

NEW EVIDENCE FOR AN IMPACT ORIGIN OF RAMGARH STRUCTURE, RAJASTHAN, INDIA.

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The Ramgarh structure, located at 25°20'N, 76°37'30"E, in the Kota District of eastern Rajasthan, India, is a prominent isolated 3 km-diameter circular feature rising 150 m above a level plain situated within flat-lying Neoproterozoic sandstones and shales of the Vindhyan Supergroup [1-6]. Topographic maps [7] and satellite imagery [11] clearly show the structure to be a crater with a raised rim having steep inner flanks and shallower outer flanks, and having the appearance of a square with rounded corners. The origin of the Ramgarh structure has been variously attributed to a kimberlite pipe [2], a diapir [1], a meteorite impact [1-3], a combination of magmatism and tectonism [4], and to a mechanism of centripetal rheid flow of kaolin-rich shales with associated cross-folding [5, 6].

The complete absence of volcanic or intrusive rocks around the Ramgarh structure has been confirmed by a vertical 452 m-deep borehole drilled in 1981/82 in the centre of the structure [5]. The lithologies found in the borehole consist of the normal Vindhyan succession of shales, siltstones and sandstones that underlie the rocks within the crater, but uplifted about 1 km above their usual stratigraphic position in the region. The shales in the central borehole display tight upright isoclinal folds, together with closely spaced normal and reversed brittle faults [5]. The hematitic quartzitic Bhandar sandstones that constitute the outer rim of the structure display radial outward dips that steepen from as little as 14° on the outer flanks to 60-70°, and in some cases almost 90°, near the top of the rim. These quartzites also have radially directed broad open folds with shallow outward plunges [5].

Although morphologically the Ramgarh structure closely resembles other terrestrial impact craters [1, 8], the evidence for an impact origin hitherto presented has been scanty and equivocal, non-diagnostic or unconfirmed. Thus, although Crawford [1] reported that "a specimen found in colluvium near the centre of the feature seems shatter-coned", no other workers in the area have reported shatter cones, and we also failed to find any shatter cones during three days of very intensive searching along the rim of the structure. The finding of granulated quartz with anomalous birefringence [2] is inconclusive and non-diagnostic. Abundant shattering and brecciation of the Ramgarh sandstones has been reported by all researchers [1-6], but by itself this is not diagnostic of impact

processes. The reported finding of magnetic pieces that "could have been part of a nickel-iron meteorite" [3] has not been substantiated.

We examined the sandstones of the SE and SW rims of the Ramgarh crater from 4-6 February, 1999. A striking feature of most outcrops and loose boulders of quartzite on the rim is the presence of abundant closely-spaced fractures. At one locality on the SE rim, we found quartzites displaying multiply-striated joint surfaces (MSJS) similar to those from the Sinamwenda impact crater [13].

Our petrographic studies indicate that most of the Ramgarh quartzites consist of well-cemented quartz grains, together with accessory authigenic hematite and detrital tourmaline grains, some of which were shattered *in situ*. Some quartz grains display undulose extinction and deformation twin lamellae. In every thin section examined of rocks from widely spaced localities on the western, southern and eastern rims of the crater, we found two or more quartz grains displaying between one and three sets of planar deformation features (PDFs), which are visible under high magnification (400x) in both plane polarised light and under crossed polars. Many of these PDFs are decorated with planar fluid inclusion trails. Since PDFs are characteristically produced in quartz under high shock pressures (>5 GPa) [14], we infer that the PDF-containing Ramgarh quartzites have undergone intense shock metamorphism. This evidence, together with the crater morphology, the abundant brecciation, the MSJS, the radial folds, the deformed central uplift, and the absence of any igneous activity, provides strong and unequivocal support for a meteorite impact origin of the Ramgarh structure.

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