Evaluation of the Shock-resetting Conditions of U–Pb Isotopic Systematics for Baddeleyite in the Martian Shergottites. H. Kaiden[1,2], K. Misawa[1,2] and T. Niihara[3], [1]Geoscience Group, National Institute of Polar Research, Tokyo 190-8518, Japan, [2]Department of Polar Science, School of Multidisciplinary Sciences, SOKENDAI (The Graduate University for Advanced Studies), Tokyo 190-8518, Japan, [3]The University Museum, The University of Tokyo, Tokyo 113-0033, Japan.

The radiometric ages of Martian meteorites (shergottites, nakhlites, chassignites, and ALH 84001) have been determined using various isotopic systems (e.g., [1]). Crystallization ages of nakhlites and chassignites are concordant at ~1.3–1.4 Ga [2–5], whereas shergottites show more diverse ages of 165–575 Ma. Most of shergottites show young ages of ~180 Ma [1].

Bouvier et al. [6] reported the old ^{207}Pb–^{206}Pb ages of ~4.1 Ga for the Zagami, Shergotty, and Los Angeles shergottites and interpreted the ages as crystallization ages of these shergottites. They also obtained young Sm–Nd and Lu–Hf ages of ~170 Ma for Zagami, and concluded that the young ages obtained by Rb–Sr, Sm–Nd, and U–Pb isotopic systematics represented resetting of the isotopic systems by shock metamorphism or aqueous fluid activities on Mars [6–8].

Uranium–lead isotopic analyses on baddeleyite (ZrO_2), which occurs as an accessory mineral in Martian meteorites, have been performed [9, 10], but the behavior of U–Pb isotopic systematics of baddeleyite under high-pressure and high-temperature conditions by shock metamorphism has been unclear. Niihara et al. [11] evaluated shock effects on U–Pb isotopic systematics of baddeleyite by shock-recovery and annealing experiments on baddeleyite whose ages are known in order to understand the geological meanings of the U–Pb ages. In the experiments, they observed no transformation to the high-pressure and high-temperature polymorph of ZrO_2 at shock pressures up to 57 GPa and at temperatures up to 1300 °C and no complete radiogenic lead loss due to shock metamorphism and subsequent annealing in the shock-loaded/annealed baddeleyites studied. They thus concluded that the U–Pb isotopic systematics of baddeleyite in shergottites were durable for shock metamorphism and would provide crystallization age of Martian magmatic rocks [11].

Niihara et al. [11] also estimated closure temperatures for lead in zircon (Fig. 1), whose lead diffusivity has been experimentally determined [12]. Assuming that lead diffusivity in baddeleyite are not so much different from that in zircon, closure temperatures for lead in baddeleyite, which is up to 10 μm in diameter in shergottites, are higher than the solidus temperature of shergottites (~1060 °C), and thus they concluded that it was hard to completely reset the U–Pb isotopic systematics of baddeleyite under their experimental conditions. On the other hand, Bloch and Gangly [13] argued that the outer 10 μm of a grain of 200–250 μm in diameter, which were used in the shock resetting experiments of Niihara et al. [11], will undergo an average resetting of only ~17% in the time scale by which a grain of 10 μm in diameter undergoes ~90% resetting at the core.

We re-evaluate the conditions of shock-resetting of U–Pb isotopic systematics for baddeleyite in the Martian shergottites considering the grain sizes of baddeleyite.

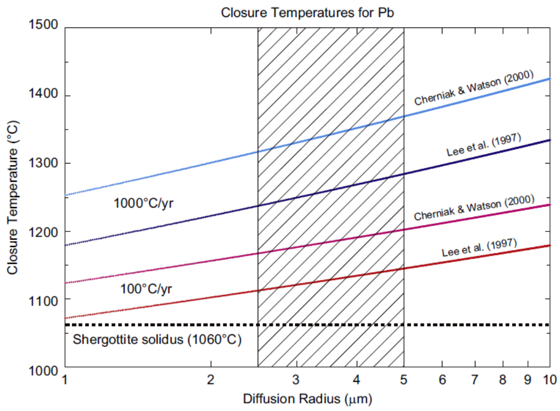

Fig. 1. Closure temperatures for lead in zircon as a function of effective diffusion radius. Taken from Fig. 8 of Niihara et al. [11].

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