OCCURRENCE AND CHARACTERIZATION OF SHOCKED QUARTZ IN SHATTER CONES

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Introduction: Shatter cones are the only shock-deformation feature that develop on a macro- to megascopic scale (e.g., [1]). Despite being one of the most distinctive products of hypervelocity impact events, very few studies of shock-metamorphic effects in minerals associated with shatter cones have been conducted (e.g., [2]). We report here on detailed petrographic investigations of shatter cone samples, including a quantitative study of the distribution of shocked quartz grains within shatter cones, and the determination of crystallographic orientations of planar deformation features (PDFs) in quartz, using universal-stage microscope.

Results and Discussion: The shatter cones studied developed in gneiss at Charlevoix, in sandstone at Haughton, and in orthogneiss at Keurusselkä; they all display a large number of microdeformation features, including random penetrative fractures, kink bands (mainly in micas and rarely in quartz and feldspar grains), planar fractures, feather textures, and PDFs in quartz grains.

We estimate that the investigated samples experienced peak shock pressures up to ~20 GPa. However, considering that for some samples no PFs and/or PDFs were observed, much lower shock pressures, probably as low as a few GPa, was enough to induce shatter cone formation. Our detailed mapping of shocked quartz grains at the thin section scale, as illustrated in Fig. 1, shows that shocked grains are heterogeneously distributed within shatter cone samples. This result is important since it is currently recognized in the literature that shocked minerals only occur within 1–2 mm of the cone surface (e.g., [3]).

Conclusions: Our study shows that shatter cone samples record variable peak shock pressures, from a few GPa up to ~20 GPa, and that shocked grains are heterogeneously distributed within shatter cone samples. Together, these observations imply that in the setting where shatter cones form in a crater, the shock wave that propagates through the target rocks is likely highly scattered, refracted, and/or reflected, even at the cm to m scale. These new observations provide some important insights into the mechanism of shatter cone formation, but they pose some problems for the different proposed models.

Acknowledgments: This work was supported by the DFAIT (L.F.) and the NSERC (G.R.O.), Government of Canada.

References: [1] Dietz R. S. 1968. In *Shock metamorphism of natural materials*, French B. M. & Short N. M., Eds, Baltimore: Mono Book Corp. pp. 267–285. [2] Fackelman S. P. et al. 2008. *Earth & Planetary Science Letters* 270:290–299. [3] Hargraves R. B. and White J. C. 1996. *Journal of Geology* 104:233–238.

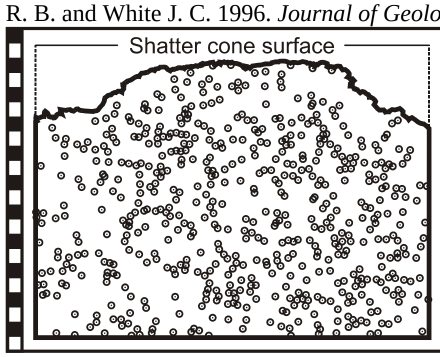

Fig.1: Thin section map of a shatter cone sample from Haugthon showing the distribution of shocked quartz grains (all grains larger than 75μm with PFs and/or PDFs) at the scale of the thin section. Scale in mm.