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Sedimentological and paleoenvironmental constraints of the Statherian and Stenian Espinhaço rift system, Brazil

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ABSTRACT

The Espinhaço Basin in eastern Brazil contains depositional sequences developed in the São Francisco paleoplate and its margins. Detailed mapping was conducted and combined with U–Pb detrital zircon dating to determine the sedimentological-stratigraphic framework, provenance and minimum and maximum ages of the syn-rift-deposits. The two cycles have minimum ages of 1192 and 923 Ma and maximum ages of 1785 and 1685 Ma. The first depositional cycle, represented by the Bandeirinha and São João da Chapada formations, is marked by contributions of Neoarchean and Paleoproterozoic detrital zircons. The second cycle, the diamond-bearing Sopa-Brumadinho Formation, also contains Mesoproterozoic zircons formed between 1300 and 1190 Ma, which suggests an additional external source of Grenvillian age, that was not previously recorded in the São Francisco Craton. The investigation of such Mesoproterozoic intraplate sedimentary records, provides clues to understanding the history of the Rodinia active margins and, therefore, the kinematic reconstruction of its paleoplates.

1. Introduction

The study of rift basin evolution in a continental context, including that of the Espinhaço Basin in eastern Brazil, has been receiving increasing attention because it enables a better understanding of depositional processes and fill-sedimentation patterns and because of its consequent predictive value, especially for the oil industry. However, one of the greatest problems faced when dealing with the stratigraphy of Precambrian basins is their lack of fossil content, which prevents major stratigraphic correlations, especially in sequences where only a sedimentary record exists without intercalated volcanic rocks. This lack of fossil content has led many authors to assemble models in stratigraphic sections that are completely timeless (e.g., Martins-Neto, 2009). Despite the large number of published papers regarding the Espinhaço Basin, many questions remain due to a lack of detailed mapping and quantitative analysis; thus, detailed studies are needed. The Espinhaço Supergroup was described by many authors as the fill sequence of an intracontinental rift-sag basin system that developed approximately 1700 Ma in the São Francisco paleoplate and its margins (Dussin and Dussin, 1995; Brito Neves, 1995; Uhlein et al., 1998; Martins-Neto, 1998, 2009) and is predominantly characterized by siliciclastic sedimentation but also includes volcanism and tuffaceous contributions. Martins-Neto (2009 and references therein) proposed a single first-order sequence with pre-rift, rift, transitional and marine sag stages for this intracontinental basin. More recently, Chemale et al. (2012), based on U–Pb detrital and volcanic zircon data from the Espinhaço Supergroup units, recognized three basinal cycles for the so-called Espinhaço Basin units in the São Francisco Craton with major sedimentation material sources from the Jequié (Neoarchean) and Transamazonian (Paleoproterozoic) orogenic cycles. Moreover, in the southern Espinhaço, during the stable period from 1800 Ma to 910 Ma in the São Francisco Craton, only two major basinal cycles are represented: the Lower (1680 to 1800 Ma) and Upper Espinhaço (910 to 1190 Ma) basins. Chemale et al. (2012) distinguished two major basins in the Espinhaço depositional locus that allow models to be developed that include the temporal element of its evolution.

The present work proposes a sedimentological-stratigraphic model for the paleogeographic evolution of these two basins in the southern

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Serra do Espinhaço based on detailed structural-stratigraphic mapping at a scale of 1:3000 and sedimentological and stratigraphic descriptions of 26 sections. The model is supported by geochronological data obtained from the southern Serra do Espinhaço, Brazil. These data made it possible to reconstitute the different depositional systems and tectonic stages beginning from the end of the Paleoproterozoic (ca. 1700 Ma) to the beginning of the Neoproterozoic (~910 Ma) for the sectors studied in the region.

2. Geological setting

2.1. The Espinhaço Rift System

Geomorphologically the Serra do Espinhaço is divided into two sectors: southern and northern, each characterized by high topographic relief and separated by a SE–NW low-relief zone (Saadi, 1995). The present paper describes the southern sector, particularly the region around the city of Diamantina, Minas Gerais (Fig. 1).

The Espinhaço Rift is located in the São Francisco Craton (sensu Almeida et al., 2000) in the Serra do Cabral region and is on the Araçuaí Fold Belt in the Serra do Espinhaço (Uhlein et al., 1995). The tectonic evolution of the rift is still controversial in the literature. One commonly held description is that this is an ensialic intracratonic basin (Dussin and Dussin, 1995; Martins-Neto, 1998). However, Almeida-Abreu (1993) proposed a rift basin model that evolved into a passive margin with the generation of oceanic crust.

The depositional systems identified in the rift include fluvial, alluvial, lacustrine, deltaic, marine and eolian systems (Dossin et al., 1987; Garcia and Uhlein, 1987; Martins-Neto, 1998; Silva, 1998). During the Brasiliano Orogeny, there would have been a collision with the São Francisco Craton and the partial deformation and metamorphism of low-grade deposits in the Espinhaço Basin (I.A. Dussin, 1994; Dussin and Dussin, 1995). Some of the deformed structures in the basin, such as thrust faults and folds with vergence to the west, are attributed to this collision (Dossin et al., 1992; Uhlein et al., 1995; Alkmim et al., 2007; Pedrosa-Soares et al., 2007).

2.2. Dating background

Geochronological data suggest dates for the rift opening of 1729 ± 14 Ma and 1770 Ma by Pb/Pb and U/Pb zircon dating methods, respectively, from a granitic emplacement in the basement (Dossin et al., 1993) and a rhyolitic emplacement in the Conceição do Mato Dentro (Brito Neves et al., 1979; Fig. 1a), at the base of the basin. The dating of Pb/Pb on zircons from a hematitic phyllite located near the city of Diamantina provides an age of 1710 Ma (Dossin et al., 1993), indicating the approximate age for the beginning of sedimentation in the basin. Machado et al. (1989) obtained an age of 906 ± 2 Ma using the U/Pb method on mafic rocks (Suíte Pedro Lessa) that intrude into the Espinhaço Basin, indicating a minimum age for the deposition of its sediments.

Chemale et al. (2012) obtained an age of 1192 ± 16 Ma in zircons from a conglomerate with a volcanogenic matrix from the Sopa-Brumadinho Formation in the Extração region and proposed dividing the basin into two sequences (i.e., Lower and Upper Espinhaço). Thus, the Espinhaço Supergroup in southern Espinhaço, Minas Gerais, contains two unconformable successions that can be interpreted as two basin fill cycles: (i) a Statherian succession (1780 to 1710 Ma) in an intracontinental rift and (ii) a Stenian–Tonian succession (1180 to 910 Ma) in an intracontinental rift-sag successor basin.

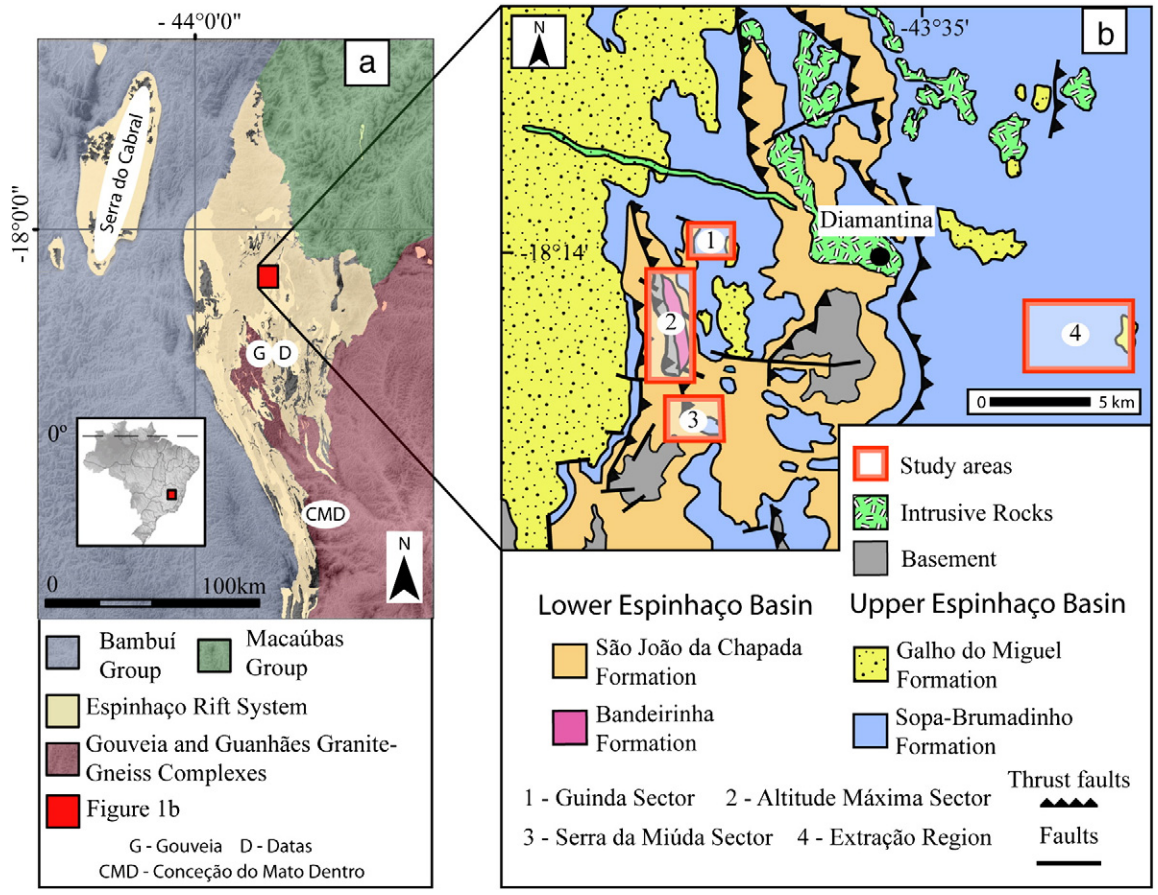

Fig. 1. (a) Localization map of the Espinhaço Basin in the southern Espinhaço. (b) Simplified geological map of the central portion of the Espinhaço Basin indicating the locations of the four studied areas (modified after Chaves, 1997).