Geophysical Research Abstracts
Vol. 19, EGU2017-15988, 2017
EGU General Assembly 2017

Application of Anisotropy of Magnetic Susceptibility to large-scale fault kinematics: an evaluation

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Major discontinuities in the Earth's crust are expressed by faults that often cut across its whole thickness favoring, for example, the emplacement of magmas of mantelic origin. These long-lived faults are common in intra-plate environments and show multi-episodic activity that spans for hundred of million years and constitute first-order controls on plate evolution, favoring basin formation and inversion, rotations and the accommodation of deformation in large segments of plates. Since the post-Paleozoic evolution of these large-scale faults has taken place (and can only be observed) at shallow crustal levels, the accurate determination of fault kinematics is hampered by scarcely developed fault rocks, lack of classical structural indicators and the brittle deformation accompanying fault zones. These drawbacks are also found when thick clayey or evaporite levels, with or without diapiric movements, are the main detachment levels that facilitate large displacements in the upper crust.
Anisotropy of Magnetic Susceptibility (AMS) provides a useful tool for the analysis of fault zones lacking fully developed kinematic indicators. However, its meaning in terms of deformational fabrics must be carefully checked by means of outcrop and thin section analysis in order to establish the relationship between the orientation of magnetic ellipsoid axes and the transport directions, as well as the representativity of scalar parameters regarding deformation mechanisms. Timing of faulting, P-T conditions and magnetic mineralogy are also major constraints for the interpretation of magnetic fabrics and therefore, separating ferro- and para-magnetic fabric components may be necessary in complex cases. AMS results indicate that the magnetic lineation can be parallel (when projected onto the shear plane) or perpendicular (i.e. parallel to the intersection lineation) to the transport direction depending mainly on the degree of shear deformation. Changes between the two end-members can be observed within the same fault zone, depending on the proximity to the core zone. The transition between them is usually defined by oblate fabrics, with the long and intermediate axes contained within the main foliation plane in SC-like structures.
The faults studied in this work are located in Northeast Iberia; most of them were formed during the Late-Variscan fracturing stage and constitute first-order structures controlling the Mesozoic and Cenozoic evolution of the Iberian plate. They include (i) large-scale (Cameros-Demanda) and plurikilometric (Monroyo, Rastraculos), thrusts resulting from basement thrusting and Mesozoic basin inversion, and (ii) strike-slip to transpressional structures in the Iberian Chain (Río Grío and Daroca faults, Aragonian Branch) and the Catalonian Range (Vallès fault). Application of AMS in combination with structural analysis has allowed us a deeper approach into the kinematics of these fault zones and namely to (i) accurately define the transport direction of Cenozoic thrusts (NNW to NE-SW for the studied E-W segments) and the flow directions of décollements and to evaluate the representativity of small-scale structures linked to thrusting; (ii) to assess the transpressional character of deformation for the main NW-SE and NE-SW Late-Variscan faults in NE Iberia during the Cenozoic (horizontal to intermediate-plunging transport directions) and (iii) to define the strain partitioning between different thrust sheets and strike-slip faults to finally establish the pattern of displacements in this intra-plate setting.