Geophysical Properties of Primitive Martian Shergottite at High Pressure-Temperature Condition

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The NASA INSIGHT mission provides unique opportunities for studying the geophysical properties of the Martian interior using impact events and marsquakes. Linking the direct geophysical observations, to the geochemical or petrological composition of the Martian interior, and then to the evolution models of Mars, requires experimental investigations on different mantle rock candidates of Mars. Primitive Martian basalt, which represents the primary melt composition separated from Martian mantle, can be another possible mantle rock candidate for the Martian interior in addition to the bulk silicate Mars model proposed by Dreibus G. and Wänke (1985). Papike et al. (2013) have demonstrated the importance of understanding the basalt-eclogite transition in the Martian mantle in the chemical evolution of the Martian mantle in terms of both major and trace element concentration. This study aims to obtain the physical properties, including the seismic velocities, densities and the phase transitions, for Yamato 980459 (a primitive Martian basalt) at high pressure (P)-temperature (T) conditions by means of PerpleX computation and multi-anvil experiments.

The PerpleX results show that the density, Vp and Vs increase steadily from 3.4 to 4.4 g/cm3, 7.2 to 10.1 km/s, 4.2 to 5.4 km/s respectively, within the depth range of 100-2000 km. Three jumps are observed within the explored depth range. The jump at 12 -13 GPa (1000-1080 km) is related to the phase transition of olivine to wadsleyite and ringwoodite. The 15-16 GPa (1250-1330 km) jump witnesses the completion of orthopyroxene to garnet phase transition. The most obvious jump takes place at 18-19 GPa (1500-1580 km), corresponding to the transformation of clinopyroxene to garnet and calcium perovskite. Our preliminary results presented here can help to explain the obtained INSIGHT mission geophysical data, especially in case of the possibly existed basaltic heterogeneities in the Martian Interior.

In order to verify our computation result, we have further carried out high P-T multi-anvil experiments on Yamato 980459 up to 12 GPa along the same Martian areotherm as Bertka and Fei (1997). More experiments will be conducted up to 20 GPa. Micro-probe analysis will be conducted on all run products to analyze the phase compositions and proportions. The experiment results will then be compared with the PerpleX computational results.