PRE-HEATED SHOCK RECOVERY EXPERIMENTS OF OLIVINE-PHYRIC BASALT FOR ESTIMATIONS OF PLANETARY SHOCK EVENTS.

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Introduction: Shock recovery experiment is one of the most significant methods to obtain new insights into planetary collisional events. However, there are several differences between shock recovery experiments and natural collisional events, for example, differences in timescales and compression processes. Different compression processes will influence the peak shock temperatures: a single compression (natural shock events) will raise temperature higher compared with the reverberation compression (shock recovery experiments) [e.g., 1]. Such temperature differences will lead misinterpretation of relationships between shock pressures and corresponding shock features when we compare shocked meteorites and experimentally shock recovered samples. In order to solve the temperature problem and to correctly investigate the relationships, we performed pre-heated shock recovery experiments and compared recovered samples with samples shocked at room temperature [2].

Methods and Samples: Shock recovery experiments were conducted using a single stage propellant gun at NIMS. The sample is a 1 mm thick disk of olivine-phyric basalt from Kita-Matsuura, Kyusyu, Japan [2]. The heating system was made around a stainless (SUS304) container in each experiment by using Kanthal (FeCrAl) wires. We performed 2 shots and experimental shock pressures and initial temperatures were <22.2 GPa at 800 °C for the first shot (Shot-1) and <39 GPa at 750 °C for the second shot (Shot-2). Although shock pressures were estimated by the impedance matching method, the actual shock pressure must be slightly lower due to thermal softening of the stainless container. Thin sections of recovered samples were observed by scanning electron microscopy (SEM: JEOL JSM-7100F) and analyzed by micro-Raman spectroscopy (JASCO NRS-1000) both at NIPR. Then, they were compared with the samples recovered from our previous shock experiments at room temperature (22.2, 28.7, 39.5 and 48.5 GPa) [2].

Results and Discussion: Plagioclase ($An_{45\text{-}69}Or_{\sim 2}$) in the Shot-2 sample is bended and shows flow-textures. The chemical zoning in plagioclase disappeared by melting of sodic rims in the Shot-2 sample. Although plagioclase in Shot-1 is not completely isotropic under crossed polarized light, Raman peaks of plagioclase were not observed. On the other hand, plagioclase shocked at the similar shock pressure (22.2 GPa) at room temperature shows recognizable Raman peaks, which indicates that plagioclase could be vitrified at lower pressures as the temperature increases. This trend is consistent with the hydrostatic amorphization experiments [3]. Olivine and pyroxene grains shocked by both Shot-1 and Shot-2 show wavy or mosaic extinction under crossed polarized light and have planar fractures, which are the same features observed in our previous experiments [2]. "Brown olivine" which is commonly reported in Martian meteorites [e.g., 4] was not formed in our experiments. On the other hand, Raman analysis revealed that olivine grain in the Shot-2 sample shows peaks at 670 cm^{-1} in addition to the common olivine peaks such as 820 and 850 cm^{-1}. This additional peak at 670 cm^{-1} is close to the peak at 660-670 cm^{-1} observed from aqueously altered materials in the intact basalt, however, the other peaks obtained from the altered materials at 220, 288, 404, 492, 608, 1050-1100 (broad) and 1313 cm^{-1} were not detected in the spectra at all. A possible explanation for the origin of this peak is the formation of defects or new bonds between SiO_4 tetrahedra similar to those in pyroxene (Si-O-Si stretching [5]). We previously found that the lamellar texture in olivine in the Tissint Martian meteorite showed identical Raman peak [6]. However, we did not observe the lamellar textures in the Shot-2 sample. In contrast, we have observed similar lamellar textures in olivine shocked at higher pressure (39.5 and 48.5 GPa) at room temperature although they showed no Raman peak at 670 cm^{-1} [2]. These observations indicate that this Raman peak may occur due to the high-temperature effects during high-pressure while the lamellar formation (or a lamellar width) may be controlled by peak shock pressures. According to the above discussion, olivine in Tissint may be shocked at the pressure between Shot-2 (<39 GPa) and 48.5 GPa, which is consistent with the shock pressure of >29-30 GPa estimated by [7].

Conclusion: This study revealed that pre-heated shock recovery experiments would lead to different results from shock experiments at room temperature such as lowering vitrified pressure and inducing the additional Raman peak of olivine. Combining with hydrostatic experiments, temperature-controlled shock recovery experiments will provide better constraints on relations between shock pressures and corresponding features in natural shock events because the timescale of natural collision must be within those of shock recovery experiments and hydrostatic experiments.

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