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Pre-vegetation fluvial floodplains and channel-belts in the Late Neoproterozoic–Cambrian Santa Bárbara group (Southern Brazil)

André Marconato [a,*], Renato Paes de Almeida [b], Bruno Boito Turra [a], Antônio Romalino dos Santos Fragoso-Cesar [a]

[a] Institute of Geosciences, University of São Paulo (USP), Rua do Lago, 562, São Paulo, SP 05508-080, Brazil
[b] Institute of Energy and Environment, University of São Paulo (USP), Av. Professor Luciano Gualberto, 1289, São Paulo, SP 05508-080, Brazil

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ABSTRACT

One key element to the understanding of the dynamics of pre-vegetation fluvial systems is the reconstruction of processes operating on their floodplains given that, in modern systems, channel banks and floodplains are the environments most affected by plant colonization. Notwithstanding, few pre-vegetation floodplains have been described, and major questions regarding their most basic characteristics are still unresolved. In order to address these questions, detailed analysis of coeval channel-belt, fluvial floodplain and alluvial-fan deposits from the Santa Bárbara Group (Late Neoproterozoic to Early Cambrian, southern Brazil) was performed. While floodplain facies resemble ephemeral stream deposits, being coarser-grained than modern floodplains and marked by the stacking of flood event cycles, channel-belt deposits show composite bars, which do not present conclusive evidence for high water discharge variation. The floodplain deposits show particular features common to other pre-vegetation fluvial systems, such as better preserved small-scale structures, lack of bioturbation, and abundance of cross-laminated sandstones, while other features differ from previous depositional models, namely abundant mudcracks and evidence of soil formation. The lateral variation of depositional systems recorded in the Santa Bárbara Group shows contrasting signatures of water discharge variation in sand-dominated coeval environments, and offers an example of the relation between different alluvial environments before the evolution of land plants.

1. Introduction

One major aspect in the evolution of fluvial systems through time is the stabilization of river banks and the indirect control on river discharge promoted by vegetation, partly through the development of fine-grained floodplains (Schumm, 1968; Cotter, 1978; Long, 1978; Davies and Gibling, 2010; Davies et al., 2011). Most of the literature on the subject focuses on the pre-Silurian fluvial systems arising in the absence of land plants (e.g., Fuller, 1985; Rainbird, 1992; Bhattacharyya and Morad, 1993; Hjellbakk, 1997; Long, 2006), and in recent years there has been increasing interest in the effects of land plants on channel styles (Davies and Gibling, 2010; Davies et al., 2011). Both these approaches are based primarily on descriptions of channel facies. Notwithstanding, the absence of vegetation in pre-Silurian systems is expected to have influenced more than just the channel style, controlling depositional and post-depositional processes on the whole subaerial realm (e.g., Murray et al., 2008; Corenblit and Steiger, 2009).

In this context, the study of pre-vegetation floodplains is critical to the understanding of the dynamics of Precambrian to Early Paleozoic fluvial systems. Floodplains are the location of intense plant colonization in modern environments and therefore are highly sensitive to the controls imposed by vegetation on sedimentation. The description of pre-vegetation floodplains is scarce in the literature (e.g., Sønderholm and Tirsgaard, 1998; Hadlari et al., 2006; Fralick and Zaniewski, 2012), which may be due to difficulties in their recognition caused by the absence of modern analogs for non-vegetated, periodically flooded areas next to perennial channels. The current models for post-Silurian floodplains generally consider the dominance of mud deposits (e.g., Bentham et al., 1993; Bridge, 2000), however, the description of coarse-grained floodplains related to modern single channel rivers (Alexander and Fielding, 2006) suggests that the idea of floodplain deposits as fine-grained environments may have led to misinterpretations in the sedimentary record, and to the overlooking of pre-vegetation floodplains. On the other hand, the limited number of described Proterozoic and early Paleozoic floodplains (e.g., Sønderholm and Tirsgaard, 1998; Hadlari et al., 2006; Fralick and Zaniewski, 2012) has been used to suggest low production of clay minerals prior to plant colonization of the land, coupled with bypass of mud to marine environments (e.g., Winston, 1978; Eriksson et al., 2006; Davies et al., 2011). However, the record of Proterozoic fine-grained floodplains, as described by Sønderholm and Tirsgaard (1998), is possibly much more frequent than what has been recorded in the literature.

* Corresponding author.
E-mail address: andre.marconato@usp.br (A. Marconato).

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This work presents descriptions and interpretations of coeval channel-belts, fluvial floodplains and alluvial fans from the Santa Bárbara Group (southern Brazil), deposited in a Late Neoproterozoic to Early Cambrian fault-bounded basin. Particular facies and facies associations are recognized, bringing new light to the nature of pre-vegetation alluvial plains, with the proposal of a sedimentary model that describes the relation of pre-vegetation floodplains with nearby environments, which can improve the understanding of landscape evolution during the transition from the late Neoproterozoic and early Paleozoic.

2. Geological setting and stratigraphy

The Santa Bárbara Group (sensu Fambrini, 2003) is part of the Camaquã Supergroup (Fragoso-Cesar et al., 2000) and crops out in southernmost Brazil (Fig. 1), overlying Paleo- and Neoproterozoic rocks that were involved in the Neoproterozoic orogenic events of Eastern Gondwana as part of a system of fault-bounded basins that extends from Uruguay to Southeastern Brazil (Almeida et al., 2010, 2012). The Camaquã Supergroup comprises unmetamorphosed sedimentary and volcanogenic rocks deposited between ca. 590 Ma and 535 Ma (Chemale Jr., 2002; Janikian et al., 2008, 2012; Almeida et al., 2010). The Santa Bárbara Group is found in three sub-basins of the Camaquã Basin (Fig. 1), separated by basement highs. Because these occurrences cannot be easily correlated, the Santa Bárbara Group includes all siliciclastics younger than the volcanic rocks of the Acampamento Velho Formation and older than the angular unconformity at the base of the overlying (more than 1000 m thick) Guaritas Group (Almeida et al., 2009; Marconato et al., 2009; Santos et al., 2012). Available ages for detritic zircon point to a maximum age of 566 ± 6.9 Ma for the deposition of the Group (Bicca et al., 2013). A minimum age is constrained by basic intrusions dated at 535.2 ± 1.1 Ma (Almeida et al., 2010). Since these volcanic rocks intrude both the Santa Bárbara Group and the overlying Guaritas Group, the depositional age of the Santa Bárbara Group is probably several to tens of million years older than this minimum age.

The type-area of the unit, the Santa Bárbara Valley and nearby ranges is located in the Western Sub-basin (Fig. 2), with continuous exposures, more than 2600 m thick, of conglomerate, feldspathic and lithic sandstone and minor siltstone and mudstone. The Santa Bárbara Group is divided into five formations (Almeida, 2005; Fambrini et al., 2006), from base to top: the basal Estância Santa Fé Formation is composed mainly of conglomerate, sandstone, and minor siltstone; the Seival Formation includes interlayered siltstone and fine-grained sandstone with minor mudstone; the Serra dos Lanceiros Formation comprises sandstone and conglomeratic sandstone; the Arroio Umbu Formation is composed mainly of siltstone and sandstone, with minor conglomerate deposits at the eastern border of the basin; and the Pedra do Segredo Formation has sandstone and conglomerate deposits.

3. Depositional systems

In this paper, descriptions and interpretations of the depositional systems of the type area of the Santa Bárbara Group were based on the study of continuous stratigraphic sections of the main units, facies and architectural element analysis of selected outcrops, paleocurrent analysis, and geological mapping of the area at the scale of 1:50,000 (Fig. 1). Three main depositional systems have been recognized: Basin border conglomerates, interpreted as alluvial-fans; sandstone deposits, interpreted as fluvial channel-belts; and heterolithic fine-grained deposits, interpreted as fluvial floodplains. The description and interpretation of lithofacies are given in Table 1, and a summary of facies associations can be found in Table 2.

3.1. Basin border conglomerates

3.1.1. Description

Conglomerate deposits (FA1a and FA1b, Tables 1, 2) are found near the western border of the basin, in outcrops of the Estância Santa Fé Formation. Near the syn-sedimentary fault to the east of the sub-basin, conglomerate deposits are found only at the upper stratigraphic levels, being lateral equivalents to the Serra dos Lanceiros, Arroio Umbu and Pedra do Segredo formations. These deposits are characterized mainly

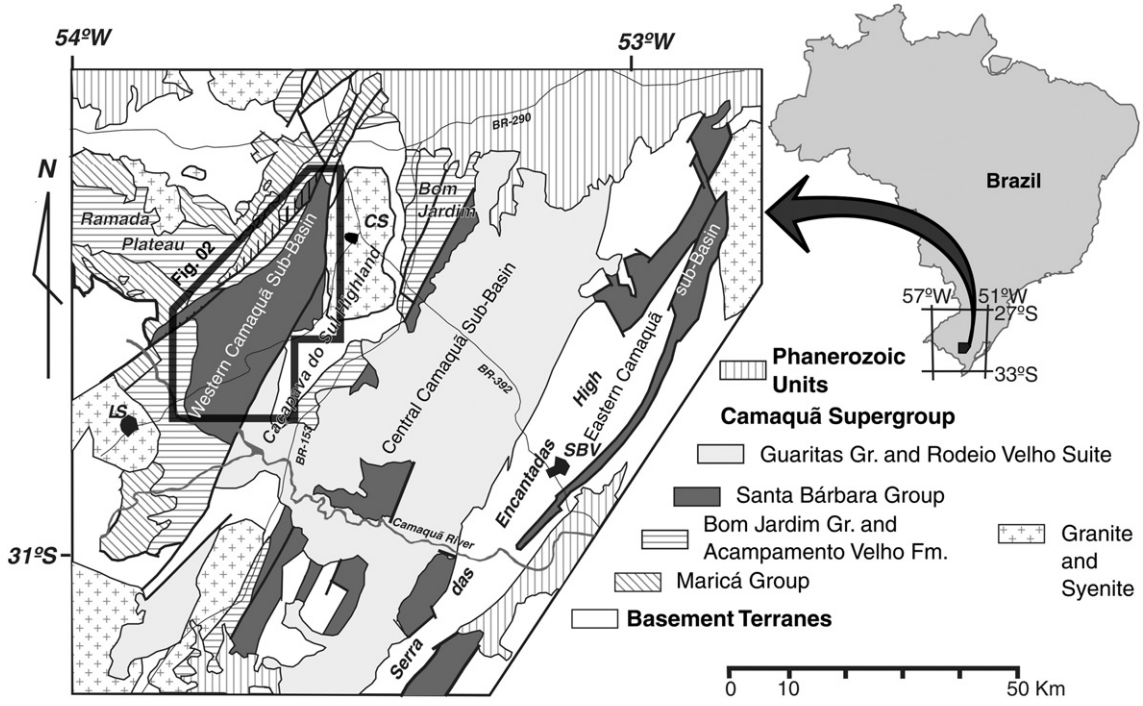

Fig. 1. Simplified geological map of the Camaquã Basin and surroundings. Localities: CS — Caçapava do Sul; LS — Lavras do Sul; SBV — Santana da boa Vista. Modified after Fragoso-Cesar et al. (2000).