WHAT DO SHOCKED QUARTZ GRAINS IN IMPACTITES FROM THE IODP EXPEDITION 364 DRILL CORE TELL US ABOUT THE CHICXULUB IMPACT EVENT? L. Ferrière[1], J.-G. Feignon[2], H. Leroux[3], and C. Koeberl[1,2], [1]Natural History Museum, Burgring 7, A-1010 Vienna, Austria (ludovic.ferriere@univie.ac.at), [2]Department of Lithospheric Research, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria (christian.koeberl@univie.ac.at), [3]Unité Matériaux et Transformations, Université de Lille, F-59655 Villeneuve d'Ascq, France.

Introduction: The peak ring of the about 200 km diameter Chicxulub impact structure (Mexico) was drilled in 2016 in a project supported by the International Ocean Discovery Program (IODP) and International Continental Scientific Drilling Program (ICDP). Unique samples were recovered (i.e., the first peak ring samples ever), giving the opportunity to better understand the nature and formation mechanism of peak rings [1] and to map the distribution of shock effects in minerals with depth. As the exact source (i.e., sampling horizon) of the shocked minerals in the K–Pg boundary is still not fully understood, the newly recovered samples can also contribute to a better understanding of the ejection process in general.

Within the framework of the 2016 drilling project, a continuous core, M0077A, was recovered between 505.7 and 1334.7 mbsf (meters below sea floor), and was subdivided into three main lithological units: (1) a "post-impact" section (from 505.7 to 617.3 mbsf), (2) an "upper peak ring" section of suevites and impact melt rocks (from 617.3 to 747.0 mbsf), and (3) a "lower peak ring" section, mainly consisting of granitoid rocks (with aplite and pegmatite dikes) intruded by different types of sub-volcanic dikes, and intercalations of millimeter to decameter thick suevite and impact melt rock units (from 747.0 to 1334.7 mbsf) (for more information, see [2]).

Here we report on investigations of shocked quartz grains from both the "upper" and "lower peak ring" samples, combining optical, universal stage (U-stage), scanning (SEM), and transmission electron microscopy (TEM) investigations. We also tentatively compare our findings with literature data on shocked quartz grains from both, previous drill core samples from the Chicxulub crater and from various K–Pg boundary locations.

Material and Methods: Polished thin sections were prepared from a number of suevite, impact melt rock, and granitoid samples. They were investigated and searched for shock metamorphic features, first using the polarizing microscope, and then quartz grains displaying planar deformation features (PDFs) were further investigated using the U-stage microscope. Selected grains were additionally analyzed using SEM and TEM (on focused ion beam (FIB) foils).

Results: Quartz grains occur in suevite samples as relic mineral clasts or within rock fragments and show planar fractures (PFs) and/or (decorated) PDFs, with up to 3 sets (as seen under the optical microscope). A few toasted quartz grains were also noted. Similar shock features in quartz as seen in suevite samples were observed in the impact melt rock samples, including PFs and PDFs, and toasted quartz. No good statistics are yet available for the PDF orientations in both suevite and impact melt rock samples, as so far we mainly studied samples from the "lower peak ring" section, in which shocked quartz grains are much more abundant and were formed "in-situ" (i.e., in both, suevite and impact melt rock samples, shocked quartz grains are "inherited", and thus, good statistics are necessary and their significance is also more difficult to interpret).

In the granitoid basement rocks from the "lower peak ring" section, shocked effects in quartz can be, in a few cases, already seen with the naked eye, in the form of macroscopically visible PFs. In thin sections, most (if not all) quartz grains are shocked, with PFs, feather features (FFs), and/or (decorated) PDFs (Fig. 1; up to 4 sets of PDFs are seen under the optical microscope). Kinkbanding was also observed in some shocked quartz grains (Fig. 2).

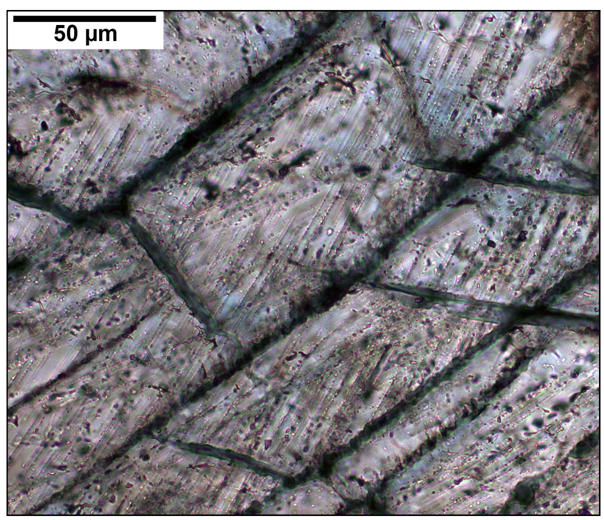

Fig. 1. Microphotograph (cross-polarized light) of a quartz grain with a number of sets of planar factures, feather features, and (decorated) planar deformation features. Granitoid sample M0077A_142R3_48-50 (862.6 mbsf).

As seen under the optical microscope, and further documented by SEM, the PDFs are decorated with vugs or tiny fluid inclusions. The TEM observations on FIB foils cut across shocked quartz grains allowed to resolve the PDFs at high magnification, indicating that they are composed of aligned fluid inclusions or vugs and dislocations (Fig. 3), microstructures typical of annealed PDFs. Free dislocations and subgrain boundaries were also observed. Dislocations preferentially occur along the "vugs/fluid inclusions trails". No glass-bearing lamellae were detected in the investigated samples.

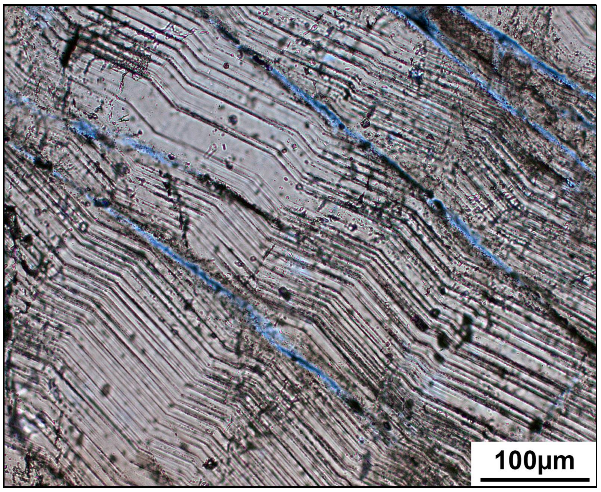

Fig. 2. Microphotograph (cross-polarized light) of a shocked quartz grain with kinkbanding. Open fractures are also visible (in blueish-grey). Granitoid sample M0077A_153R3_55-56 (893.4 mbsf).

Using the U-stage, we were able to characterize the crystallographic orientation of both PFs and PDFs. The PFs are mainly oriented parallel to (0001) and $\{10\bar{1}1\}$. The PDFs are preferentially oriented parallel to $\{10\bar{1}3\}$ and $\{10\bar{1}4\}$ orientations (i.e., representing together between ~70 to 80% of the total). In order of relative decreasing abundance, PDF planes parallel to (0001), $\{10\bar{1}2\}$, $\{10\bar{1}1\}$, $\{11\bar{2}2\}$, and $\{31\bar{4}1\}$ orientations also occur, but they rarely represent more than a few percent of the total. A few PDF planes parallel to other orientations exist but are rare.

Discussion: Based on our U-stage results we estimate shock pressures between ~12 and 15 GPa for the granitoids from the "lower peak ring" section, consistent with preliminary observations [3], and little to no attenuation of shock pressure with depth within the investigated core. The observation that PDFs are annealed and decorated indicates that the originally amorphous PDFs were recrystallized during a post-shock thermal episode. Kinkbanding of some shocked quartz grains shows that, after the propagation of the shock wave and formation of PDFs, the granitoids from the "lower peak ring" section were subject to intense stress and were sheared, as also indicated by mineral-specific fracturing and localized cataclasites.

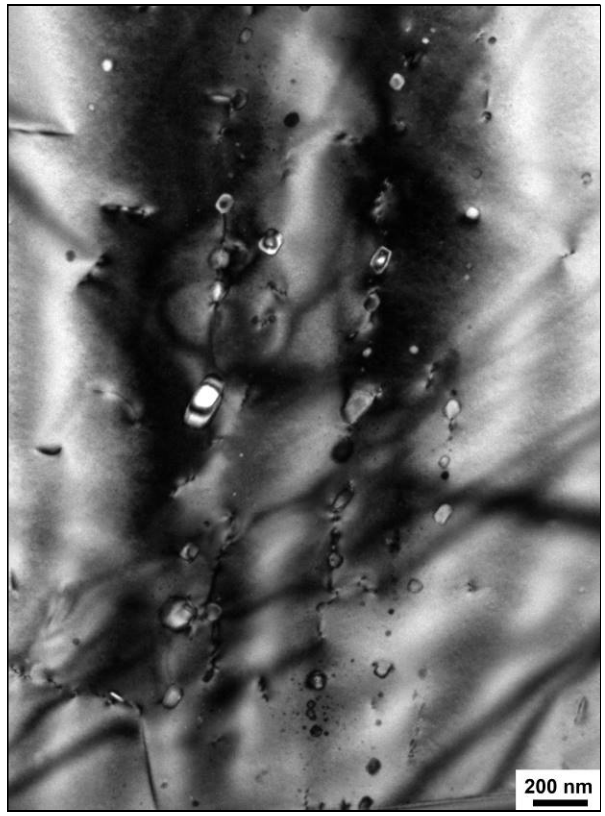

Fig. 3. Bright field transmission electron micrograph of a quartz grain with one set of decorated PDFs. Granitoid sample M0077A_142R3_48-50 (862.6 mbsf).

Previously published data for drill core samples from the Chicxulub crater and from a number of K–Pg boundaries (see [4] and references therein) showed that the relative abundance and the size of the shocked quartz grains, as well as the PDF orientations, vary from one site to another, but also within one site. Our results are difficult to compare in detail with existing data, but it is obvious that the abundance of shocked quartz grains and the average of 2.4 PDF sets/grain are significantly higher than in all previously investigated drill core and most K–Pg boundary samples.

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