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Petrology and Mineralogy of the RBT 04261 Shergottite

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Ages from cratering analysis of image data on the Martian surface [1] and radiometric ages of Martian meteorites [2] provide important insights into the crustal evolution of Mars. These ages, however, have come under great debate recently. Bouvier et al., [3. 4] reported Pb-Pb ages of ˜4100 Ma for the Martian meteorites, Zagami, Shergotty, and Los Angeles, and concluded that the lithosphere of Mars is extremely old, and furthermore that the young Rb-Sr and Sm-Nd ages of ˜180 Ma so far reported for Martian meteorite shergottites [2] represent resetting of the isotopic systems by shock metamorphism or by aqueous fluid activities on Mars.

The U-Pb isotopic system for baddeleyite (ZrO_2) has several advantages for resolving this age conflict. First, baddeleyite occurs in shergottites as an accessory mineral and retains some uranium but excludes thorium and common lead during its crystallization. Second, baddeleyite is known to be highly durable in aqueous fluids [5]. Finally, the thermal diffusivities of uranium and lead in baddeleyite are considered to be much smaller than those of strontium and rare earth elements in pyroxene, plagioclase, and phosphates, making the U-Pb system of baddeleyite more resistant to resetting during reheating events. To determine robust crystallization ages of shergottites, we have undertaken petrological and mineralogical study of RBT 04261, enriched lherzolitic shergottite, to determine shock effect on baddeleyite.

RBT 04261 is mainly composed of pyroxene, olivine, and plagioclase glass (maskelynite) and shows poikilitic and non-poikilitic lithologies. Melt pockets (˜100 micrometer in size) are found in pyroxene and maskelynite in non-poikilitic area. Baddeleyite grains are found in the non-poikilitic lithology, and most of them are associate with ilmenite. A few baddeleyite grains showed euhedral in shape and occurred with maskelynite. The baddeleyite does not convert from monoclinic to any high-pressure and -temperature polymorph of ZrO_2 in RBT 04261. There is no SiO_2glass, which is associate with baddeleyite, suggesting that the baddeleyite is not a decompositional product of $ZrSiO_4$ by shock metamorphism [6]. Baddeleyite surrounded by melt pocket was rarely observed. Baddeleyite is not melted even in melt pocket.

The U-Pb age for baddeleyite in RBT 04261 [7] thus is consistent with the radiometric ages (˜180 Ma) previously reported for Zagami, Shergotty, Los Angeles, and RBT 04262 [2, 8]. The implication from petrology, mineralogy, and isotopic study [7] of baddeleyite in Martian meteorites is that volcanic activity on Mars continued to the resent past, at least to a few hundred million years.

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Keywords: Shergottite, Crystallization age, Baddeleyite, Shock