CHARACTERIZATION OF SHOCKED QUARTZ GRAINS AND SHOCK PRESSURE ESTIMATIONS IN THE CHICXULUB IMPACT STRUCTURE PEAK-RING GRANITES FROM IODP-ICDP EXPEDITION 364 DRILL CORE. J-G. Feignon[1], L. Ferrière[2], and C. Koeberl[1,2], [1]Department of Lithospheric Research, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria (jean-guillaume.feignon@univie.ac.at), [2]Natural History Museum, Burgring 7, A-1010 Vienna, Austria.

Introduction: The peak-ring of the ~200-km diameter Chicxulub impact structure (Mexico) was drilled in 2016 during the International Ocean Discovery Program (IODP) and International Continental Scientific Drilling Program (ICDP) supported Expedition 364.

A continuous core (M0077A) was recovered between 505.7 and 1334.7 mbsf (meters below sea floor). It was divided into three main lithological units: (1) a "post-impact" sedimentary rocks section (from 505.7 to 617.3 mbsf), (2) a "upper peak-ring" section (from 617.3 to 747.0 mbsf) made of ~105 m of melt-bearing polymict impact breccia (suevite) overlaying ~25 m of impact melt rocks, and (3) a "lower peak-ring" section (from 747.0 to 1334.7 mbsf) consisting of granitoid (coarse-grained leucogranite with aplite and pegmatite dikes) intruded by several pre-impact sub-volcanic dikes and intercalations of millimeter- to decameter-sized suevite and impact melt rocks [1].

Here we report on the main results of a detailed investigation of shocked quartz grains in granites from the "lower peak-ring". The characterization of the shock features in quartz was followed by an estimation of the average shock pressure recorded by each sample.

Material and Methods: Forty-one polished thin sections were prepared for a selected number of granite samples taken at intervals as regularly spaced as possible between 747.0 and 1334.7 mbsf. They were investigated for shock metamorphic features in quartz and other minerals using optical and scanning electron microscopy (SEM). Planar deformation feature (PDF) orientations were further investigated using the Universal stage (U-stage) on an optical microscope for ten thin sections ranging from 747.0 to 1311.1 mbsf, and an additional thin section with granite clast included in impact melt rock sample from the "upper peak-ring" (743.6 mbsf). These thin sections were selected due to their high abundance in individual quartz grains (at least 20) in order to provide reasonable statistics. The indexing of the PDFs orientations was performed using the WIP software [2] as well as manually [3]. Shock pressure estimates were done following the method described in [4].

Results: Quartz grains are relatively abundant in the granite from the "lower peak-ring" section, representing 25 to 35 vol. % of the mineral phases. Orthoclase (25-40 vol. %) and plagioclase (25-35 vol. %) and, to a lesser extent, biotite (generally chloritized [1-5 vol. %]), are the other main minerals (i.e., all these minerals show more or less abundant shock deformation features).

In rare cases, shock effects in quartz grains can be seen with the naked eye, in the form of macroscopically visible planar fractures (PFs). In the investigated thin sections, nearly all observed quartz grains are shocked (99.8%), including PFs with (or without) feather features (FFs) associated and decorated PDFs (up to 6 sets of PDFs as seen under the U-stage) (Fig. 1). In addition, a number of quartz grains show strong undulose extinction and rarely even kinkbands. As seen under the optical microscope and further documented under the SEM, PFs can be filled with calcite and PDFs are decorated with tiny vugs or fluid inclusions.

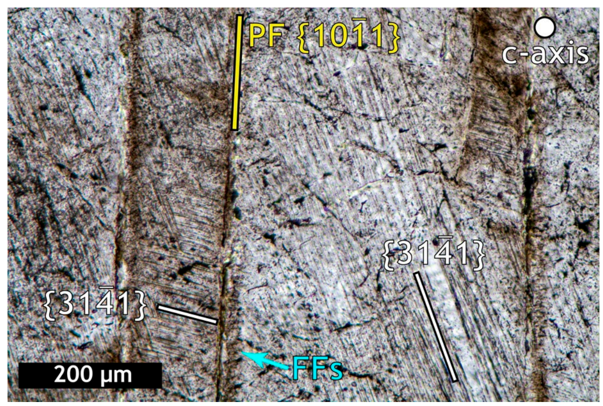

Fig. 1. Microphotograph (transmitted light) of a quartz grain with one set of PFs (oriented parallel to {10$\bar{1}$1}) with branched FFs and two sets of decorated PDF (both oriented parallel to {31$\bar{4}$1}). The grain c-axis is vertical. Granite sample 97R3_10-12.5 (752.5 mbsf).

The U-stage was used to characterize the crystallographic orientation of both PFs and PDFs in quartz. In total, 917 sets of PDFs were measured in 335 quartz grains, resulting in an average of ~2.7 PDFs sets per grain.

Planar fractures 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}$4} orientations (i.e., representing together 66.8% of the total measured orientations; Fig. 2). Then, by decreasing abundances, PDFs parallel to {10$\bar{1}$2} (7.4%), {10$\bar{1}$1} (4.1%), {22$\bar{4}$1} (3.3%), {11$\bar{2}$2} (3.1%), and {21$\bar{3}$1} (2.5%) occur. Other orientations have frequencies below 2%, with a few basal PDFs parallel to (0001) (1.7%), whereas PDFs with {51$\bar{6}$0} orientation were not observed in our dataset. The frequency of unindexed sets is below 10% (i.e., ~6% in average) which is reasonable considering that quartz grains often exhibit undulose extinction.

The average number of PDF sets per grain seems to slightly decrease with increasing depth. The three deepest samples investigated so far have mainly shocked quartz grains with two sets of PDFs (representing ~32 to 49 % of the total), whereas the shallowest samples have a majority of quartz grains with three sets of PDFs (representing ~30 to 48 % of the total).

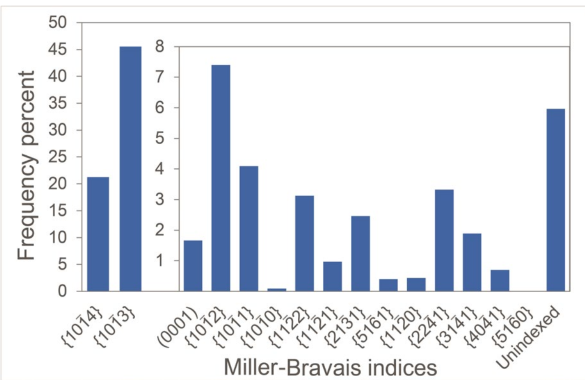

Fig. 2. Compilation of PDF orientations frequencies for all the investigated samples (917 PDF sets in 335 grains). The total proportion of unindexed sets is ~6%.

Discussion and Conclusions: Based on our U-stage results we estimate that the granites from the "lower peak-ring" section have recorded shock pressures between ~15 and 18 GPa with a very slight shock attenuation with increasing depth (Fig. 3). Our pressure estimates are consistent with observations on zircon grains [5]. In general, the range of pressure estimates from sample to sample is very narrow, taking into account the errors associated with the measurements. Interestingly, PDFs parallel to the {10$\bar{1}$2} orientation (i.e., known to form at pressures of ~20 GPa [4]) are significantly more abundant in the upper section of the granite basement (representing between 6 and 14 %) than in the lower section (representing less than 3 %). This further supports the suggestion that the upper section of the granite basement experienced slightly higher shock pressures than the lower section. In addition, the granite clast included in impact melt rock experienced a higher shock pressure, with a significantly higher abundance of grains with 5 PDF sets (i.e., 30.4% vs. less than 15% for the other investigated samples).

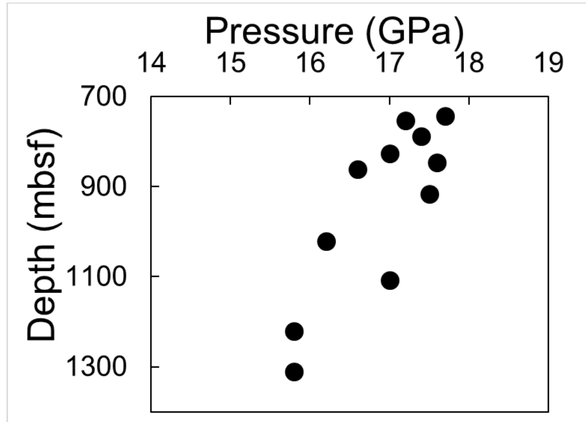

Fig. 3. Average shock pressure estimates versus depth in granites from the "lower peak-ring" section. The pressure range is narrow but a slight decrease with depth is apparent.

Interestingly, the abundance of shocked quartz grains (99.8 %) and the average of 2.7 PDF sets per grain is significantly higher than in all previously investigated drill cores recovered at the Chicxulub structure and for most K–Pg boundary samples for which shocked quartz data are available (e.g., [6] and references therein).

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