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NEWS AND NOTES

Impact Craters in India

Amar Agarwal, Department of Earth Science, Indian Institute of Technology Kanpur, Kanpur, Uttar Pradesh - 247 667, India
E-mail: *amarag@iitk.ac.in*

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Impact craters are roughly hemispherical depressions formed due to impact of a meteorite. In the last few decades, geologists have gradually realized that collisions of extra-terrestrial objects with Earth have significantly shaped Earth's surface, disturbed its crust, and altered its geological history. The impact structures range from only a few kilometres or less in diameter to large complex structures of more than 200 km.

We need to study and understand impact cratering since it is an ongoing process. A meteoritic impact with energy equivalent to 100 kiloton TNT is recorded yearly, while that with energy equivalent to 1 megaton TNT explosive is recorded once every century. Note that the Hiroshima atom bomb was merely 15 kiloton. Terrestrial life has not escaped this cosmic bombardment. The Cretaceous–Tertiary mass extinction event is attributed to the c. 180 km wide Chicxulub impact crater in the Yucatan peninsula, Mexico. This impact generated a blast of air and heat, tsunamis and earthquakes. The impact injected a huge amount of dust in the upper atmosphere, which may have inhibited photosynthesis for up to 2 months, forest fires got triggered when the impact ejecta re-entered the Earth's atmosphere, and the production of vast quantities of N_2O from the shock heating of the atmosphere. Estimates suggest a 15°C decrease in the average global temperatures, which when coupled with the other effects of the impact event resulted in severe environmental consequences. Additionally, impact structures are often associated with economically significant deposits of building stone, diamonds, uranium, nickel-copper sulphide ore, gold bearing veins and hydrocarbons (petroleum and gas).

Geological processes other than impact cratering, such as volcanic eruptions, may also lead to hemispherical depressions. Owing to the intense deformation, the impact craters are highly susceptible to erosion. This increases the difficulty in identifying impact craters. Scientists have, therefore, identified geochemical and structural markers of a meteoritic impact. These markers do not form by other geological processes. These markers are: (1) preserved meteorite fragments, (2) anomalous amounts of siderophile elements as Ni, Co, Cr, Au, and the platinum group elements (PGEs; Ru, Rh, Pd, Os, Ir, and Pt), (3) shatter cones, (4) high-pressure (diaplectic) mineral glasses, (5) high-pressure minerals, (6) high-temperature glasses and melts, (7) planar fractures (PFs) in quartz, and (8) planar deformation features (PDFs) in quartz.

Till date, 204 impact craters have been proved on earth and of these three are in India. The first one to be proved was the Lonar crater (19° 58' N, 76° 31' E) in Maharashtra. The discovery of shocked material, such as impact glasses in the impact breccia by Nayak in 1972 and Fredriksson et al. in 1973, established its impact origin. This simple and pristine crater was formed by a hypervelocity impact in the tholeiitic Deccan basalt. Recently published exposure dates of ^{10}Be, ^{26}Al, and ^{14}C of pre-impact paleosols constrain the age of the Lonar crater at 37.5 ± 5.0 ka. The impact crater has a diameter of c. 1.88 km and 150 m deep from the rim, with an about 7-10 m deep shallow saline lake at its bottom. The crater is filled with 30-100 m thick unconsolidated post-impact sediments which are underlain by about 225 m of impact breccia. A continuous blanket of ejecta extends outward up to a distance of 1350 m from the rim crest.

The second one to be proved was the Dhala impact structure (25°17'59.73 N, 78°80'3.13 E) in Madhya Pradesh. The structure was initially classified as a crypto-volcanic explosion structure. Subsequent investigations by Pati in 2005 revealed diagnostic microscopic shock metamorphic features, which resulted in the confirmation of Dhala as an impact structure. The structure is biggest in Asia and has a diameter of c. 11 km and covers an area of about 64 km^2. Unlike Lonar crater, Dhala is supposed to be a complex impact crater. The stratigraphy of the Dhala impact structure starts with a fractured granitoids, which forms the basement with a 12.36 m thick suevite horizon occurring within the fractured basement. Over the fractured granitoids lies a c. 65m thick layer of impact melt breccia. It comprises quartz, feldspar, zircon, and some opaque mineral clasts with partially to completely melted granitoid and highly vesiculated melt clasts embedded in a very fine-grained matrix of mainly quartz and feldspar. A 1.8 m thick layer of altered suevite occurs above the impact melt breccia.

The third crater to be proved was the Ramgarh Crater (25.33°N, 76.63°E) in Rajasthan. For long, the crater was believed to have an impact origin. However, convincing shock metamorphic features or geochemical indicators were missing. In 2021, Agarwal and his co-authors reported planar deformation features and feather features to establish its meteoritic impact origin. Ramgarh impact structure formed in upper Vindhyan sedimentary rocks, perhaps during the middle Jurrasic age. The crater has an apparent diameter of 10 km, which is constrained by large scale low angle normal faults, and the collar is 200 m high and 3.5–4 km wide. Arguably, the most remarkable feature of the complex impact crater is its 200 m high and 3.5–4 km wide annular collar. Within the collar, the central depression is covered by soil with an underlying sequence starting at the top with Ganurgarh Shale and followed by other underlying shales, siltstone, and sandstones belonging to the Rewa and Kaimur Groups of the Upper Vindhyan.

Besides the three impact craters proved so far, there are several other structures that are suspected of having a meteoritic impact origin. Out of these, Simlipal crater in Singhbhum, Luna Crater in Kachchh, and Kaveri Crater of Southern India are the prime on-shore candidates.

Along with more craters yet to be discovered and proved, there are many phenomena related to impact cratering and shock metamorphism that are poorly understood. More scientists are needed to work in the exciting field of Impact cratering research and bridge the gap between planetary and earth sciences.