A new microstructural indicator of subduction polarity

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Résumé

The Betic-Rif orogen comprises two major metamorphic nappe complexes: the Nevado-Filabride complex (below) and the Alpujarride-Sebtide complex (above). Abundant garnet, staurolite, plagioclase and andalusite porphyroblasts in these units preserve sigmoidal and spiral-shaped inclusion trails, whose orientation and timing have been recently studied in significant detail in about 150 oriented samples from around the Gibraltar Arc (Aerden et al., 2022; Ruiz-Fuentes & Aerden, 2023; Farrell et al., 2024; Ruiz-Fuentes et al. 2025). This research has shown that these internal fabrics are mainly subvertical, consistent with their development during crustal shortening, and further implying a lack of porphyroblast rotation. A weaker detected preference for subhorizontal positions reflects intermitted gravitational collapse stages. Three sets of inclusion trails have been distinguished based on their specific and regionally consistent trends and different timing, which match the relative plate-motion path of Iberia and Africa established independently from paleomagnetic data. This, under the assumption that internal foliations developed normal to the direction of crustal shortening. So far, plate-motions could only be reconstructed based on kinematic modelling of seafloor anomalies and paleomagnetic rotation poles for stable areas far away from orogenic belts. Here, we demonstrate a new microstructural indicator of relative plate-motion present within the orogens themselves regardless of their age. We show that the axes and sense (asymmetry) of relative porphyroblast-matrix rotation is related to the direction of regional tectonic transport and hence the polarity of subduction. In the Betic-Rif orogen, the polarity of subduction has long remained debated. Our data concerning the orientation and asymmetry of inclusion trails in this orogen unambiguously demonstrate NNE-directed subduction that gradually changed to NNW-directed from the late-Eocene to the early Miocene. Younger (middle -Miocene) garnet porphyroblasts only found in the upper parts of the Nevado-Filabride complex exhibit an opposite inclusion-trail asymmetry as all others, suggesting a major back-thrusting stage accompanied exhumation. It is finally noted that Aerden (2021) already found a similar relationships between inclusion-trail curvature sense and subduction polarity in the Variscan suture of Ile de Groix.

Mots-Clés: Subduction polarity, Betic Cordillera, Porphyroblast, Inclusion trails

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