Experimental report

21/02/2022

Proposal: **5-21-1147** **Council:** 10/2019

Title: Texture transition in paleosubduction systems. Implications for Seismic anisotropy

Research area: Other...

This proposal is a new proposal

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Samples: FeMgNaSiAlO OH

Instrument	Requested days	Allocated days	From	To
D1B	5	4	03/03/2021	07/03/2021
D20	4	0		

Abstract:

Most of the rocks properties are directionally dependent, i.e. anisotropic. It is a main concern both in Geology and Materials Science the microstructure/property relations. In natural polycrystals grain orientation (or texture) are the main responsible of anisotropy. In depth, texture is commonly attained in rocks by the accumulation of plastic strain, and can be related to active or ancient geodynamic flows. Since seismic anisotropy is our best diagnostic tool to determine tectonic flow in deep Earth the interpretation of seismological data in terms of the deformation state and mechanisms must be calibrated with representative natural samples where quantitative texture analyses can be used to explore the elastic anisotropy of the aggregate and set the contribution of each mineral phase to the bulk seismic anisotropy. We propose to use texture analysis to characterise significant fabric transition at high pressure / low-high-T gradients as sampled in the Paleozoic and Cenozoic orogens, mainly in Europe and North America. Those data will be used to model seismic anisotropy and calibrate the geophysical response of rocks in terms of strain gradients.

Experimental report 5-21-1147 @ D1B _ ILL 03/03/2021To 07/03/2021

Texture transition in paleosubduction systems. Implications for Seismic anisotropy

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Most of the rock's properties are directionally dependent, i.e. anisotropic [9]. This has a huge impact on practical uses of geomaterials on e.g. civil engineering [10] or energy resources [11]. Microstructure/property relationship it is a main concern both in Geology and Materials Science. In natural polycrystals grain shapes and, specially, their orientation (or texture) are the elements responsible of anisotropy [12]. In depth, texture is commonly attained in rocks by the accumulation of plastic strain, and can be related to active or ancient geodynamic flows [13]. Besides, seismic anisotropy is our best diagnostic tool to determine tectonic flow in deep Earth [14], and a very active debate exits around the interpretation of seismological data in terms of the deformation state and mechanisms [e.g. 15, 16]. Theoretical models and experiments [3,17,18] must be calibrated with representative natural samples, where quantitative texture analyses can be used to explore the elastic anisotropy of the aggregate and set the contribution of each mineral phase to the bulk seismic anisotropy [3, 12]. Subduction boundaries are fascinating geodynamic systems characterized by a strong seismicity and P-T-deformation gradients [19, 20]. Textures, deformation mechanisms and their evolution along the subduction zone are not well constrained [21] and may shed some light into the rheology and seismic/aseismic behavior of the system [e.g. 22, 23, 24].

We have conducted experiments to quantify the texture of tectonites formed in paleosubduction systems from Palaeozoic and Cenozoic tectonics cycles. ca 1cm3 cubes of selected rock samples have been analysed to quantify the texture minerals components, using the approach already tested at ILL and elsewhere [2, 6]. We have calculated the Orientation Distribution Functions (EWIMV) of every mineral phase, using Rietveld method as implemented in Maud software [1, 2, 5]. In previous experiments in D20 and D1B experimental advantages and limitations have been identified (see experimental report 1-02-163) and during this experiment technical improvements on the system configuration were tested, resulting in significant optimization of beam time. Some strategies have been set for texture extraction in critical combinations of hydrated and non-hydrated mineral phases from natural rocks as well as phases with complex structures (modulated, stacking-faults...) and low symmetry (triclinic-monoclinic). While much work is still to be done on that respect some goals have been reached.
Overall, our texture data were used to calculate the elastic properties of the aggregates based on averages of single crystal properties over the ODF of each mineral phase, using BEARTEX. Those data are used now to model seismic anisotropy and calibrate the geophysical response of rocks in terms of strain gradients, in particulate to define geometry deployments on very recent high-resolution seismic-noise surveys focused on collapsed structures in the Variscan of Iberia.

Cubes (1cm3) were mechanized from selected tectonites. Lineations and foliation were used as sample reference system. Each sample was mounted in transmission and measured with a scan grid of 10º by using 4-circle goniometer. Wavelength used was 2.52Å. Thanks to the low absorption of neutrons, acquisition time was, on average, 10 s per spectrum, resulting in 360 measured scans per sample (ϕ: 0→355º; χ: -90→0º). ω angle was set at 45º to make use of the detector 2θ full range (0-128º). In house standards (NAC and Si) were measured to refine experimental parameters at both wavelengths. Texture standards were used for symmetry control. Raw data was converted into *.F1B format with macro d1b_2_F1B at LAMP for latter refinement at MAUD (Lutterotti et al, 1999; Benítez Pérez, 2017). Quantitative texture analysis was done in Rietveld software package MAUD, computing ODF using E-WIMV. Selected pole figures were recalculated and rotated to show the foliation/and lineation reference system. In the Figure 1 an example of a high-P gneiss is showed in a 2D piled multiplot (experimental data dots/ Rietveld fitting solid lines. Selected pole figures of (a) quartz, (b) garnet and (c) kyanite for this sample is depicted in Figure 2 where quartz shows the highest texture.

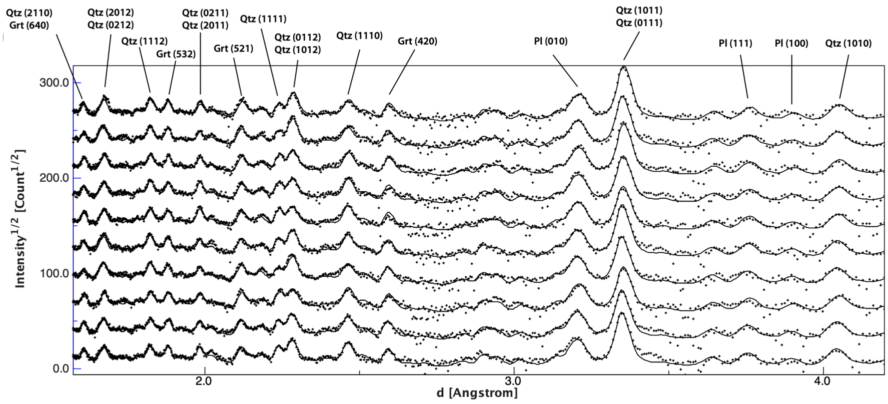

Figure 1: *2D-piled multispectra, with principal peaks indexed.*

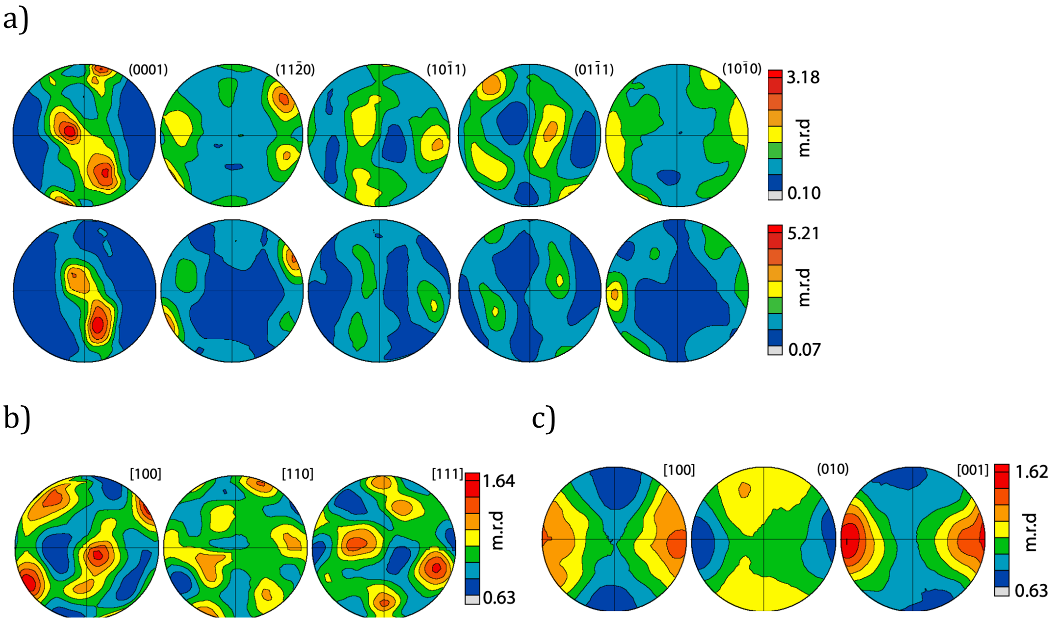

Figure 2: *Pole figures of selected planes and phases. texture in multiples of a random distribution (m.r.d.). Maximum values are 5.21 m.r.d. a) Quartz, b) Garnet, c) Kyanite.*

Texture based elastic properties are depicted in Figure. 3 as calculated in BEARTEX. Polyphasic P-waves (Vp) surfaces (km/s; a) and birefringence (dVs; b)

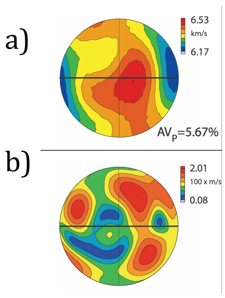

Figure 3: *a) Polyphasic P-waves (Vp) surfaces (km/s) and b) birefringence (dVs; m/s) calculated for an average composition polyphasic HP-granulite.*

Our results clearly suggest that main phase in term of accommodation of plastic deformation control the seismic behaviour of the aggregate.

Conclusions

Neutron diffraction is the reference technique for polyphasic and dense materials, resulting in good grain statistics comparing with EBSD or X-rays. Our results have been very useful to model seismic properties of HP- lithotypes and to understand the close constraint of seismic anisotropy and CPO in paleosubduction environments. Some problems persist on dealing with incoherent scattering from some samples which need to be explored in the future. Besides, this experiment has been used to improve the method and optimize beamline efficiency, coordinating translation speed along the eulerian cradle and precise angle acquisition strategies, to obtain the best coverage as possible.

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