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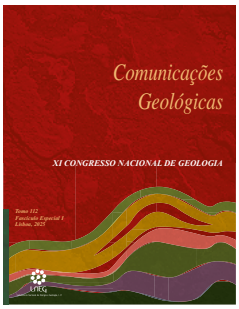
High strain peralkaline orthogneisses within orogenic scale shear zones: geological and structural mapping in the Arronches region (Tomar-Badajoz-Córdoba Shear Zone, Ossa-Morena Zone)

Deformação em ortognaisses peralcalinos em zonas de cisalhamento de escala orogénica: cartografia geológica e estrutural na região de Arronches (Zona de Cisalhamento Tomar-Badajoz-Córdoba, Zona de Ossa-Morena)



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Abstract: The lithological units in the Arronches region (included within the Arronches tectonic unit, Tomar-Badajoz-Córdoba Shear Zone, northernmost Ossa-Morena Zone) and in particular the peralkaline orthogneisses therein, have been the target for petrological, geochemical and structural studies in order to constrain its petrogenesis and tectono-metamorphic contextualization within the broader regional geology. Two detailed geological-structural maps of the Arronches region (from the Arronches village and the Fialha area), as well as the structural analysis allow the description of two mylonitic high strain fabrics found in different peralkaline orthogneiss bodies (the dominantly Arronches-type S fabric and the dominantly Fialha-type S-L fabric), which provide better insights about the internal architecture of the Tomar-Badajoz-Córdoba Shear Zone.

Keywords: peralkaline gneisses, structural mapping, high strain, Arronches region, Tomar-Badajoz-Córdoba Shear Zone.

Resumo: As unidades litológicas na região de Arronches (incluídas na unidade tectónica de Arronches, Zona de Cisalhamento Tomar-Badajoz-Córdoba, extremo norte da Zona de Ossa-Morena) e em particular os ortognaisses peralcalinos, têm sido alvo de estudos de petrologia, geoquímica e geologia estrutural, para constranger a petrogénese e contextualização tectono-metamórficas para a geologia regional. Dois mapas geológico-estruturais detalhados da região de Arronches (da vila de Arronches e da área da Fialha), bem como uma análise estrutural permitiram a descrição de dois tipos de texturas miloníticas encontradas em diferentes corpos de ortognaisses (o *fabric* S dominante no tipo Arronches e o *fabric* S-L dominante no tipo Fialha) o que fornece uma visão mais detalhada sobre a arquitectura interna da Zona de Cisalhamento Tomar-Badajoz-Córdoba.

Palavras-chave: gnaisses peralcalinos, cartografia estrutural, deformação, região de Arronches, Zona de Cisalhamento Tomar-Badajoz-Córdoba.

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1. Introduction

Mylonites and their textures are crucial to characterize the extent of ductile shear zones, as they occur mainly in high-strain shear belts, and therefore provide valuable information into the history and deformation mechanisms associated with different stages of Wilson Cycle(s) (*e.g.*, Passchier and Trouw, 2005, and references therein). In particular, the strongly developed planar foliation and straight lineation of mylonites tend to reflect the direction and sense of shear, therefore consisting of mappable criteria for the determination of shear zone kinematics, as well as the main tectono-metamorphic processes.

Orthogneisses with protoliths consisting of tabular or elongated minerals (alkali feldspar, mica and amphibole) can exhibit pronounced high strain textures when subjected to shearing (*e.g.*, colour segregation of mafic-felsic phases due to mechanical rotation and stretching, blastesis, etc.). Likewise, felsic orthogneisses encompassed in mylonitic zones can provide structural data able to comprehend the development and segmentation of first order shear zones.

In the SW of the Iberian Massif, orthogneisses of alkaline and peralkaline composition are widespread throughout the Tomar – Badajoz - Córdoba Shear Zone (in both Portugal and Spain, *e.g.*, Ribeiro *et al*., 2007), showing different mylonitic fabrics with well-defined foliation and lineation, which can provide some insights about the development of this Variscan shear zone, and its internal architecture. The deformation found in the Arronches region (NE Alentejo) is an outstanding example of high strain tectonites developed in the peralkaline orthogneisses, herein described.

2. Geological setting

The northernmost boundary of the Ossa-Morena Zone (OMZ, SW Iberian Massif) corresponds to an orogenic scale shear zone (the Tomar-Badajoz-Córdoba Shear Zone, TBCSZ), with complex structural architecture (*e.g.*, Pereira, 1999), and distinct stratigraphic and metamorphic features that led to the individualization of a litho-stratigraphic sector of OMZ, defined as the Blastomylonitic Belt (Oliveira *et al*., 1991; Figura1). The generic stratigraphic succession is characterized by variably metamorphosed Neoproterozoic (Ediacaran) metasediments, with some metavolcanic intercalations, – the Série Negra – and the Lower Cambrian detrital and carbonated successions, intercalated with rift-related felsic and basic metavolcanic rocks and orthogneisses, some reaching alkaline/peralkaline mineralogical and chemical composition (*e.g.*, Coelho and Gonçalves, 1972; Oliveira *et al*., 1991; Pereira, 1999).

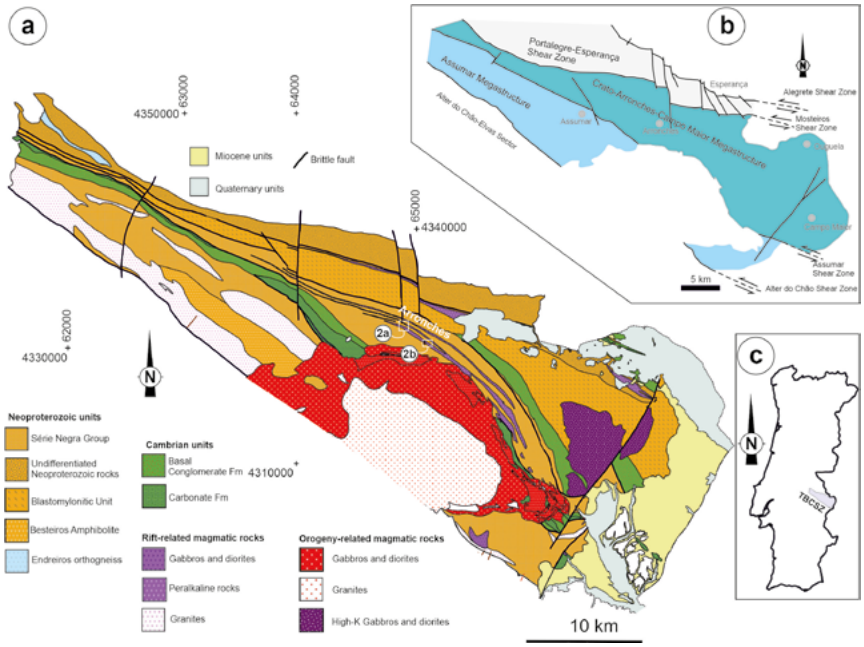

Figure 1. (a) Geological map of the Tomar-Badajoz-Córdoba Shear Zone (northernmost Ossa-Morena Zone) with the (b) major structures as defined by Pereira (1999) and (c) its geographic location.

Figura 1. (a) Mapa geológico da Zona de Cisalhamento Tomar-Badajoz-Córdoba (extremo norte da Zona de Ossa-Morena) com as maiores estruturas como definido por Pereira (1999) e (c) a sua localização geográfica.

The TBCSZ affects either the northern domains of the OMZ, or the southernmost Central Iberian Zone domains, bounded by the Portalegre-Esperança Shear Zone, a second order shear zone within TBCSZ (Pereira *et al*., 1999). The southern boundary of TBCSZ with the Alter do Chão – Elvas Sector is defined by the Alter do Chão second order shear zone, which is extending NW-SE to Spain. Within the OMZ, the TBCSZ is further subdivided in two major megastructures based on tectono-metamorphic features: the Crato - Arronches - Campo Maior Megastructure in the NE (with peak amphibolite facies metamorphism), and the Assumar Megastructure (greenschist facies), in the SW, separated by the sinistral transpressive Assumar Shear Zone (Pereira, 1999; Pereira and Silva, 2006; Figura 1b). Within the Crato - Arronches - Campo Maior Megastructure, five tectonic units separated by high strain shear zones were described, from north to south: Ouguela, Azeiteiros, Campo Maior, Contenda-Barragem do Caia and Arronches tectonic units (Pereira, 1999; Pereira and Silva, 2004; Pereira *et al*., 2008, 2010). The Arronches tectonic unit (ca. 550º-600ºC, 8-10 kbar; Pereira, 1999) hosts the most extensive alignments of peralkaline orthogneisses, outcropping within the Neoproterozoic-Lower Cambrian sequence (Pereira and Silva, 2004).

Two major distinct types of peralkaline orthogneisses have already been described based solely on the mineralogy, particularly regarding the presence of nepheline and the type of amphibole (Coelho and Gonçalves, 1972), with ^{238}U-^{206}Pb crystallization ages of 470 ± 2.8 Ma of the protolith (determined with LA-MC-ICP-MS; Díez-Fernández *et al*., 2014).

3. Geological map and structural features of the peralkaline orthogneisses

Geological mapping and extensive structural analysis were carried out, focusing on two main areas in the Arronches region (Figura 1a): (i) in the outer and center of the Arronches village area (Figura 2a), and in the Fialha area (Figura2b), located approximately 1.5 km to SE from the village. The country rocks are micaschists, meta-greywackes and dark quartzites similar to the Ediacarian Série Negra

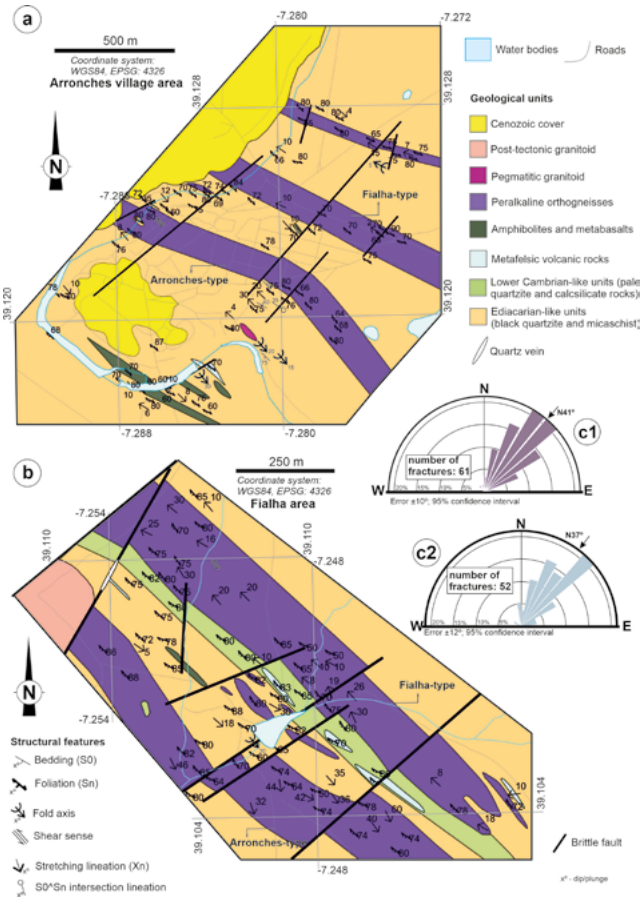

Figure 2. (a) Geological map of the Arronches village. (b) Geological map of the Fialha area. Projection of fracturation pattern in the Arronches village (c1) and in the Fialha area (c2).

Figura 2. (a) Mapa geológico da vila de Arronches e (b) Mapa geológico da área da Fialha. Projeções do padrão de fraturação na vila de Arronches (c1) e na área da Fialha (c2).

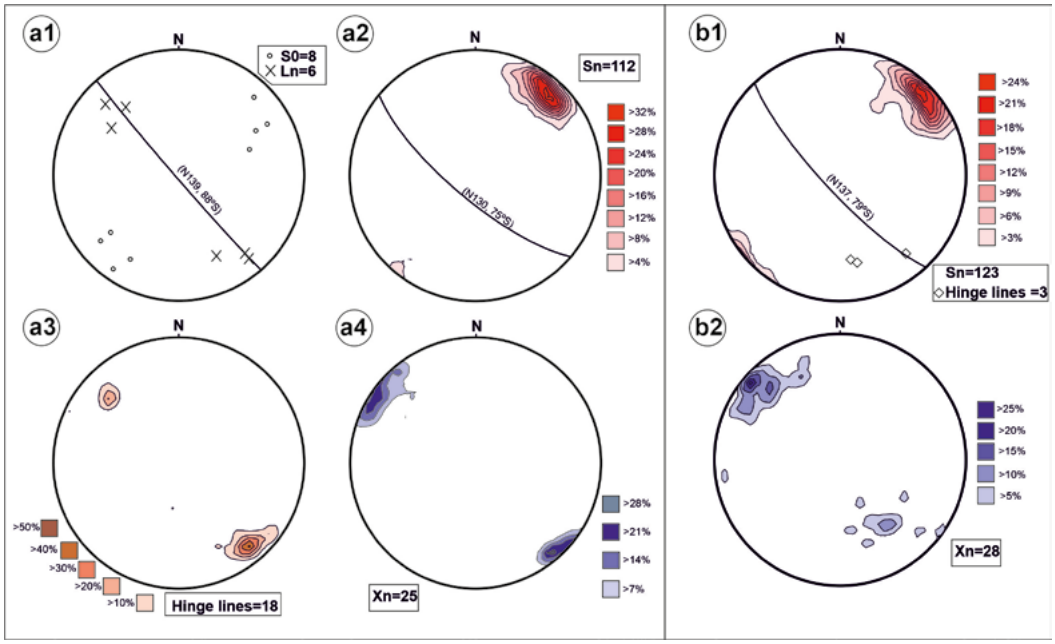

Figure 3. Projections of planar and linear structures corresponding to bedding and intersection lineation (a1), foliation (a2), hinge lines (a3) and stretching lineation (a4) measured in the Arronches Village, and the foliation and hinge lines (b1) as well as stretching lineation (b2) in the Fialha area.

Figura 3. Projeções das estruturas planares e lineares correspondentes à estratificação e lineação de interseção (a1), foliação (a2), eixos de dobra (a3) e lineação de estiramento (a4) medidas na Vila de Arronches, e a foliação e eixo de dobras (b1), bem como a lineação de estiramento (b2) na área de Fialha.

succession, though in the Fialha area several outcrops of banded pale quartzites and calcsilicate rocks, with NW-SE trend (Figura 2b) are also reported (Coelho and Gonçalves, 1972; Pereira, 1999; Pereira and Silva, 2004), resembling the Lower Cambrian strata. Elongated peralkaline orthogneisses, amphibolites and felsic volcanic rocks also outcrop. The NW and W of the Arronches village is partially covered by fluvial detrital deposits (Figura 2a). The late fracture pattern is similar throughout the region, with very steep NE-SW fractures (ca. N40º) and coeval sinistral brittle faults (Figs. 2c1 and 2c2).

The high strain sinistral shearing of TBCSZ (with a pervasive NW-SE trend) overprinted most of the primary sedimentary features, although in the southern of the Arronches village area, folded bedding (S_0, with mean direction N140º, subvertical) can be observed, generally subparallel to foliation (S_n), developing a gently plunging S_0^S_1 intersection lineation (L_n) (15º-35º to either the SE or NW; Figs. 3a1 and 3a2). The S_n foliations are dominantly verticalized (> 60º) and concordant with the regional trend (mean direction N130º), showing gently plunging stretching lineation (X_n; Figura 3a4), ranging from subhorizontal to 20-30º, close to hinge lines, undulating to SE and NW (Figura 3a3).

In the Fialha area, no S_0 or intersection lineation were found, and the foliation are comparable to those characterize the Arronches village area, with high dipping (> 55º) planes towards N140º, sometimes folded, with hinge lines gently plunging 29º to the SE quadrant (Figura 3b1). Also, gently plunging stretching lineation pattern is found (ca. 2º towards NW; Figura 3b2).

4. Two different types of mylonitic fabric in peralkaline orthogneisses

In both areas studied, medium to coarse-grained, leucocratic to mesocratic peralkaline orthogneisses are found. They outcrop as small highly deformed intrusions or as major prominent elongated km-scale stripes (Figura 2), three of them outcropping in the Arronches village area, and two in the Fialha area. They exhibit two distinct mylonitic fabrics, which are observable at outcrop scale, resulting in the identification of the Arronches-type and the Fialha-type peralkaline orthogneisses.

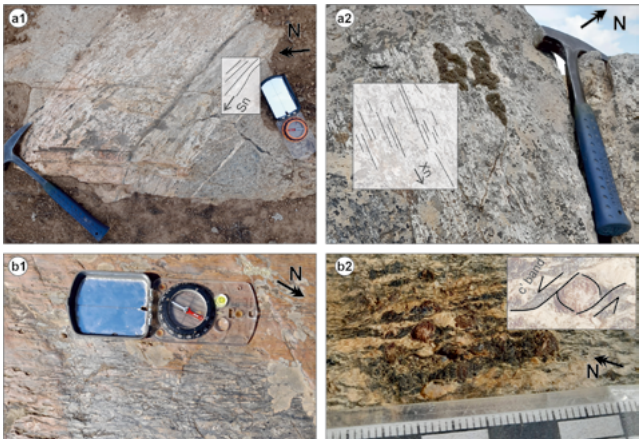

Figure 4. (a1) Typical aspect of the Arronches-type peralkaline orthogneisses. (a2) Although rare, the well-marked stretching lineation (Xn) of the Arronches-type. (b1) Augen development in the Fialha-type fabric. (b2) c'-type bands indicating sinistral shear sense on garnet-amphibole porphiroclasts of Fialha-type orthogneisses.

Figura 4. (a1) Aspecto típico dos ortognaisses peralcalinos tipo-Arronches. (a2) Apesar de rara, a lineação de estiramento (Xn) bem marcada dos ortognaisses tipo-Arronches. (b1) Desenvolvimento de ocelos no fabric tipo-Fialha. (b2) Bandas do tipo c' indicando critérios esquerdos em porfiroclastos de granada e anfibola dos ortognaisses tipo-Fialha.

The Arronches-type texture characterizes the southernmost body (Figs. 2, 4a1 and 4a2) and is characterized by a prevailing S fabric, dominated by mylonitic foliation all throughout the region, with the exception on the SW segment (in Fialha area) showing

a proeminent S-L fabric with a well-marked moderately plunging stretching lineation (> 30º) to the SE quadrant (Figs. 2b and 4a2).

The Fialha-type texture is identified in the central and northern peralkaline orthogneisses in the Arronches village are, and in the northernmost in the Fialha area (Figura 2), presenting distinctive features, with dominant S-L fabric and gently plunging X_n (< 30º) to NW. This orthogneiss usually develops augens (usually σ-type porphyroclasts of amphibole, feldspar and garnet; Figura 4b) that often show c'-type shear bands with direction varying N100º to N160º, indicating prevalent sinistral shear sense (Figura 4b2).

5. Final remarks

Geological and structural mapping of the Arronches region show well-preserved high strain deformation features of the Arronches tectonic unit, that reflect the regional deformation associated with the evolution of the Variscan sinistral TBCSZ. The peralkaline orthogneisses exhibit different deformation features, presumably because of different primary textural-mineralogical features which probably underwent distinct P-T-t high strain deformation paths during the development and evolution of the TBCSZ (Coelho and Gonçalves, 1972; Pereira and Silva, 2006). Both the Arronches-type and the Fialha-type peralkaline mylonites show regional NW-SE foliation, and contrasting subhorizontal to moderate plunging X_n, indicating the segmentation of different blocks within the Arronches tectonic unit, associated with a significant strain partitioning component during sinistral-dominant shearing of the TBCSZ. The previous mentioned discrepant structural relations also result in a block segmentation of the first order TBCSZ, with metamorphic bounds demarked by second order shear zones between tectonic units and megastructures as pointed by Pereira (1999) and Pereira and Silva (2006).

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References

Coelho, A. P., Gonçalves, F., 1972. Novos elementos sobre gnaisses nefelínicos e rochas hiperalcalinas albíticas do Alto Alentejo. *Boletim da Sociedade Geológica de Portugal*, **18**: 105-117.

Díez-Fernández, R., Pereira, M. F., Foster, D. A., 2014. Peralkaline and alkaline magmatism of the Ossa-Morena zone (SW Iberia): Age, source, and implications for the Paleozoic evolution of Gondwanan lithosphere. *Lithosphere*, **7**(1): 73-90. https://doi.org/10.1130/L379.1

Oliveira, J. T., Oliveira, V., Piçarra, J. M., 1991. Traços gerais da evolução tectono-estratigráfica da Zona de Ossa-Morena. *Cad. Lab. Xeol. Laxe*, **16**: 221-250.

Passchier, C. W., Trouw, R. A., 2005. *Microtectonics*. Springer Science & Business.

Pereira, M.F., 1999. *Caracterização da estrutura dos domínios setentrionais da Zona de Ossa-Morena e seu limite com a Zona Centro-Ibérica, no Nordeste Alentejano*. Doctoral thesis (Unpublished). Universidade de Évora.

Pereira, M. F., Silva, J. B., 2004. Development of local orthorhombic fabrics within a simple-shear dominated sinistral transpression zone: the Arronches sheared gneisses (Iberian Massif, Portugal). *Geological Society, London, Special Publications*, **224**(1): 215-227.

Pereira, M. F., Silva, J. B., 2006. Nordeste Alentejano. In: Dias, R., Araújo, A., Terrinha, P., Kullberg, J. C. (Eds.), *Geologia de Portugal no contexto da Ibéria*, 145-150.

Pereira, M. F., Apraiz, A., Silva, J. B., Chichorro, M., 2008. Tectonothermal analysis of high-temperature mylonitization in the Coimbra–Córdoba shear zone (SW Iberian Massif, Ouguela tectonic unit, Portugal): evidence of intra-continental transcurrent transport during the amalgamation of Pangea. *Tectonophysics*, **461**(1-4): 378-394.

Pereira, M. F., Apraiz, A., Chichorro, M., Silva, J. B., Armstrong, R. A., 2010. Exhumation of high-pressure rocks in northern Gondwana during the Early Carboniferours (Coimbra–Cordoba shear zone, SW Iberian Massif): tectonothermal analysis and U–Th–Pb SHRIMP in-situ zircon geochronology. *Gondwana Research*, **17**(2-3): 440-460.

Ribeiro, A., Munhá, J., Dias, R., Mateus, A., Pereira, E., Ribeiro, L., Fonseca, P., Araújo, A., Oliveira, T., Romão, R., Chaminé, H., Coke, C., Pedro, J., 2007. Geodynamic evolution of the SW Europe Variscides. *Tectonics*, **26**(6). https://doi.org/0278-7407/07/2006TC002058$12.00.