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Deformation of quartz and feldspar at mid-crustal depths in an extensional normal fault (Viveiro Fault, NW Spain)

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Metamorphic reactions, deformation mechanism and chemical changes during mylonitization and ultramylonitization of granite affected by a crustal-scale shear zone are investigated using microstructural observations and quantitative analysis.

The Vivero Fault (VF) is a large extensional shear zone (>140Km) in NW of Iberia that follows the main Variscan trend dipping 60° toward the West. The movement accumulated during its tectonic history affects the major lithostratigraphic sequence of Palaeozoic and Neoproterozoic rocks and the metamorphic facies developed during Variscan orogenesis. Staurolite, and locally, andalucite plus biotite grew in the hangingwall during the development of VF, overprinted the previous regional Variscan greenschist facies metamorphism. Andalusite growth took place during the intrusion of syntectonic granitic bodies, such as the deformed granite studied here.

The Penedo Gordo granite is coarse-grained two-mica biotite-rich granite intruding the VF and its hangingwall. This granite developed a localized deformation consisting of a set of narrow zones (mm to metric scales) heterogeneously distributed subsequently to its intrusion. Based on pseudosections for representative hangingwall pelites hosting the granite and the inferred metamorphic evolution, the shear zone that outcrops at present-day erosion surface was previously active at 14,7-17 km depth (390-450 MPa). Temperature estimates during deformation reach at least the range 500-600°C, implying a local gradient of 35±6°C/km.

Microstructures in the mylonites are characterized by bulging (BLG) to subgrain rotation (SGR) recristallization in quartz with the increasing of deformation. Albitisation, flame-perthite and tartan twining are common in K-feldspar at the early stage of deformation. The inferred dominant deformation mechanisms are: i) intracrystalline plasticity in quartz, ii) cataclasis with syntectonic crystallisation of very fine albite-oligoclase and micas in K-feldspar, and iii) cataclasis with precipitation of K-feldspar in fractures and other dilatational sites in plagioclase.

Ultramylonites consist of a matrix mainly containing feldspar, quartz and micas (mainly biotite) with an average grain size below 15 μm, usually featuring some quartz pods and small feldspar porphyroclast. Quartz pods disintegrate into polycrystalline aggregates, and the resultant grains are mixed into the surrounding matrix reaching its average grain size. In the matrix, grain size is uniform and the distribution of mineral phases tends to be homogeneous.

Mass balance analysis based on major elements indicates that the deformation process was not isochemical for some elements. Preliminary XRF results show that the mylonitic/ultramylonitic samples are depleted in Na and Mn and enriched in K and Ca respect to the original protolith, while others remains stable (Si, Al or Fe). This data suggests a large-scale transport of some components, and therefore, that fluids were involved during deformation.

Similar feldspar microstructures in mylonites, implying cataclasis and neocrystallisation, have been previously reported in natural rocks where the temperature was estimated between 250 to 450ºC (see Fitz-Gerald and Stünitz 1993, Hippertt 1998 or Ree et al. 2005). In opposition to this, petrological and mineralogical thermometry data indicate that temperatures during deformation of FV reached at 500-600ºC, extending the temperature range previously reported.