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Denudation history of the Bocaina Plateau, Serra do Mar, southeastern Brazil: Relationships to Gondwana breakup and passive margin development

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ABSTRACT

The Bocaina Plateau, which is situated on the eastern flank of the continental rift of southeastern Brazil, is the highest part of the Serra do Mar. Topographic relief in this area is suggested to be closely related to its complex tectono-magmatic evolution since the breakup of Western Gondwana and opening of the South Atlantic Ocean. Apatite fission track ages and track length distributions from 27 basement outcrops were determined to assess these hypotheses and reconstruct the denudation history of the Bocaina Plateau. The ages range between 303 ± 32 and 46 ± 5 Ma, and are significantly younger than the stratigraphic ages. Mean track lengths vary from 13.44 ± 1.51 to 11.1 ± 1.48 μm, with standard deviations between 1.16 and 1.83 μm. Contrasting ages within a single plateau and similar ages at different altitudes indicate a complex regional tectonothermal evolution. The thermal histories inferred from these data imply three periods of accelerated cooling related to the Early Cretaceous continental breakup, Early Cretaceous alkaline magmatism, and the Paleogene evolution of the continental rift of southeastern Brazil. The oldest fission track ages (>200 Ma) were obtained in the Serra do Mar region, suggesting that these areas were a long-lived source of sediments for the Paraná, Bauru, and Santos basins.

1. Introduction

The topographic relief of southeastern Brazil, an area that is a classic example of a passive continental margin with great escarpments (Ollier, 1985; Battiau-Queney, 1991; Thomas, 1994), is characterized by a low-lying coastal plateau separated from the elevated inland plateau by a steep escarpment. Relief evolution in this area is probably closely related to its complex tectono-magmatic evolution since the breakup of Western Gondwana and opening of the South Atlantic Ocean in Early Cretaceous.

The continental rift of southeastern Brazil (Riccomini et al., 2004) is the most important Cenozoic tectonic feature of the onshore continental margin. It extends parallel to the coast for about 1000 km, from Curitiba (Paraná) to Barra de São João (Rio de Janeiro) and includes the Curitiba, São Paulo, Taubaté, Resende, and Volta Redonda basins (Fig. 1). In the central segment of the rift, four morphostructural compartments occur separated by scarps of hundreds of meters high, namely: (1) the low-lying coastal plain, (2) Serra do Mar, (3) Paraíba do Sul river valley, and (4) Serra da Mantiqueira. The resulting "double escarpment" of Serra do Mar and Serra da Mantiqueira is a particularly peculiar feature of the continental margin.

Remnants of the oldest erosion surface in southeastern Brazil, the Campos surface (De Martonne, 1943), were recognized in the highest areas on both sides of the Paraíba do Sul Valley (Ab'Sáber and Bernardes, 1958; Fig. 1).

Before the Early Cretaceous formation of the Atlantic Ocean, the summit surfaces in the Brazilian Precambrian terranes included the Bocaina and the Campos do Jordão plateaus (Ab'Sáber, 1954, 2000). However, the origin, age, and even existence of the Campos surface remains controversial. According to Freitas (1951) and Almeida (1964), this possible surface results from deformation and uplift of the Late Cretaceous to Paleogene Japi surface. However, the regional correlation of the Campos and Japi surfaces in southeastern Brazil is not clear. This erosion surface covers extensive areas of southeastern Brazil that are considered to be chronological markers for the beginning of sedimentation in the continental rift (Almeida, 1976). Based on isotopic and paleontological data from the older deposits of

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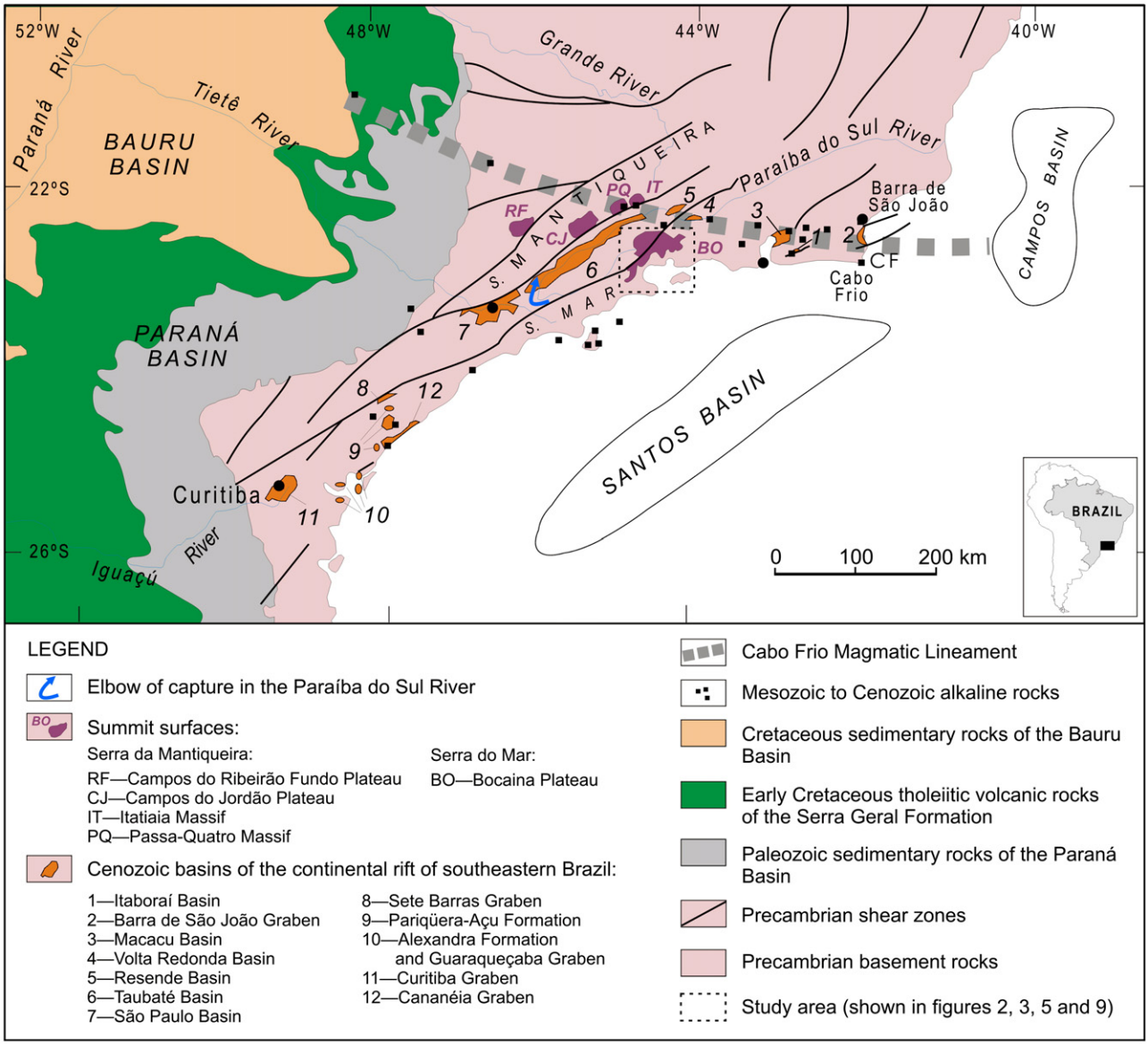

Fig. 1. Regional geologic context of the continental rift of southeastern Brazil.
Modified from Melo et al. (1985) and Riccomini et al. (2004).

the rift, a Late Cretaceous to Paleogene age is assumed for the end of the Japi planation. Phonolitic hyaloclastites directly overlying the Japi surface and underlying the Paleogene sediments of the Macacu basin yielded an Ar–Ar age of 65.65 ± 0.05 Ma (Ferrari et al., 2001). Ankaramite lavas interbedded with sedimentary rocks of the Volta Redonda and Itaboraí basins have Eocene ages (Riccomini et al., 1983, 1991; Riccomini and Rodrigues-Francisco, 1992). Mammalian fauna of probable Late Paleocene age are described by Couto (1953, 1958) in the Itaboraí basin. The alluvial fan rudaceous deposits from the Paleocene to Eocene Itaqueri Formation, which lie above the Serra Geral and Botucatu Formations, are considered to be correlative deposits of the Japi surface (Soares and Landim, 1976; Melo and Ponçano, 1983; Riccomini, 1997).

The continental rift of southeastern Brazil is flanked by extensive areas of Proterozoic crystalline rocks in which traditional stratigraphic markers are absent. In this case, apatite fission track thermochronology may be used to elucidate the cooling history of rocks in the upper 3–5 km of the crust, over timescales of millions to hundreds of millions of years. Among other applications, this method has been used to examine the evolution of passive continental margins (Gallagher and Brown, 1997, 1999; Bishop and Goldrick, 2000; Cockburn et al., 2000; Gunnell et al., 2003), preservation of apparent erosion surfaces (Bonow et al., 2006; Japsen et al., 2006; Jolivet et al., 2007), and denudation response to intracontinental tectonism (Hackspacher et al., 2004; Emmel et al., 2006). Published thermochronological data from southeastern Brazil indicate significant uplift and erosion from the Early Cretaceous to the present (Vignol-Lelarge et al., 1994; Gallagher et al., 1995; Amaral et al., 1997), with possible denudation peaks at 100, 75, and 40 Ma (Gallagher and Brown, 1999); in general, denudation rates decrease inland.

The Bocaina Plateau (1800 km^2), which is situated on the eastern flank of the continental rift of southeastern Brazil, is the highest part of the Serra do Mar, reaching more than 2000 m in altitude. It is comprised of a succession of plateaus that decrease in altitude from northwest to southeast (isolated plateaus of Ponçano et al., 1981), separated by deep valleys (Fig. 2). The origin of the isolated plateaus has been attributed to (1) Cenozoic reactivation of Proterozoic shear zones by normal faulting (Ponçano et al., 1981; Gontijo-Pascutti et al.,