

PLANAR DEFORMATION FEATURES IN QUARTZ AT THE NEWLY DISCOVERED PRINCE ALBERT IMPACT STRUCTURE, NORTHWEST TERRITORIES, CANADA. A. E. Pickersgill¹ and G. R. Osinski¹, ¹Centre for Planetary Science and Exploration, Dept. of Earth Sciences, Western University, 1151 Richmond Street, London, ON, Canada, N6A 5B7 (apickers@uwo.ca).

Introduction: The newly discovered Prince Albert impact structure [1, 2] is located on Victoria Island, in the Canadian high arctic (72°30' N, 114°0' W). The structure is approximately 28 km in diameter, and deeply eroded with little evidence of preserved crater-fill deposits [2]. The target rocks are flat-lying sedimentary units of the Arctic Platform dominated by dolomite, siltstone, and shale of Cambrian to Silurian age. Target rocks are overlain by Quaternary glacial sediments. Based on the age of the target rocks the impact structure is estimated to be <350 Ma [1].

Shock metamorphism: The origin of suspected meteorite impact structures can only be confirmed by the detection of diagnostic shock metamorphic effects such as planar deformation features (PDFs). Measurements of the orientation of PDFs in quartz have shown that they are oriented parallel to rational crystallographic planes of known Miller indices [3]. The orientation of PDFs is not only crucial to confirming hypervelocity impact, but provide valuable data about the peak pressures to which material has been exposed during impact [4]. Specific orientations of PDFs are formed at different shock pressures [e.g., 3]. Grieve and Robertson [3] assigned specific peak pressure values to certain rational crystallographic orientations of PDFs in quartz grains based on average shock pressure values from laboratory shock experiments.

Methods: During a two week field excursion in July 2012 samples of target rock (dolostone, limestone, sandstone, shale, diabase intrusions) and impact breccias, were collected throughout the structure.

Nineteen polished thin sections were made from representative lithologies collected at and around what is interpreted to be the central uplift at the Prince Albert structure. These sections were examined for microstructural shock metamorphic using Nikon LV100POL compound petrographic microscopes, located in the Earth and Planetary Materials Imaging and Analysis Laboratory at the Western University.

When PDFs were found their orientations were measured and indexed using a four-axis universal stage (U-stage) microscope following the method summarized by Ferrière et al. [4]: (1) Determine the orientation of the optic or c-axis of the host grain; (2) measure the orientation of the poles to all PDFs; (3) plot data on a stereographic Wulff net; and (4) index planes using a standard stereographic projection template. In this study measurements were indexed using the Automat-

ed Numerical Index Executor (ANIE v1.2) program developed by Huber et al. [5].

Results: Some of the best-preserved *in situ* shatter cones on Earth were found in a canyon (~2 km long) that cuts through a portion of the central uplift (see [2] for further details and imagery).

Sample CI-AP-04, sandstone interbedded with layers of dolostone, was collected at a location near the inferred centre of the structure in part of the Victoria Island Formation. The thin sandstone layers were more prominent than the surrounding dolostone, suggesting the presence of quartz in the field.

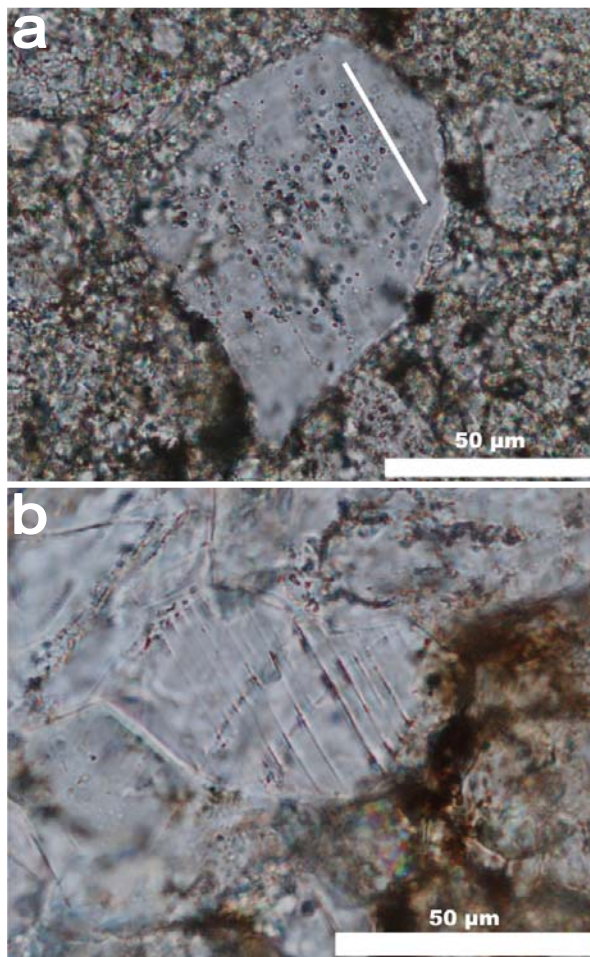


Figure 1: Two quartz grains in CI-AP-04 **a)** ~60 μm quartz grain displaying decorated PDFs (tiny fluid inclusions aligned along the plane of deformation); the white line is parallel {101}3 to the PDFs to make viewing them easier; **b)** fresh PDFs in ~70 μm quartz grain near the edge of the thin section (unmeasurable).

Petrography: Carbonate minerals (dolomite and calcite) dominate all rock types, generally making the search for planar deformation features in quartz difficult. Out of thousands of quartz grains in 19 thin sections, only 14 grains displayed PDFs (11 in one thin section, 3 in 3 separate thin sections). The quartz grains in which they occur are all small ($\sim 40\ \mu\text{m}$). All but one set of PDFs appear decorated (i.e. bands of tiny aligned fluid inclusions) (Figure 1a). In all but one sample (CI-AP-04) it was not possible to measure PDF orientations because they were too close to the edge of the section and therefore not possible to view on a U-stage (only the central area of a thin section is accessible with a U-stage as a function of the instrument geometry).

Petrographic studies revealed CI-AP-04 to be composed of approximately 50% quartz, 40% carbonates (mostly dolomite), $\sim 8\%$ unresolvable dark grey/brown material, and $\sim 2\%$ opaque sulfides. Carbonate grains in this section are small ($< 15\ \mu\text{m}$), anhedral, weathered, and fill spaces between quartz grains.

Quartz grains in CI-AP-04 are small ($10\text{--}60\ \mu\text{m}$), subhedral, subrounded with intermittent angular grains. Quartz is fairly evenly distributed throughout the section, occasionally occurring in aggregate groups. All quartz grains show undulatory extinction, and up to first order yellow interference colours. 11 out of several hundred quartz grains in this section exhibit planar deformation features (e.g., Figure 1). The c-axis of these 11 grains and the orientation the 14 sets of PDFs they host were measured. The results of this analysis are presented in Figure 2.

Discussion: We have presented the first report of PDFs in quartz from the Prince Albert structure. When coupled with the observation of shatter cones [1, 2], this confirms the structure as a meteorite impact structure.

The presence of *in situ* shatter cones throughout the central area of the structure suggests deep erosion of the original structure down to levels well below the crater fill. Low peak pressure estimates are confirmed by the orientation of PDFs at specific crystallographic orientations which match pressures of $\sim 12\text{--}17.5\ \text{GPa}$ according to the scheme of Grieve and Robertson [3].

If we take a lack of PDFs throughout the sections to indicate areas exposed to relatively low peak pressures, then the low proportion of quartz grains found to contain PDFs (11 out of thousands) throughout the sample suite, could further support the hypothesis that the Prince Albert structure is deeply eroded. However, this may also be due to complexities of shock wave

passage through a heterogeneous target in which quartz is not the dominant mineral. It is important to acknowledge that the low numbers of grains measured also present a statistical difficulty in that studies (e.g., [4]) have found that the error induced in measuring only small batches of PDFs is far greater than that in measuring large numbers of sets in large numbers of grains. Therefore, with such a small sample size (14 sets) one must question the reliability of the indexing – but not the actual observations. Future work includes creating more thin sections from CI-AP-04 and other samples to expand the search for PDFs.

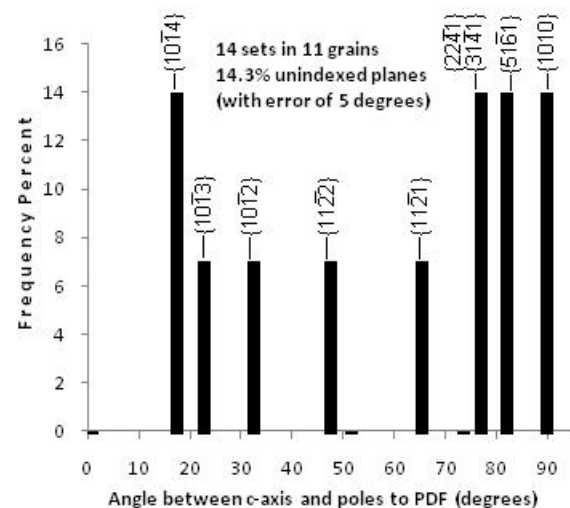


Figure 2: Histograms of the absolute frequency percent of indexed PDFs, recalculated to 100% to exclude unindexed planes, in quartz grains from one sample of sandstone (CI-AP-04), as determined using ANIE v1.2.

References: [1] Dewing et al. (2012) *MAPS*, in press. [2] Osinski et al. (2012) LPSC XLIV, this conference. [3] Grieve & Robertson. (1976) *Contr. to Min. & Pet.* 58:37–49. [4] Ferrière et al. (2009) *MAPS* 44:925–940. [5] Huber et al. (2011) *MAPS* 46:1418–1424.

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