Tectonophysics 679 (2016) 73–87

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Curie surface of Borborema Province, Brazil

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ARTICLE INFO

Article history:
Received 18 November 2015
Received in revised form 13 April 2016
Accepted 22 April 2016
Available online 27 April 2016

Keywords:
Borborema Province
Spectral analysis
Curie depth
Crustal thermal structure

ABSTRACT

The Curie surface interpreted from magnetic data through spatial frequency domain techniques is used to provide information on the thermal structure of Borborema Province. The Borborema Province is part of the neoproterozoic collision of an orogenic system situated between the São Francisco-Congo and São Luís-West Africa cratons, which formed the Gondwana Supercontinent. The Curie surface of Borborema Province varies from 18 to 59 km, which reveals the complexity in the crustal composition of the study area. The thermal structure shows different crustal blocks separated by the main shear zones, which corroborates the evolution model of allochthonous terranes. The Curie surface signature for the west portion of Pernambuco Shear Zone may indicate processes of mantle serpentinization, once the Curie isotherm is deeper than Mohorovic discontinuity. In this region, the amplitude of Bouguer anomaly decreases, which corroborates long wavelength anomaly observed in the magnetic anomaly. We interpreted this pattern as evidence of the Brasiliano-Pan-Africano's subduction/collision event. Earthquakes in the region are concentrated mainly in shallow Curie surface regions (less resistant crust) and in transition zones between warm and cold blocks. We calculated the horizontal gradient of the Curie depth to emphasize the signature of contact between the thermal blocks. These regions mark possible crustal discontinuities, and have high correlation with orogenic gold occurrence in the study area.

1. Introduction

Raising the temperature of a magnetic material, the spontaneous magnetization disappears at Curie temperature (Lowrie, 2007). The crust Curie depth refers to the isotherm of 580 °C, which is the demagnetizing point of magnetite (Frost and Shive, 1986). Thus, the depth associated with this temperature is an indicator of the extent of magnetic signal.

The rheology of solids is controlled mainly by temperature, thereby to understand the mechanical behavior of crust and lithosphere is necessary to know its thermal structures (Turcotte and Schubert, 2002). Processes such as volcanism, intrusion, earthquakes, mountains uplift and metamorphism are controlled by the generation and heat transfer inside Earth (Fowler, 2005).

In general, the crust thermal structure is investigated by heat flow measurements. However, such data are scarce and can be contaminated with shallow anomalies of the local geological environment (Siler and Kennedy, 2016; Blackwell, 1983). This may occur in Borborema province due to the presence of heat flow data up to 259 mW/m^2 (Hamza et al., 2005), which may be influenced by shallow geothermal circulation. Thus, the Curie surface interpreted from magnetic data through spatial frequency domain techniques is an alternative to understand the crust thermal structure (Ross et al. 2006).

Curie depth studies calculate the depth to the bottom of magnetization (DBM), which is used to infer the Curie temperature depth. Thus, the biggest challenge is to interpret what the DBM means. There may be regions where the DBM is equivalent to Mohorovic discontinuity (Moho), where it is a magnetic boundary (Wasilewski et al., 1979); long wavelength variations in DBM may be due to the Curie isotherm which in turn may be in some areas the same surface as Moho (Salem et al., 2014). Finally, there are rare situations where the Curie isotherm is deeper than Moho, which calls for a serpentinized mantle (Bucher and frey, 1994; Guimarães et al., 2014; Blakely et al., 2005). All these possibilities are discussed in this study.

Although the technique has some limitations as the need of large windows to sample the DBM, uncorrelated sources and difficulty to interpret the geological mean, it has been successfully applied in Blakely (1988), Tanaka and Ishikawa (2005), Trifonova et al. (2009), Aydin and Oksum (2010), Aydin and Oksum (2012), Aydin and Oksum (2012), Manea and Manea (2010).

The Borborema province was defined by Almeida et al. (1977) as a geological-structural domain located in northeastern Brazil which occupies an area of approximately 450,000 km^2 (Fig. 1). There are several

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http://dx.doi.org/10.1016/j.tecto.2016.04.037
0040-1951/

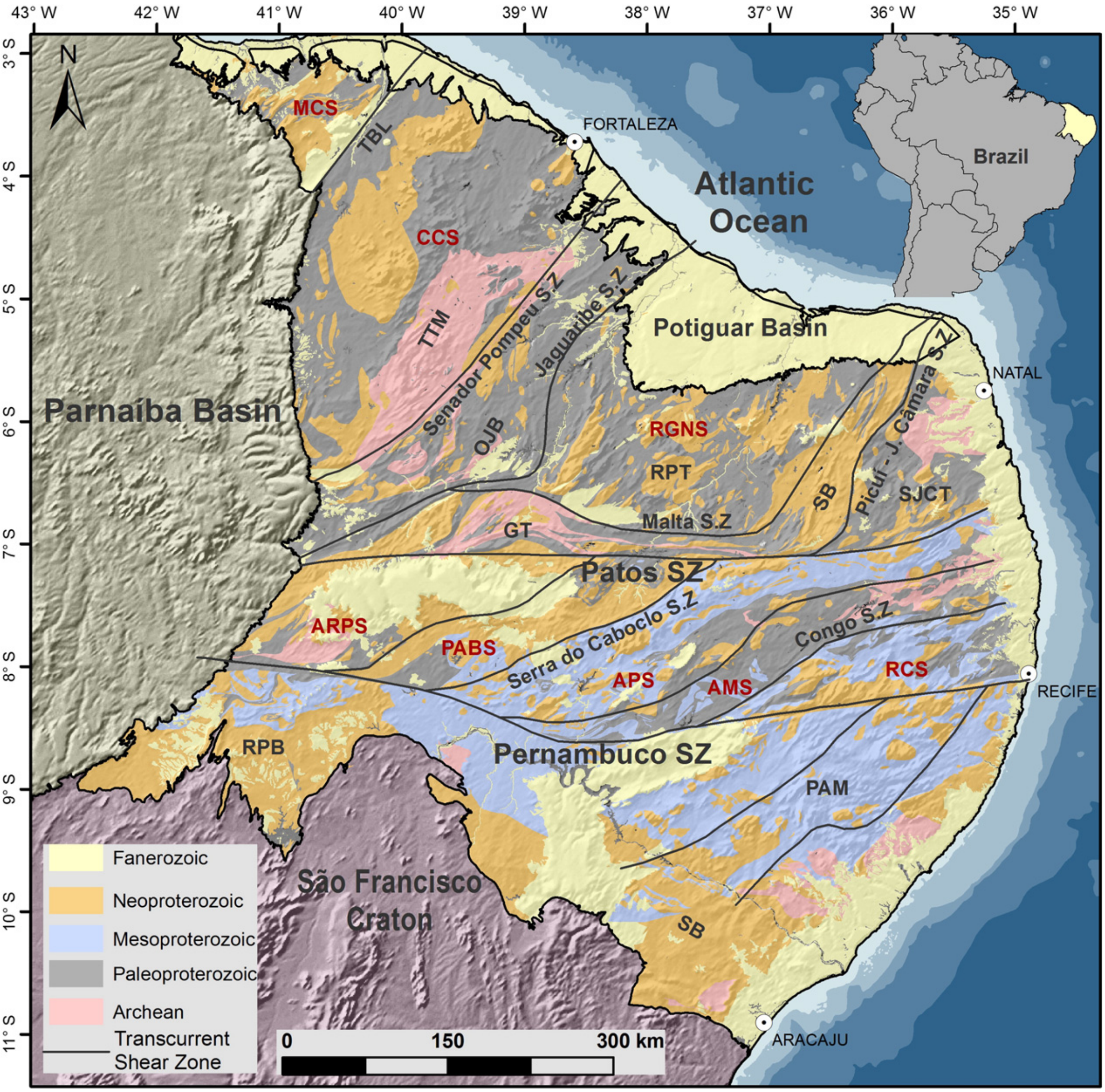

Fig. 1. Borborema Province Chronostratigraphic map (adapted from Bizzi et al., 2003). Abbreviations for Setentrional domain: TBL — Transbrasiliano Lineament, MCS — Médio Coreaú subdomain, CCS — Ceará Central subdomain, TTM — Tróia Tauá massive, RGNS — Rio Grande do Norte subdomain, OJB — Orós Jaguaribe belt, RPT — Rio Piranhas terrane, SB — Seridó belt, SJCT — São José do Campestre terrane; Central domain: ARPS — Araripina subdomain, PABS — Piancó Alto Brígida subdomain, APS — Alto Pajeau subdomain, AMS — Alto Moxotó subdomain, RCS — Rio Capibaribe subdomain; Meridional domain: PAM -Pernambuco Alagoas massive, SB — Sergipana belt, RPB — Riacho Pontal belt. Shear zones proposed by Oliveira (2008). Inset highlights the location of the study area in South America. Limits of the province based on Bizzi et al. (2003).

theories related to its development, but the most accepted one claims that the province is composed of an assemblage of allochthonous terranes, with at least two orogenic events related to its history (Jardim de Sá et al., 1992; Santos, 2000).

Knowledge of the thermal structure of the Borborema province can help on understanding the crustal evolution of tectonostratigraphic terranes, since there are indications (Lima et al., 2014) that the major shear zones are crustal scale, thereby it is expected a variation in the thermal field of the different subdomains. We analyze if these major crustal scale breaks may be important conduits for mineralizing fluids to reach the upper crust (Korschv and Doublier, 2015). The causes of the Borborema plateau uplift are one of the most controversial issues in the Borborema Province (Luz et al., 2015), once receiver function data reveals crustal thickening around 5 km, which may disturb the thermal structure. Futhermore, it is tested if high heat flow regions let the crust susceptible to earthquakes generation.

2. Geology

The Borborema Province is part of the Neoproterozoic collision between the São Francisco–Congo and Luís–West Africa cratons, which formed the supercontinent Gondwana (Van Schmus et al., 1995; Brito Neves et al., 2000). According to Santos (2000), the province consists of three main domains: Setentrional, Central or Transversal Zone and Meridional or Extremo sul (Fig. 1). There is no consensus on some limits, and this work adopts the limits proposed by Santos et al. (2000) and Brito Neves et al. (2000). Table 1 resumes the geological context of each subdomain related to the main orogenic systems.