Shock attenuation within the Manicouagan impact structure

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Introducton: A shock attenuation study is being carried out on the Manicouagan impact structure, a late Triassic complex structure located in Quebec, Canada. The structure was formed in gneisses of the Canadian shield. Here we present results from the first locations analysed.

Background: Planar deformation features (PDFs) are shock-produced microstructures which occur as multiple sets of closed, extremely narrow parallel planar regions. PDFs are typically oriented parallel to specific crystallographic planes of the quartz lattice [1]. PDFs with distinct orientations are known to form at different shock pressures, allowing estimation of peak shock pressure from measured PDF orientations [2]. The orientations of planar deformation features (PDFs) with respect to the optic axis of the host quartz grain were determined using the universal stage microscope. The samples included in this presentation were all melanocratic gneisses. The locations of the samples are shown in Figure 1.

Great! But why are you doing this? The goal of this study is to use estimates of peak shock pressure based on this PDF survey to reconstruct the shock pressure distribution that was developed during the creation of the Manicouagan impact structure. This distribution can be used to verify numerical models of impact crater genesis. For example, Figure 1 shows the radial peak shock pressure distribution predicted by iSALE for three impact scenarios. Each predicts a dramatic decrease in shock at a different radius. It is clear that the 5 km diameter impactor travelling 20 km/s (vertically) does not match the data collected thus far, as in this scenario we would expect the shock pressure to have been near zero GPA by a radial position of 25 km (see sample 3). This low pressure would not be expected to generate PDFs. Further samples from greater radial distances will allow us to further constrain the parameters of the impact event.

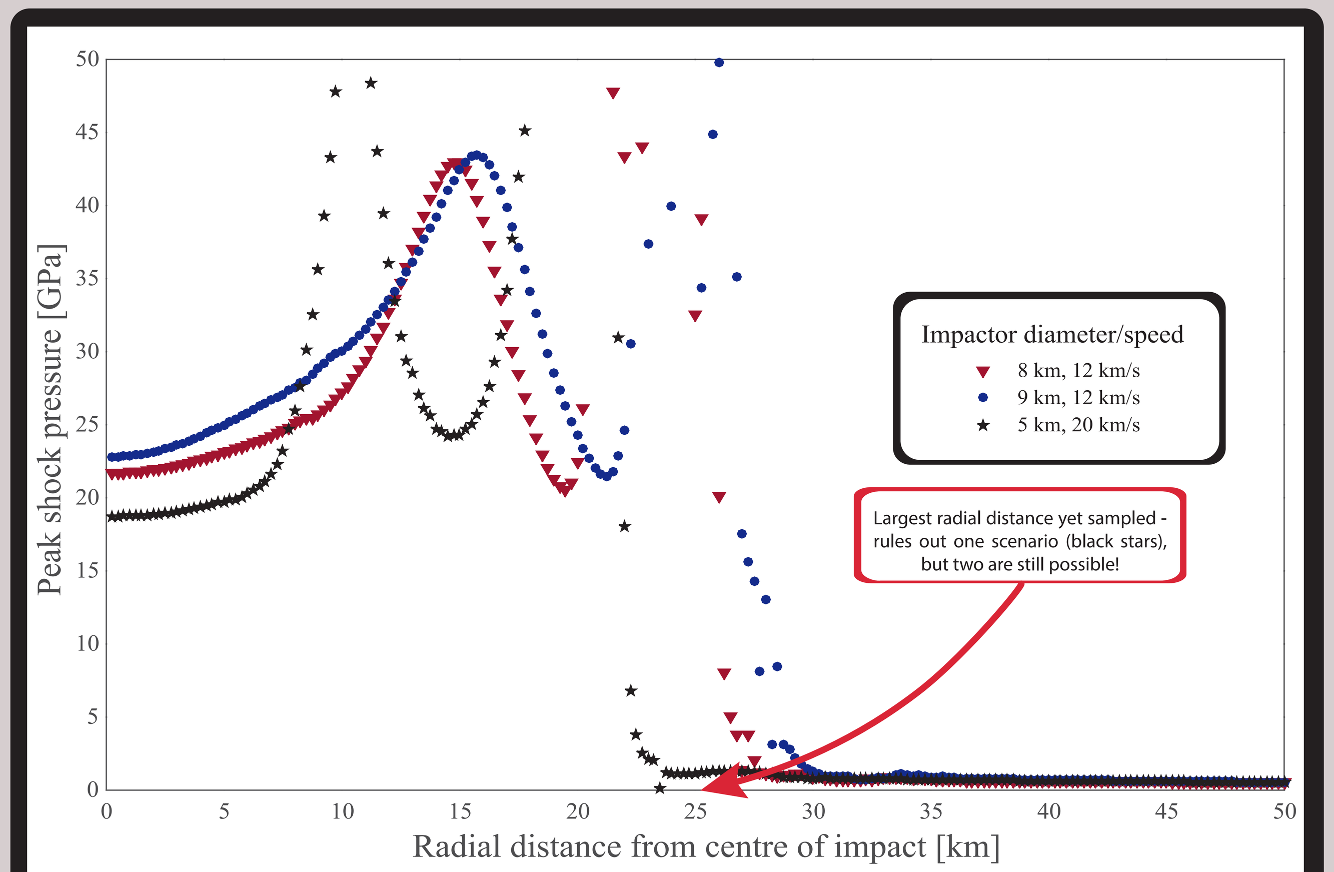
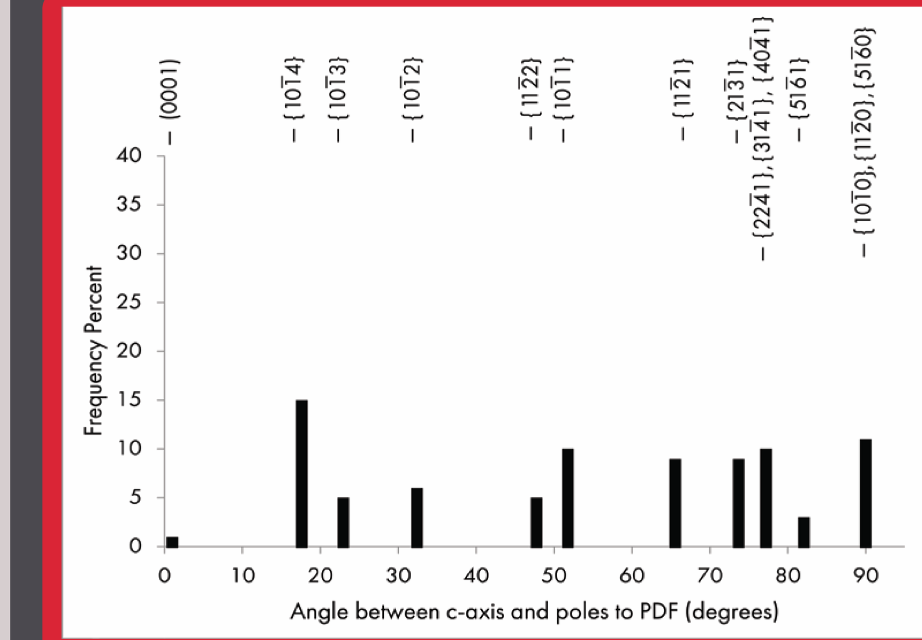


Figure 1: Theoretical shock attenuation with horizontal distance from impact centre for three modelled impact events. These profiles are all taken 3 km beneath the original target surface.

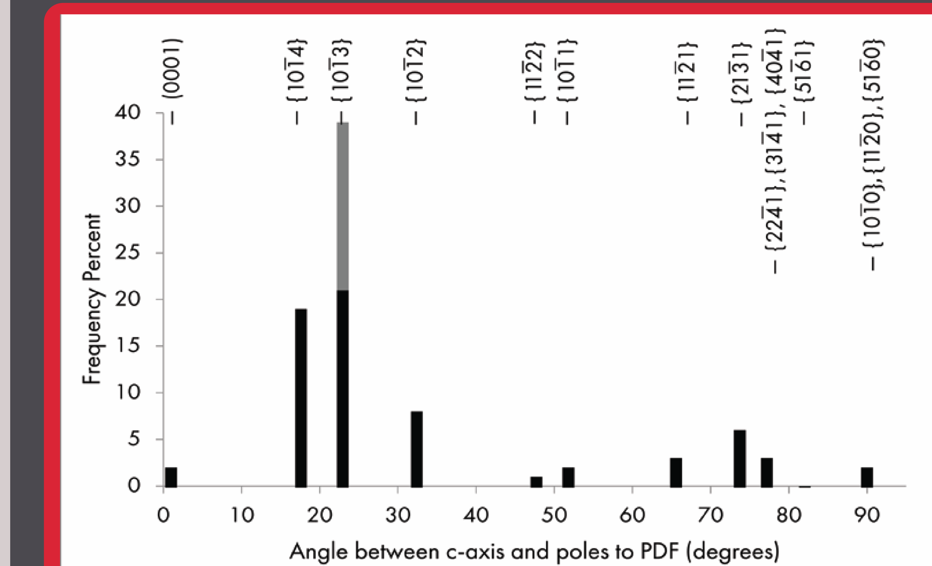
References: [1] Engelhardt & Bertsch. Shock induced planar deformation structures in quartz from the Ries crater, Germany. *Contr. Miner. Petrol.* 1969 [2] Robertson & Grieve. Shock attenuation at terrestrial impact structures. *Impact and Explosion Cratering.* 1977 [3] Ferrière, Morrow, Amgaa & Koeberl. Systematic study of universal-stage measurements of planar deformation features in shocked quartz: Implications for statistical significance and representation of results. *Meteorit. Plan. Sci.* 2009 [4] Huber, Ferrière, Losiak & Koeberl. ANIE: A mathematical algorithm for automated indexing of planar deformation features in quartz grains. *Meteorit. Plan. Sci.* 2011 [5] Stöffler & Langenhorst. Shock metamorphism of quartz in nature and experiment: I. Basic observation and theory. *Meteorit.* 1994

Questions/Suggestions? Please contact Jessie Brown: jessie.brown@unb.ca



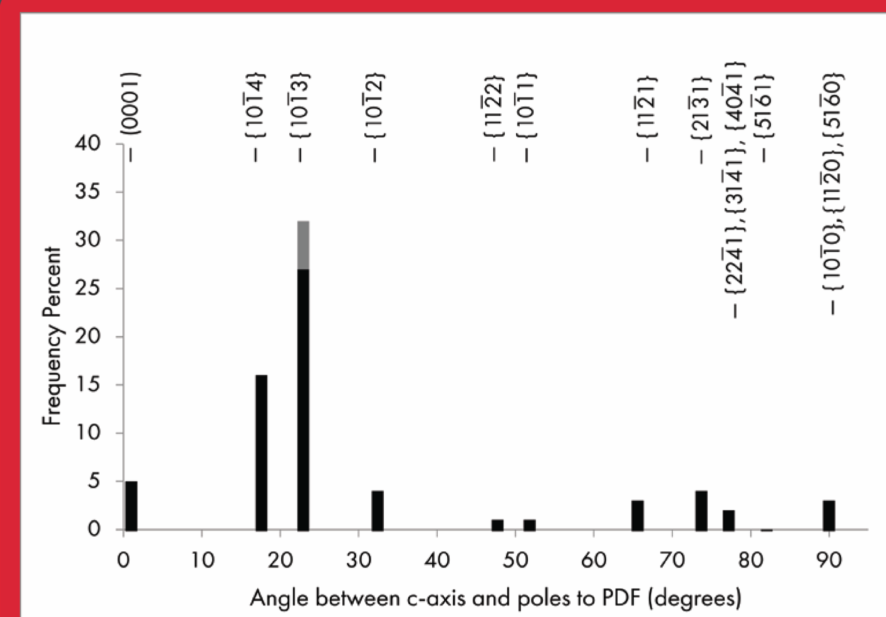
Sample 5/6/7: Three thin sections taken from the same section of drill core were grouped for this analysis. Based on 75 sets of PDFs in 27 quartz grains examined. 9.3% unindexed planes. Average of 2.8 sets of PDFs per grain. These samples are more mafic than the other samples included on this poster, and have undergone some alteration. Located ~5 km from centre. XPL.

1.35 mm

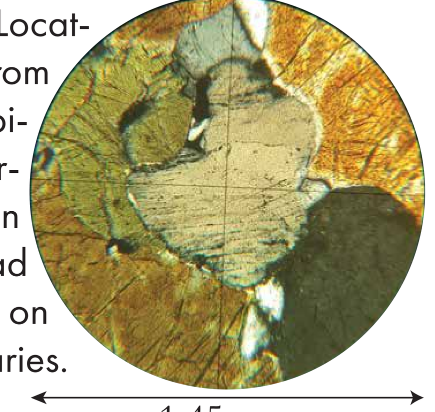


Sample 11/12/13: Three thin sections taken from the same section of drill core were grouped for this analysis. Based on 159 sets of PDFs in 50 quartz grains examined. 10.7% unindexed planes. Average of 3.2 set of PDFs per grain. Located ~15 km from centre. PDFs often do not pervade grains, are concentrated on boundaries. PPL.

1.40 mm



Sample 3: Based on 105 sets of PDFs in 50 quartz grains examined. 21% unindexed planes. Average 2.1 sets of PDFs per grain. Located ~25 km from centre. PDFs typically do not pervade entire grain and are instead concentrated on grain boundaries. XPL.



1.45 mm

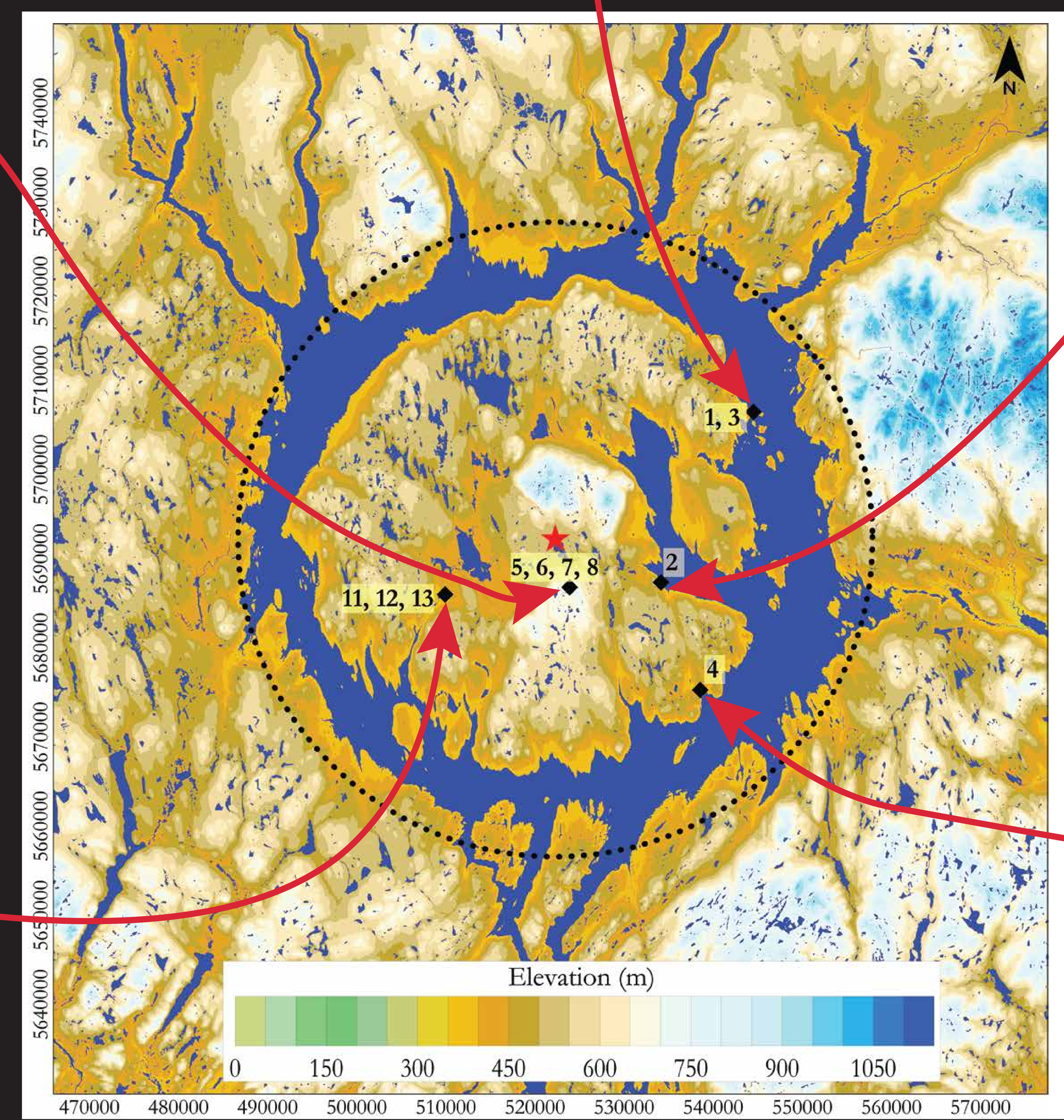
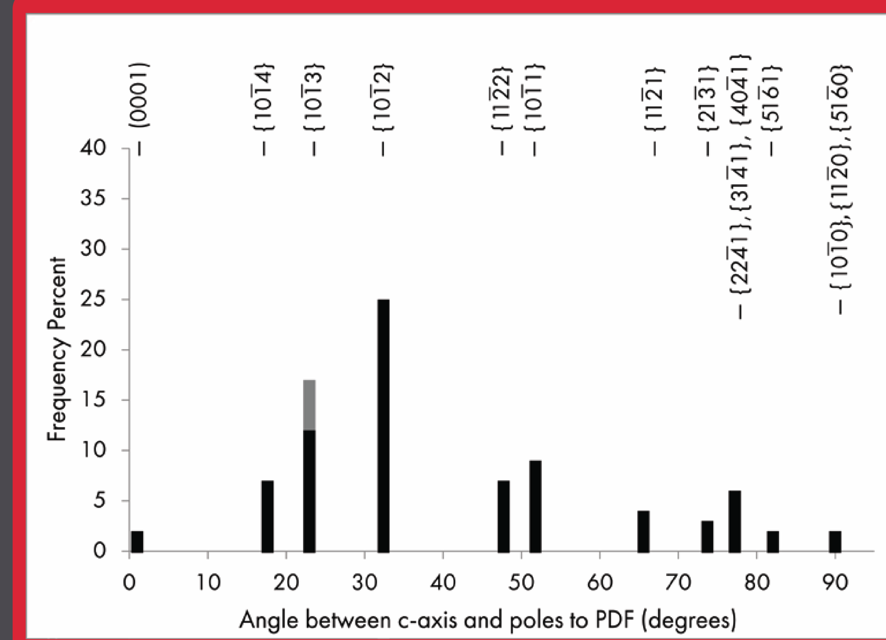
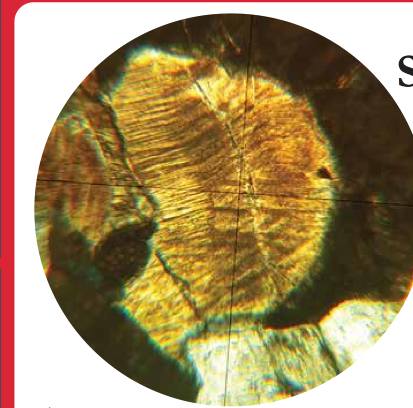


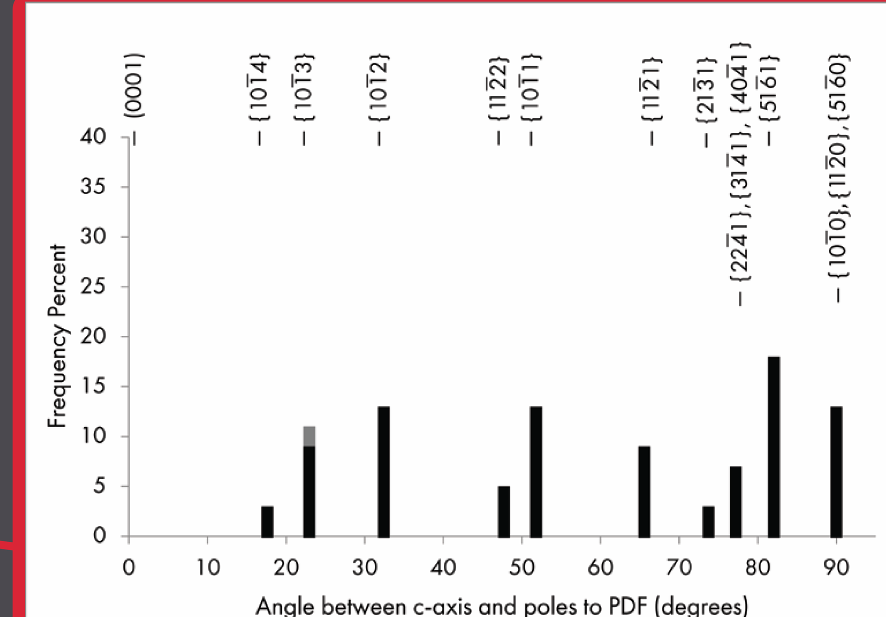
Figure 2: Topographic map of the Manicouagan impact structure. Sample locations examined in this study are indicated by black diamonds. The black dashed circle represents the approximate diameter of the impact structure, and the red star indicates the rough location of geometric centre.



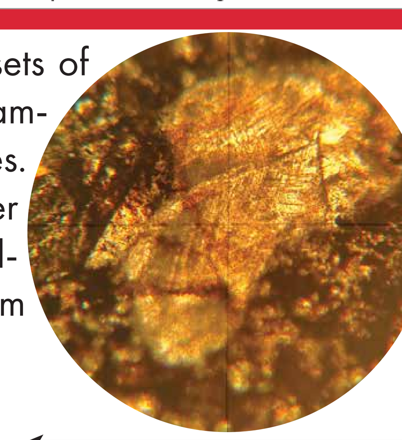


0.84 mm

Sample 2: Based on 162 sets of PDFs in 50 quartz grains examined. 7.4% unindexed planes. Average 3.2 sets of PDFs per grain. PDFs typically pervade entire grain. Located ~10 km from centre. XPL.



Sample 4: Based on 53 sets of PDFs in 21 quartz grains examined. 0% unindexed planes. Average 2.5 sets of PDFs per grain. Sample has been altered. Located ~20 km from centre. PPL.



1.28 mm

What is the deal with all of these HISTOGRAMS?

Each of the histograms shown above represents one sampling location, and shows the absolute frequency [3] percentage of indexed PDFs, where:

$$\text{absolute frequency} = \frac{\text{number of planes of a given orientation observed in sample}}{\text{total number of indexed planes in sample}} \times 100\%$$

Indexing was carried out using the program ANIE, described in [4] (angular error 5%, range of measured values used for indexing). Captions on individual histograms below detail total number of quartz grains examined, total number of PDFs identified, and the percentage of those PDFs that were not indexed. Each caption is accompanied by a photo showing a representative quartz grain from that location. The frequency of development of PDFs along the specific planes can then be used to estimate the peak pressure experienced by that rock sample, as detailed in [5].