

DHALA - A NEW, COMPLEX, PALEOPROTEROZOIC IMPACT STRUCTURE IN CENTRAL INDIA.

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Introduction: The Dhala structure (N25°17'59.7" and E78°8'3.1") is situated in Shivpuri district, Madhya Pradesh State, India [1,2]. Currently, the diameter of the structure is estimated at 11 km based on field observations. The basement rocks are predominantly composed of granitoids, and in the centralmost part of the structure voluminous melt breccia containing target rock clasts with shock metamorphic features are directly overlain by a post-impact siltstone-shale-sandstone sequence of the Vindhyan Supergroup. Recent geochronological dates suggest that the age of the impact event lies in the range between 1.6 and 2.5 Ga [2,3].

Geology of the Dhala area: The Dhala structure can be easily identified in satellite images with a mesa-shaped central elevated area (CEA; ~2.5 km in diameter), off-center to the mapped outline of the structure, and a weakly defined annular drainage pattern observed on a Survey of India topographic map (54K/3; 1:50,000). The remote sensing study based on Landsat-TM and Indian Remote Sensing (IRS-1D) satellite data suggests that the diameter of the structure could be as large as 25 km (Fig.1). There are three distinct litho-tectonic domains from north to south. The bedrock lithology mainly includes calc-silicate rocks, granitoids (including rocks of Tonalite-Trondhjemite-Granodiorite affinity), very large quartz veins (GQV) [4], and dolerites, besides a cover sequence comprising shale-siltstone of varying composition and arkosic lenses followed by a shale-sandstone (locally pebbly) unit. There are more than 114 whale-back-like and low-lying monomict granitoid breccia outcrops occurring in the form of a ring of varying clast size. There is a voluminous melt breccia occurring over a length of ~6 km in a semi-circular fashion between E and NE of CEA above and within the monomict granitoid breccia, respectively. The melt breccia lithology has not been observed to the south of the CEA so far.

The cover sediments show distinct sub-horizontal lamination-bedding with syn-sedimentary deformation structures in places. Tectonically, the area shows a strong pervasive and penetrative sub-vertical E-W trending shear (sinistral) fabric in granitoids, which is dissected by GQV (NNE-SSW to NE-SW) and mafic dyke (mostly NW-SE) trends. The shear fabric is observed to swerve with a semi-circular trend to the south of the CEA. The calc-silicate rock is

folded on E-W to NW-SE disposed bedding. All rock types show extensive brittle structures (joints and faults) at meso- and macroscopic scales. The faults show both dextral and sinistral displacements and are most conspicuous in GQVs to the SE of the CEA. At least five major inferred faults dissect the CEA. The joints overall show a radial trend, although they are slightly accentuated along E-W, NNE-SSW and NW-SE directions (pre-impact fabric elements).

Evidence of impact: Study of 401 normal and polished thin sections of various rock types has shown the presence of shock metamorphic features in clasts within the melt breccia lithology only. These features include multiple sets of PDFs in quartz and feldspar, ballen texture, checkerboard feldspar, and shock deformed zircons based on Raman spectroscopic study. The geochemical analysis of the melt breccia samples has so far only shown Ir concentrations up to 0.8 ppb that is very close to the detection limit of the INAA instrument [2].

Mineralization: The Geological Survey of India (Central Region) has drilled three boreholes after encountering Cu and Au in parts of Dhala. The Atomic Minerals Division, Government of India has so far drilled 11 boreholes in search of uranium in the Dhala area. The twelve analyzed samples from the Dhala area [2] show Au content between 0.3 and 2.6 ppb. The U content ranges from 1.19 to 7.58 ppb.

Age of the impact: The predominantly granitoid country rocks of 2.5 Ga age are intruded by 2.0-2.15 Ga mafic intrusives. They are overlain by sediments belonging to Vindhyan Supergroup of 1.6 Ga age. Our recent SHRIMP U-Pb single-zircon data [3] further corroborates a 1.6-2.5 Ga age range for the Dhala area.

Conclusion: The present study summarizes the field, petrological, limited geochemical, and geochronological data on the Dhala structure carried out to date. The presence of unequivocal shock metamorphic evidence confirms its impact origin, and at 11 km, it is the largest known impact structure in Southeast Asia. The extensive drilling by government agencies also suggests possible economic mineralization associated with the Dhala structure.

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References: [1] Pati, J.K. (2005), *MAPS 40* (S): A121. [2] Pati, J.K. et al. (2008) *MAPS* (In Press). [3] Jourdan, F. et al. (2008) *LPSC XXXIX*, Abstract #1244. [4] Pati, J.K. et al. (2007), *Jour. Earth System Sci.* 116, 497-510.

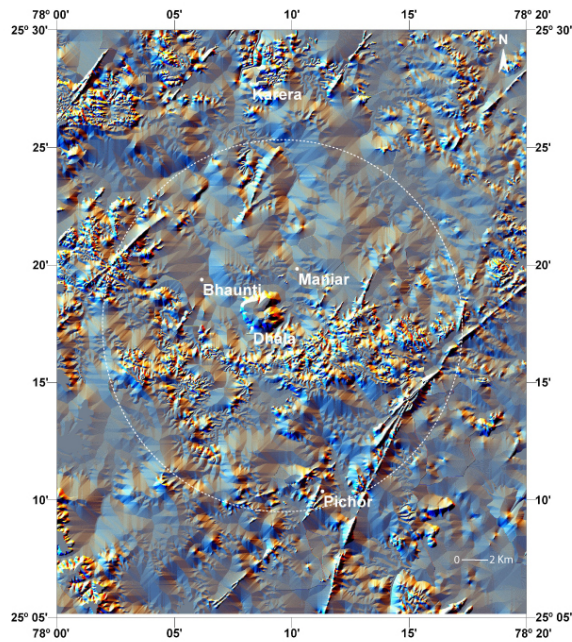


Figure 1. Digital Elevation Model of Dhala impact structure, India based on Survey of India topographic contour data (54K/3, 4, 7 and 8). The estimated diameter (~25 km) based on remote sensing data is shown in dotted line. Linear ridges are quartz veins (GQV).