DEFORMATION, SHOCK BAROMETRY, AND POROSITY WITHIN SHOCKED TARGET ROCKS OF THE CHICXULUB PEAK RING: RESULTS FROM IODP-ICDP EXPEDITION 364.

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Introduction: Peak rings are highly distinctive features of large impact structures and yet the mechanism of their formation remains debated [1]. Seismic imaging, numerical simulations, and the recent IODP-ICDP drill-core at the Chicxulub crater suggest that peak rings are formed by the dynamic collapse of an over-heightened central uplift during crater modification [2]. The collapse of complex craters, however, requires a substantial temporary reduction in the strength of deforming crater rocks and induces unique changes to the physical properties of para-autochthonous impactites.

Numerical impact simulations are capable of predicting geologically observable properties: strain, peak shock pressures, and the porosity of peak ring materials, e.g., [3,4]. By measuring these properties in recovered cores, it is possible to corroborate the predictions made by numerical impact simulations, and therefore to gain insight into the process of peak ring formation.

Located in the Yucatán peninsula, Mexico, beneath ~600–1000 m of Cenozoic sedimentary rocks, the ~200 km diameter Chicxulub impact structure is one of the three largest known impact structures on Earth [5]. The Chicxulub impact structure contains the only known unequivocal, pristine peak ring on Earth, ~80 km in diameter [6].

In April-May 2016, IODP-ICDP Expedition 364 drilled a single hole into the Chicxulub peak ring, achieving a final depth of 1335 mbsf. With ~100% recovery, over 500 m of shocked target rocks were recovered, largely consisting of coarse-grained granitic rocks.

Here, we present observational data sets; shock barometry, density, and porosity measurements, for comparison with the results of numerical impact simulations, to constrain the mechanism of peak ring formation.

Methods: Several techniques were used to obtain data for comparison with numerical models. Firstly, estimates of peak shock pressures can be obtained by characterising the orientations of planar deformation features (PDFs) in quartz. PDF orientations were obtained using an optical microscope and a universal stage and were indexed using ANIE v1.1 [7], individual quartz grains were assigned shock pressures based on [8, and refs. therein], and overall shock pressure estimates were obtained using the method of [9].

Secondly, density and porosity measurements were carried out by members of the Expedition 364 science party using He-pycnometry. Combining this data with a continuous computed-tomography (CT) scan of the entire core provides high-resolution (0.3 mm) density and porosity logs. Furthermore, back-scattered electron (BSE) images of discrete samples have been obtained

Samples	Number of measured sets	Number of indexed PDFs (N*)	Unindexed %	Number of quartz grains (n)
10	753	626	16.8	296

No. of PDF sets, % relative to n

0	1	2	3	4
0.34	23.0	44.6	29.1	3.04

Indexed plane abundance (absolute frequency %)

c (0001)	ω $(10\bar{1}3)$	Π $(10\bar{1}2)$	r, z $(10\bar{1}1)$	m $(10\bar{1}0)$	ξ $(11\bar{2}2)$	s $(11\bar{2}1)$	ρ $(21\bar{3}1)$	x $(51\bar{6}1)$	a $(11\bar{2}0)$	$(22\bar{4}1)$	$(31\bar{4}1)$	t $(40\bar{4}1)$	k $(51\bar{6}0)$	e $(10\bar{1}4)$
31.3	26.0 + 8.9	5.9	4.2	0.64	2.9	1.6	1.6	0.6	0.2	0.5	2.1	0.3	0.3	12.9

Table 1: *Summary of all universal-stage results collected at the time of writing, Indexed plane abundance, given in absolute frequency percent, does not include unindexed PDFs. PDF sets in overlap between* $(10\bar{1}3)$ *and* $(10\bar{1}4)$ *were assigned the* $(10\bar{1}3)$ *orientation indicated by the bracketed value. A 5° error envelope was used to assign PDFs.*

using a scanning electron microscope (SEM) to ascertain the size, shape, orientation, and formation mechanisms of porosity in these samples. Finally, numerical simulations of the Chicxulub impact event were carried out using the iSALE shock physics code [10, and refs. therein].

Results: Preliminary results from 10 samples of granitic basement rocks (**Table 1**) indicate that the assemblage of PDFs in quartz is dominated by ω orientations; suggesting that all of the granitic basement rocks experienced shock pressures of ~12.5–17.5 GPa. Through the recovered core, there appears to be little or no attenuation of recorded shock pressure with depth (**Figure 1**).

The shocked target rocks have unusually low densities (~2.4 g/cc), and high porosities (~8–10 %). Preliminary analyses suggest that the cause of this high porosity is a combination of pervasive fracturing and micro-brecciation on the sub-grain scale, and abundant, localized, cataclastic shear zones (**Figure 2**).

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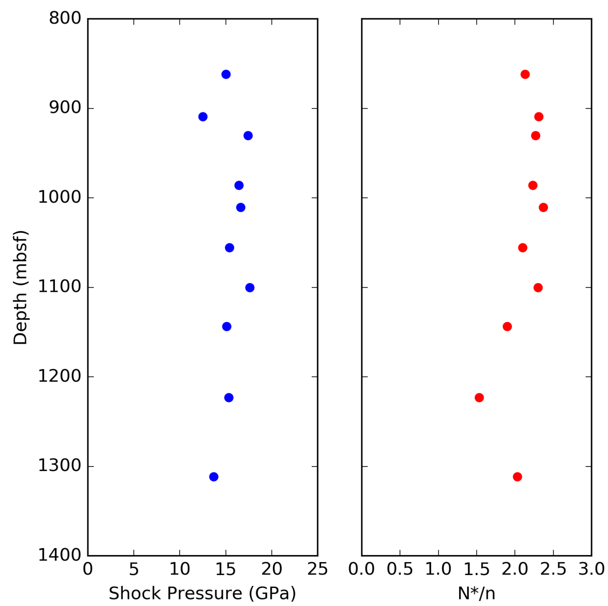

Figure 1: *Estimated shock pressures, and number of indexed PDF sets per grain (N*/n) in samples from site M0077A.*

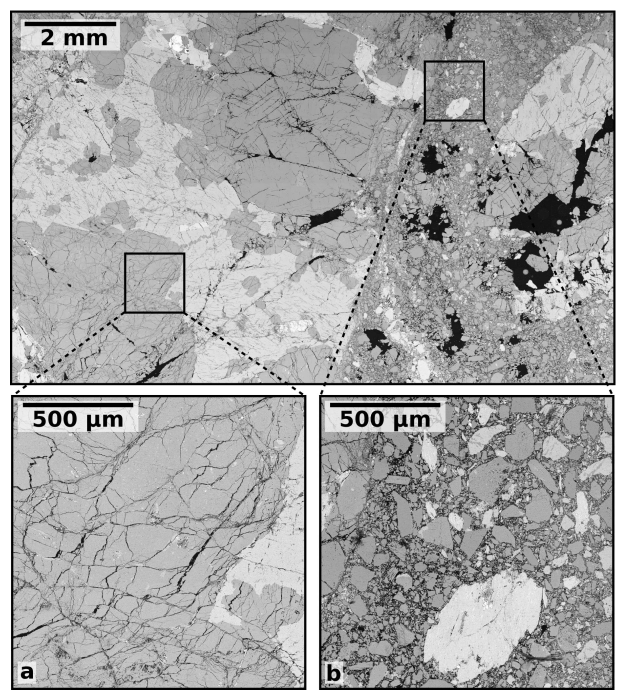

Figure 2: *BSE SEM image of deformed granitic basement (814.85 mbsf) displaying (a) pervasive fracturing and (b) cataclastic shear deformation.*