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The role of tectonics and climate in the late Quaternary evolution of a northern Amazonian River

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ABSTRACT

The Amazon basin has most of the largest rivers of the world. However, works focusing the geological evolution of the trunk river or its tributaries have been only partly approached. The Branco River constitutes one of the main northern Amazonian tributaries. A previous work proposed that, before flowing southward into the Negro-Amazon Rivers, the Branco River had a southwest to northeast course into the Caribbean Sea. The present work aimed to establish if the proposed change in the course of this river is supported by morphological and sedimentological data. Other goals were to discuss the factors influencing river development and establish its evolution over time within the chronological framework provided by radiocarbon and optically stimulated luminescence dating. The work considered the entire course of the Branco River downstream of the Precambrian Guiana Shield, where the river presumably did not exist in ancient times. The river valley is incised into fluvial sedimentary units displaying ages between 100 and 250 ky old, which record active and abandoned channels, crevasse splay/levees, and point bars. The sedimentary deposits in the valley include two alluvial plain units as old as 18.7 ky and which intersects a Late Pleistocene residual megafan. These characteristics suggest that a long segment of the Branco River was established only a few thousand years ago. Together with several structural anomalies, these data are consistent with a mega-capture at the middle reach of this river due to tectonic reactivation in the Late Pleistocene. This integrated approach can be applied to other Amazonian tributaries to unravel how and when the Amazonian drainage basin became established.

1. Introduction

Landforms and sediments formed by large rivers play an important role in understanding the Earth's dynamics over the Cenozoic. The majority of the existing large river systems is located in South America, particularly in the Amazon basin (Latrubesse et al., 2005). With a length of approximately 6992 km (INPE, 2010) and a discharge of 175,000 $m^3 s^{-1}$ (Wohl, 2007), the Amazon River is a transcontinental drainage with crucial contribution for the maintenance of an ecosystem that holds one of the highest levels of biodiversity on Earth. Despite this relevance, several aspects of this river system remain to be investigated. For instance, the geological history of the Amazon River and its tributaries is an issue open for debate. Previous publications approaching this theme have chiefly aimed at discussing hypotheses of the time when the Amazon River shifted its flow from westward into the Pacific to eastward into the Atlantic Ocean (e.g., Potter, 1978; Figueiredo et al., 2009; Shephard et al., 2010; Sacek, 2014). Earlier works provided only a preliminary discussion on the geological history of the Madeira and Negro trunk rivers (e.g., Latrubesse and Franzinelli, 1998; Latrubesse and Franzinelli, 2005; Latrubesse, 2003; Rigsby et al., 2009; Plotzki et al., 2013, 2015; Rossetti et al., 2014a).

The Branco River is the main tributary of the Negro River. An existing hypothesis claimed that before its establishment as a north- to south-flowing river over the northern Amazonian landscape, the Branco River comprised an ancient drainage basin called Proto-Berbice (Guerra, 1956; Crawford et al., 1985; Gibbs and Barron, 1993; Schaefer and Dalrymple, 1996). According to these authors, this basin drained from southwest to northeast into the Caribbean Sea during the Late Neogene or Early Quaternary. Since then, erosion of highland basement rocks of the Guiana Shield has beveled the terrain, allowing the connection between the Tacutu and Solimões Basins located to the north and south, respectively (Fig. 1). This process would have promoted the reorganization of the Proto-Berbice drainage basin and the southward reversal of its main flow in order to discharge into the Negro-Amazon

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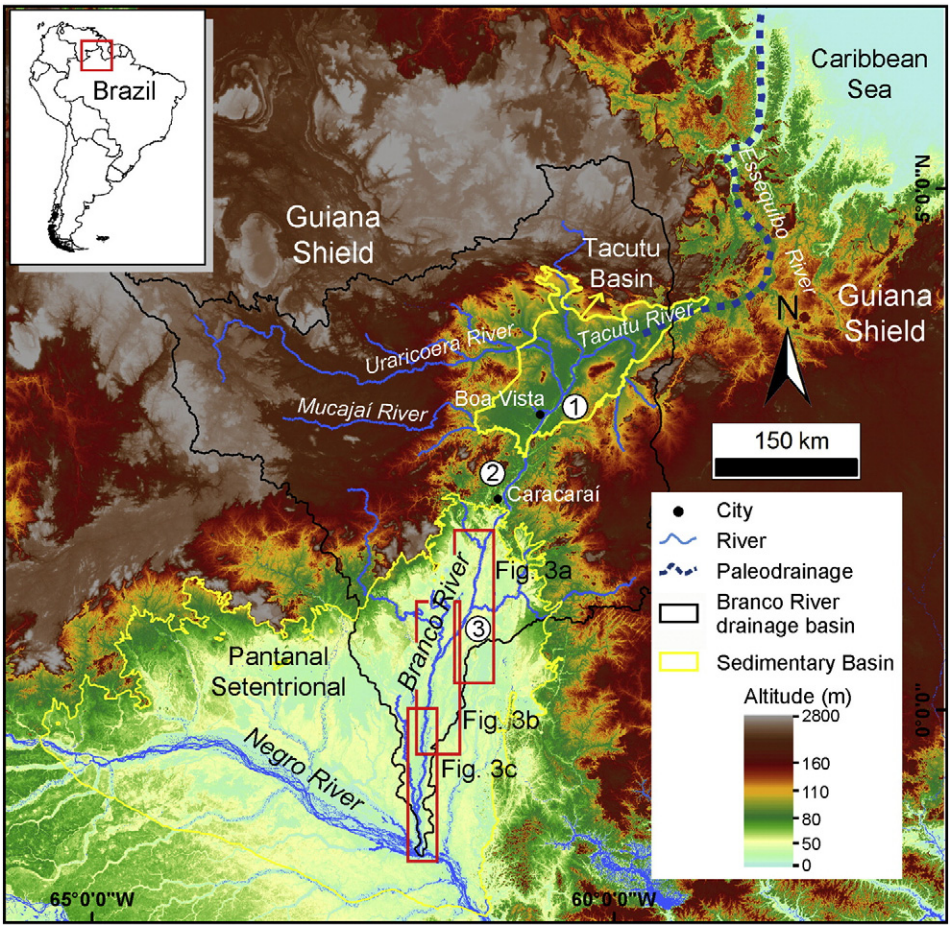

Fig. 1. Map of the Branco River drainage basin in northern Brazil. Numbers 1 to 3 correspond respectively to the upper, middle and lower segments of this river, as discussed in the text. Note that segment 1 is located in the Tacutu Basin to the north, segment 2 intercepts Precambrian rocks of the Guiana Shield and segment 3 extends through a long area of the *Pantanal Setentrional* wetland (northern part of the Solimões Basin) before discharging into the Negro River.

River basins (Schaefer and Dalrymple, 1996). Although such drainage reconstruction is supported by the presence of common fish species on both the Essequibo and Branco River drainage basins (Lujan, 2008; Lujan and Armbruster, 2011), there is an overall lack of geological and geomorphological data to test this hypothesis.

Another issue of interest for investigation is the temporal relationship between the Branco River and residual megafan deposits previously mapped in the region (e.g., Rossetti et al., 2012a, 2014b). Such deposits dominate the landscape of the Negro-Branco River basins, being associated with the most expressive occurrences of open vegetation that are anomalously intermingled with the rainforest, a phytophysiognomy long under debate (e.g., Takeuchi, 1960; Anderson, 1981; Furley et al., 1992; Pessenda et al., 2001; Sanaiotti et al., 2002; Cochrane and Cochrane, 2010; Rossetti et al., 2012b). The megafan deposits also constitute the largest Amazonian wetlands, which are testimony of a distributary paleodrainage that differs significantly from modern tributary systems that form the Amazon basin. Thus, it is expected that the establishment of the temporal relationship between the Branco River and the megafan deposits may bring about new elements for determining when this river developed its course southward into the Negro River.

This work aims to test if the proposed change in the course of the Branco River is supported by geomorphological and sedimentological data. This investigation, carried out within a geochronological framework provided by radiocarbon and optically stimulated luminescence (OSL) dating, considers the entire course of the Branco River downstream of the Precambrian Guiana Shield, where this river presumably did not exist until at least the early Quaternary.

2. Physiography and geological context

The Branco River, which accounts for about one third of the Negro River basin, drains an area of approximately 193,700 km^2 and has a mean annual discharge at the Caracaraí station (Fig. 1) of 2875 m^3 s^{-1}. This area is dominated by a tropical climate (Aw in Köppen's classification), with an average annual temperature of 24 °C and average rainfall accumulation of 1500 mm year^{-1}. The dry season is well defined, being concentrated between October and March. Rainy seasons occur between May and July, when 55–66% of the annual rainfall is received (Radambrasil, 1975). The prevalent vegetation on non-flooded areas consists of dense rainforest, whereas seasonally-flooded areas display white-sand vegetation, locally known as *campinarana* (Anderson, 1981; Cordeiro and Rossetti, 2015).

The Branco River is formed by the confluence of the Uraricoera and Tacutu Rivers, both located to the north of the city of Boa Vista (Fig. 1) and extending southward into the Negro River. Along its course, the Branco River can be described in terms of three segments (Fig. 1): an upper channel along the Tacutu Basin from the confluence of the Uraricoera and Tacutu Rivers up to the Mucajaí River; a middle channel that cuts down into Precambrian rocks of the Guiana Shield and forms several rapids downstream up to the city of Caracaraí; and a lower channel that flows into sedimentary rocks of the Solimões Basin and extends