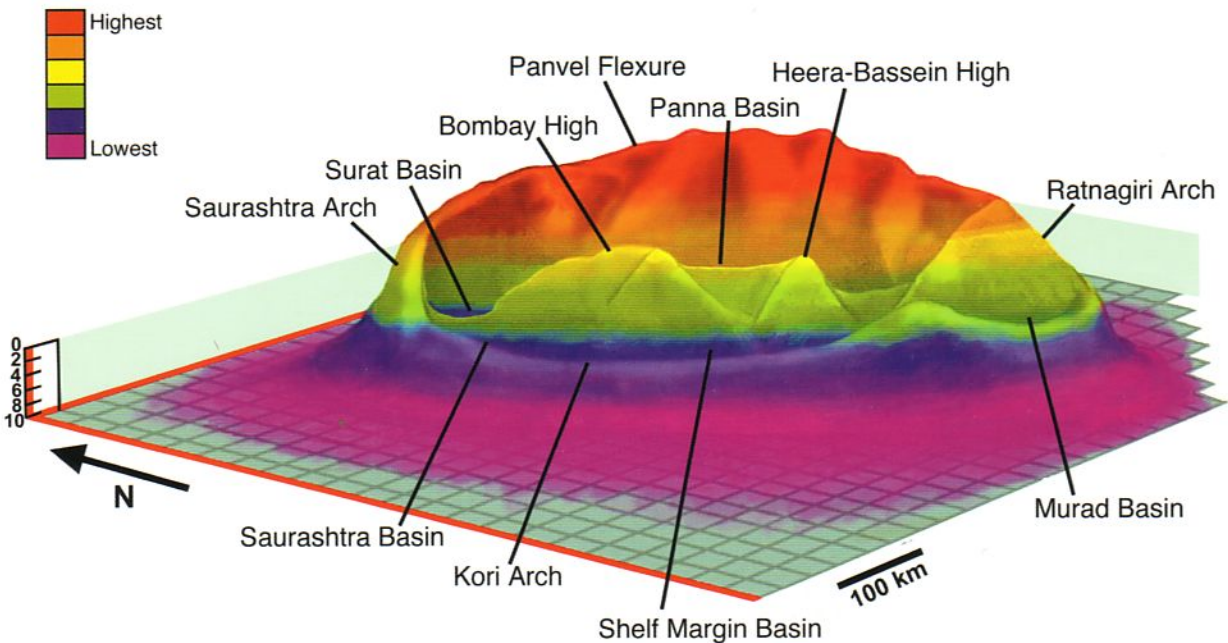




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SHIVA STRUCTURE: A POSSIBLE KT BOUNDARY IMPACT CRATER ON THE WESTERN SHELF OF INDIA



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ABSTRACT

Evidence is accumulating for multiple impacts across the Cretaceous-Tertiary transition, such as the Chicxulub crater in Yucatan Peninsula, Mexico, the Shiva crater offshore western India, and the much smaller Boltysh crater in Ukraine. Among these, the submerged Shiva crater on the Mumbai Offshore Basin on the western shelf of India is the largest (~500 km diameter), which is covered by 7-km-thick strata of Cenozoic sediments. It is a complex peak ring crater with a multiring basin, showing a structural relief of 7 km. A ring of peak is surrounded by an annular trough, which is bounded by a collapsed outer rim. Four different ring structures have been identified: an inner ring (peak ring) with a diameter of 200 km, a second 250-km-ring, a third ring (final crater rim) of about 500 km, and a probable exterior elevated ring of about 550 km. The crater outline is irregular squarish with a tapering end to the northeast indicating a possible oblique impact in a SW-NE direction. We speculate that the Shiva bolide (~40 km diameter) crashed obliquely on the western continental shelf of India around 65Ma, excavating the crater and shattering the lithosphere. The peak ring of the Bombay High area has a core of Neoproterozoic granite with a veneer of Deccan Trap that rebounded upward for more than 50 km during the transient cavity stage as revealed by the mantle upwarping. Pseudotachylite veins of silica melt are observed within the drill cores of granitic target rock that may be linked to the impact-melting event.

The combined Neoproterozoic granite and Deccan Trap target lithologies generated two kinds of impact melt ejecta that were emplaced radially in the downrange direction within the Deccan lava pile: rhyolite dikes, and iridium-rich alkaline igneous complexes. The age of the crater is inferred from its brecciated Deccan lava floor and the overlying Paleocene Panna Formation within the basin, isotopic dating of the presumed proximal ejecta melts, and the magnetic anomaly of the Carlsberg Ridge that was created by the impact. Concentric geophysical anomalies, thermal anomalies, seismic reflection, and structural and drill core data endorse the impact origin of the Shiva structure. The KT boundary sections in India, often preserved within the Deccan lava flows, have yielded several cosmic signatures of impact such as an iridium anomaly, iridium-rich alkaline melt rocks, shocked quartz, nickel-rich spinels, magnetic and super paramagnetic iron particles, nickel-rich vesicular glass, sanidine spherules, high-pressure fullerenes, glass-altered smectites, and possibly impact-generated tsunami deposits. The impact was so intense that it led to several geodynamic anomalies: it fragmented, sheared, and deformed the lithospheric mantle across the western Indian margin and contributed to major plate reorganization in the Indian Ocean. This resulted in a 500-km displacement of the Carlsberg Ridge and initiated rifting between India and the Seychelles. At the same time, the spreading center of the Laxmi Ridge jumped 500 km westerly close to the Carlsberg Ridge.

The oblique impact may have generated spreading asymmetry, which caused the sudden northward acceleration of the Indian plate in Early Tertiary. The central uplift of a complex crater and the shattered basement rocks form ideal structural traps for oil and gas. Many of the complex impact structures and events at the KT transition such as the Shiva crater, Chicxulub crater, and the Boltysh crater create the most productive hydrocarbon sites on the planet. The kill mechanisms associated with the Shiva impact appear to be sufficiently powerful to cause worldwide collapse of the climate and ecosystems leading to the KT mass extinction, when the dinosaurs and two-thirds of all marine animal species were wiped out.