CONFIRMATION OF SHOCKED QUARTZ GRAINS IN THE CRATER IN-FILL OF THE GLASFORD IMPACT STRUCTURE C. Alwmark[1] and C. C. Monson[2], [1]Department of Geology, Lund University, Lund, Sweden (carl.alwmark@geol.lu.se), [2]Illinois State Geological Survey, University of Illinois at Urbana-Champaign, 615 East Peabody Drive, Champaign, Illinois, 61820, USA.

Introduction: The Glasford structure in Illinois (USA) is a poorly studied 4 km-in-diameter complex impact structure, formed in a marine environment in the Late Ordovician (Sandbian) [1]. The structure is not visible on the surface, as it is overlain by ~350 m of younger units. Drillings into the structure revealed that these younger units are underlain by a sequence of syn- and post-impact crater fill units, including breccias, sandy dolomites, and dolomitic shales (e.g., [1]). For a detailed description of the stratigraphic units, see [1].

An impact origin for the Glasford structure was first proposed in the early 1960s, although no diagnostic evidence for impact was presented at that time [2,3]. It was not until very recently, when [1] verified previous, but ambiguous [4,5], claims of the presence of shatter cones, that an impact origin could be confirmed. In their study they also describe what they refer to as "planar microdeformation features" in quartz grains in samples from the in-fill of the structure, interpreted as possible shock metamorphic features. These include planar fractures (PFs) and planar deformation features (PDFs). [1] did not, however, present any crystallographic data to support the suggestion that the features were related to shock metamorphism.

In this contribution, we present preliminary results from a study aimed at re-examining the sample that [1] described as containing possible shock metamorphic features, in order to determine their nature.

Material and Methods: Three thin sections from a sample of a sandy dolomite interval of the crater in-fill from a drill-core (Peters #1 well) from the central part of the structure were selected for this study. This is the same sample that was described in [1] as containing possible microscopic shock metamorphic features. The sample is comprised of a dolomitic matrix with abundant vugs and clasts, up to 5 mm in size, of quartz, chert, carbonates, and fossil fragments [1]. The interval has previously been interpreted as part of the debris flows that followed after impact [1].

The thin sections were studied for shock metamorphic features with an optical microscope. Quartz grains displaying suspected PFs, PDFs, and feather features (FFs), were further studied using a Leitz 5-axis universal stage. The orientations of c-axes and the poles perpendicular to PDF planes in individual quartz grains were determined following the techniques described in [6,7], and then indexed with Miller–Bravais indices (hkil), using the updated stereographic projection template of [7]. All measured orientations that fell into the overlapping zone between ω $\{10\bar{1}3\}$ and $\{10\bar{1}4\}$ were treated as belonging to ω $\{10\bar{1}3\}$.

Results: A total of 42 quartz grains displaying one or more sets of PDFs (53 sets in total) and/or PFs (64 sets in total) were identified in the investigated sample (Fig. 1a, b). FFs were only detected in two grains, and the features were only poorly developed in a minor portion of the grain (Fig. 1c).

The majority of grains contain either PFs (40% of total measured grains) or both PFs and PDFs (24% of total). Grains with only PDFs make up 36% of the total. In quartz grains where both PFs and PDFs were observed, the PDFs are generally only present in the margin of the grains. In quartz grains that contain exclusively PDFs, these generally penetrate the entire grain. The average size (max. diameter) of quartz grains with PFs or PFs and PDFs is 390 μm, while grains only displaying PDFs have an average size of 170 μm. Furthermore, the grains with only PDFs are generally more angular.

The number of PF sets within each individual quartz grain varies from one to four, with an average of 2.6 sets/grain. For PDFs, the number of sets vary between one to five, with an average of 2.3 sets/grain.

Orientations of poles perpendicular to PDF, PF, and FF planes (126 in total) were measured and those corresponding to rational crystallographic planes in quartz, indexed and plotted (Fig. 1d). Of the total measured planes, seven (∼5%) did not correspond to any rational crystallographic orientation and, thus, remained unindexed.

Discussion and Conclusion: Multiple sets of PFs and PDFs in quartz grains oriented parallel to crystallographic planes that are typical for shock metamorphism (e.g., [6,7]) are present in a sample from the crater in-fill of the Glasford structure. The confirmation of these impact diagnostic shock metamorphic features further corroborates the idea that the structure was created by a hypervelocity impact.

There is a difference in grain size and also in appearance of the PDF sets in the investigated quartz grains. An average grain size of 390 μm of grains with PFs (± PDFs) differs from the size of quartz grains (170 μm) in which only PDFs were observed. This could imply that the shocked quartz grains are sourced from different portions of the target rocks. It is possible that the different populations were sourced either from target rock that experienced different shock pressures, or from different rock types (or a combination of both), where lithological features, e.g., porosity, influenced the development of shock metamorphic features. Different lithologies for the material is further implied by the varied roundness of the grains.

Calculation of average shock pressures of the two different populations of shocked quartz grains (i.e., with PFs or without PFs and with penetrative PDFs) according to the method described in [8] results in 8 GPa for the PF (± PDFs) -grains, and 16.5 GPa for the PDF-grains. Note that the method described in [8] is for determining shock pressures in crystalline quartz-bearing lithologies, and that the pressure here should be taken as a comparison value, not an absolute value.

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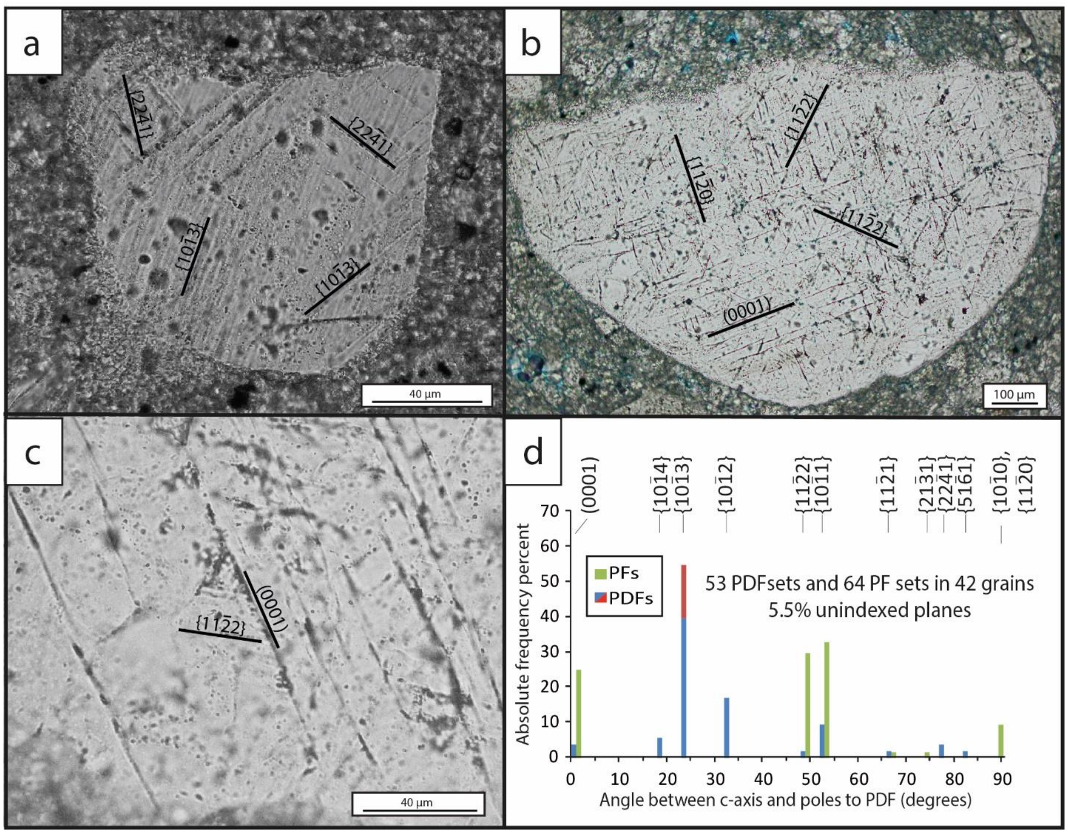

Fig. 1. Thin section photomicrographs (a-c) of shocked quartz grains from the sandy dolomite interval in the Peters-1 drill core from the Glasford impact structure (uncrossed polars). a) Quartz grain displaying five sets of decorated PDFs, two sets oriented parallel to ω $\{10\bar{1}3\}$ equivalent orientations and two sets oriented parallel to $\{22\bar{4}1\}$ equivalent orientations. A fifth set of PDFs, not visible on this image but observable under the U-stage microscope, are oriented parallel to ω $\{10\bar{1}3\}$. b) A large quartz grain with four sets of PFs, two oriented parallel to ξ $\{11\bar{2}2\}$, one parallel to *a* $\{11\bar{2}0\}$ equivalent orientations and one set oriented along the basal plane c (0001). c) Close-up of part of a quartz grain displaying one set of PFs oriented along the basal plane c (0001) and weakly developed FFs, oriented parallel to ξ $\{11\bar{2}2\}$ equivalent orientations. d) Histogram of absolute frequency percent of indexed PDFs and PFs in quartz grains from the sandy dolomite interval. Note that the total number of values was recalculated to 100% without unindexed PDF/PF orientations. PDFs that plot in the overlapping zone between the $\{10\bar{1}4\}$ and $\{10\bar{1}3\}$ crystallographic orientations are plotted in red on top of the uniquely indexed $\{10\bar{1}3\}$ planes.