Quantitative texture analysis by neutron diffraction in deformed crystalline aggregates: Contín Shear Zone, Morais Complex, N Portugal.

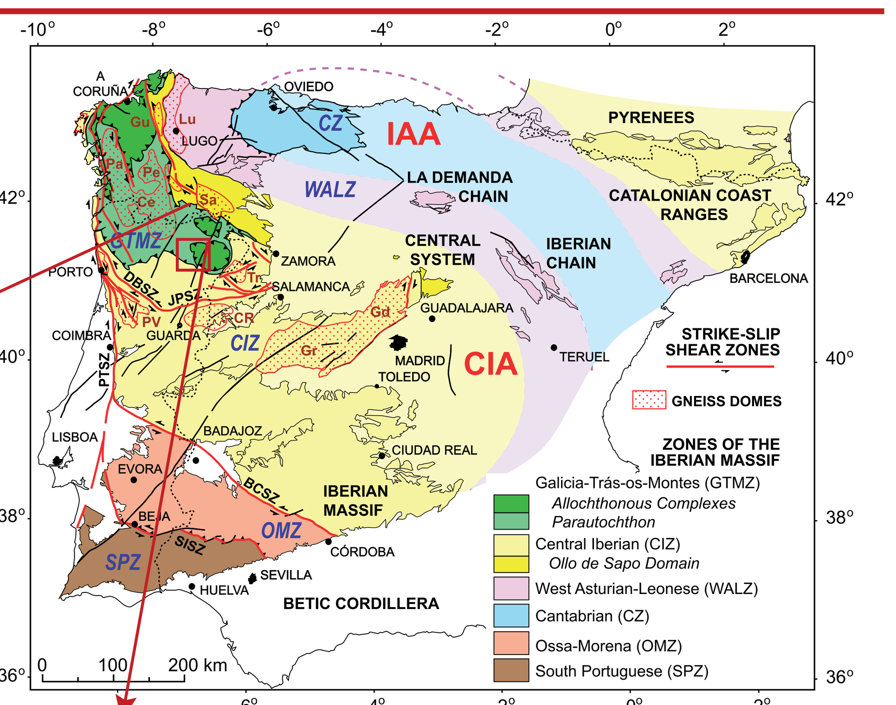
Durán Oreja, Manuela[1], Malecki, Jeremie[1] and Gómez Barreiro, Juan[1]

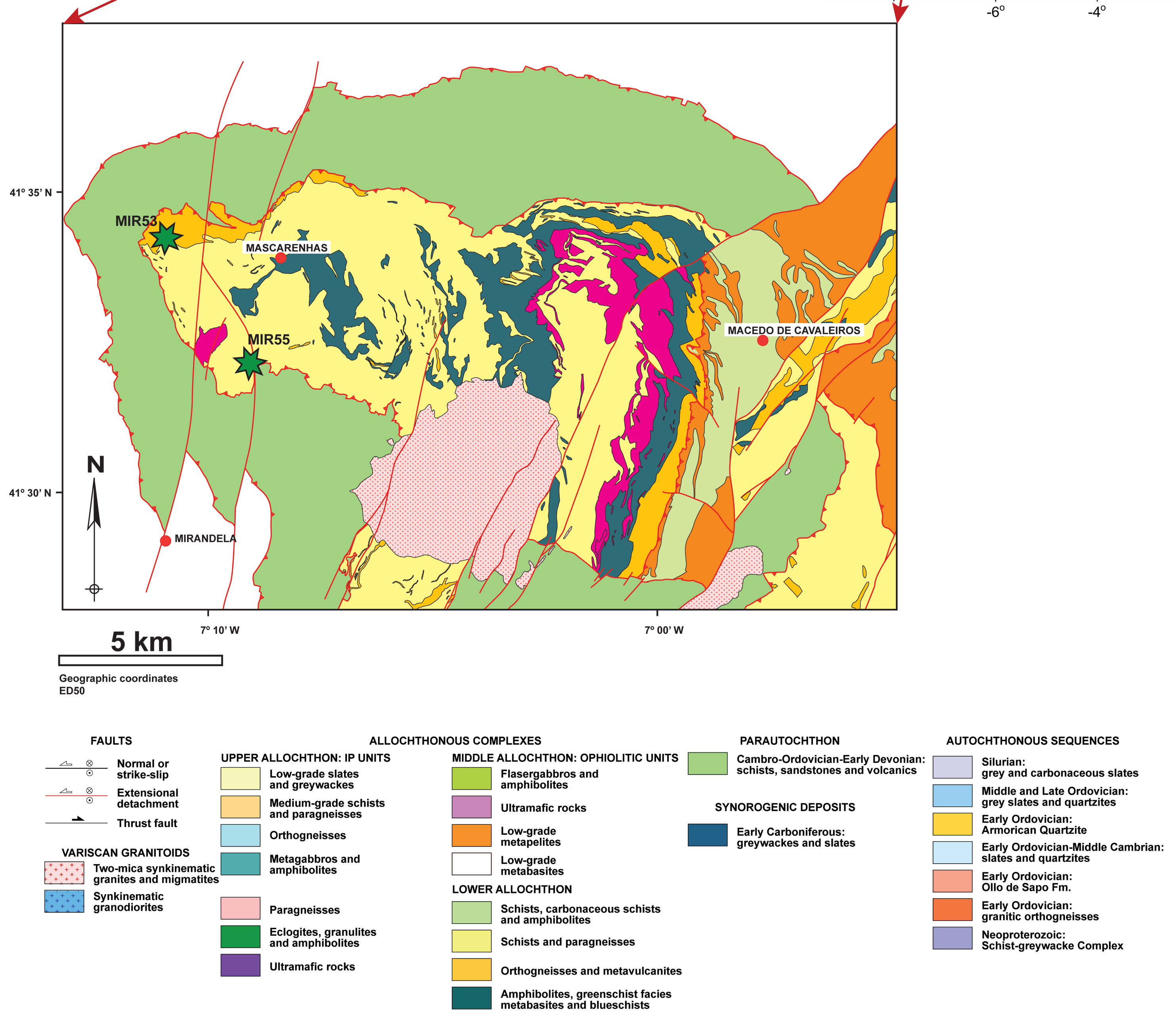
(1) Departamento de Geología, Universidad de Salamanca, Spain (manuduor@usal.es)

Abstract

Two samples of mylonitic-ultramylonitic orthogneisses collected along the Contín shear zone were investigated for crystal preferred orientation and seismic anisotropy. Neutron diffraction data obtained at the D1B beamline at ILL (Institute Laue-Langevin, Grenoble) were analyzed with the Rietveld method as implemented in the code MAUD, to obtain the orientation distribution functions (ODF) of the principal phases (quartz, K-feldspar, plagioclase, phlogopite, muscovite and riebeckite). Texture and microstructure are compatible with the plastic deformation of the aggregates under medium to low-temperature conditions. Kinematic analysis supporhts a top-to-the SE sense of shear, suggesting a thrust character. Using preferred orientation data and single crystal elastic tensors, P and S-waves velocities and elastic anisotropy have been calculated. We have explored the role of several factors controlling the elastic properties of rocks, particularly the role of strain state and mineral changes in a shear zone. Those factors have a direct impact on the medium impedance and consequently on the interphase reflectivity. P-wave velocities, S-wave splitting and anisotropy increase with muscovite content. Seismic anisotropy is linked with the texture symmetry, which can result in large deviations between actual anisotropy and that measured along Cartesian XYZ sample directions (lineation/foliation reference frame). This is significant for the prediction and interpretation of seismic data.

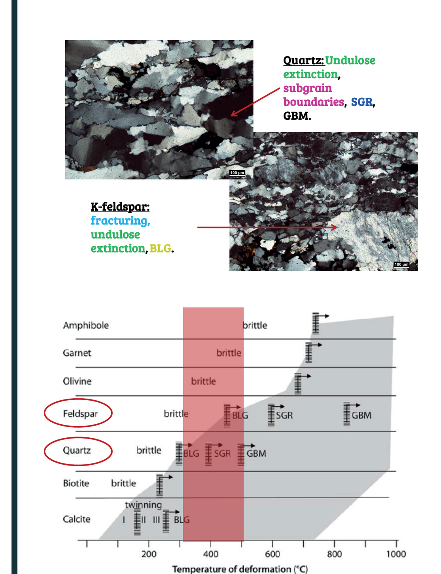
Geological setting and sample location





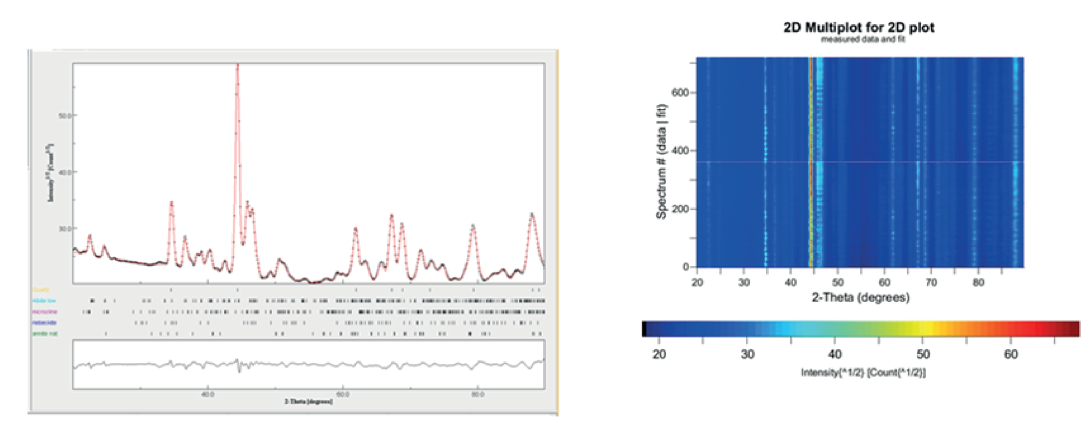
Methods and results

1. Microstructural analysis



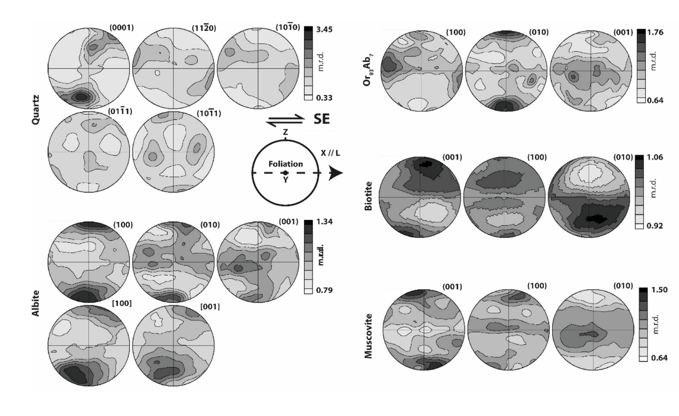
Based on Paschier and Trow (2005)

2. Diffraction data processing

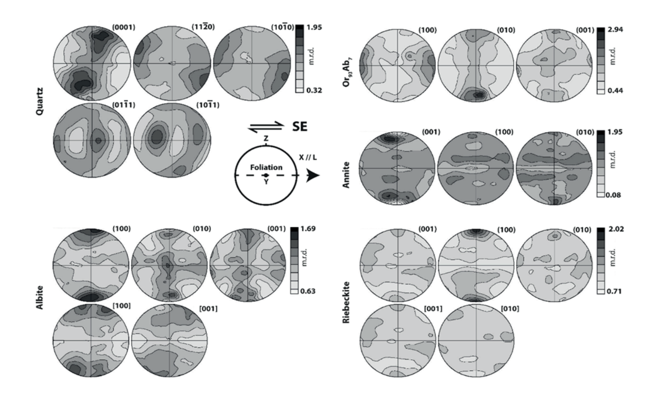


A true, MAUD-adjusted, real diffractogram of mylonite derived from a peralkaline orthogneis. 2D graph for checking the fit between the actual experiment and the theoretical model implemented in E-WIMF.

3. Texture analysis

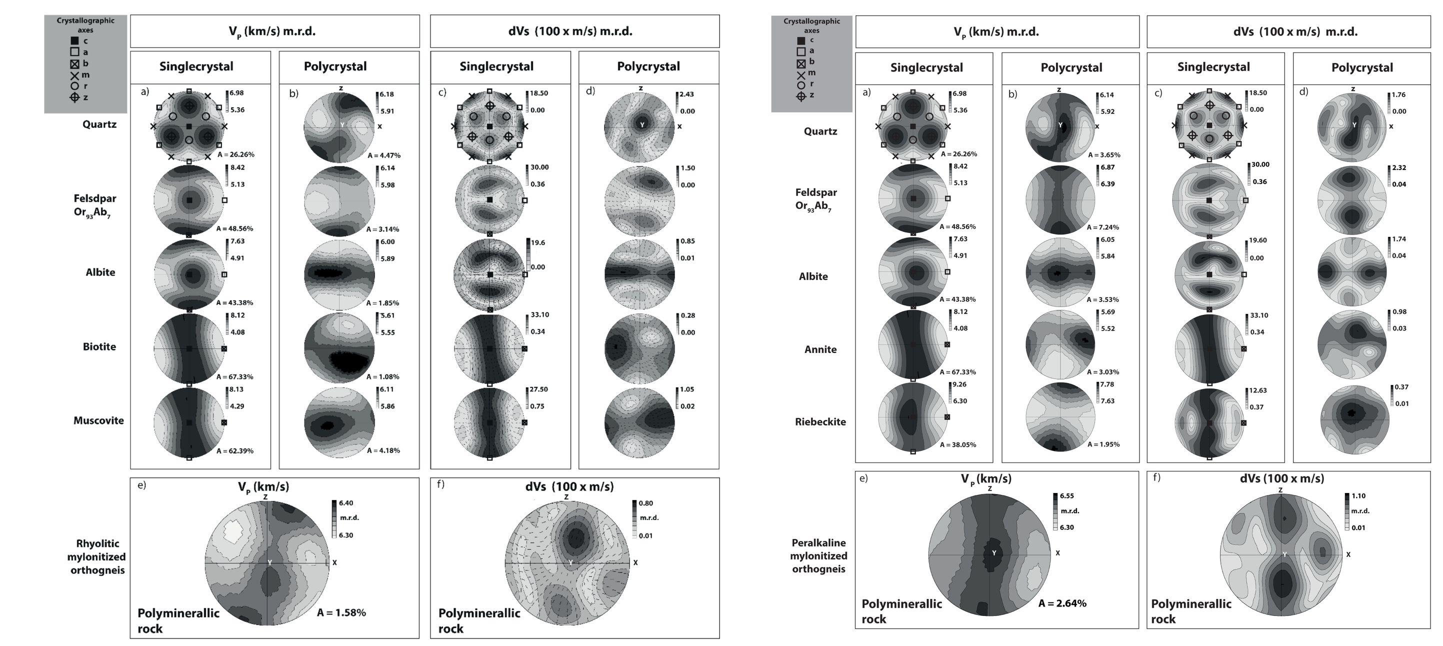


Orientarion Distribution Function (ODF) for MIR55 an orthogneis of ryolitic composition.



Orientarion Distribution Function (ODF) for MIR53 a peralkaline orthogneis

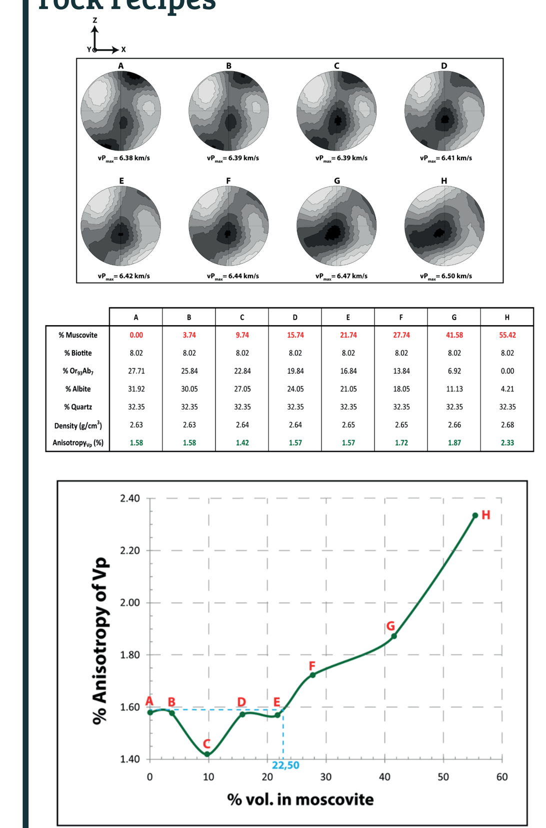
4. Analysis of elastic properties and anisotropy in real rocks



Sample MIR55 Sample MIR53

Models made with BEARTEX (Wenk et al. 1998; Mainprice, 1990; Mainprice and Humbert, 1994).

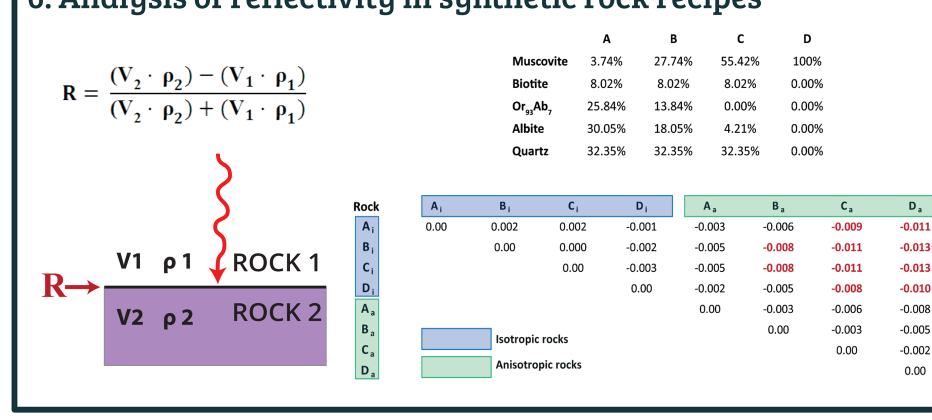
5. Seismic anisotropy in synthetic rock recipes



Increasing the percentage of mica at the expense of potassium feldspar and albite increases the maximum value of Vp, density and anisotropy. The direction in which the maximum values for Vp are located rotates as the % of muscovite increases from a position close to the Z axis to one very close to the Y axis, i. e. from being perpendicular to the mylonitic foliation, to being contained in it and forming a large angle with the lineation.

6. Analysis of reflectivity in synthetic rock recipes

$$R = \frac{(V_2 \cdot \rho_2) - (V_1 \cdot \rho_1)}{(V_2 \cdot \rho_2) + (V_1 \cdot \rho_1)}$$



The increase of muscovite and in particular the filonitization in a shear zone have a clear impact on reflectivity. Although these values are not typical of strong reflectors, they are significant for making such interfaces visible under favourable conditions. This is consistent with the reflector observations associated with large deformation zones in the lithosphere and underlines the usefulness of detailed study of the seismic properties of tectonites for the interpretation of geophysical observations

Conclusions

The textures developed in the Contins shear zone have been investigated, both in chalcoalkaline and peralkaline felsic rocks. This shear zone is relevant because it brings rocks with evidence of high P metamorphism into contact with low-grade rocks without traces of this metamorphism. The results of the kinematic study allow us to conclude that the Contins shear zone is a thrust with a sense of movement from the roof block towards the SE.

The deformation conditions in such thrust have been constrained by microstructural observations and the quantitative calculation of textures by neutron diffraction. Both the textures and microstructures of the different mineral phases indicate that the deformation occurred between 300 and <500ºC, in the upper part of the Green Schist Facies. These deductions are compatible with the thermobarometric calculations made in the unit.

Quartz textures are compatible with the combined activity of two sliding systems (0001) <a> and {r}{z}<a>. It is not possible to rule out the activity of dislocations in feldspars, but considering the textures and microstructural evidences, it is proposed that if there is intracrystalline sliding, this must have been assisted by diffusion phenomena, giving rise to a change in the shape of the crystals due to their preferential growth.

The calculation of the velocities of propagation of seismic waves in mylonites is consistent with observations made on similar felsic rocks that are located in the middle and lower crust. In particular, the absolute values of Vp, AVp and dVs are strongly conditioned by the dominant mineral phase (quartz). However, interaction with the response of the rest of the phases can lead to constructive/destructive interference, blurring the overall signal of the rock. Moreover, the spatial distribution of anisotropy and polarization directions are very sensitive to such interferences, which can misinterpret the deformative conditions of the rock in depth.

The reflectivity of a shear zone increases as the content of micas in it rises. The process of filonitization, which leads to a stabilization of the deformation zones in time, is therefore traceable as long as it is permeable in the crust.

Rheological models based on geophysical interpretations should consider the role and impact of texture in the seismic anisotropy of rocks. Similarly, numerical models should include the influence of preferred orientation on the elastic and plastic parameters of aggregates.

References

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