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Paleoenvironmental reconstruction of the Lower Mogi Guaçu River Basin (São Paulo State — Brazil), morphopedosedimentary records and fluvial processes

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ABSTRACT

The Mogi Guaçu River rises in Bom Repouso (Minas Gerais State — Brazil) in the Mantiqueira Ridge, and flows into the Rio Pardo river at an elevation of 483 m in Pontal (São Paulo State — Brazil), after running a 530 km long course. Especially along the Lower Mogi Guaçu Basin, the river morphology is extremely sinuous, characterized by intense processes of channel migration, avulsion, abandonment and reactivation of the channel, producing an extensive alluvial plain composed of a series of associated relief forms and sedimentary facies. Among these forms, point bar deposits by lateral accretion, abandoned meanders, paleo-channels and fluvial terraces are notable features. In this sense, the objective of this work was to investigate whether these features could be linked to environmental changes. To reach this goal, soil properties of a catena of the Jataí Ecological Station (Luiz Antonio — São Paulo State) were analyzed in four sectors: Slope, Terrace I, Terrace II and Alluvial Plain. The results from grain-size determination, geochemical and isotopic studies, dating, paleopalynology, coal fragments and micromorphology are presented in this paper. From these analyses, a paleo-environmental evolution divided in three stages is proposed for the area: 130,000 YBP (Upper Pleistocene), when the Mogi Guaçu River base level was approximately 6 m above the present one; a drier second phase 10,250 years BP (Lower Holocene), when an organic horizon was formed inside of an abandoned meander (oxbow lake), and a third phase, 2096 YBP (Upper Holocene), of reactivation of a warm and humid climate that promoted the development of a two meters thick Typic Udifluvent in a sector where the Mogi Guaçu River no more floods due to the incision of its thalweg, reaching more than six-meters depth in the last 130,000 years BP. Thus, this paper used a fluvial geomorphologic approach and its interplay with climate to understand how the landscape was shaped from Upper Pleistocene to Holocene, however, Neotectonics might have played a relevant role as well, not only in the Mogi Guaçu River Basin, but also in the Paraná Sedimentary Basin.

1. Introduction

During the Quaternary the Earth was affected by glacial and interglacial stages. It is estimated that during the last interglacial stage (130,000–120,000 BP) known as Sangamon in North America and Eemian in Europe, the temperatures were higher and the relative sea level was between 4 and 6 m above the present one (Beets et al., 2006; Eynaud et al., 2004; Mercer, 1968; Shackleton, 1988; Shackleton et al., 2003). According to Dahl-Jensen et al. (2013), on the basis of water stable isotopes, surface temperatures of the Eemian (126,000 years ago) peaked at 8 ± 4°C above the mean of the past millennium. The soil profiles of this period, in North America, are known as Sangamon Geosol (MIS-5) (Illinois-USA), which are well developed and relatively well preserved, evolved under hot climatic conditions and variable humidity (Curry and Backer, 2000; Grimley et al., 2003; Jacobs, 1998; Jacobs et al., 2009; McKay, 2007). In South America, Van der Hammen and Hooghiemstra (2003) pointed out that the temperatures in the Eastern Cordillera of Colombia were estimated maximally in 1 °C above the Holocene, under a dry condition. In the Uruguay River, fluvial deposits were attributed to the MIS-5 stage under a warm and humid climate (Krohling, 2009). In Brazil, Suguio and Martin (1978) showed that during the Cananeia transgression (120,000 BP), the relative sea level was 8 m above the present. Horn Filho and Simo (2008) studied marine deposits from 10 to 17 m above present mean sea level in an island in south Brazil, these deposits would represent the Cananeia transgression as well. However, the most widely studied period in Brazil corresponds to the last 30,000 years, from Late Pleistocene to Holocene (De Freitas et al., 2001; Ferraz-Vicentini and Salgado-Labouriau, 1999; Ledru et al., 1998; Pessenda et al., 2004; Turcq et al., 1997 and others).

In this work proposed a 130 ka paleoenvironmental reconstruction using detailed analysis of an upland-to-lowland soil sequence is presented. In order to do this, our work was guided by the understanding how the river meandering processes, such as cut bank erosion and

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point bar deposition, climate and tectonics can shape the floodplain at the landscape scale.

The main objective of this paper is to work with a soil sequence that we labeled as catena "Infernão", a regional small stream (Celarino and Ladeira, 2011), located on the Mogi Guaçu River fluvial plain. The Mogi Guaçu River rises in Minas Gerais state and crosses part of São Paulo State along 531 km. The study area includes the lower Mogi Guaçu River Basin, which is a geomorphological sector showing an extremely sinuous meandering pattern and strong lateral migration (Zancopé, 2008).

With this point of view, several authors have studied the Mogi Guaçu River Basin aiming at the discussion of geomorphological, pedologic and geologic processes responsible for lateral migration and fluvial capture that are observed in the region, both under a paleoclimatic and a structural perspective. Perez Filho et al. (1980, 1983) studied four geomorphic surfaces in the same basin and argued that its terraces were formed by changes in river sediment yield linked to Quaternary climate oscillations. Silva (1997) identified neotectonic movements in the upper Mogi Guaçu River Basin, arguing that the river has moved its channel towards the NE direction. Zancopé (2008) worked on Mogi Guaçu longitudinal profile and stated that the meandering processes, such as avulsion, meander neck cutoff and oxbow lakes were related to changes in the channel sediment load, affected by structural features. Celarino and Ladeira (2011) studied the relationship between soil mineralogy and parent material at the same landscape that this paper presents, and they concluded that soil mineralogy in terrace sector is related to the former conditions of an abandoned meander bend filled with organic material, such as absence of iron oxides (Ferric Iron) and peaks of clay minerals 2:1 (Vermiculite).

From this premise, the specific objective of this work is to understand the landscape shaping processes operated and how these processes were influenced by the regional paleoclimate and fluvial geomorphology, using methods that integrate soil science, geomorphology and palynology.

2. Materials and methods

2.1. The study area

The Ecological Station of Jataí (EEJ) is located in Luís Antônio City in São Paulo State (Fig. 1), between latitudes 21°33′S and 21°37′S and longitudes 47°45′W and 47°51′W, in the lower Mogi Guaçu Basin. The station has been managed by the Forestry Institute (IF) (Santos et al., 2000).

The Mogi Guaçu River rises at an elevation of 1650 m a.s.l and reaches its mouth at 490 m a.s.l. The drainage area is 17.964 km^2 and the mean annual discharge, 17 km upstream from its mouth, is about to 396 m^3/s (Zancopé, 2008) but can reach 1000 m^3/s during the rainy season. The mean annual temperature ranges between 23 °C and 19 °C and the annual mean precipitation is between 1400 and 1600 mm (DAEE, n.a.). The channel pattern of the study area is typical of a lowland tropical river, a single sinuous meandering channel which has built a broad floodplain, reaching 3–5 km in width with point bar deposits and oxbow lakes mainly produced by avulsion and meander neck cutoffs.

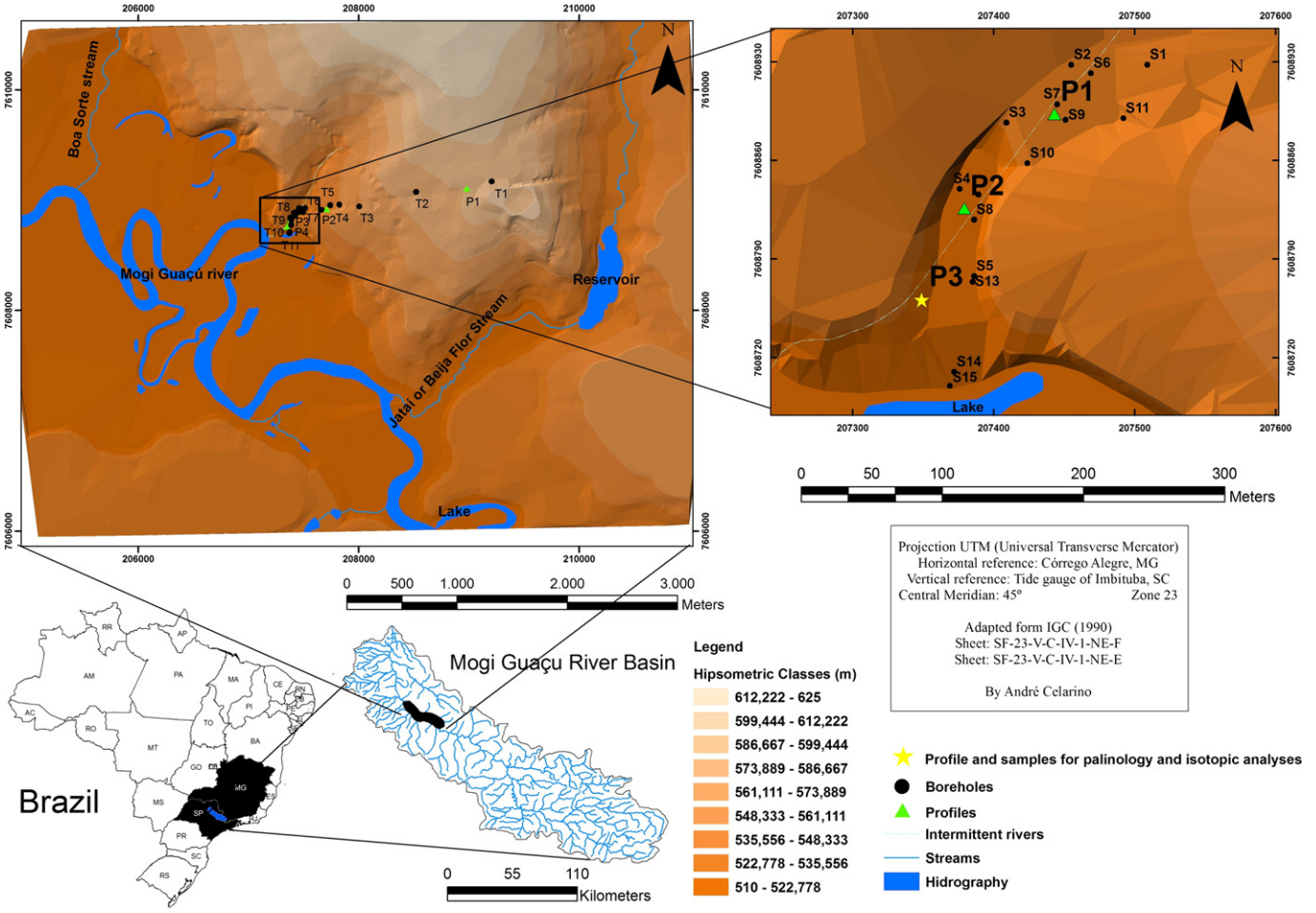

Fig. 1. Location of the study area.