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An Appraisal of Microstructures and Deformation Temperature in a Fold and Its Implications for the Structural Context of the Area Around Bagalkot, Karnataka, India

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Abstract

The study investigates the tectonothermal history of a WNW-ESE trending fold system within the Proterozoic southern Kaladgi basin, India, an area where such analysis has been previously limited. Through detailed microstructural analysis of ten oriented quartzite samples using petrographic microscopy, we correlate observed deformation features with established experimental data to constrain the paleo-deformation conditions. The analysis identified a suite of recovery and recrystallization microstructures in quartz and feldspar grains, including bulging grain boundaries (BLG), sub-grain rotation (SGR), grain boundary migration (GBM), and chessboard extinction. These features constrain the average deformation temperature to a low-to-medium range of 300°C to 580°C, corresponding to lower-middle greenschist to lower amphibolite facies conditions. Higher temperatures are consistently localized in zones of increased strain, such as vicinity of faults, shears, and fold limbs. Fabric analysis and shear-sense indicators reveal a multi-stage deformation history driven by compressional forces, oriented NE-SW and N-S, which was overprinted by a significant NW-SE transpressional shear regime. By linking micro-scale evidence to the regional stress field, this research provides a comprehensive model for the basin's structural evolution, offering crucial insights for tectonic reconstructions and resource exploration.

Keywords: Microstructures; Deformation temperature; Quartz; Grain boundary migration; Sedimentary basin; Proterozoic

Introduction

Intracratonic basins are surrounded by cratons and are found to be broad, shallow and saucer shaped. Many basins of North Africa, between Atlantic ocean and red sea, Illinois basin of America covering Indiana and Kentucky has similar complex tectonic deformation history of evolution, Tagus basin within Iberian microplate is a result of differential tectonic strain during alpine orogeny and west Siberian basin is one of the largest intracratonic basins in the world, like others it has a complex multiphase tectonic history and is poorly understood having a basement of metamorphic, folded rocks and platformal blocks. Even in Indian context we have basins like, Cudduppah, Vindhyan, Chattisgarh, Pranhita-Godavari *etc.* These basins all around the world seems to be similar in structural evolution and deformational characters as our study area (Goswami *et al.*, 2023).

Deformation occurs in episodes and, there is a possibility of several episodes of deformation in an area. Deformation in solid Earth materials, particularly microscale and megascale structures, has recently been a topic of immense interest. Penetrative structures in rocks have created a wide riveting research scope. This proved indispensably important in deciphering the structural evolution of an area (Sigue *et al.*, 2023; Mamtani, 2025). Rock deformation varies with depth, being brittle and temperature-independent near the surface but ductile under higher temperatures and pressures at greater depths. With sufficient pressure, temperature, and time, rocks undergo internal adjustments such as microfractures, dislocation movements, and creep mechanisms to accommodate strain. These processes stabilize mineral grains and produce structures that record deformation history. Microstructure analysis of minerals like quartz and feldspars provides insights into past tectonic disturbances by examining their optical features, textures, and structures. Low-grade conditions typically form brittle structures, whereas high-grade conditions produce ductile ones.

Considering above background knowledge, the southern fringe of the Kaladgi basin is chosen for investigation as it is structurally disturbed and substantially retains the pages from the past. Several important aspects of the basin and its evolution have been documented, particularly the deformation phases in basement evolution and the kinematics of the south-central sector (Mukherjee *et al.*, 2016; Mukherjee and Modak, 2017; Pillai and Kale, 2019; Pujar *et al.*, 2021; Hanji *et al.,* 2025). Nevertheless, a

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