CONSTRAINTS ON THE PRESSURE RANGE OF FEATHER FEATURES IN SHOCKED QUARTZ.

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Overview: Feather features have been found in impactites with shock pressures ranging from 7 to 20 GPa.

Introduction: Feather features (FFs) are shocked-derived microstructures that can be found together with planar fractures (PFs) and planar deformation features (PDFs) in quartz. However, they have rarely been observed in shock experiments. [1] reported FFs from one shock recovery experiment performed on a vertically arranged quartz-feldspar-quartz sandwich. Shock for this experiment is estimated at 7-10 GPa. The lack of further data has led researchers to incorrectly quote 7-10 GPa as the range of formation (e.g., [2]).

Shock barometry constraints for feather feature formation: Observation of FFs in natural samples that contain numerous PDFs in quartz show that FFs also form under shock pressures above 10 GPa. Detailed studies from the IODP/ICDP Expedition 364 drill cores of shocked granite from the peak ring of the Chicxulub crater show the presence of FFs throughout ~587 m of core [3]. Shock barometry measurements of PDFs in quartz grains in these granites yield shock pressures of ~16-18 GPa [4]. In further studies, [5] performed shock barometry on granites from the Hättberg and Vålarna drill cores of the Siljan structure in Sweden. Here, FFs were documented in samples that experienced 15-20 GPa shock pressure, based on indexing of PDFs in quartz. [6] analyzed gneisses from the CAR103 drill core of the Carswell structure in Canada. FFs were observed in samples, which, based on preliminary shock barometry measurements, suggest 18-20 GPa shock pressure. [7] documented FFs in sandstones from the Spider structure, Australia. Based on the occurrence of basal PDFs and a lack of other PDF orientations, they infer minimum shock pressures of 10 GPa. Sandstones and conglomerates of the Rock Elm Structure, Wisconsin, USA have numerous FFs, yet no PDFs have been found there [8]. This indicates the formation of FFs below 10 GPa. Finally, the East Clearwater Lake structure in Canada was subject to drilling in the 1960s [9]. [10] recently indexed PDFs in granite and monzonite samples from the 1-64 drill core to create a shock barometry log over 900 m of core. I was able to scan the thin sections used in the study from [10] and found FFs in 28 of 65 samples. Based on the shock barometry log, FFs here formed under shock pressures between 7 and 16 GPa.

Discussion: The formation of a feather feature requires the existence of a planar fracture on which shearing occurs, leading to the formation of subsidiary fractures on one side of the PF. Therefore, the pressure range of FFs is constrained by the pressure range of PFs. The lower range of PF formation is given at 5 GPa, with 7 GPa as "the most probable value for the onset" of PFs (page 165 of [11]). The upper range for PF formation is poorly constrained. They become less common with the onset of reduced refractive indeces at ~25 GPa and have a presumed upper limit of ~35 GPa ([11]). Based on this, FFs seem highly probable up to at least 25 GPa. Fig. 1 shows a corrected diagram of this relationship relative to other shock features in quartz (from [2]).

References: [1] Poelchau, M. H., & Kenkmann, T. (2011) *Journal of Geophysical Research: Solid Earth*, 116(B2). [2] Stöffler, D. et al. (2018) *Meteoritics & Planetary Science*, 53:5-49. [3] Ebert, M. et al. (2020) *Geology*, 48:814-818. [4] Feignon, J. G. et al. (2020) *Meteoritics & Planetary Science*, 55:2206-2223. [5] Holm-Alwmark, S. et al. (2017) *Meteoritics & Planetary Science*, 52:2521-2549. [6] Epstein, J. et al. (2022) *LPS LIII*, Abstract #2053. [7] Cox, M. A. (2021) *Meteoritics & Planetary Science*, 56:331-351. [8] French, B. M., et al. (2004) *Geological Society of America Bulletin*, 116:200-218. [9] Grieve, R. A. F. (2006) Impact Structures in Canada, St Johns: Geological Association of Canada. [10] Rae. A.S.P. (2018) Doctoral dissertation, Imperial College London. [11] Stöffler, D., & Langenhorst, F. (1994) *Meteoritics*, 29:155-181.

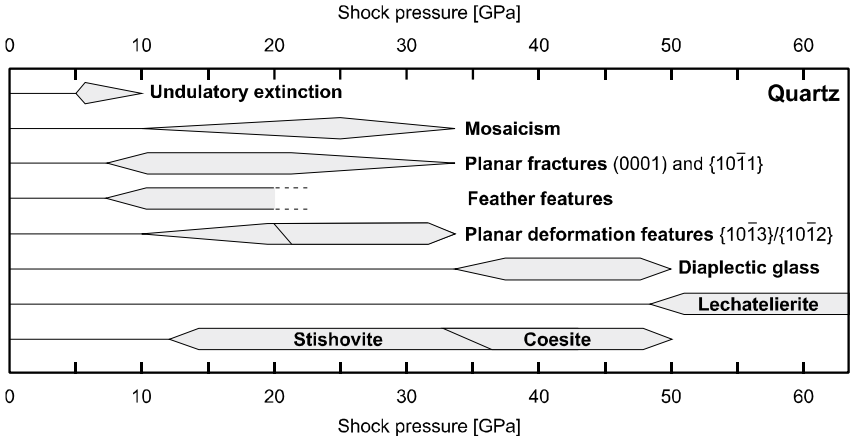

Fig. 1: The shock pressure range for feather feature formation is currently estimated at 7-20 GPa, based on barometry of natural samples. The upper limit is presumably higher. The figure is taken from [2] and has been revised to reflect these shock pressures.