DEFORMATION OF THE CHICXULUB PEAK RING: FIRST INSIGHTS FROM FAULT-SLIP ANALYSIS.

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Introduction: During IODP-ICDP Expedition 364 at site M0077A, lithologies that make up the Chicxulub peak ring were cored, including over 500 m of deformed granitoid rocks [1,2]. Two of the main goals of the drilling are to investigate the nature and formational mechanism of peak rings and to study how rocks are weakened during large impacts. To better understand the structure and deformational history of these peak ring rock, granitoids were mapped in detail by their deformational styles.

Fault-slip analysis: During the onshore segment of Expedition 364, discrete fault surfaces with impact-generated striations were found within the granites. Fault-slip analysis can potentially give insights into the local stress state during formation of the faults. Therefore, 602 fault surfaces and striation orientations were measured, and the sense of slip on faults was determined. High-resolution acoustic images of the borehole wall in combination with dual energy CT scans (Weatherford Laboratories, Houston, TX, and Enthought, Austin, TX, [3]) were used to reorient the fault surfaces to their pre-coring orientation [4]. Fault planes were then evaluated using the TectonicsFP software package (version 1.7.8, [5]), observing recommendations given in [6].

Mapping results: Large stretches of macroscopically intact basement rocks were recognized. Other portions consist of moderately deformed rocks that show a high density of shear fractures. Stronger deformed zones are often pervasively penetrated by localized cataclasites or crenulated foliation. Impact melt rock intrusions are found and often occur together with thick localized cataclasites. In total, 28% of the basement rocks were categorized as intact, 15% have tensile fractures, 28% have shear fractures, cataclasites and ultracataclasites, 14% have crenulated foliation and 14% have impact melt rock and suevite bodies as the dominant feature.

Fault-slip results: 602 striated faults are well-distributed within the granitic units of the core, while only six of them were found in the lower suevites and impact melt rocks. Single core sections can contain either several faults with the same fault and slip orientation, or with several highly varying fault and slip orientations. Six fault planes were found where two different slip orientations were measurable on the same surface. Approximately 40% of the faults are reverse faults, while the rest are normal faults.

Evaluation of the complete dataset with TectonicsFP indicates that the faults did not form under a uniform stress state. Subdivision of the dataset into reverse and normal faults, as well as into more localized sections of reverse and normal faults based on mapping described above could also not identify single statistically valid stress states for the subsets (e.g., fluctuation histograms show a large percentage of errors >20°). The evaluation clearly shows that the faults did not form as simple conjugate sets in a compressive or tensile regime. Multiple deformation phases have occurred, visible e.g. in dual striations found on single fault planes.

Interpretation & consideration of deformation stages: Based on mapping and initial fault-slip results, different types of deformation are interpreted to correspond to phases of the crater and peak ring formation process.

(I) After the passage of the shock wave, the excavation stage forms zones of flattening through subsimple shear. High strain-rate and more pervasive deformation is expected, leading to non-discrete deformation in the form of crenulated foliation, plus cataclasite formation as the main deformation styles. (II) The excavated transient cavity begins to collapse, leading to gravity driven crater-inwards directed flow that may result in transpressional deformation. Softening mechanisms like acoustic fluidization are required for continued crater flow, and cataclasites may be a prime expression of this. The formation of radial transpression ridges is possible and may mark a gradual transition from pervasive to discrete deformation and localized, discrete faulting, including the generation of a complex system of striated faults. (III) The central uplift then overshoots and itself collapses, leading to outwards directed material flow in the form of localized thrusting and imbrication as well as possible transtensional deformation, forming a second, complex system of striated faults that overprint the first system. The formation of radial transtension troughs is possible and may lead to the incorporation of melts and suevites through tensile hoop stresses. Ongoing shear faulting and large-scale imbrication of granite blocks through the exploitation of weak melt rock zones is expected.

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