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Theoretical crystallization of depleted shergottite Martian meteorites using MELTS

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Shergottite is the largest group of Martian meteorites and can offer important informations about igne-ous activity of the red planet. Recent oxygen fugacity measurements on shergottites have revealed that they show wide ranges of redox conditions during their formation. They could be subdivided into de-pleted (reduced) and enriched (oxidized) subgroups, which are also closely related to their distinct iso-topic abundances. The depleted subgroup shows more primitive natures compared to the enriched sub-group, and thus is important to understand primary parent magma compositions of Martian meteorites in general. Y980459 has the most mafic bulk composition among the depleted shergottites and is possibly a rock directly crystallized from a primitive primary magma. The texture and mineralogy of Y980459 show that it experienced a simple quenching history of primary magma at the cooling rate of about 5 degree C/hr. Al-though Dar al Gani 476 has a similar bulk composition to Y980459, its mineral compositions are quite different from those of Y980459 and it is considered to be a cumulate rock. Dhofar 019 has a slightly more ferroan bulk composition than Y980459 and Dar al Gani 476, and is another depleted shergotiite. QUE94201 has the most Fe-rich bulk compostion among depleted shergotittes. We used the MELTS pro-gram to calculate major element melt and mineral compositions by assuming that the Y980459 bulk com-position is a starting magma composition (logfO2=IW+1) and explore formation histories of Dar al Gani 476, Dhofar 019 and QUE94201. We assumed a total pressure of 1 atm under anhydrous conditions. As previous studies showed, liquidus temperature of the Y980459 melt is about 1440 degree C and olivine (Fo86) immediately appears at 1430 degree C. This olivine composition is close to the olivine core composition of Y980459. When the temperature drops down to 1250 degree C without fractionation, olivine is Fo75 and pyrox-ene is En76Wo3, respectively. These compositions are close to their core compositions in Dar al Gani 476. Because these two minerals are extensively zoned in Dar al Gani 476, we suggest that two-stage cooling history could produce Dar al Gani 476. At first equilibrium cooling of the Y980459 melt produced homo-geneous olivine cores until 1250 degree C, and then rapid cooling crystallized the fine-grained groundmass. The estimated cooling rate for Dar al Gani 476 (0.03-5 degree C/hr) probably records the second-stage rapid cooling. Therefore, there is a possibility that both Y980459 and Dar al Gani 476 came from the same composi-tional melt. In fact these two meteorites have nearly identical crystallization ages (about 470 Ma). If we consider fractionation of solid phases from the Y980459 melt, the residual melt is close to the Dhofar 019 bulk composition at 1350 degree C. The fractionated melt is then close to the QUE94201 bulk composition at 1160 degree C. When the fractionated Y980459 melt at 1350 degree C goes down to 1210 degree C without fractionation, olivine (Fo67) and pyroxene (En64Wo7) compositions are similar to those of cores in Dhofar 019. If we assume rapid cooling from this temperature, we can produce Dhofar 019. QUE94201 can be formed in more simple way by rapid crystallization from the fractionated Y980459 melt at 1160 degree C without fractionation. Thus, both Dhofar 019 and QUE94201 could also originate from the primary melt represented by the bulk compositions of Y980459 and Dar al Gani 476. The Y980459 and Dar al Gani 476 bulk com-positions are also important because they are similar to a partial melt composition of the estimated Martian mantle at around 1500 degree C.