Development of Mesoproterozoic Fold-and-Thrust Belt Structures in Central India: New Evidence from Detachment-Controlled Deformation in the Lower Vindhyan Basin

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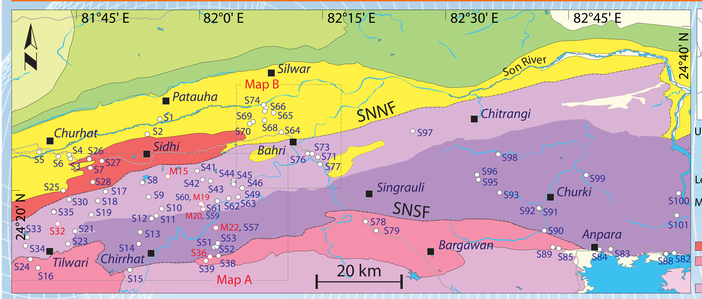
OVERVIEW

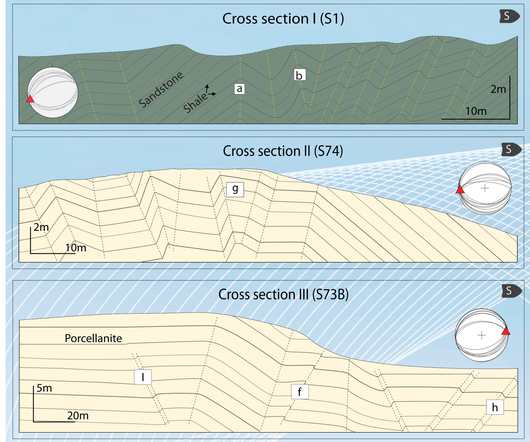
The Mesoproterozoic collision of the Bundelkhand and Bastar cratons formed the Central Indian Tectonic Zone (CITZ), but the effects of this north-south directed collision on the adjacent Vindhyan Basin remain poorly understood. We examined outcrop-scale deformation structures within the Late Paleoproterozoic Lower Vindhyan sequence and the adjacent Mid-Paleoproterozoic Mahakoshal Supracrustal Belt (MSB) in the Son Valley to investigate the tectonic history of this region. Structural data collected from 105 locations, including five north-south trending road-cut sections, were analyzed to establish the regional deformation sequence in son valley and construct a 20 km long litho-structural section across the Lower Vindhyan sequence and MSB.

Unlike previous studies that attributed these structures in the Lower Vindhyan sequence to soft-sediment deformation, we demonstrate that the collision of cratons producing the CITZ also generated compressional deformation structures in the Lower Vindhyan sequence.

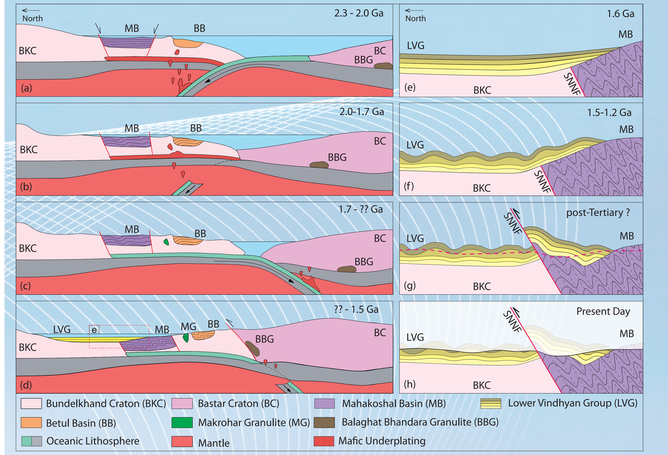
LITHO-STRUCTURAL MAP OF THE STUDY AREA



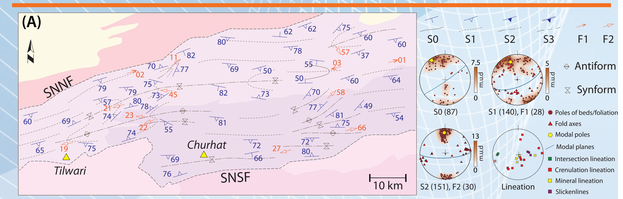
CROSS SECTIONS

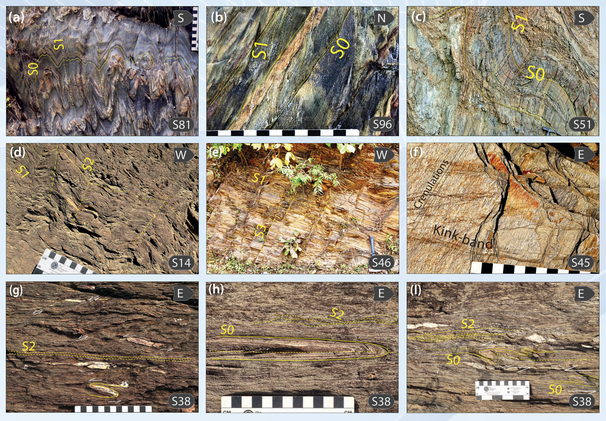


TECTONIC MODEL

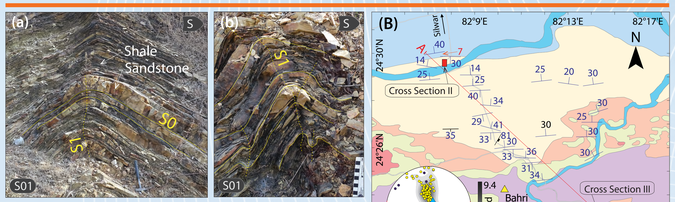


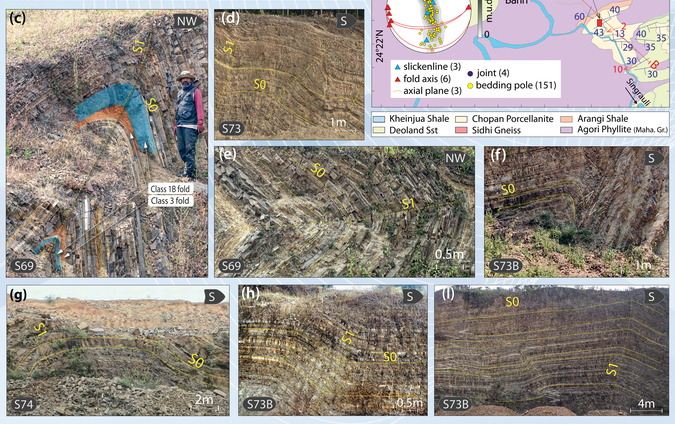
DEFORMATION STRUCTURES IN MAHAKOSHAL ROCKS



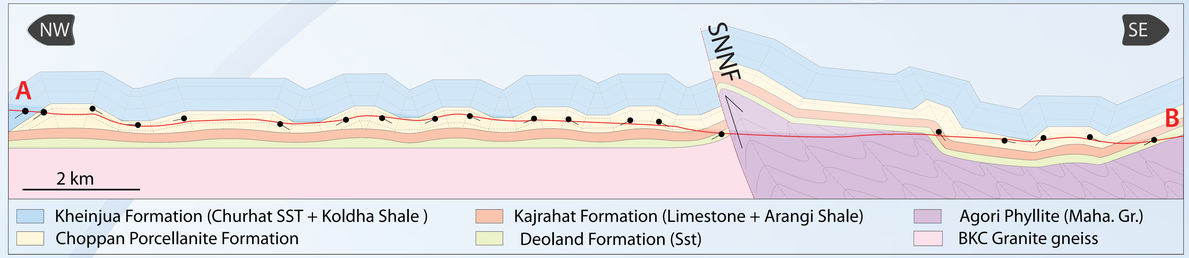


DEFORMATION STRUCTURES IN LOWER VINDHYAN ROCKS



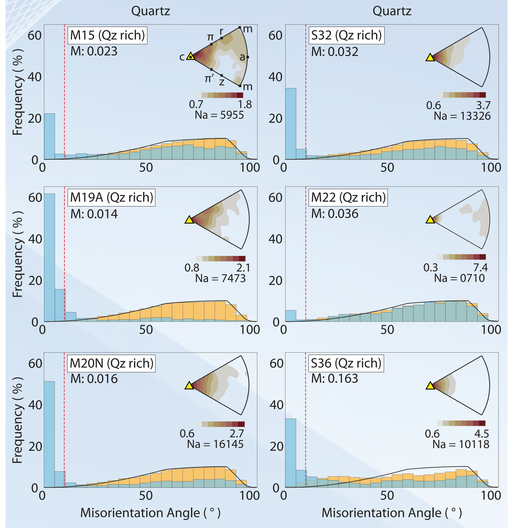


PART I :

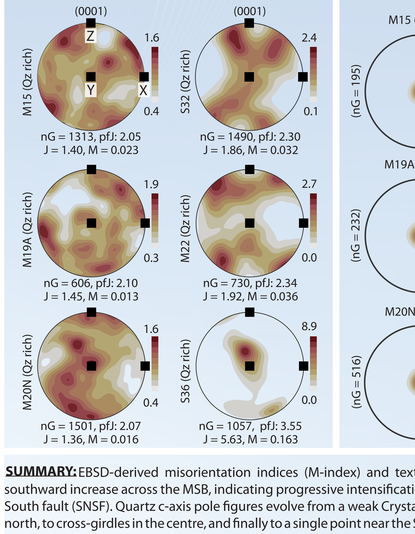


SUMMARY: This study examines the deformation history of the Lower Vindhyan Group and Mahakoshal supracrustal belt in Son valley. Our field investigations suggest that the deformation of the Lower Vindhyan Group occurred due to N-S compressional tectonics during 1.5–1.2 Ga, i.e. after the D3 deformation phase in the Mahakoshal and before the sedimentation of Upper Vindhyan Group. Our inference challenges the previous ones that attributed the deformation in the Lower Vindhyan Group to seismic activity or soft-sediment deformation processes. With the help of the kinematic model, we demonstrate that the Vindhyan basin developed as a peripheral foreland basin during the southward subduction of the Bundelkhand Craton beneath the Bastar Craton. The continued late-stage convergence of Mesoproterozoic collision along the Central Indian Tectonic Zone triggered and maintained the deformation that propagated northward via detachment folding into the Lower Vindhyan Group.

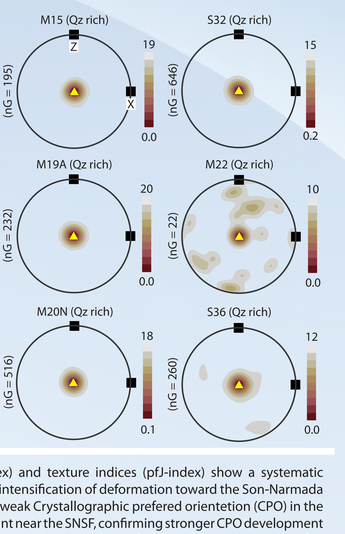
PART II : MISORIENTETION ANALYSIS



CRYSTALLOGRAPHIC PREFERED ORIENTETION



CRYSTALLOGRAPHIC VORTICITY ANALYSIS



SUMMARY: EBSD-derived misorientation indices (M-index) and texture indices (pfJ-index) show a systematic southward increase across the MSB, indicating progressive intensification of deformation toward the Son-Narmada South fault (SNSF). Quartz c-axis pole figures evolve from a weak Crystallographic prefered orientetion (CPO) in the north, to cross-girdles in the centre, and finally to a single point near the SNSF, confirming stronger CPO development and higher deformation temperatures in the south. Misorientation axis analysis of subgrain boundaries identifies prism-(a) slip as the dominant slip system, constraining peak deformation temperatures to 500–700°C. Crystallographic Vorticity Analysis (CVA) consistently shows bulk vorticity axes oriented at low angles to the kinematic Y-direction across all samples, indicating simple shear-dominated transpression throughout the MSB .

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