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Record of a Pennsylvanian-Cisuralian marine transgression, southern Bolivia: A short-lived event in western Gondwana?

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ABSTRACT

Largely terrestrial Pennsylvanian strata (Macharetí and Mandiyutí groups) in Bolivia and northern Argentina contain a brief marine incursion. Dominated by glacio-fluvial and glacial diamictites, much of the thick succession is peri-glacial in origin and deposited within a basin with paleohighs. In southernmost Bolivia (Balapuca section), new discoveries of poorly preserved orthotetacean brachiopods (*Derbyoides* sp.) document the marine systems. Without the brachiopod, co-occurrence of numerous in situ gastropods (*Mourlonia balapucense*), with all ontogenetic growth stages, could not be confirmed as marine. Palynomorphs corresponding to the TB Zone di Pasquo stratigraphically below the megafossil occurrence place the age of the assemblage in the Kasimovian/Gzhelian Stage. Many units show extensive recycling of Devonian and Mississippian palynomorphs (*Retispora lepidophya*, and others) and a brachiopod demonstrate pre-Gzhelian erosion and high energy deposition in diamictites during deposition of the Tarija Formation, and through much of the succession. This brief marine transgression in this basin corresponds to regionally more long-lived marine transgressions in western Argentina, characterized by the *Tivertonia-Streptorhynchus* Fauna (Moscovian-Gzhelian) linked with the beginning of a global major sea level rise as an interlude in the Gondwana glaciations. The marine transgression exceeded isostatic rebound. Further in Bolivia, the transgression from the north produced the Copacabana Formation carbonates. Coeval siliciclastics of the San Telmo Formation in the south show contrasting in lithologic facies and faunal composition as a result of thermal barriers (warm – cold waters).

1. Introduction

The Pennsylvanian of South America (Western Gondwana) was deposited in active basins on its western border and intracratonic basins in its central to eastern border (Fig. 1). In Bolivia, deposits of this age are known from areas between Western Cordillera and the Guapore Shield to the east, characterized by glacially-influenced depositional systems to the south (Macharetí and Mandiyutí groups), with warmer water carbonates (Titicaca Group) in the north and west (Fig. 2; Starck and del Papa, 2006; Grader et al., 2008; di Pasquo, 2009a; di Pasquo et al., 2015a). The clockwise rotation of Gondwana produced occurrences of glacial deposits in southern South America during the Carboniferous (Caputo and Crowell, 1985; Isaacson and Díaz-Martínez, 1995; Azcuy and di Pasquo, 2000; Suárez-Soruco, 2000; Iannuzzi and Rösler, 2000; Isbell et al., 2003; Torsvik and Cocks, 2004, 2013; Limarino et al., 2014). A mid-Carboniferous erosional event deeply scoured and recycled Devonian and Mississippian rocks (Starck and del Papa, 2006), and it is dated by palynological records in Bolivia and northern Argentina (Fig. 2; di Pasquo and Azcuy, 1997; di Pasquo, 2003, 2009b). In the Pennsylvanian, glacially-influenced sedimentation in southern Bolivia and northern Argentina contain not only recycled material from earlier units, but also evidence of direct ice contact (Starck et al., 1993a, 1993b; Díaz-Martínez, 1996; Starck and del Papa, 2006). Post-Paleozoic tectonic and magmatic events removed Paleozoic strata throughout Bolivia, thereby complicating the preserved record in this region (Sempere, 1995; Azcuy et al., 2007; Jiménez et al., 2009).

1.1. Equivocal previous paleontologic information

The combination of glacially-caused lower sea levels and the isostatic rebound with glacial withdrawals (Starck and del Papa, 2006) provided occasional, brief marine transgressions in southernmost Bolivia during the Pennsylvanian. Early discoveries of some invertebrate assemblages in southern Bolivia (Cathcart, 1928; Chamot, 1960; Ayaviri, 1962, 1972; Branisa, 1965), could not be verified as marine organisms (Rocha Campos et al., 1977; Ikeda, 1989; Babin and Dalenz, 1993). Branisa (1965) compiled illustrations of Carboniferous and Permian invertebrates and trace fossils in southern Bolivia (e.g. San Telmo

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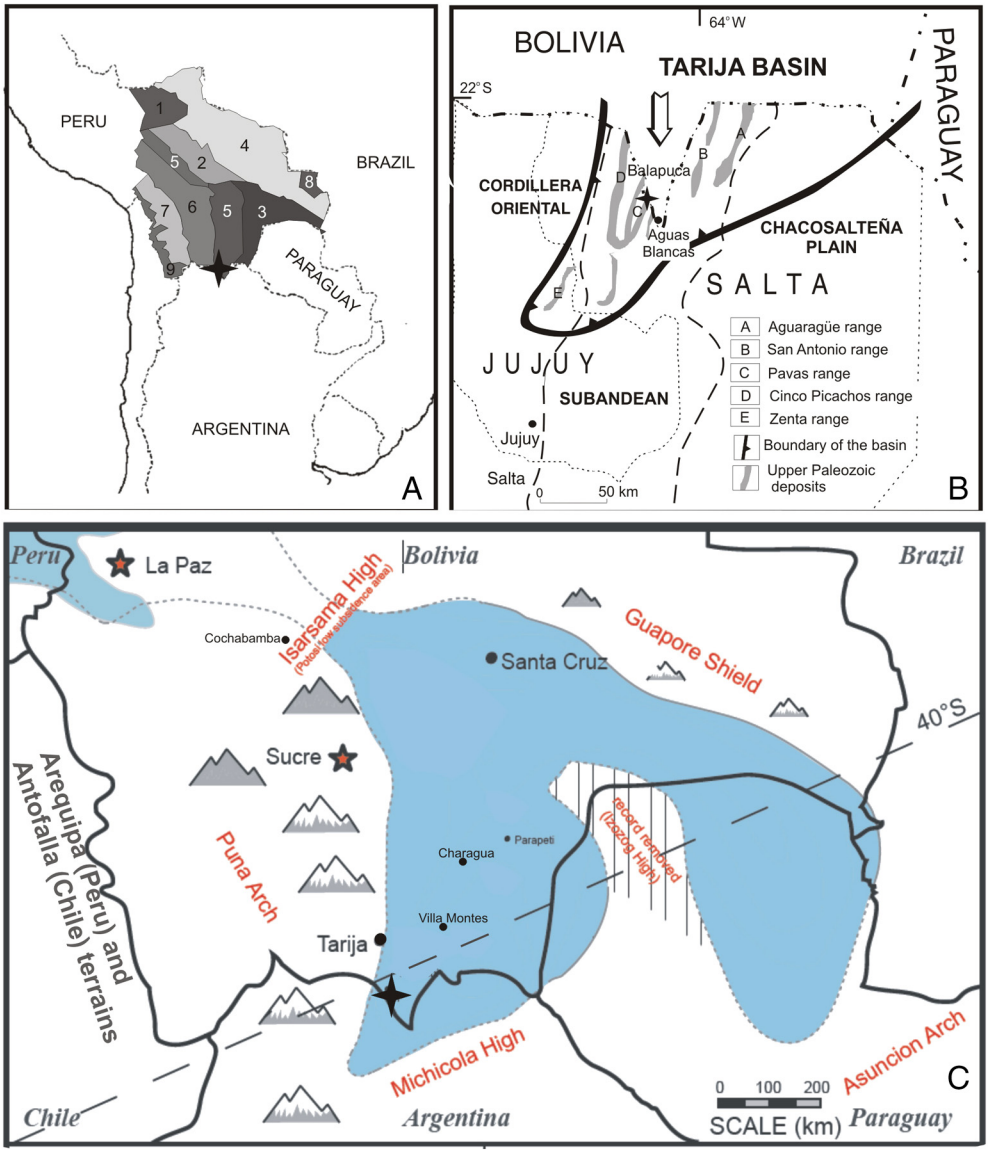

Fig. 1. (A) Location of the Balapuca section (cross symbol) in the context of the Modern geologic provinces of Bolivia (after Suárez-Soruco, 2000): 1 - Madre de Dios, 2 - Beni, 3 - Chaco and Chaco-Salta Plain, 4 - Guaporé Craton, 5 - Subandean, 6 - Cordillera Oriental, 7 - Altiplane, 8 - Pantanal, 9 - Cordillera Occidental. (B) Geology of southern Tarija Basin and location of Balapuca section (after di Pasquo, 2003). (C) Basement structure and paleogeographic highs present during deposition of the Macharetí and Mandiyutí groups (Sempere, 1995; Tankard et al., 1995; Ramos, 2008) (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.).

Formation near Villa Montes in Fig. 1C). Rocha Campos et al. (1977) illustrated a marine fauna with the brachiopod *Levipustula levis* Maxwell (*Levipustula* Fauna) as well as bivalves and gastropods in the Taiguati Formation (Fig. 2) in two localites (Río Parapetí, western flank of the Charagua anticline and at San Antonio de Parapetí 6 km upriver) from Subandean Bolivia (Fig. 1). They described the gastropod *Mourlonia balabucense* from the San Telmo Formation only at Balapuca. Babin and Dalenz (1993) described pteriomorph bivalves (*Limipecten*, *Aviculopecten*) from the Taiguati Formation in the Charagua range near Charagua (Fig. 1C), and Ikeda (1989) found a pteriomorph (*Naiadites*) and Anomalodesmata (*Sphenotus*, *Wilkingia*) in the Taiguati Formation from the Chori creek in the Caipipendi range near Villa Montes (Fig. 1C). While the marine invertebrates found in the Taiguati Formation by Rocha Campos et al. (1977) suggested that there was a brief marine transgression, gastropods found at Balapuca could possibly have occurred in a terrestrial paleoenvironment. The age of these assemblages was inferred only by their stratigraphic position, as the lack of palynological data from the Taiguati Formation prevented a more accurate age and correlation into the palynozonation proposed by di Pasquo (2003), Fig. 2).

The aim of this contribution is to present significance of newly found marine invertebrates from the Pennsylvanian age San Telmo Formation at Balapuca in southern Bolivia (Fig. 1). We discuss whether it is a short-lived deglacial transgressive event that occurred with local extent that established migration routes for marine invertebrates in western Gondwana. Additionally, we describe the first reported occurrence of a single brachiopod mold in the diamictites of the Tarija Formation at Balapuca and its interpretation in the context of deposition in glacial paleovalleys.

2. Geological setting

The Carboniferous of southern Bolivia and northern Argentina is exposed along the Subandean Range (Fig. 1A) and is represented by the Macharetí and Mandiyutí groups (Fig. 2), deposited within the Tarija-Chaco Basin. This basin has been called Tarija Basin, Chaco Basin, Bolivia Trench, Bolivia Basin, and Peru-Bolivia Basin in different works (Reyes,

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