STRUCTURAL DEFORMATION IN THE PEAK RING OF THE CHICXULUB IMPACT CRATER – FIRST RESULTS FROM IODP-ICDP EXPEDITION 364. M. H. Poelchau[1], U. Riller[2], A. S. P. Rae[3], J. Lofi[4], S. Gulick[5], N. McCall[5] T. Kenkmann[1], M. Pfaff[1], M. Scheiblich[1], and Expedition 364 Scientists, [1]University of Freiburg, Geology, Freiburg, Germany (Michael.poelchau@geologie.uni-freiburg.de), [2]Institut für Geologie, Universität Hamburg, Hamburg, Germany, [3]Department of Earth Science and Engineering, Imperial College London, UK, [4]Géosciences Montpellier, Université de Montpellier, France, [5]Institute for Geophysics, University of Texas, Austin, TX, USA.

Introduction: IODP-ICDP Expedition 364 targeted and cored rocks from the peak ring of the Chicxulub impact crater. Among the goals cited for this drilling, emphasis was placed on gaining a deeper understanding of the mechanisms that enable the formation of peak rings and large impact basins. Structural indicators for successive phases of deformation were observed during offshore and onshore coring and logging, and preliminary results are presented here.

Coring of the peak ring began at 505.7 mbsf (meters below sea floor). Cores consist of ~110 m of post-impact sediments that transition into a ~130 m thick succession of suevites and impact melt rocks. A suite of shocked granitoids interspersed with minor pre-impact magmatic intrusions occurs below 747.1 mbsf down to the final coring depth of 1334.7 mbsf [1,2]. These basement rocks contain several meter-sized bodies of impact melt rock and suevite, and a ~58 m thick unit of suevite and melt rock was recovered near the bottom of the core.

Methods: Halved cores were inspected visually during the IODP onshore science party for shear faults and fractures, with a strong focus on the granitic portions of the peak ring. General overprinting relationships were established for different types of faults and fractures. The orientations and shear sense of over 600 fault surfaces and striations were measured on the archive halves of the cores. Thin sections were available for qualitative analysis of shock metamorphism and microstructural deformation. High-resolution acoustic images of the borehole wall from slimline downhole logging yielded azimuthal and dip data of lithological contacts. Downhole images in combination with dual energy CT scans (scans thanks to Weatherford Laboratories, Houston, TX, processing thanks to Enthought, Austin, TX, [3]) were used to reorient the cores to their pre-coring orientation [4], thus a true 3D analysis of fault kinetics is now possible.

Structural deformation styles: Deformation in the granitoids shows a large range of respective structures, including hairline fractures, sub-mm-thick brittle shear faults, mm- to cm-thick (ultra)cataclasites, striated shear planes that occasionally show multiple shear orientations, and dm-thick zones of foliated and crenulated mineral fabrics. Fractures and faults are observed throughout the granitoid cores. Spacing of prominent shear faults is typically on the order of one to several dm, but isolated portions of macroscopically undeformed granitic rock may reach 1-2 m. Fault displacement in the granitoids is often difficult to determine and observed throws are commonly < 1 cm, although local displacement can exceed several dm when shear markers are present.

Of particular note is that up 5 m thick, pre-impact mafic and intermediate dikes show less deformation than the granitic host rocks with regard to occurrence and spacing of faults and fractures. This effect may be related to the stronger influence of the shock wave on coarse-grained, quartz-rich granitoids; preliminary geophysical results indicate an abnormally high porosity and low density of the granitoids (~10% and ~2.4 g/cm³, [2,5,6]), and during handling of the cores it was observed that quartz grains in the granitoids were particularly brittle. Initial rock mechanic testing of the granitoids at the University of Freiburg yielded a very weak uniaxial compressive strength value of ~15-20 MPa, compared to typical handbook values of intact granite of 100-200 MPa.

Orientational data: Shear fault surfaces and striations measured in the cores are currently being evaluated and results are expected for the conference. A first look at reoriented data based on the method described in [4] shows no preferential orientation of the fault surfaces. Fault-slip analysis will be carried out to determine principal strain axis orientations.

The orientations of pre-impact magmatic dikes and impact-derived suevite and melt rock bodies were determined from downhole acoustic imaging and are shown in Fig. 1. Surprisingly, the pre-impact dike orientations are tightly clustered. This may indicate that the granitoids in the core were not subject to large magnitudes of differential rotation during crater formation. The contact margins of suevites and melt rock zones on the other hand are more variable in orientation than pre-impact dike margins. Hence, suevite and impact melt rock emplacement may have occurred under a more complex dilational stress field.

Succession of deformation mechanisms: Structural overprinting criteria of deformation features were observed in the cores and point to a relative age of impact-induced planar structures, leading to the following succession of events: (1) Shock metamorphic generation of new microflaws within the granitoids (e.g., planar fractures in quartz) which structurally weakened the rock. (2) Formation of cataclasites and ultracataclasites in localized zones. (3) Displacement of cataclasites by shear faulting. (4) Opening of faults and emplacement of suevite and impact melt rock into dilation zones. Clasts of granitoids containing cataclasites and shear faults were observed within impact melt rock. (5) Deformation of suevite and impact melt rock, including granitoid clasts, observed as ductile shear bands in a horizontal extensional regime.

Discussion of deformation events: The granitic rocks of the peak ring must have experienced a range of pressures and stress fields during the cratering event that may prove difficult to differentiate. Striated shear faults were occasionally observed with two or rarely more striation orientations, thus indicating multiple deformation episodes, and are a potential indicator for the process of acoustic fluidization as a weakening mechanism during crater formation. In spite of multiple kinematic episodes, pre-impact dikes do not seem to have been affected by large differential rotations. Thus, a large portion of the ~500 m succession of granitoids may have behaved as a semi-coherent block during crater excavation and modification. Large-scale thrusting of the target rocks as apparent in hydrocode models of peak-ring formation [1] appears to have occurred without inducing internal rotation.

Furthermore, the ~58 m succession of suevite and impact melt rock encountered at the bottom of the cores may have served as a glide plane for the ~500 m granitoid block during peak ring formation. The emplacement of suevites and impact melt rocks is discussed in [7].

Outlook: We intend to perform detailed fault slip analyses of shear faults in the granitoids in the near future. These results can potentially give further insights into the stress and strain history of the peak ring rocks.

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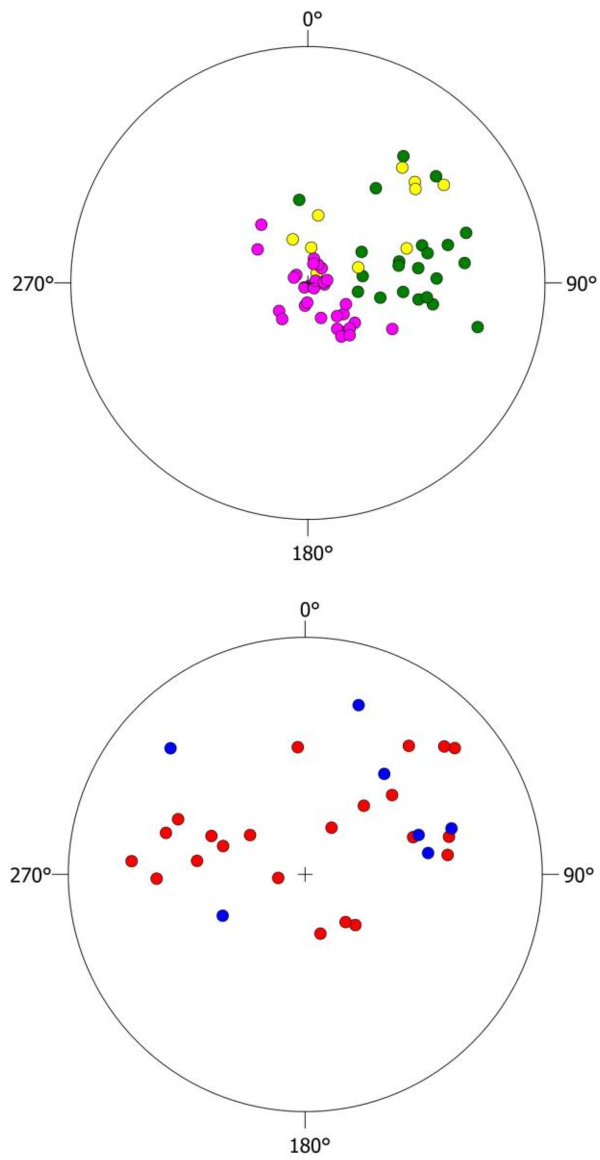

Fig. 1: Stereoplots showing poles to margins of pre-impact dikes (top; n=62) and impact-derived suevite and impact melt rock bodies (bottom; n=30) determined from downhole acoustic imaging. The tight clustering of pre-impact dikes indicates a lack of folding in the ~500 m succession of granite in the peak ring. Green: mafic dikes, yellow: intermediate dikes, pink: aplites and pegmatites, blue: suevite, red: impact melt rock.