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The kinematic vorticity analysis of ductile shear zones of Ambaji Granulite, NW India and its tectonic implications

Sudheer Kumar Tiwari[1], Anouk Beniest[2,3], and Tapas Kumar Biswal[1]
[1]Department of Earth Sciences, Indian institute of Technology Bombay, Mumbai, India (sudheer030192@gmail.com)
[2]GEOMAR, Helmholtz-Zentrum für Ozeanforschung Kiel, Germany
[3]Department of Earth Sciences, Vrije Universiteit Amsterdam, the Netherlands

The Neoproterozoic (834 – 778 Ma) Ambaji granulite witnessed four deformation phases (D_1- D_4), of which the D_2 deformation phase was most significant for the exhumation of granulites in the ductile regime. We performed a field study to investigate the tectonic evolution of the D_2 deformation phase and investigated the deformation evolution of the ductile extrusion of the Ambaji granulite by estimating the vorticity of flow (Wm) with the Rigid Grain Net and strain ratio/orientation techniques.

During the D_2 deformation phase, the S_1 fabric was folded by F_2 folds that are coaxial with the F_1 folds. The F_2 folds were produced in response to NW-SE compression. Because the large shear zones are oriented parallel to the axial plane of the F_2 folds, they likely formed simultaneously during the D_2 deformation phase. Compression during the D_2 deformation phase accommodated most of the exhumation of the granulite along the shear zones. D_2 shearing was constrained between 834 ± 7 to 778 ± 8 Ma (Monazite ages).

The shear zones evolved from a high temperature (>700 °C) thrust-slip shearing event in the lower-middle crust to a low temperature (450 °C) retrograde sinistral shearing event at the brittle-ductile-transition (BDT). The Wm estimates of 0.32–0.40 and 0.60 coincide with the high temperature event and suggests pure shear dominated deformation. The low temperature phase coincides with Wm estimates of 0.64–0.87 and ~1.0, implying two flow regimes. The shear zone was first affected by general non-coaxial deformation and gradually became dominated by simple shearing.

We interpreted that the high temperature event happened in a compressive tectonic regime, which led to horizontal shortening and vertical displacement of the granulite to the BDT. The low temperature event occurred in a transpressive tectonic setting that caused the lateral displacement of the granulite body at BDT depth. The Wm values indicate a non-steady strain during the exhumation of granulite. From the BDT to surface, the Ambaji granulite exhumed through the NW-SE directed extension for normal faults via brittle exhumation through crustal extension and thinning.