Geophysical Research Abstracts
Vol. 14, EGU2012-916-1, 2012
EGU General Assembly 2012

Fabrics of migmatites and relationships between partial melting and deformation in high-grade transpressional shear zones: the Patos anatexite (Borborema Province, NE Brazil)

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Migmatites are heterogeneous rocks that record flow processes in the middle crust of actively deforming orogens. The Patos anatexite is located within a transpressional, high-temperature shear zone in which mylonites are associated with partial melting at different scales. The relationships between melting and deformation inside continental ductile shear zones can be hindered due to the apparent structural complexity of migmatites, which encompass shear zone-parallel syntectonic leucosome veins, randomly-oriented nebulites and isotropic leucogranite accumulations of various sizes. A comprehensive petrostructural study was carried out in these rocks in order to test the compatibility of field, magnetic and crystallographic fabrics with the kinematics of melt deformation within high-grade shear zones. Magnetic fabrics of partially molten rocks were investigated using the anisotropy of magnetic susceptibility (AMS) and anisotropy of anhysteretic remanence (AAR). Crystallographic preferred orientations (CPOs) were measured using Electron Backscatter Diffraction (EBSD). Bulk AMS results indicate that ferromagnetic minerals dominate the overall susceptibility of the Patos anatexite, while a subset of samples shows composite ferro- and paramagnetic susceptibilities. AAR in the paramagnetic subfabrics reveals coaxiality between ferro- and paramagnetic fabric ellipsoids, suggesting formation of the magnetic fabric in the Patos anatexite as resulting from a single viscous flow process. AMS lineations display a well-oriented pattern in which magnetic foliations rotate consistently with a dextral simple shear sense, while AAR subfabrics are broadly parallel to the main AMS axes. The CPO of biotite crystals shows a good correlation of <001> axes with the k3 direction of the magnetic susceptibility ellipsoid in samples displaying orientations consistent with the shear-zone fabric and dominantly ferromagnetic behavior. In sites where the nebulitic fabric displays complex patterns and is not a reliable marker of the regional strain field, magnetic fabrics can still record magmatic flow directions in ferromagnetic migmatites, but biotite and quartz CPOs show contrasting directions and are not directly compatible with the AMS fabric, being rather related to local strain field perturbations due to flow instabilities. Outcrops with no visible mesoscopic foliation ("isotropic") are usually associated with significant interactions between ferro- and paramagnetic phases. In these sites, CPO directions can be distinct from AMS and AAR, which in turn can also differ due to dispersions in the directions of the main ferromagnetic axes caused by interactions with paramagnetic components. However, magnetite crystals retain orientations consistent with the regional strain field, as revealed by AAR fabrics. These data suggest that the correlation of field, magnetic and crystallographic fabrics is not always straightforward; complex foliation geometries can be characterized by simple patterns of magnetic fabric orientations well correlated with the regional strain field, even when the field fabric and the CPO of rock-forming minerals are governed by local field-flow instabilities. Interactions between para- and ferromagnetic phases can result in fabric weakening and dispersion, resulting in local AMS directions not consistent with the regional pattern. Hence, detailed fabric analysis shows that magnetite shape fabric is a good strain marker where nebulitic fabrics are randomly oriented and CPO fabrics are weak. The results of this study highlight the importance of careful mapping the internal fabrics of anatexites in order to constrain the relationships between melting and deformation in the partially molten middle crust.