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Emplacement and deformation of the Cachoeirinha pluton (Borborema province, NE Brazil) inferred through petrostructural studies: Constraints on regional strain fields

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Abstract

The East Pernambuco shear zone system (EPSZ) conventionally has been taken as the limit between the central and southern domains of the oriental sector of the Neoproterozoic Borborema province (NE Brazil). To constrain the tectonic evolution of the southern domain during the Brasiliano orogeny, the authors undertake a structural and anisotropy of magnetic susceptibility study of the 580 Ma Cachoeirinha pluton, located 10 km south of the EPSZ. The results suggest a model for its emplacement and deformation in which (1) successive magma batches accumulated at the gently dipping interface between orthogneisses and overlying schists and paragneisses and (2) homogeneous NNE–SSW stretching of the pluton was followed by strain localization along conjugate subvertical corridors of noncoaxial shear during the last stages of crystallization. Outcrop-scale, magmatic to solid-state dextral and sinistral shear zones that affect the pluton have similar orientations to the large transcurrent mylonitic belts that characterize the central domain of the Borborema province. Thus, at the time of intrusion of the Cachoeirinha pluton, the central and southern domains of the Borborema province were undergoing deformation related to the same far-field stresses, and the EPSZ is not a major suture zone between domains with distinct geological histories. Instead, the present-day separation of the eastern Borborema province into central and southern domains resulted from progressive deformation that led to the development of the EPSZ. The absence of large shear zones in the southern domain can be explained by the faster regional cooling than in the central domain, where the longer magmatism duration resulted in persistent elevated crustal temperatures, which in turn allowed a greater amount of finite strain to accumulate.

Keywords: AMS; Magmatic fabric; Pluton emplacement; Shear zones

Resumo

A Zona de Cisalhamento Pernambuco Leste (ZCPE) é tradicionalmente tomada como o limite entre os domínios central e sul do setor oriental da Província Borborema (NE do Brasil). Com o objetivo de auxiliar no entendimento da evolução tectônica do domínio sul durante a Orogênese Brasiliana, estudos estruturais e de anisotropia de susceptibilidade magnética foram efetuados no plúton Cachoeirinha, localizado 10 km ao sul da ZCPE. Os resultados obtidos permitem a proposição de um modelo para o alojamento e deformação deste plúton onde (1) pulsos sucessivos de magmas foram acumulados no contato sub-horizontal de ortognaisses com xistos e paragneisses sobrejacentes e (2) estiramento homogêneo do plúton na direçao NNE–SSW foi seguido, nos estágios finais de cristalização, por localização da deformação ao longo de faixas subverticais de deformação não-coaxial. Zonas de cisalhamento dextrais e sinistrais conjugadas, de escala métrica a decimétrica, que cortam o plúton têm orientações similares à das grandes zonas de cisalhamento transcorrentes que caracterizam o domínio central da Província Borborema. Isto sugere que, quando da intrusão do plúton Cachoeirinha, os domínios sul e central da Província Borborema estavam sofrendo deformação relacionada ao mesmo campo de esforços e que o desenvolvimento da ZCPE resultou de uma história deformacional mais prolongada no domínio central que no domínio sul. Isto, por sua vez, provavelmente reflete a maior duração do

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magmatismo no domínio central e conseqüente persistência de temperaturas crustais elevadas por um período de tempo maior. Portanto, a ZCPE não representa uma zona de sutura entre domínios com histórias geológicas distintas.

1. Introduction

Plutonic bodies have been used successfully as markers of regional deformation for some time (e.g. Brun and Pons, 1981; Marre, 1986; Hutton, 1988; Tobisch et al., 1995). Knowledge about their internal structure and fabric has caused profound changes in classical interpretations of their regional geological context. For example, Mesoproterozoic (1.5–1.2 Ga) plutons in the southwestern United States, interpreted as anorogenic granites on the basis of their geochemical characteristics and apparent lack of deformation during emplacement (Windley, 1993), have been shown to display a well-developed magmatic fabric and local solid-state deformation that indicate emplacement in a regional contractional strain field (Nyman et al., 1994; Nyman and Karlstrom, 1997). These plutons are part of a belt that extends to the Baltic shield through northeastern Canada and southern Greenland, previously thought to have formed during platewide extension and rifting (e.g. Windley, 1993). On the basis of the evidence of contractional deformation, this belt is now interpreted as the inboard response to compressive stresses that resulted from convergence in a margin located more than 1000 km to the south (Nyman et al., 1994; Karstrom et al., 2001). Another example comes from the Pyrenees, where voluminous granitic plutonism, until recently, was believed to postdate the main contractional Hercynian tectonic events. However, an interpretation of the magmatic structure of the plutons demonstrates their syntectonic nature (Gleizes et al., 1997), as confirmed by conventional structural and U–Pb geochronological work (Evans et al., 1997, 1998; Paquette et al., 1997).

As these examples show, studies of the internal structure of plutons and their country rocks are important tools for the investigation of the geological evolution of a given region. These studies are particularly useful in places where systematic structural work has not been conducted, as is the case in the southern domain of the Brasiliano (=Pan-African) Borborema province of northeastern Brazil. Plutonic bodies are abundant in this domain (Da Silva Filho and Guimarães, 2000; Da Silva Filho et al., 2002), and knowledge of their internal fabric thus may help constrain the regional tectonic regime during and just after their emplacement. In this article, field and anisotropy of magnetic susceptibility (AMS) studies conducted in the Cachoeirinha pluton are discussed with regard to the tectonic conditions prevailing during its emplacement. These results are used to propose a model of the evolution of the southern domain of the Borborema province, which then is compared with similar investigations in the central domain of the province, where tectonic evolution during the Brasiliano orogeny is better constrained.

2. Geological setting

The Cachoeirinha pluton crops out as a NNE–SSW elongate body (30×8 km) and is located 10 km south of the East Pernambuco shear zone system (EPSZ) (Fig. 1). The EPSZ (Neves and Mariano, 1999), conventionally regarded as the limit between the central and southern domains of the Borborema province (e.g. Brito Neves et al., 2000), consists of several dextral mylonitic belts that strike E–W to ENE–WSW. High-temperature (amphibolite facies) mylonitic belts are located at the southern border of the Caruaru–Arcoverde batholith (Fig. 1), which is composed of coarse-grained to porphyritic amphibole–biotite granitoids and minor intrusions of quartz diorite. In the high-temperature mylonitic belts, the granitoids convert to S–C mylonites. The high-temperature mylonitic belts are connected to intrabatholithic, NE- to NNE-striking sinistral shear zones. A former shallowly dipping regional fabric is preserved between the high-temperature belts and dominantly low-temperature (greenschist facies) mylonitic belts that occur farther south or east of the Caruaru–Arcoverde batholith (Fig. 1). These observations have been taken as evidence that the emplacement of the Caruaru–Arcoverde batholith favored the localization of strain and then the development of high-temperature shear belts (Neves et al., 1996, 2000; Neves and Mariano, 1999). The biotite–muscovite-bearing Cabanas granite, which crops out on the southern side of the EPSZ (Fig. 1), contains xenoliths of high-temperature mylonites apparently derived from lithologies of the Caruaru–Arcoverde batholith, indicating intrusion after the onset of the activity in the EPSZ (Neves et al., 2003). The ENE-trending shape of the Cabanas granite, together with the parallelism of magnetic foliations and lineations inside the pluton and the mylonitic fabric of the EPSZ, indicates crystallization under the influence of the dextral transcurrent regime (Neves et al., 2003).

The northern and northeastern contacts of the Cachoeirinha pluton are made, respectively, with the Cabanas granite and an unnamed granitic batholith (Fig. 2), the latter of which is intruded by the Cabanas granite. Although the contact between the Cabanas granite and the Cachoeirinha pluton has not been directly observed in the field, dykes of biotite granite and muscovite-bearing pegmatite, which might be related genetically to the Cabanas granite, locally intrude the Cachoeirinha pluton. The contact between the Cachoeirinha pluton and the granitic batholith is concordant and dips shallowly to the northeast.

The dominant country rocks of the Cachoeirinha pluton are orthogneisses and migmatites. Supracrustal rocks occur along part of the southern contact (Figs. 1 and 2) and consist of biotite schists and paragneisses, which are locally