Melting experiments of plagioclase under the shock-vein conditions

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High-pressure phase transitions of minerals have been frequently observed in heavily shocked meteorites, mainly within or around the shock veins (e.g., Chen et al. 1996). The plagioclase entrained in or adjacent to the shock veins transformed into maskelynite (e.g., Chen and El Goresy 2000), lingunite (e.g., Gillet et al. 2000) or jadeite plus amorphous materials (Miyahara et al. 2013). These transformations likely occurred in solid state, and the processes could be highly affected by the crystallization kinetics, as demonstrated by the kinetics studies of Kubo et al. (2010, 2016) at 18-25 GPa below 1673 K. On the other hand, the shock-metamorphic products of plagioclase exhibit some melting features (e.g., Chen and El Goresy 2000), and it is also likely that the shock metamorphism of plagioclase proceeded under the shock-vein conditions, typically 20-24 GPa and 2273-2673 K (Chen et al. 1996). Thus, high-temperature studies are necessary for further understanding the shock metamorphism of plagioclase in heavily shocked meteorites.

In this study, subsolidus and melting phase relations of $Ab_{85}An_{10}Or_5$ (oligoclase, the typical composition for the plagioclase found in heavily shocked meteorites) have been investigated by multi-anvil experiments at 16-23 GPa and 2273-2700 K. At 19-22 GPa, the subsolidus phase assemblage of $Ab_{85}An_{10}Or_5$ is jadeite (Jd) + stishovite (St) + hollandite (Holl) + CAS phase, and the melting sequence is Jd (the solidus phase), Holl, CAS phase and St (the liquidus phase). The liquidus temperature of $Ab_{85}An_{10}Or_5$ is at least 100 K higher than that of KLB-1 peridotite at 19-22 GPa. If the liquidus temperature of KLB-1 peridotite is used to infer the shock-vein temperatures, and if oligoclase completely melted at 19-22 GPa during impact, the oligoclase needed to be hotter than the shock veins, and therefore a localized heating in oligoclase is essential. It is found that Na-rich Holl and Na-rich CAS phase are stable in the composition of $Ab_{85}An_{10}Or_5$ at 22 GPa and ~ 2500 K; the silicate liquid formed by melting crystallized into Holl, CAS phase and St during quenching. These phenomena likely relate with the natural occurrence of lingunite (e.g., Gillet et al. 2000) and CAS phase (Beck et al. 2004) in heavily shocked meteorites, but the kinetics problem must be further discussed. In addition, the intergrowth of CAS phase and St observed in some Martian meteorites (Beck et al. 2004) has been reproduced by quenching a labradorite melt at 23.5 GPa.

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