THE RELATIONSHIP BETWEEN SHOCK-INDUCED PHASE TRANSFORMATION AND ISOTOPIC RESETTING: INSIGHTS FROM PB ISOTOPIC SYSTEMATICS OF PHOSPHATES IN L CHONDRITES

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Introduction: Isotope geochronology has become a preponderant tool for dating impact events and provides one of the most robust constraints on the impact history of solar system. However, the interpretation of isotopic data are not always straightforward, which was largely hampered by the lack of knowledge about how shock metamorphism affects isotopic systematics in individual minerals and in whole rocks. This is best illustrated by the considerable investigations and debates on the age of shergottite (>4.0 Ga versus <0.6 Ga) [e.g. 1–4], shocked lunar and terrestrial samples [e.g. 5–6]. The controversies for many meteorites in general, and for shergottites in particular, mainly resulted from the blurred relationship between isotopic disturbance and pervasive shock-induced melting as well as phase transformation [7]. In this study, the shock-induced phase transformation and Pb isotopic compositions of phosphates in two strongly shocked L6 chondrites (Suizhou and Sixiangkou) were investigated in order to clarify their relationships.

Results and Discussions: Merrillite grains in the host of Suizhou and Sixiangkou well preserved their crystal structure along with other silicate minerals. Raman spectra indicate that merrillite in the SMV of Suizhou has transformed to its high-pressure polymorph tuite, consistent with the P–T conditions (20–22 GPa and 1800–2000 ℃) constrained by the high-pressure assemblage in the SMV [8]. The merrillite in the SMV of Sixiangkou, though experienced peak shock conditions of 20–24 GPa and 2000–2300 ℃ [9], have a low-pressure crystal structure. Because merrillite can be transformed to tuite at pressure as low as 2 GPa under 1000 ℃ [10], it is possible that merrillite in the SMV of Sixiangkou had been transformed to tuite during the peak shock but reverted to its original structure due to post-shock relatively "slow cooling". This is similar to the transformation scenario experienced by baddeleyite in shergottite, as suggested by El Goresy et al., (2013). They further suggested that phase transformations would result in a polycrystalline aggregate, which prompts resetting of radiogenic Pb via rapid grain boundary diffusion within this phase [4].

Pb compositions of phosphates experienced different extent of transformation in Suizhou show a considerable overlap. The merrillite in the host yields a Pb–Pb age of ~4550 Ma, consistent with our previous results on the undisturbed apatite [11]. The Pb–Pb "ages" of tuite in the SMV show a variation of 4560–4460 Ma. The upper limit is similar to the age of undisturbed phosphates in the host and the the lower limit is close to the "age" of the partially transformed apatite (4480 Ma) [11]. The merrillite in the host of Sixiangkou yields Pb–Pb "ages" similar to that of Suizhou, and those in the SMV of Sixiangkou show a wide variation (4560–4090 Ma). These "ages" are generally related to the position of analysis relative to the SMV, and are significantly older than the impact age of Sixiangkou (480 Ma) [12]. Therefore, the merrillite in the SMV of Sixiangkou seems to have largely retained original Pb compositions during the impact, although the merrillite was subjected to shock-induced phase transformation in the compression and back inversion in the decompression stage. The wide "age" ranges observed in phosphates from the SMV of both meteorites indicate that Pb isotopic resetting is far from achieved, and it is local thermal conditions rather than phase transformation that result in the isotopic disturbance.

Based on these observations, it can be concluded that phase transformation of merrillite during impacts does not necessarily result in Pb isotope resetting. Because the Pb diffusion in zircon and baddeleyite is much sluggish than that of merrillite, we suggest that these U-bearing phases could retain their original Pb compositions during the peak-shock P–T conditions experienced by the host meteorites, if only diffusion are considered.

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References: [1] Borg et al. (2005) *Geochimica et Cosmochimica Acta* 69:5819–5830. [2] Bouvier et al. (2005) *Earth and Planetary Science Letters* 240: 221–233. [3] Bouvier et al. (2009) *Earth and Planetary Science Letters* 280: 285–295. [4] El Goresy et al. (2013) *Geochimica et Cosmochimica Acta* 101: 233–262. [5] Grange et al. (2013) *Geochimica et Cosmochimica Acta* 101: 112–132. [6] Moser et al. (2011) *Canadian Journal of Earth Sciences* 48: 117–139. [7] Bloch and Ganguly (2014) *Earth and Planetary Science Letters* 395: 173–183. [8] Xie et al. (2001) *European Journal of Mineralogy* 13: 1177–1190. [9] Chen et al. (1996) *Science* 271: 1570–1573. [10] Zhai et al. (2014) *Physics of the Earth and Planetary Interiors* 228: 144–149. [11] Li and Hsu (2018) *American Mineralogist* 103: 1789–1799. [12] Li and Hsu (2018) *Meteoritics & Planetary Science* 53: 2107–2122.