Geophysical Properties of Martian Basalt at High Pressure-Temperature Condition W-Y. Zhou[1], J. S. Zhang[2], C. K. Shearer[3], C. B. Agee[4] and J. P. Townsend[5], [1]Department of Earth and Planetary Sciences, University of New Mexico, [2]Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico jinzhang@unm.edu, [3]Institute of Meteoritics, University of New Mexico, [4]Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, [5] High Energy Density Physics Theory, Sandia National Laboratories, Albuquerque.

Introduction: The three scientific instruments SEIS HP3 and RISE from the NASA INSIGHT mission provide unique opportunities for measuring various physical properties of Martian interior including the seismic reference model, the density structure and the heat flow [1]. Linking the direct geophysical observations, to the geochemical or petrological composition of the Martian interior [2], and then further to the evolution models of Mars [3-6], requires experimental investigations on different mantle rock candidates of Mars. Bertka and Fei (1997) have used multi-anvil experiments to study the phase proportion and mineral composition of the bulk Martian mantle (Dreibus and Wänke model: DW model [7]) along a potential areotherm [8], then calculated the density profile as a function of depth [9-10]. However, investigations of the predicted geophysical properties for other candidate lithologies, such as basalt, at high pressure (P)-temperature (T) conditions are limited. In addition to interpreting new geophysical measurements on the martian surface, understanding the characters of the basalt-eclogite transition on Mars and properties of martian eclogite has implications for martian magma ocean processes [5], global dynamics, crustal recycling, and volatile behavior [11-13].

Methods and Results: We have carried out PerpleX computation [14], as well as high P-T multi-anvil experiments on a primitive Martian basalt (Yamato 980459) to study its mineral composition, proportion and the geophysical properties along a typical Martian areotherm [8].Unlike most other shergottites, the Yamato 980459 basalt represents primary melt separated from its mantle source at a depth of ~ 100 km. Its mineralogy consists of olivine and orthopyroxene megacrysts immersed in a glassy matrix [15].

To verify the robustness of our calculation, we have calculated the mineral composition and proportion of a DW model for bulk Mars along the same areotherm in [8]. The computational result is in agreement with Bertka and Fei's experiments, suggesting that the calculation using PerpleX is reasonably reliable. For the DW model, olivine (Ol) is the most abundant mineral (~ 60 vol.%), whereas the garnet (Gt) content is the lowest (~ 9 vol.%) under the Martian upper mantle condition. The content of Gt at P > 22 GPa is slightly less in our calculated results compared with the experiments in [9]. In contrast, for Yamato 980459 shergottite composition, the orthopyroxene (Opx) content remains to be the highest within the P-T range of the upper mantle of Mars. Opx converts into Gt at high P-T condition, resulting in the decrease of Opx content from ~60 vol. % to ~ 25 vol. %. Ol is the least abundant yet important component (10 vol.%) of the bulk Martian basalt.

Three high-pressure multi-anvil experiments have been successfully completed on the Yamato 980459 under the following conditions: 3 GPa, 1200 ℃, 6 GPa, 1400 ℃ and 4.5 GPa, 1300 ℃, and an additional experiment will be performed at 9 GPa, 1550 ℃. The 6 GPa run product is shown in the Fig.1. Micro-probe analysis will be conducted on all run products to analyze the phase compositions in the near future.

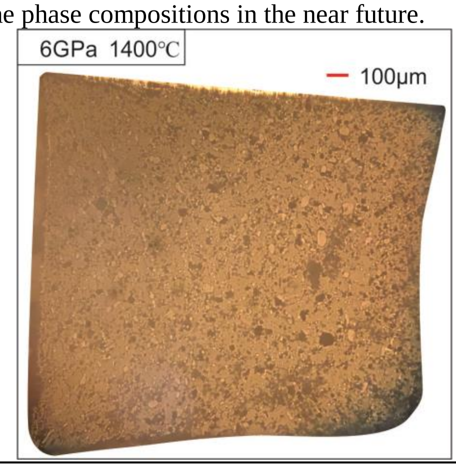

Figure 1. Run product of the Yamato 980459 at 6 GPa and 1400°C.

P (GPa) Depth (km)	*12-13* 1000-1080	*15-16* 1250-1330	*18-19* 1500-1580
V_P jump	2.3%	2.4%	3.7%
Vs jump	1.9%	2.6%	5.1%
Density jump	1.4%	1.7%	2.9%

Table 1. V_p, V_s and density jumps of the Yamato 980459 along the expected Martian areotherm [8].

The computed density, V_p and V_s profiles along the Marian areotherm [8] for the Yamato 980459 are shown in Fig. 2. The density, V_p and V_s increase steadily from 3.4 to 4.4 g/cm^3, 7.2 to 10.1 km/s, 4.2 to 5.4 km/s respectively, within the depth range of 100-2000 km.

Three are three jumps within the explored depth range as shown in Table 1. The jump at 12 -13 GPa (1000-1080 km) is related to the phase transition of Ol to wadsleyite and ringwoodite. The 15-16 GPa (1250-1330 km) jump witnesses the completion of Opx to Gt phase transition. The most obvious jump takes place at 18-19 GPa (1500-1580 km), corresponding to the transformation of clinopyroxene to Gt 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.

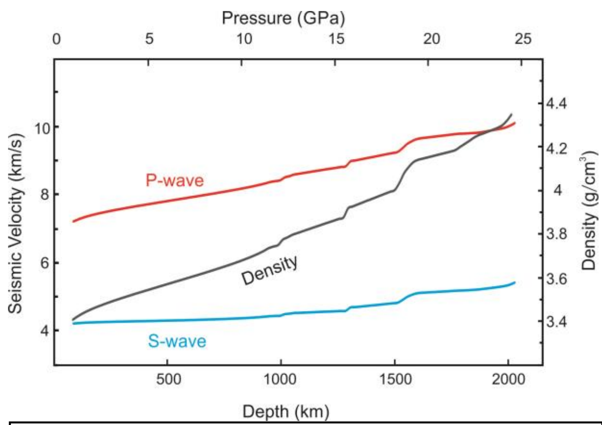

Figure 2. V_p, V_s and density profiles of the Yamato 980459 along the expected Martian areotherm [8].

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