SHOCKED QUARTZ CONFIRMS AN IMPACT ORIGIN FOR THE ILKURLKA STRUCTURE, WESTERN AUSTRALIA.

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Introduction: The Ilkurlka structure is a ~12 km diameter circular aeromagnetic and gravity anomaly located ~400 km NW of Eucla, Western Australia, within the Officer Basin. The structure has been previously identified as a possible impact structure based on the geophysical anomalies [1,2,3]. The lack of diagnostic evidence of shock metamorphism has led to a range of origins being postulated for Ilkurlka, including a salt dome, an igneous intrusion, or a meteorite impact crater. The Officer Basin is regionally undeformed, except for local salt tectonics. We report the presence of shocked quartz grains with multiple sets of planar deformation features (PDFs) parallel to the $\{10\bar{1}3\}$-orientation that confirms an impact origin for the buried Ilkurlka structure.

Methods: This study aimed to investigate and document the presence of deformation features at various scales in drill cores from two boreholes (BH01 and BH02) drilled by Maria Resources Pty Ltd. in 2019, which targeted the circular gravity anomaly. A survey of quartz from samples spanning the two boreholes was conducted to search for microstructural evidence of deformation uniquely produced by impact cratering (e.g., PDFs). Twenty samples from sandstone intervals were selected for investigation. Ten representative samples were cut and cast into 1-inch round epoxy mounts and polished. Scanning electron microscopy (SEM), including backscattered electron (BSE), energy dispersive spectroscopy (EDS), and electron backscatter diffraction (EBSD), was performed at Curtin University. Nineteen samples were prepared into polished thin sections. Petrography and a search for planar fractures (PFs) and PDFs in quartz in thin section was conducted at Curtin University. Crystallographic orientations of PDFs in shocked quartz were determined using a universal stage at Lund University.

Results and Discussion: Samples from BH01 and BH02 generally consist of poorly to moderately sorted fine to coarse grained sandstone interlayered with siltstone and mudstone, and are locally brecciated. These rock units have been provisionally assigned to the lower Cambrian Marla Group based on lithological similarities to that succession in other drill cores in the eastern Officer Basin. The sandstones consist of medium to coarse, sub-rounded to rounded quartz, lithics, and feldspar grains, set in matrix and/or cements (~10-25%). The matrix components consist of micas and carbonates, silts and clays, and very fine to fine, angular to subangular quartz grains that appear to be crushed. Original pore space is locally cemented with calcite, gypsum, and minor anhydrite.

Petrographic analysis and SEM imaging reveal variably deformed quartz grains. Two adjacent grains of shocked quartz were found, each with multiple sets of PDFs parallel to the $\{10\bar{1}3\}$-orientation, in a sample from 415.9 m (downhole depth) in BH02. Other deformation features observed in quartz include discrete zones of crushed angular grains, sub-planar fractures, grains with high fracture density in random orientations including shattered grains, concussion fractures at the boundary of multiple grains, and fractures that offset grains, indicating shear displacement. The concussion fractures are Hertzian fractures that emanate from grain-to-grain contacts and cut across up to six adjacent grains. Concussion fractures in quartz have been reported previously in shock-metamorphosed sandstone samples from several impact craters [e.g. 4–7] and in shock experiments [e.g. 8]. Kink bands in biotite are also present.

The presence of PDFs parallel to the $\{10\bar{1}3\}$-orientation in quartz suggests that the target underwent shock pressures corresponding to shock stage 3 [9]. However, the apparent preservation of porosity and lack of diaplectic glass or high pressure SiO_2 phases are characteristic of shock stage 1a [9]. The timing of cementation of the porosity with respect to impact-related deformation is difficult to ascertain. It is possible that impedance contrasts between cements and quartz grains created discrete zones of deformation which could have allowed spatially variable shock effects to occur. Regardless of shock stage assignment, PDFs allow confirmation of an impact origin.

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