

# OUTSTANDING NATURAL OCCURRENCE OF $\text{TiO}_2$ -II AT THE CHICXULUB CRATER – ANATOMY OF A SHOCK-PRODUCED HIGH-PRESSURE POLYMORPH

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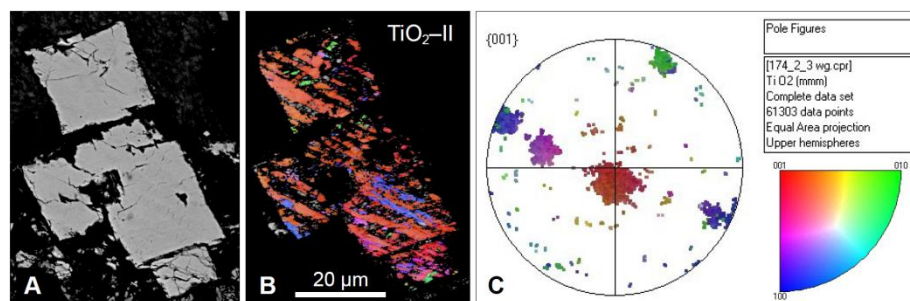
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**Introduction and Background:** Scientific drilling of the end-Cretaceous, ~180 km-diameter Chicxulub crater (Yucatán Peninsula, Mexico) during IODP-ICDP Expedition 364 has provided new insights into the formation, shock metamorphism, structural evolution, and thermal history of peak rings in large complex impact craters [1–6]. An outstanding feature in uplifted granitoid rocks of the Chicxulub peak ring is the preservation of  $\text{TiO}_2$ -II, an orthorhombic high-pressure polymorph of  $\text{TiO}_2$  with an  $\alpha\text{-PbO}_2$  structure [7,8], produced during the impact from rutile and/or anatase at shock pressures of ~12.5–17.5 GPa [4]. Unlike other mostly micro- and cryptocrystalline occurrences of  $\text{TiO}_2$ -II at terrestrial impact sites, ejecta deposits ([9,10] and references therein), and in rare ultra-high pressure metamorphic rocks [11],  $\text{TiO}_2$ -II at Chicxulub occurs as abundant euhedral crystals  $\leq 70\ \mu\text{m}$  in size within aggregates of altered magmatic titanite. This mode of occurrence provides an excellent opportunity to investigate the crystallography and transformation kinetics of the shock-produced high-pressure polymorph using scanning electron microscopic, micro-Raman, electron backscatter diffraction (EBSD) [9,10], focused ion beam (FIB), as well as transmission-EBSD and transmission electron microscopic (TEM) techniques. Here we present refined microstructural and new crystallographic results for  $\text{TiO}_2$ -II at the Chicxulub crater.

**Sample and Analysis:**  $\text{TiO}_2$  in shocked granitoid rock sample 174-2-19-20 (core depth 949 m below seafloor [1,2,9,10]) from the Chicxulub peak ring was analyzed using a 7600f JEOL field emission gun scanning electron microscope (FEG-SEM) with an Oxford Instruments Symmetry EBSD detector for phase and orientation mapping and transmission-EBSD; a Quanta 3D FEG for FIB sectioning; and a JEOL 2500 field-emission scanning-transmission electron microscope (FE-STEM) for diffraction pattern analysis, indexing, and the determination of unit cell parameters at the NASA Johnson Space Center.

**Results and Interpretation:** High-resolution EBSD mapping of  $\text{TiO}_2$  crystals (Fig. 1A) reveals a complex arrangement of lamellar and granular crystal domains.  $\text{TiO}_2$ -II, which commonly forms larger, coherent, lamellar subdomains (Fig. 1B), is the dominant mineral phase. Rutile occurs as microcrystalline granules and lamellae that locally overprint shock-produced  $\text{TiO}_2$ -II and is, thus, interpreted as a post-shock reversion product. Individual  $\text{TiO}_2$ -II lamellae are related to one another by rational twin orientations (Fig. 1C), indicating twinning occurred during the solid-state transformation to minimize intracrystalline strain energy. Three dominant twin orientations are observed with a disorientation axis of  $87^\circ/\langle 010 \rangle$ ,  $55^\circ/\langle 010 \rangle$ , and  $85^\circ/\langle 100 \rangle$ . Moreover,  $\text{TiO}_2$ -II and neoblastic rutile are systematically misoriented from one another, suggesting the solid-state  $\text{TiO}_2$ -II-to-rutile reversion is crystallographically controlled. High-resolution transmission-EBSD and TEM analyses were carried out to further characterize the nanostructure and unit cell parameters in natural, shock-produced  $\text{TiO}_2$ -II. Results from TEM electron diffraction analysis and indexing are consistent with the unit cell parameters of experimentally produced  $\text{TiO}_2$ -II [12]. These results underline the outstanding natural occurrence of  $\text{TiO}_2$ -II at the Chicxulub impact crater, which may be an appropriate type locality for this high-pressure polymorph.



**Fig. 1:**  $\text{TiO}_2$ -II in shocked granitoid rock from the Chicxulub peak ring (sample 174-2-19-20). **A:** Back-scattered electron image of  $\text{TiO}_2$  crystals. **B:** EBSD inverted pole figure map of  $\text{TiO}_2$ -II. **C:** Pole figure corresponding to map shown in B (IPF-z).

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