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Microfabrics and zircon U–Pb (SHRIMP) chronology of mylonites from the Patos shear zone (Borborema Province, NE Brazil)

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ABSTRACT

Microstructures, U–Pb SHRIMP zircon ages and temperature estimates were used to constrain the fabric evolution and timing of mylonitisation in the Patos shear zone (NE Brazil). Melt-bearing HT-mylonitic orthogneiss displays solid-state fabrics with coarse quartz ribbons and sutured grain boundaries. K-feldspar is often fractured and shows peripheral myrmekite. The textures typically become magmatic at the contacts with the Espinho Branco anatexite. Zircon crystals from two samples of the leucosome show Paleoproterozoic (ca. 2.2 Ga) inherited cores that are enveloped by recrystallised Neoproterozoic rims. These zircon grains define a discordia with lower intercept ages of 558 and 562 Ma but with large analytical errors. A leucogranite with transitional contacts with host diatexites provides a well-constrained zircon mean age of 566 ± 6 Ma (n = 15, 95% conf.), which is considered the best estimate for the peak metamorphic conditions. The transition from HT-mylonites to fine-grained mylonites and ultramylonites is marked by a progressive grain size reduction assisted by recrystallisation. Quartz crystallographic fabrics display [0 0 0 1] concentrations between Z and Y. K-feldspar and plagioclase fabrics record the activity of the (0 1 0)[0 0 1] and (0 1 0)[1 0 0] slip systems and, in the lower-temperature tectonites, the (1 0 0)[0 1 0] slip system. These results suggest a diachronic evolution in which an initial HT northern domain was deformed by intracrystalline slip and melt-assisted granular flow, followed by medium- to low-temperature solid-state creep in the southern shear zone domain. The mylonites therefore record the rheological heterogeneities responsible for the formation of a late continental shear zone that nucleated under partially molten conditions and was later reactivated through melt-absent strain localization following exhumation.

1. Introduction

The Neoproterozoic Brasiliano/Pan-African orogeny produced an anastomosing, wide network of conjugate shear zones that affected the Benin-Nigeria and Cameroon shields in West Africa and the Borborema Province in NE Brazil. This type of transcontinental fault system is believed to be typical of mid- to upper crustal conditions in that a large amount of shear strain is accommodated in relatively narrow high-strain corridors. From West Africa to NE Brazil these shear zones are roughly parallel to the suture that assembled the West African craton (WAC, Fig. 1) to the Dahomeyides-Nigeria-Borborema provinces in the Early Ediacaran (Attoh et al., 1997; Caby, 2003; Arthaud et al., 2008). Some of these shear zones, such as the Transbrasiliano-Kandi, Senador Pompeu-Ile-Ife, and Patos-East Nigeria (PSZ, Fig. 1), constitute major ductile strike-slip faults that can be used to link both continents prior to the Mesozoic continental break-up and drifting (e.g., De Witt et al., 2008). Likewise, the Patos-East Nigeria shear zone attracts particular attention primarily because it might constitute a terrane boundary. According to Van Schmus et al. (2008), this shear zone limits major geochronological provinces that, in the Nigerian segment, are associated with mafic–ultramafic complexes (Ferré et al., 2002). Further north, in the Air shield, the East Nigeria shear zone would connect to transpressional structures related to terrane amalgamation processes that ended at ca. 620 Ma (Black et al., 1994; Navez et al., 1997; Ferré et al., 2002). In NE Brazil, the E-trending Patos transcurrent shear zone also separates domains of contrasting geological histories, but with no evidence of rock assemblages typical of suture zones. Instead, the shear zone appears to be a late structure as suggested by studies of emplacement fabrics and ages of granite plutons (Archanjo and Fetter, 2004;

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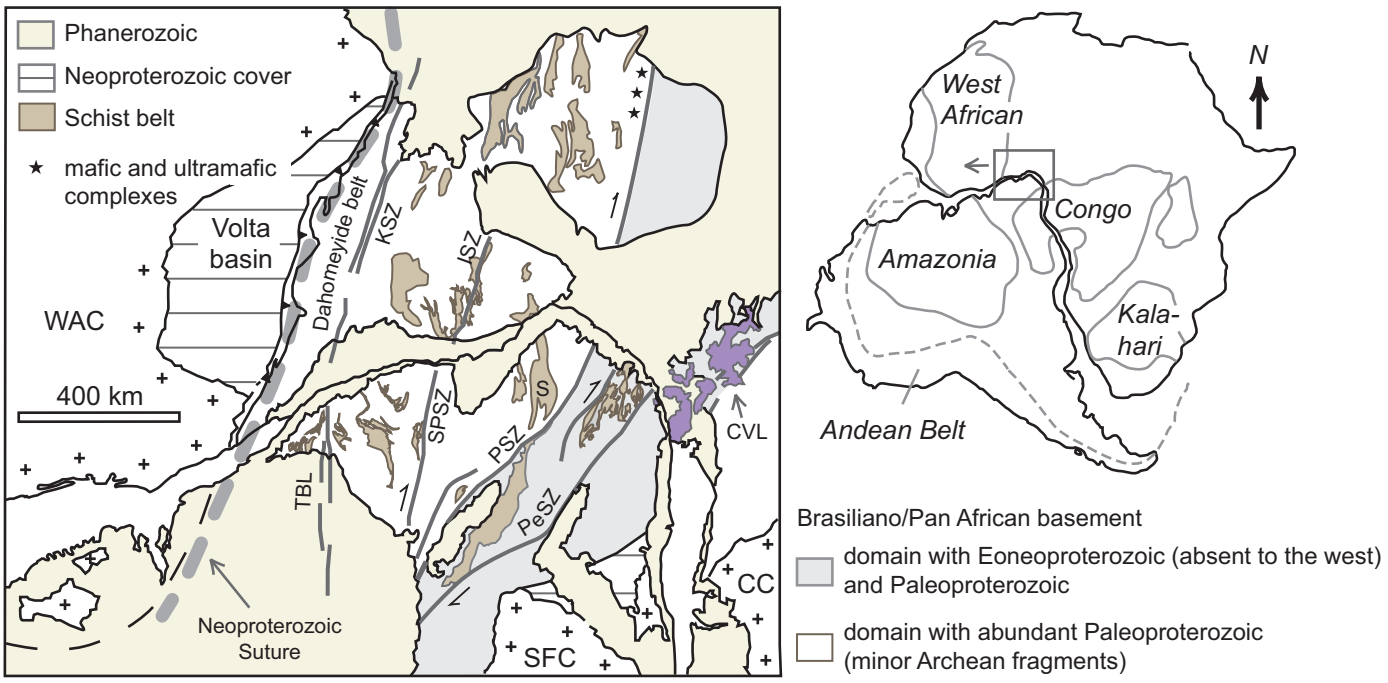

Fig. 1. Pre-Mesozoic fit between West Africa and NE Brazil and location of the main cratons in South America and Africa (upper left). Brasiliano-Pan African shear zones used for correlating the Benin-Nigeria and Borborema provinces: Transbrasiliano (TBL)-Kandi (KSZ), Senador Pompeu (SPSZ)-Ile-Ife (ISZ) and Patos (PSZ)-E Nigeria (Van Schmus et al., 2008). Mafic and ultramafic complexes in NE Nigeria after Ferré et al. (2002). S, Seridó belt; PeSZ, Pernambuco shear zone; CVL, Cameroon Volcanic Line. WAC, SFC and CC are the West Africa, São Francisco and Congo cratons.

Archanjo et al., 2008), as well as mineral cooling ages of the Patos mylonites (Monié et al., 1997; Corsini et al., 1998).

The correlation between the Patos, East Nigeria and Air shear zones and their role as a terrane boundary therefore requires further investigation. In the Borborema Province the Patos shear zone is associated with widespread granitic plutonism and synkinematic anatexis (Vauchez et al., 1995), which resulted in the development of wide high-temperature/low-pressure zones composed of mylonitic gneisses and metapelites, migmatites and granites (Neves et al., 1996; Archanjo et al., 2002; Viegas et al., 2013). In some shear zones, such as the Patos and Pernambuco (PeSZ, Fig. 1), high-temperature tectonites occur in abrupt contact with relatively narrow but continuous zones of greenschist-facies mylonites and ultramylonites (Corsini et al., 1991; Vauchez and Egydio-Silva, 1992; Davison et al., 1995). Some medium- to low-grade E-trending mylonitic corridors with kinematics similar to the Patos and Pernambuco shear zones include syntectonic granites and subvolcanic dikes of Cambrian age (Hollanda et al., 2010); these features support the assumption that some shear zones of the Borborema Province may be regarded as late-stage structures.

This paper provides the first direct determination of the age of the high-temperature mylonitisation of the Patos shear zone using U–Pb (SHRIMP, Sensitive High-Resolution Ion Microprobe) determinations in zircon crystals collected from synkinematic leucosomes. Furthermore, we investigate the deformation mechanisms along the transition from high-temperature tectonites to greenschist-facies mylonites by examining the crystallographic preferred orientation of quartz and feldspar fabrics. The results allow us to conclude that partial melting along the Patos shear zone occurred relatively late in relation to the collision events recorded at the Air shield and in the oriental margin of the West African craton. Moreover, the microstructures indicate the activity of strain localization mechanisms highlighting the importance of reactivation processes during the exhumation of the province.

2. Geological setting

The Patos shear zone, mainly composed of high-temperature mylonitic orthogneiss, consists of a ~600 km long strike-slip structure that deforms the Precambrian rocks of the Borborema Province. This fault connects with Neoproterozoic metapelites, paragneisses and mica-schists grouped in the Seridó metasedimentary belt (Figs. 1 and 2). Partially molten rocks occur in-between the Patos shear zone and the Seridó Belt over a ~30 km wide connection zone. They are composed of stromatic metatexite, nebulitic diatexite and partially molten leucogranite, being divided into the Espinho Branco anatexite, observed within the Patos shear zone (Viegas et al., 2013), and the Santa Luzia anatexite in the Seridó Belt (Archanjo et al., 2013). Unpublished U–Pb and Sm–Nd data indicate that these anatexites derive from melting of the Palaeoproterozoic to Archean basement (Costa, 2002). A narrow medium- to low-temperature mylonite belt forms the southern margin of the Patos shear zone (Fig. 2) and reworks the high-temperature mylonites and migmatites from the northern border at lower temperatures. Recent structural and geochronological studies have shown that some E-trending transcurrent structures record late-stage strain localization. This is demonstrated in the Coxixola shear zone, situated between Patos and Pernambuco shear zones, in which A-type granite plutons and dikes were emplaced in a strain field that combines dextral shear and extension. U–Pb (SHRIMP) zircon ages in granites and dikes suggest that the Coxixola fault was nucleated between 550 and 530 Ma (Hollanda et al., 2010).

In the Patos shear zone, zircon crystals dated by U/Pb (TIMS – Thermal Ionization Mass Spectrometry; Costa, 2002) showed strong disturbance but provided unconstrained upper intercept ages between 2.2 and 2.0 Ga. $^{40}Ar/^{39}Ar$ plateau ages in amphibole, muscovite and biotite range from 540 Ma to 490 Ma and were attributed to cooling of the shear zone (Monié et al., 1997; Corsini et al., 1998). Similar $^{40}Ar/^{39}Ar$ plateau ages were documented in muscovite from the Coxixola mylonites; the ~510 Ma