

Title of the Ph.D. thesis:

On the genesis, evolution and characterization of veins, dykes and fracture networks: Unravelling the brittle tectonics in the rocks of the Chitradurga region, Western Dharwar Craton, India

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Abstract

Deformation within the upper crustal regime is predominantly brittle in nature, manifested through rock fracturing, creating major pathways for fluid flow. The present research focuses on the structural investigation and characterization of brittle structures developed within the rocks of the Chitradurga Schist Belt, an Archean granite-greenstone sequence in the Western Dharwar Craton of southern India. The study aims to understand the varying controls on the formation, emplacement mechanisms, spatio-temporal evolution and inter-relationships of these brittle structures in order to reconstruct the brittle tectonic history of the terrain under ambient stress states.

Through this investigation, the research seeks to examine the tectonic evolution of cratons in general, during late stages of crustal deformation, focusing on how fracture systems evolve across successive tectonic episodes, the role of magma and fluids, the spatial link between brittle deformation and craton-scale architecture, and the broader implications for tectonic rejuvenation and long-term stabilization of cratonic blocks.

Field-based studies have been employed to identify the brittle structures within different lithologies of the schist belt. Three major suites of brittle structures have been recognized in the rocks of the study area: 1) Veins occurring in consistent orientations within both the metavolcanic rocks of the greenstone sequence and the younger granites that intrude them; 2) mafic dykes intruding the younger granites; 3) fracture networks developed through mutually interacting faults within the younger granites and the metavolcanic rock suite of the greenstone sequence.

Structural analyses coupled with statistical and mathematical methods involving field data collected from these brittle features have been employed to better constrain the conditions of their genesis. Observations on outcrop geometry and spatial relations of structures along with study of petrographic thin sections are utilized to determine the relative temporal evolution of brittle tectonic structures from the region.

The study demonstrates that pre-existing structural anisotropies played a key role in controlling vein emplacement, and further reveals at least three separate fluid pressure events that contributed to the development of the shallow-crustal quartz vein system in the metavolcanic rocks of the Chitradurga region, identified through statistical fuzzy-clustering of heterogeneous planar data.

Novel methodologies have been developed to calculate complete dyke dimensions from their partial exposures, enabling the estimation of magma overpressure and depth of origin for the mafic dykes of the region. Structural investigation of dyke outcrop patterns revealed sinistral shearing of the dykes induced by the effect of the adjacent Chitradurga Shear Zone and a geological model of their formation and subsequent emplacement under varying regional stress fields of the terrain has been proposed.

Fracture networks developed within the granites and metavolcanic rocks of the greenstone sequence have been characterized in terms of their geometrical, kinematic, topological and fractal attributes from 2D outcrop surfaces, indicating their development through a regional Riedel shear system activated by sinistral shearing along the Chitradurga Shear Zone during D₃ deformation of the terrain.

Spatial dispositions and relative temporal sequence of the brittle structures as established from all these studies collectively point towards a brittle tectonic event that the schist belt has undergone during the protracted D₃ deformation of the terrain. Accordingly, a comprehensive model has been developed to elucidate the brittle tectonic evolution of the region during late stages of deformation and craton stabilization.

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