SHOCK RECOVERY OF GRANITE: IMPLICATIONS FOR FEATHER FEATURES FORMATION. T. Tada[1], K. Kurosawa[2], J. Isa[2], H. Ono[2], C. Hamann[3], T. Okamoto[2], T. Niihara[4], and T. Matsui[1,2], [1] Institute for Geo-Cosmology, Chiba Institute of Technology, 2-17-1, Tsudanuma, Narashino, Chiba 275-0016, Japan (tada.toshihiro@p.chibakoudai.jp), [2]Planetary Exploration Research Center, Chiba Institute of Technology, 2-17-1, Tsudanuma, Narashino, Chiba 275-0016, Japan, [3]Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung, Invalidenstr. 43, 10115 Berlin, Germany, [4] Department of Applied Science, Okayama University of Science, 1-1 Ridai-cho, Kita-ku, Okayama, Okayama 700-0005, Japan.

Introduction: Quartz develops striking and unique shock deformation features such as feather features (FFs), planar fractures (PFs), and planar deformation features (PDFs) [e.g., 1]. Most shock recovery experiments with quartz have been conducted at shock pressures above 10 GPa, and shock deformation features in quartz in the low pressures range have not been well investigated. FFs have been experimentally confirmed to form at pressures about 7–10 GPa only in one shock recovery experiment [2] and are of interest as one of the shock deformation features in quartz that occurs below 10 GPa. FF is composed of a PF and fine lamellae (FFL) extending in one direction from the PF. Since FFs have rarely been observed in detail under electron microscopes, it is not well understood what kind of structure appears as lamellae in optical microscopy. Based on the lack of reports of FFs from unshocked rocks, FFs are expected as a primary indicator to identify impact structures along with PDFs [2]. In addition, it has been proposed that the orientation of FFL indicates the propagation direction of the shock front mainly based on the observations of FFs in natural impactites [2–5].

To investigate the pressure range required for producing FFs, the component of FFL, and the relationship between the orientation of FFL and the propagation direction of the shock front, we have conducted shock recovery experiments of granite with decaying compressive pulses [6–8]. The pressure distributions in the non-transparent targets were estimated with shock physics modeling.

Methods: Shock recovery experiments were conducted with a two-stage light gas gun at Planetary Exploration Research Center of Chiba Institute of Technology, Japan. The recently developed technique with decaying compressive pulses was used [6–8] except that we used granite as targets. The initial results were reported last year [9]. We have increased the number of experiments and observations of FFs, allowing us to confirm the occurrence and characteristics of FFs formed by shock experiments such as pressure range, shape, and crystallographic orientation. We further conducted observations of FFs using a scanning electron microscope (SEM).

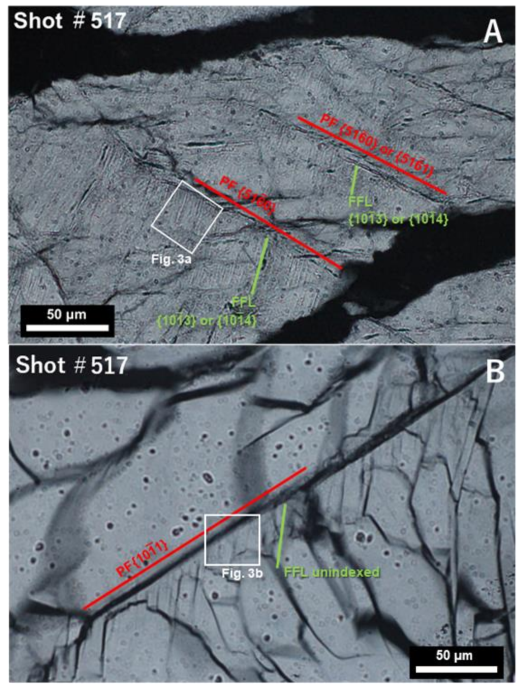

Figure 1. Photomicrographs of FFs formed by the shock recovery experiments (crossed nicols).

The recovered samples were indurated with resin and polished thin sections of the recovered samples were prepared. The thin sections were observed under a polarized microscope and a field emission-scanning electron microscope (FE-SEM) at Chiba Institute of Technology. The crystallographic orientations of the FFs in quartz were measured using a four-axis universal stage microscope. The peak pressure distributions in the shocked targets were estimated with the iSALE shock physics code [10–12] combined with ANEOS [13] granite [14] and the "ROCK" strength.

Results: 21 sets of FFs were found from 7 recovered samples so far. FFL are ~10–60 μm in length and have a spacing of < 1–10 μm (Fig. 1). FFL tend to be parallel to the crystallographic planes, such as $\{10\bar{1}1\}$, $\{11\bar{2}2\}$, $\{11\bar{2}1\}$, and $\{10\bar{1}3\}/\{10\bar{1}4\}$. The angles between FFL and PF are higher than 35° and typically around 45°–60° (Fig. 2). These characteristics of FFs formed by the shock experiments are consistent with those of the FFs previously reported from natural impactites [2]. Based

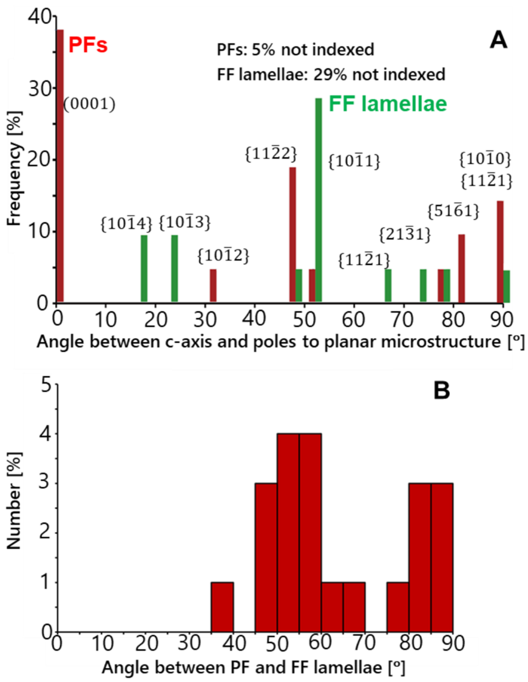

Figure 2. A) Absolute frequency plot of PF and FFL orientations. B) Histogram of angles between PF and FFL.

on the result of the numerical calculations using iSALE, the pressure range in the region where the FFs were observed was estimated to be about ~4 to 18 GPa.

SEM observation of the FFs reveals that the FFLs formed in the lower pressure range (~4–15 GPa) are open fractures with 0.1–0.5 µm in thickness and spacing of 1–2 µm (Fig. 3B). The FFLs formed in the higher-pressure range (~15–18 GPa) appear as grey lines darker than the host quartz in SEM-BSE image with <0.1–0.2 µm in thickness and spacing of 0.2–1 µm (Fig. 3A) indicating that these lamellae are not open fracture.

Discussion and Conclusions: The result of this study suggests the pressure range of FFs formation in quartz as ~4–18 GPa. This pressure range is roughly consistent with the previous estimation of the lower and upper-pressure limit of FFs formation based on the observations of natural impactites (~5–20 GPa) [2].

SEM observation of FFs indicates that the component of FFL may change with the shock pressure that FFs formed at, although further investigation at higher magnification will be needed to reveal the component of FFL at the higher-pressure range.

The relationship between the FFs orientation and the direction of the shock front propagation will be discussed in the presentation.

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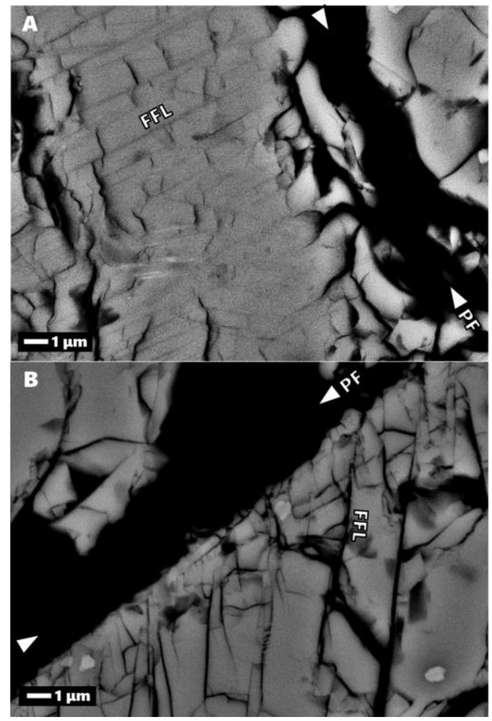

Figure 3. SEM-BSE images of the FFs. A) FFs formed at high shock pressure (~16 GPa). B) FFs formed at low shock pressure (~5 GPa).

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