Quantitative textural analysis of geological low-symmetry materials :

amphiboles from the Sesia-Lanzo Zone (Italy)

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Quantitative texture analysis of geological low symmetry material from the Alpine chain, carried out at the D1B diffractometer, allows to compare neutron with X-rays data in the quantitative determination of multiphase geological textures and to define the relationship between microstructure and texture. Texture of amphiboles, deformed at 15-20 kbar and 550-6000C during the Alpine time, shows a pronounced crystallographic preferred orientation related to the rigid body rotation and dislocation creep components of the deformation mechanisms. [010] axis and (hol) planes axis are parallel to the mesoscopic mineralogical lineation. This study shows the neutron reliability compared to X-ray for quantitative texture analysis purposes in polyphasic rocks, which is the first step for the understanding of deformation mechanisms and mechanical proprieties of rocks during subduction.

The development of planar and linear fabrics in metamorphic rocks occurs under different physical conditions (temperature, pressure, stress, strain, strain rate, fluid-mineral grain boundaries interaction, etc.) and depends on the deformation mechanisms active within metamorphic minerals accommodating strain during each stage of mechanical and mineralogical re-equilibration. Microstructural analysis, using classical optical microscopes, even providing a complete description of the relationships between individual grains and subgrains and allowing the description of the multistage mechanical and mineralogical re-equilibration of rocks, remains inadequate for the quantitative analysis of textures (lattice preferred orientation). Scattering probes such as neutrons provide the necessary information.   The investigated samples are hornblendites and eclogites from the Sesia-Lanzo Zone (Western Italian Alps). The Sesia-Lanzo Zone is a kilometre wide slice of continental crust subducted and exhumed during the Alpine orogeny [1]. The quantitative texture analysis of eclogite facies fabrics, developed at high pressure (15-20 kbar) and low temperature (550-600°C) allows investigating the deformation mechanisms of rock forming minerals within a subducting continental crust. The samples are made of recrystallised calco-sodic amphibole (98% of rock volume), chlorite and rutile. The preferred orientation of amphiboles defines the macroscopic mineralogical lineation.

The texture of amphiboles with respect to the microstructure (lineation) has been studied in order to: i) compare neutron data with X-rays in the quantitative determination of multiphase geological material textures; ii) define the relationship between microstructure and texture; iii) describe the active slip system(s) of amphiboles. The D1B diffractometer has been chosen for its curved Position Sensitive Detector (PSD), comparable in angular span to the one used at our laboratory [2], and using a previously developed methodology [3]. Figure 1 compares the summed neutron and X-ray diffraction pattern of M26 sample for the 1368 and 1080 measured scans respectively. The defocussing effect that occurs using flat specimens with X-rays makes high angular ranges (2theta and chi) comparatively less reliable.   This effect is partly compensated for higher incidence (omega) angles (figure 1c). Orientation Distribution (OD) refinements for neutrons, X-rays (at 2 omega values) are compared in figure 2, using experimental and recalculated pole figures. While X-rays at low omega offer unreliable calculation of the OD, using a higher omega value permit a relatively better approximation of it. Neutrons data still show the best reliability (see R-factors), whereas several X-rays experiments on the same samples are needed to compensate the relatively low number of probed grains.

Recalculated pole figures (figure 2) show the concentration of the [010]* axis (a = 9.540 Å, b = 5.281 Å, c = 17.717 Å, g = 103.770°) parallel to the macroscopic lineation (vertical direction in pole figures) and the dispersion of [001]* - [100]* directions within a plane perpendicular to the lineation and foliation. Those patterns reproduce the observation on naturally deformed amphiboles [4 and refs. therein]. In recalculated pole figures from neutron and X-ray experiments the same distribution of lattice axes occurs. It can be shown that the shape preferred orientation of amphiboles, marking the mesoscopic lineation/foliation, corresponds directly to the lattice preferred orientation of the [010]*directions, suggesting a component of rigid body rotation for the fabric development, and that the preferred orientation of the (hol) planes, parallel to the lineation, can be due to slip along [010](hol) systems.   The orientation of the [110]* and the [010]* directions with respect to the lineation and foliation can be interpreted as due to a dominant constrictional component of the finite strain [5]. The pronounced asymmetry of the [010]* directions can also be interpreted as developed during a non-coaxial deformation, where comparable asymmetries have been observed in other materials (e.g. calcite and quartz [6, 7, 8]). The comparison of the two techniques shows that X-ray data can produce semi-quantitative results, which reproduce the overall texture if a sufficient area of the sample, or different pieces of the same sample are scanned in similar conditions and that the neutron results are much more reliable as also shown by the RP values (16.5 for neutron-derived OD and 66.4 for X-ray derived OD).

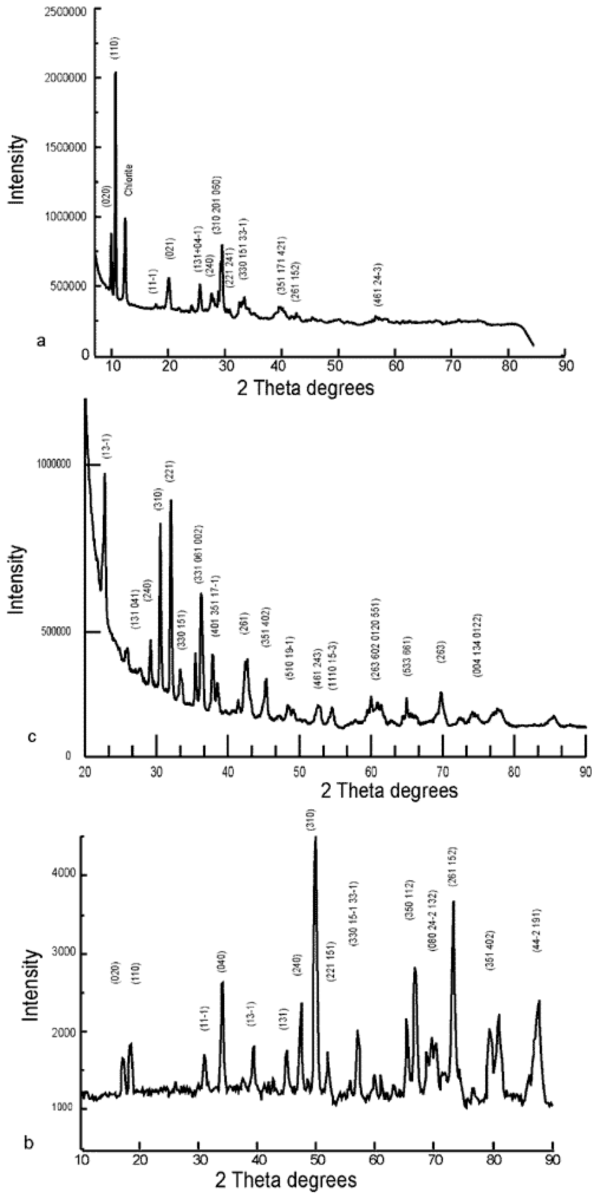

Figure 1: X-ray and neutron diffraction pattern of M26 hornblendite. a) sum of 1080 X-ray diffraction patterns with an incidence angle of 5.36°. b) sum of 1368 neutron diffraction patterns with an incidence angle of 20°. c) Summed X-ray diffraction pattern of 1080 scans with an incidence angle of 16°.

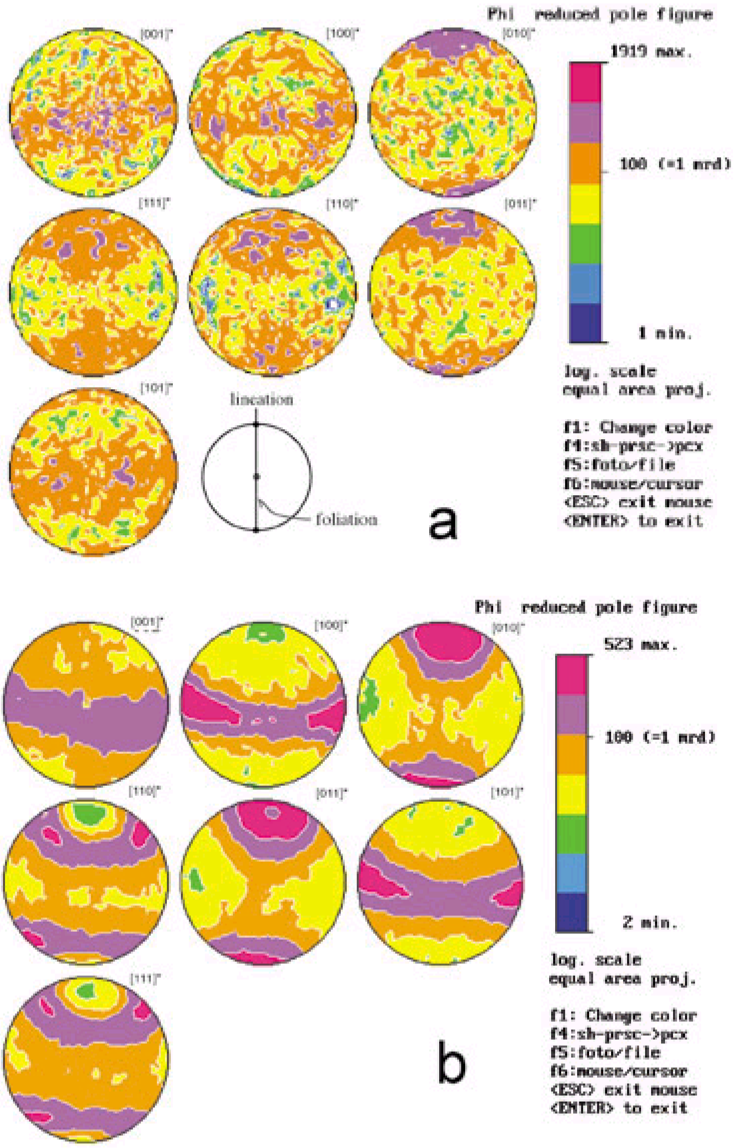

Figure 2: Recalculated pole figures for X-ray (a) and neutron (b) experiments.

References

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