CHICXULUB ZIRCON (AND APATITE!)

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Introduction: Zircon ($ZrSiO_4$) has been studied for its impact metamorphism, and its potential to record the age of the impact and source rocks for Chicxulub ejecta (e.g., [1−7]). IODP-ICDP Expedition 364 recovered 829 m of drill core down to a depth of 1334.7 meters below sea floor (mbsf) from the peak ring of the Chicxulub impact crater [8−9]. This study of the impact metamorphism of zircons in granitic rocks from the lower peak ring (LPR; 747 to 1335 mbsf) complements my study of suevites and impact melt rocks from the upper peak ring section (UPR; 617 to 747 mbsf; [7]) to obtain a comprehensive record of impact-related P-T conditions in Chicxulub's peak ring rocks.

Samples and Methods: At Arizona State University, I analyzed 10 samples from granitic and doleritic rocks of the LPR in petrographic thin sections by optical microscopy, and electron microprobe analysis. Using X-ray intensity mapping and imaging, I quantitatively characterized impact-metamorphic features in zircon assemblages.

Results: Seven of the ten LPR samples are variably brecciated granites, one is a trachyte dike, and two are a basanite dike with granite wallrock, and a phonotephrite dike with a garnet gneiss inclusion, repectively. The major granitic components are quartz, albite with patches of oligoclase, and perthitic orthoclase with a celsian component <5 mol%. Quartz exhibits multiple sets of decorated planar deformation features and occasional feather features; no high pressure polymorphs of SiO_2 or diaplectic SiO_2 glass occurs in the studied samples. This indicates a >10 - <25 GPa shock metamorphic overprint followed by post-shock annealing and aqueous alteration (e.g., [10−16]. Planar deformation features in feldspar tend to be corroded and less well developed as those in quartz. Up to ~0.7 mm apatite crystals exhibit multiple sets of planar elements, which are mostly planar fractures with irregular spacings of <10 to >100 µm (Fig. 1A). In X-ray intensity maps of the 10 samples, we identified more than 500 zircon grains up to 190 µm in size. Most zircon grains are intensely fractured along irregular microfaults and comminuted to <10 µm fragments; these microfaults in zircon do not extend into the surrounding feldspar and quartz crystals. In addition, less than 10% of the zircon crystals exhibit planar elements (Fig. 1B).

Discussion & Conclusions: Brittle response suggests the shock wave affecting most zircon crystals did not exceed their Hugoniot elastic limit (HEL) at ~20 GPa [17], which is regarded as the onset of planar elements in impact metamorphosed zircon (e.g., [6,18]) and for the occurrence of planar fractures in apatite [19]. This <20 GPa shock pressure constraint agrees with the 12−18 GPa shock pressure constraints for quartz determined with universal stage measurements in the LPR (e.g., [12−16]). Heterogeneous shock pressure effects may explain the occurrence of planar elements in a small fraction of zircon crystals but seem unlikely for LPR apatite because most apatite crystals >0.5 mm exhibit multiple sets of planar elements. Thus, planar fractures in impact-metamorphosed apatite (Fig. 1A) likely indicates equilibrium shock pressures lower than 20 GPa.

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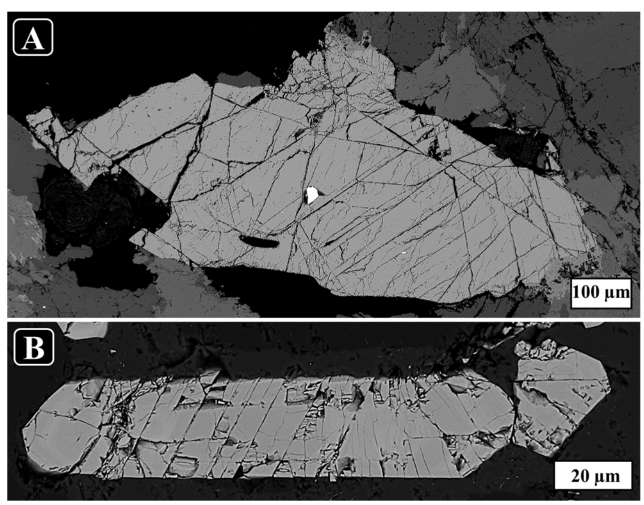

Fig. 1. Planar elements in IODP-Chicxulub sample C247_1159.99 mbsf. A – apatite; B – zircon; back-scattered electron images.

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