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Orientation of magmatic dykes and impact-induced faults in the peak ring of the Chicxulub crater inferred from borehole imaging

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The Chicxulub impact crater formed ∼65.5 My ago on the Yucatan peninsula and is currently buried below post-impact sediments. It is the only known terrestrial impact structure directly linked to a mass extinction event (K-Pg) and presenting an intact, unequivocal topographic peak ring. In 2016, in the framework of IODP and ICDP, the mission specific platform Expedition 364 drilled a ∼1.3 km deep borehole at Site M0077A into the crater's peak ring. It allowed recovery of 303 excellent quality cores from 505.7 to 1334.7 mbsf and the acquisition of more than 5.8 km of open hole logs. The first expedition results published by Morgan et al.(2016) argue that the drilling confirms the dynamic collapse model of peak-ring formation and highlight that this peak ring mainly consists of uplifted granitoids from the mid crust. When brought to the surface during crater formation, these rocks get deformed in a way that dramatically reduces their density and increased their porosity.

Downhole logs are rapidly collected, continuous with depth, and measured in situ; these data are classically interpreted in terms of stratigraphy, lithology, porosity, fluid content, geochemical composition and structure of the formation drilled. During Expedition 364, high-quality high-resolution acoustic borehole images of the borehole wall were acquired. These data can ideally resolve features such as bedding, stratification, fractures and burrows. Because the images are oriented to magnetic north, further analysis can be carried out to provide measurement of the dip and dip direction of planar structures. An inclined plane in the borehole (e.g., a fault) appears as a sinusoid on the image, and the amplitude of this sinusoid is proportional to the dip of the plane. The lowest part of the sinusoid indicates the dip direction of the plane.

In order to better understand how the rocks weakened and deformed during the impact, we used borehole images to characterize the spatial orientation and vertical distribution of two types of planar features contained in the granitic target rocks of the peak ring: (1) dykes (either pre-impact or impact-related dykes) and (2) fractures. Pre-impact dyke orientations are tightly clustered. Assuming that these dykes were emplaced under the same stress field (i.e. dike swarms), differential rotation of target rocks appear to have been minimal, suggesting they behaved as a semi-coherent block during crater formation. These results agree with both feather features studies at the mineral scale (Poelchau et al., in prep.) and numerical impact simulations (Rae et al., in prep.). Impact related dykes are more variable in orientation than pre-impact dykes, while the impact-related fractures show three well-defined clusters, the origin of which still needs to be determined.

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