AMS interpretation of major shear zones with contrasting rock rheology (Bragança Massif, NE Portugal)

Silva, P. F. (1), Marques, F. O. (1,*), Miranda, J. M. (1,3), Matias, A. (2), Henry, B. (1)
(1) Centro de Geologia da Universidade de Lisboa, R. Escola Politécnica S.L., Lisboa, p.silva@fct.unl.pt
(2) Dep. de geologia da Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1700 Lisboa
(3) Instituto de Física do Globo da U. de Paris 6, PI Jussieu, 75004 Paris

SUMMARY

We used AMS to help analyze two major shear zones in the Bragança Massif, one corresponding to the contact between the overlying Continental Allelochthonous Terrane (CAT) and the underlying Northern Ultrabasic Terrane (NOT), and the other to a duplex structure within the CAT. AMS results revealed the existence of lineations not observed in outcrop as natural lineations, and showed possible relationships between superposing tectonic events through the interference between the corresponding magnetic ellipsoids. The lineations detected in rheologically contrasting rocks can not be directly associated with tectonic events, because they were generated in distinct metamorphic conditions. Post-rheological recrystallizations are common and tend to erase structural features that can be detected by AMS and are critical in kinematic and dynamical characterization and interpretation.

1. INTRODUCTION

Shear zones (especially those separating terranes) are major features of orogenic belts, and hence the importance of studying them in terms of geometry, kinematics and dynamics. AMS studies can be of great help in the kinematic analysis and interpretation, through the determination of the magnetic ellipsoid. Although not directly comparable to the finite strain ellipsoid in terms of axial ratios (or ratios), they tend to be coincident in terms of axial orientations (Portaille and Henry, 1997). For instance, the longest principle axis of the magnetic ellipsoid tends to be parallel to the neutral point and lineal-corrected animal lines.

AMS data and mineralogy

2.1. CAT/NOT CONTACT (north)

3. Transient of the CAT/NOT contact first took place under amphibolite facies conditions, and later in greenschist facies.

2.2. AMPHIBOLITITES (CAT)

Microprobe analyses showed that the paramagnetic minerals hornblende and epidote are the main constituents. In the amphibolites, samples display two distinct groups, one with low magnetic susceptibility values (less than 9 x 10^3 SI) and another formed by two samples with higher susceptibility values than reach 9 x 10^3 SI. These results agree with microprobe analyses and magnetic measurements that revealed the existence of multi-domain magnetite. These results also suggest that the samples with lower susceptibility values present a similar contribution of paramagnetic and ferromagnetic (CL) minerals for the magnetic fabric, while in samples with high susceptibility values the magnetic fabric result from the magnetite contribution. Both types of samples display the same shape of the magnetic ellipsoid (oblate shape) but with greater corrected degree of anisotropy for the samples richer in magnetite. However, all the samples of the site display coincident orientation of the principal axes of the magnetic ellipsoids, which agrees with a sin-isotachic recrystallization of the magnetic minerals. The magnetic ellipsoid has K1 oriented N-S.

2.2. GREEKCHINITES (NOT)

The greenschists result from retrogression of the amphibolites of the NOT. The magnetic susceptibility measurements revealed a very homogeneous behavior in what concerns the buli anisotropy.
values. The low values of the magnetic susceptibility found for this lithotype agree with the microprobe analyses, which revealed mainly paramagnetic minerals (mostly actinolite and chalcopyrite) with a low content of magnetic minerals. The magnetic fabric displays an oblate shape. However, it is possible to identify a good cluster of the principal axes of the average magnetic ellipsoid, outing in evidence a cluster of the K1 axis along an E-W direction, which is not marked in the outcrop by a mesoscopic mineral lineation. 2.2. CATNAT CONTACT (SOUTH) Here the ophiolitic rocks still preserve the earlier amphibolite facies. 2.2.1. GNEISES (CAT) The magnetic susceptibility measurements display a homogeneous behavior. This reflects a stable mineralogical composition that was revealed by microprobe results to be of dominantly dia-
magnetic and paramagnetic minerals, with a small percentage of ferromagnetics (1%). The low values of magnetic susceptibility (<350*10^-6 SI) agree with these results. The magnetic fabric displays an oblate shape for the samples of the two involved sites. The geographical orientation of these two ellipsoids display a preferential cluster of the K1 axes along a NW-SSE trend, coincident with the mesoscopic mineral lineation, not present in these sampled sites but observed in other outcrops of the same contact. 2.2.2. AMPHIBOLITES (NOT) The amphibolite samples of this contact display lower bulk val-
ues of the magnetic susceptibility than the amphibolite samples of the Northern contact. These magnetic results are typical of a mineral-
alogy poor in ferromagnetics (k1 minerals), which suggests that the magnetic fabric is the result of the paramagnetic mineralogy (mostly plagioclase and hornblende). The magnetic ellipsoid di-
fined by the samples of this site display a homogeneous behavior in its principal axes and oblate shape and geographical orientation of the principal axes, with K1 trending NW- SSE as in the overlying gneisess. 2.3. DUPLEX WITHIN THE CAT This contact is developed under amphibolite facies conditions and puts gneisess on top of peridotites and mafic gneisess. 2.3.1. GRANULITES In these rocks, the high field and thermomagnetic measure-
ments reveal the presence of a nanomagnetic poice in Ti, with pseudo-single-domain. Because they present low values of mag-
netic susceptibility, we suggest that the magnetic fabric is a result of a similar contribution of paramagnetic and ferromagnetic mineral-
as, as also revealed by microprobe analyses. The magnetic fabric displays a slight tendency for an oblate shape. However, the principal axes of the magnetic ellipsoids ap-
pear very well clustered, with K1 axes trending approximately E-W. 2.3.2. PERIDOTITITES In this duplex structure, just over the granulites, we find more incoherent peridotites. The thermomagnetic analyses indicate magnetite as the main magnetic carrier. These magnetite grains dis-
play a population that fall in the pseudo-single-single domain tran-
sition (Day et al., 1976, Dunlop, 1986), a result that can be responsi-
ble for some anomalies in the functions of the principal axes of the magnetic ellipsoids (Borradaile, G. J. & Henry, B., 1997). The magnetic fabric of these samples display an intense oblate shape (T > 0.8) with the corrected degree of anisotropy values ranging from 86% to 109%. The directional analysis displays a K1 and K2 dipersion on a well marked magnetic foliation plane. 2.3.3. GNSSES These samples display similar magnetic behaviors when com-
pared with the gneisess of the southern CATNAT contact. The magnetic fabric is probably caused by the paramagnetic minerals as suggested by the low values of magnetic susceptibility. The magnetic fabric displays an oblate shape with the pole of the magnetic foliation sub-vertical. The principal axes of the mag-
netic ellipsoid, K1 and K2, display a dispersion along the primitive, only allowing a conclusion of a sub-horizontal magnetic foliation. 3. DISCUSSION The CATNAT contact puts competent amphibolites directly on top of incompetent gneisess, and we come to the conclusion that these have taken up some deformation after the N-S event, re-
corded in the amphibolites. Then, E-W magnetic lineation detected, by AMS in gneisess, is younger than the N-S lineation in am-
phibolites. The duplex shear zone within the CAT puts incompetent gneis-
ess on top of competent mafic gneisess, through a thin sheet of mi-
competent siltstones. Then, the incompetent rocks must take up most shearing and granulites preserves the earlier structures. We come to the conclusion that, before, the E-W lineation observable in gneisess is older than the N-S lineation detected by AMS in gneisess and siltstones. In the footwall precipitates and hanging-
wall gneisess the magnetic foliation is very strong (as in the mylonitic and metamorphic foliations) but there is a great disper-
sion of K1 and K2 (which agrees with the absence of a mesoscopic mineral lineation), indicating a “panslice” shape of the magnetic ellipsoid. This could be the result of a superposition of two high angle transport foliations (in parallel: generation of a new ellipsoid by the younger deformations) and/or pervasive pre-
kinematic recrystallization. Although there are two E-W lineations, one can not directly asso-
miate them just because they have the same trend: E-W lineation in the CATNAT contact was generated in previous facies condi-
tions, and E-W lineation in the duplex under gneissic facies condi-
tions. Besides, it is known from regional geology that the high-grade lineation is associated with transport to the W, and the low-grade lineation with transport to the E. The N-S lineations can be the re-
sult of the same tecrtic event because they were produced under similar amphibolite facies conditions and are associated with the same transport to the N of the CAT over the NOT. In sampled locations where mineral lineations and mylonitic folia-
tions are observed, AMS results agree with mesoscopic observations, with the exception that the mineral lineation is observed. AMS data revealed a magnetic foliation that is in agreement with lineations and transport directions known from regional geology. 4. CONCLUSIONS Amphibole is in general post-tectonically recrystallized and/or in metamorphic replacement of higher grade minerals (e.g. pyro-
zois), which masks the true fabric strain and magnetic ellipsoids. There one must look for rocks that preserve the mylonitic fabric (which is sometimes not possible) to try and assess the actual ellip-
oids. AMS proved to be an excellent tool in the kinematic analysis of mylonitic shear zones, especially those lacking mineral linea-
tions or a result of intense post-tectonic recrystallization. 5. ACKNOWLEDGEMENTS Thanks are due to Dr. Maxime Le Goff and Dr. Maurose Billaud, Instra-