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# Calibrating the Ediacaran-Cambrian transition in the SW Gondwana

## *Calibrando la transición ediacárico-cámbrica en Gondwana suddoccidental*

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### ABSTRACT

The paleontological, isotopic and geochronological data summarized below support the paleogeographic and temporal correlation between Itapucumi (Paraguay) and Corumbá (Brazil) groups, suggesting a coeval sedimentary evolution of these units in the margins of the Amazon Craton and the Rio Apa Block.

**Keywords:** Itapucumi Group; SHRIMP ages; Detrital and volcanic zircon; Nama assemblage; Ediacaran-Cambrian transition; SW Gondwana.

### RESUMEN

Los datos paleontológicos, isotópicos y geocronológicos que se resumen a continuación apoyan la correlación paleogeográfica y cronológica entre los Grupos de Itapucumi (Paraguay) y Corumbá (Brasil), sugiriendo una evolución sedimentaria contemporánea entre estas unidades en los márgenes del Cratón Amazónico y del Bloque del Río Apa.

**Palabras clave:** Grupo de Itapucumi; Edades SHRIMP; Zirrones detríticos y volcánicos; Asociación tipo Nama; Tránsito Ediacárico-Cámbrico; SO Gondwana

### Introduction

Recent advances in the paleontology, geochemistry and geochronology of terminal Neoproterozoic successions worldwide have contributed substantially to

the calibration of the Ediacaran-Cambrian timescale. The majority of new data is reported from Ediacaran successions in North America, Asia and Africa. South American successions, in contrast, still lack reliable radiometric ages, hampering intercontinental

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correlations and impeding the detailed characterization of the Ediacaran-Cambrian transition for SW Gondwana. Here, we present several SHRIMP zircon ages from the Itapucumi Group, Paraguay, tied to a solid stratigraphic, palaeontological and isotopic framework.

## Results

The Itapucumi Group occurs extensively in north-eastern Paraguay close to the Paraguay River, with the thin sedimentary package deposited directly on the Paleoproterozoic basement of the Rio Apa Craton. The entire stratigraphic thickness of this unit is about 400 m, comprising siliciclastic/volcanic rocks of the basal Vallemí Formation, overlain by limestones and dolostones of the Camba Jhopo and Tagatiya Guazu formations, and capped by carbonates and siliciclastic rocks of the Cerro Curuzu Formation. The Itapucumi Group is interpreted as deposited in a homoclinal, rimmed carbonate ramp that faced a (paleo) western ocean, presenting an extensive protected lagoonal environment in which microbialites and Ediacaran skeletal organisms thrived (Warren *et al.*, 2017). Recently published carbon isotope data from unaltered carbonates of the Itapucumi Group show mean values of +1.9‰  $\delta^{13}\text{C}_{\text{VPDB}}$  and  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios of 0.708604 (Warren *et al.*, 2019). The consistent positive  $\delta^{13}\text{C}$  plateau in the entire stratigraphic succession and the  $^{87}\text{Sr}/^{86}\text{Sr}$  values are typical of the end of Ediacaran Period ca. 550 Ma. In addition, the presence of *Cloudina* index fossil in the Tagatiya Guazu Formation reinforces this age and confirms a depositional age between 550 and ~539 Ma (Linnemann *et al.*, 2019) for the oldest carbonate rocks of the Itapucumi Group. However, fossils are apparently absent from the overlying Camba Jhopo and entire Cerro Curuzu formations, so the depositional age of the uppermost Itapucumi Group is constrained only by chemostratigraphic data. Similarly, the depositional age of the siliciclastic rocks of the basal Vallemi Formation is unconstrained by biostratigraphy. In order to provide new geochronological constraints for these rocks, we analyzed 78 zircon grains using U-Pb Sensitive High Resolution Ion Microprobe (SHRIMP), targeting three stratigraphic intervals of

the Itapucumi Group (Fig. 1). A total of 37 detrital rounded zircons were analyzed from coarse sandstones (8 zircons from sample VLM28C) and red fine sandstones (29 zircons from sample VLM53D) samples from the base and top of the Vallemi Formation, respectively. Several small, euhedral volcanic zircons were also collected from an ash bed (41 zircons from sample VLM11) located in the top of the Cerro Curuzu Formation (Figs. 2A and B). The rock samples were processed by standard methods for zircon grain separation and the U and Pb isotope ratios in zircon grains were measured in a High Resolution Ion Micro Probe (SHRIMP II) equipment housed at Curtin University, Australia. Reported age constraints are based on analyses of zircon with <10% discordance.

The detrital zircon ages obtained for the Vallemi Formation vary between minimum and maximum of  $598 \pm 13$  Ma and  $2590 \pm 49$  Ma, respectively, with a well-defined age peaks around 600 Ma and 900 Ma, indicating the predominance of Neoproterozoic source regions. Paleoproterozoic and Archean zircons correspond to material sourced from igneous and high-grade metamorphic basement units from the Rio Apa Craton (e. g. Alumiador and Centurion suites and Apa Basal Complex, Cordani *et al.*, 2010).

The maximum depositional age of the Vallemi Formation (base of the Itapucumi Group) corresponds to the minimum age obtained for the detrital zircon assemblage ( $598 \pm 13$  Ma).

The volcanic zircon grains from the ash bed located at the top of the Cerro Curuzu Formation present ages varying between a maximum of  $2092 \pm 15$  Ma and a minimum of  $498 \pm 19$  Ma. The main population (29 grains) of Archean and Palaeoproterozoic zircons were considered as inherited from units of the regional basement of the Rio Apa Craton.

A total of 12 volcanic zircon grains presenting early Cambrian to Ediacaran ages varying between  $537 \pm 10$  Ma and  $565 \pm 10$  Ma provided a “concordia” age of about  $545 \pm 4.5$  Ma (Fig. 1), placing the deposition age of the top of Itapucumi Group close to the Ediacaran-Cambrian transition. If the youngest analyzed zircon is taken as significant ( $498 \pm 19$  Ma), it would indicate deposition in the late Cambrian. Considering the regional deformation of Itapucumi

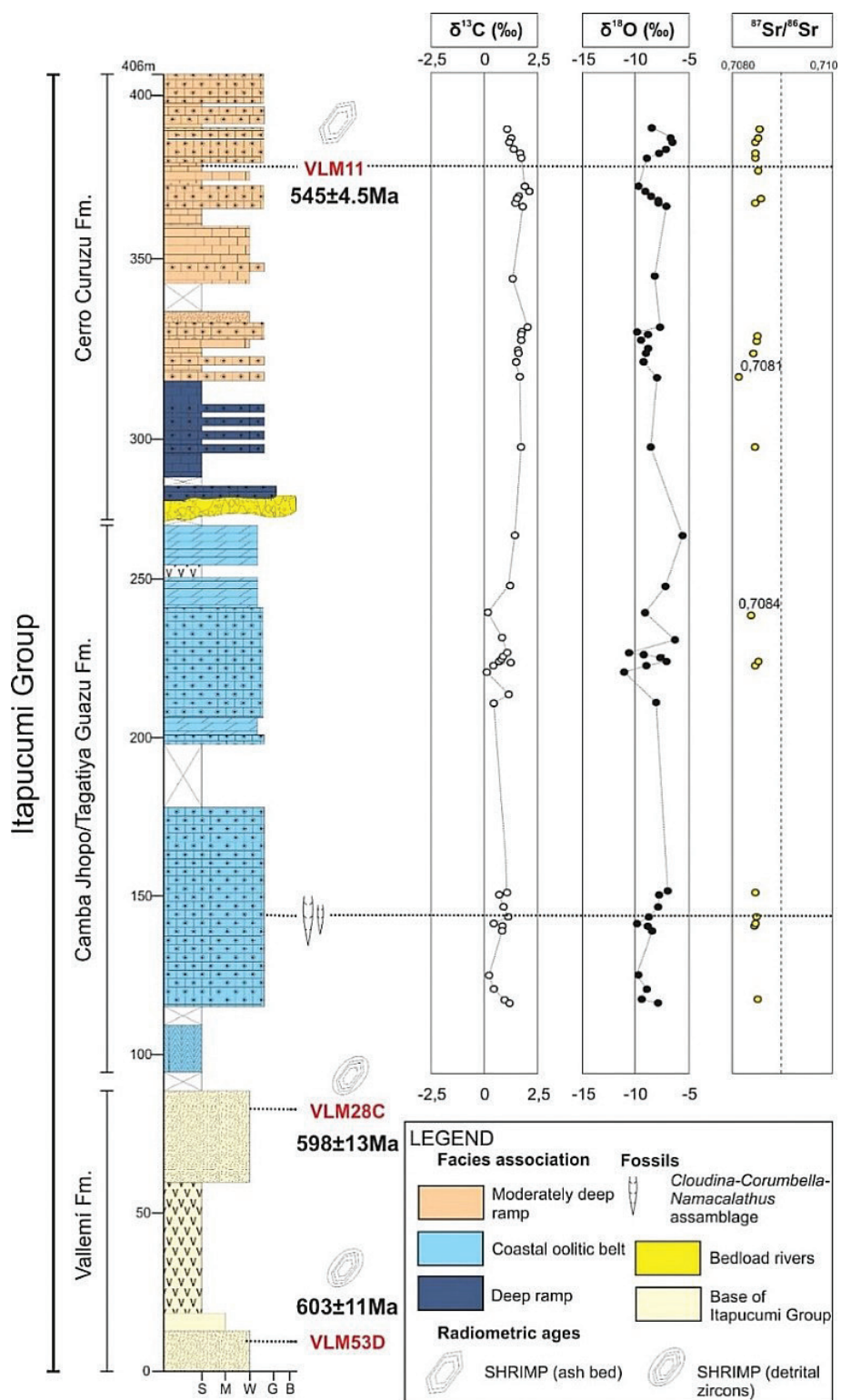


Figure 1.—Composite stratigraphic column and high-resolution chemostratigraphic (C, O and Sr) data of the Itapucumi Group. The main facies associations, Ediacaran skeletal fossils and SHRIMP ages are marked.

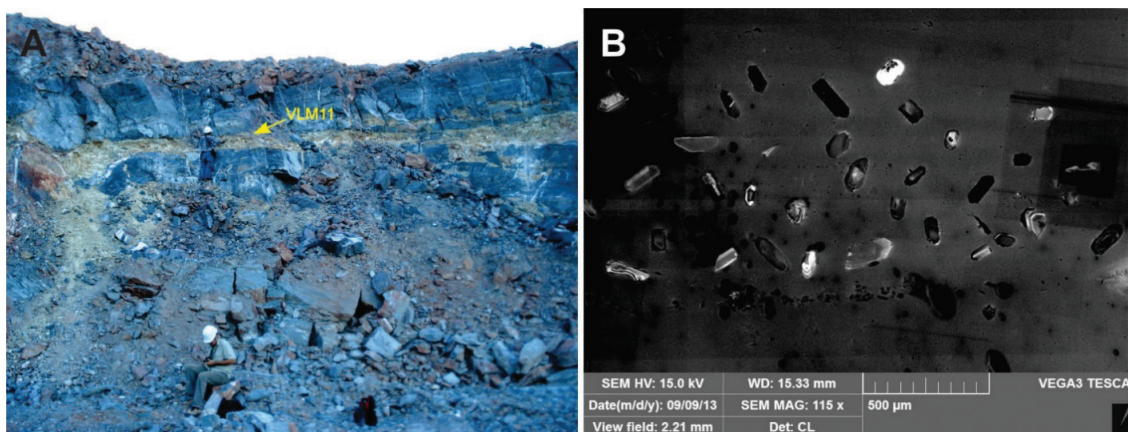


Figure 2.—A. Tuff bed stratigraphically located at the upper part of the Cerro Curuzu Formation, Itapucumi Group, northern Paraguay. B. Cathodoluminescence images of detrital zircons from the tuff bed shown in A (sample VLM11). Note the predominance of euhedral zircon grains.

and Corumbá basins took place at approximately 528–490 Ma ago (Tohver *et al.*, 2010), it is plausible that the upper part of the Itapucumi Group was deposited into a foreland basin near the end of the Brasiliano. Thus, the paleontological, isotopic and geochronological data support the paleogeographical and temporal correlation between Itapucumi (Paraguay) and Corumbá (Brazil) groups, suggesting a coeval sedimentary evolution of these units in the margins of the Amazon Craton and the Rio Apa Block.

Last but not least, the presence of volcanic zircons constraining an Ediacaran age at the top of the Itapucumi Group opens an innovative perspective for paleontological and ichnological investigations in this unit and help to calibrate the Ediacaran-Cambrian transition in the SW Gondwana.

## Conclusions

Several SHRIMP zircon ages from the Itapucumi Group, Paraguay, tied to a solid stratigraphic, paleontological and isotopic framework, are presented here. A total of 12 volcanic zircon grains presenting early Cambrian to Ediacaran ages varying between  $537 \pm 10$  Ma and  $565 \pm 10$  Ma provided a “concordia” age of about  $545 \pm 4.5$  Ma, placing the deposition age of the top of Itapucumi Group close to the Ediacaran-Cambrian transition.

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