SHOCK RECOVERY OF GRANITE WITH A DECAYING SHOCK WAVE: FEATHER FEATURES FORMATION IN QUARTZ. T. Tada[1], K. Kurosawa[2], H. Ono[2], C. Hamann[3], T. Okamoto[2], T. Niihara[4], 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

Introduction: Evidence of impacts is recorded in minerals in the form of shock deformation features, which can be used to estimate the shock pressure experienced in the minerals. Quartz, in particular, has been used to search for impact craters and ejecta layers on Earth because of its abundance, resistance to chemical and physical alternation, and tendency to develop striking and unique deformation features such as feather features (FFs), planar fractures (PFs), and planar deformation features (PDFs) [e.g., 1].

In natural impactites, a shock wave decays rapidly as it spreads out from the impact point. Thus, the fraction of rocks subjected to relatively low pressures of a few GPa is likely to be larger than that subjected to pressures above 10 GPa [e.g., 2]. However, 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.

In this context, FFs 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 (FF lamellae) extending in one direction from the PF. The formation of FFs has been experimentally confirmed at 7–10 GPa only in one shock recovery experiment by Poelchau and Kenkmann (2011) [3]. Based on the occurrence of FFs in natural impactites, the lower pressure limit of FFs formation is between 5 and 10 GPa, and the upper pressure limit is less than 15–20 GPa [3].

To confirm the formation of FFs experimentally and to investigate the pressure range of FFs formation, we carried out shock recovery experiments of granite with decaying compressive pulses [4]. In this experiment, a sample that suffered a variety of shock pressures ranging from 1 to 18 GPa could be collected at a single shot [4]. The pressure distributions in the non-transparent targets were estimated with shock physics modeling.

Methods: We conducted impact experiments with a two-stage light gas gun at Planetary Exploration Research Center of Chiba Institute of Technology, Japan [5]. We used Inada granite (Ibaraki, Japan) and shaped the granite blocks into cylinders with a diameter of 30 mm and a height of 24 mm. A titanium container with a detachable front plate was used for shock recovery. Polycarbonate spheres of 4.8 mm diameter were used as projectiles. The impact velocity was 6 to 7 km/s. Polished thin sections of the recovered targets were prepared and observed under a polarized microscope. The crystallographic orientations of the PDFs, PFs and FFs in the quartz were measured using a universal stage microscope. The peak pressure distributions in the shocked targets were estimated with the iSALE shock physics code [6-8] combined with ANEOS [9] granite [10] and the “ROCK” strength

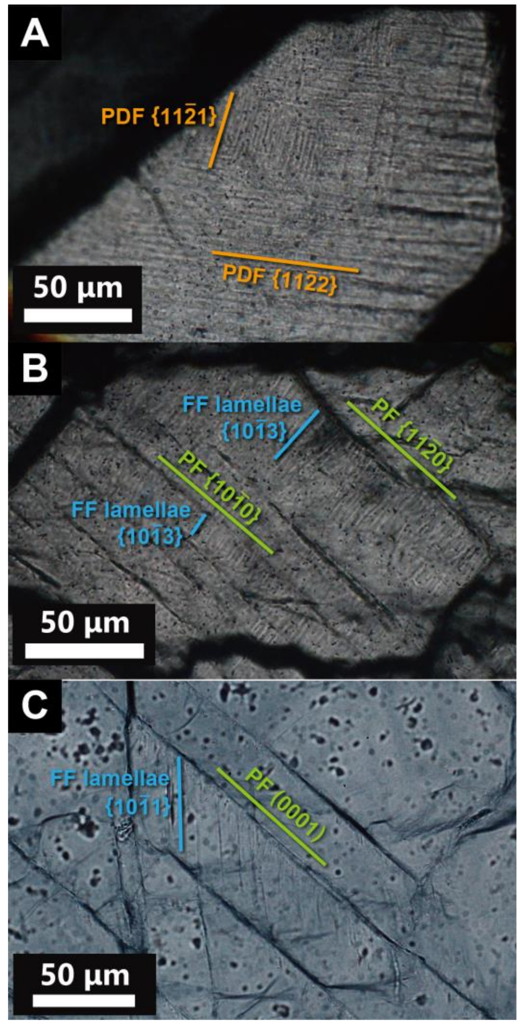

Figure 1. Photomicrographs of PDFs and FFs formed by the shock recovery experiments of this study (crossed nicols).

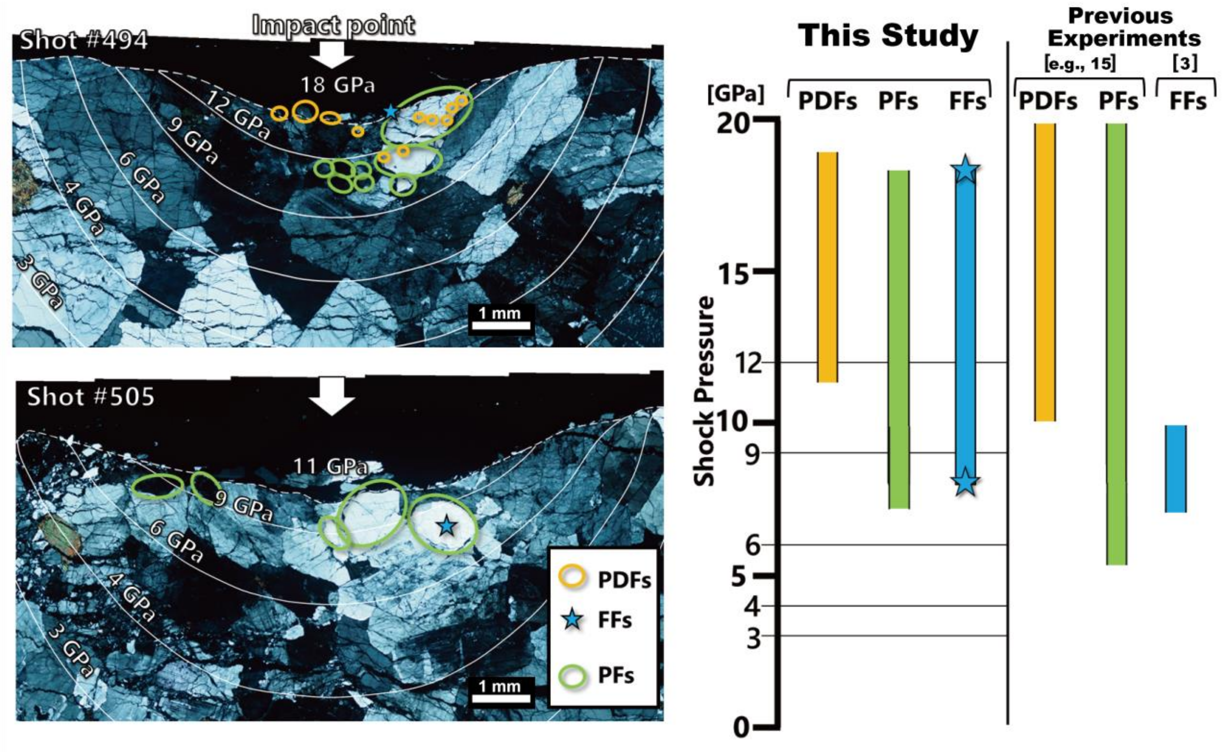

Figure 2. Photomicrographs of the recovered targets (left) and the pressure range where PDFs, PFs and FFs were formed in the experiments (right). The distribution of peak pressures calculated by iSALE and the locations where PDFs, PFs and FFs were identified are shown in the photomicrographs.

model [e.g., 7]. We also used Tillotson EOS [11] for polycarbonate [12] and Ti [11] and Johnson-Cook constitutive model [13] pertaining to the Ti container and front plate.

Results: As shown in Figure 1, we observed FFs as well as PDFs and PFs in quartz near the impact point in the recovered targets. The orientations of the PFs constituting the FFs were $\{10\bar{1}0\}$, $\{11\bar{2}0\}$, and (0001), and the orientations of FF lamellae were $\{10\bar{1}3\}$ and $\{10\bar{1}1\}$. The angles between the PFs and the FF lamellae were about 50–90°. The orientations of the PFs and FF lamellae are consistent with those of the FFs reported from natural impactites [3]. Based 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 8 to 18 GPa (Fig. 2). Shock deformation features in the shocked Inada granite (#494) were investigated in detail by a companion study [14].

Discussion and Conclusions: The result of this study and the previous experiment [3] suggest the pressure range of FFs formation in quartz as 7–18 GPa, although further constraints are needed for an upper and lower pressure limit. It seems that FFs do not necessarily represent relatively low shock pressures below < 10 GPa.

Acknowledgments: We appreciate the developers of iSALE, including G. Collins, K. Wünnemann, B. Ivanov, J. Melosh, and D. Elbeshausen. We also thank Tom Davison for the development of the pySALEPlot.

References: [1] French, B. M. and Koeberl, C. (2010) *Earth-Science Reviews*, 98, 123-170. [2] Melosh, J. H. (1989) *New York: Oxford University Press*. [3] Poelchau, M. H. and Kenkmann, T. (2011) *Journal of Geophysical Research*, 116, B02201. [4] Kurosawa, K. et al. (2021) *LPI Contributions* 2609, 6163. [5] Kurosawa, K. et al. (2015) *Journal of Geophysical Research: Planets*, 120(7), 1237-1251. [6] Amsden, A. A. et al. (1980) *LANL Report LA-8095*, 101 p. [7] Ivanov, B. A. et al. (1997) *IJIE*, 20, 411-430. [8] Wünnemann, K. et al. (2006) *Icarus*, 180, 514-527. [9] Thompson, S. and Lauson, H. (1972) *SNL Rep.*, SC-RR-71 0714:113p. [10] Pierazzo, E. et al. (1997) *Icarus*, 127, 408-423. [11] Tillotson, J. H. (1962) *General dynamics San Diego CA General Atomic Div*. [12] Sugita, S. and Schultz, P. H. (2003) *Journal of Geophysical Research: Planets*, 108.E6. [13] Johnson, G. R. and Cook, W. H. (1983) *Proceedings 7th International Symposium on Ballistics*, 541-547. [14] Hamann, C. et al., This meeting. [15] Stöffler, D. and Langenhorst, F. (1994) *Meteoritics*, 29, 155-181.