.4‰ to +4.7‰) in [2]. Low-Ca pyroxene showed $\delta^{18}O$ values from +4.9‰ to +5.2‰. The $\delta^{18}O$ value of high-Ca pyroxene is +4.3‰, which is marginally lower than those of olivine (+4.7‰ to +4.8‰) and plagioclase (+5.9‰) in the same particle.

Discussion: The average $\Delta^{17}O$ value of the Itokawa particles (+1.34‰) is closer to that of St. Séverin (+1.31±0.49‰; LL6) than Guareña (+0.86±0.59‰; H6), which were analyzed for comparison. The average bulk $\delta^{18}O$ value of the 7 Itokawa particles is estimated as +4.8‰ using volume fraction data of the Itokawa particles [5], which is within the $\delta^{18}O$ range of bulk LL5 and LL6 chondrites [6]. It is suggested that Itokawa particles are similar to equilibrated LL chondrites, which strengthens a link between asteroid Itokawa and equilibrated LL chondrites that fell to Earth.

The Itokawa particles and two type 6 chondrites show a reversed $\delta^{18}O$ fractionation between olivine and high-Ca pyroxene, indicating oxygen isotope disequilibrium between the two minerals. Likewise, oxygen isotopes might be disequilibrium between low-Ca pyroxene and olivine; the small $\delta^{18}O$ fractionations (≤1‰) correspond to temperatures higher than peak metamorphic temperatures [1]. In contrast, the mineral pair of plagioclase and high-Ca pyroxene yields ~800°C, consistent with mass-dependent fractionation during recrystallization (and possibly by diffusion) caused by thermal metamorphism.

References: [1] Nakamura T. et al. 2011. *Science* 333:1113-1116. [2] Yurimoto H. et al. 2011. *Science* 333:1116-1119. [3] Nakamura E. 2012. *PNAS* 109:E624-E629. [4] Nakashima D. et al. 2013. This volume. [5] Tsuchiyama A. et al. 2011. *Science* 333:1125-1128. [6] Clayton R.N. et al. 1991. *GCA* 55:2317-2337.