Estudios Geológicos
julio-diciembre 2019, 75(2), e118
ISSN-L: 0367-0449
https://doi.org/10.3989/egeol.43593.573

Calibrating the Ediacaran-Cambrian transition in the SW Gondwana

Calibrando la transición ediacárico-cámbrica en Gondwana suddoccidental

L.V. Warren[1], E. Tohver[2], L. Inglez[1], J. Okubo[1], C. Riccomini[3], S. Xiao[4]

[1]Department of Applied Geology, Institute of Geosciences and Exact Sciences, São Paulo State University (Unesp), Rio Claro-SP, Brazil. Email: lucas.warren@unesp.br; ORCID ID: http://orcid.org/0000-0002-2050-6514, http://orcid.org/0000-0002-2815-8788, http://orcid.org/0000-0001-9160-9994
[2]Institute of Astronomy and Geophysics, São Paulo University (USP), São Paulo, Brazil. ORCID ID: http://orcid.org/0000-0002-3333-0917
[3]Institute of Energy and Enviroment, São Paulo University (USP), São Paulo, Brazil. ORCID ID: http://orcid.org/0000-0002-7249-5706
[4]Department of Geosciences, Virginia Tech, Blacksburg, Virginia 24061, USA. ORCID ID: http://orcid.org/0000-0003-4655-2663

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; Zircones 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

Recibido el 8 de mayo de 2019; Aceptado el 1 de julio de 2019; Publicado online el 2 de diciembre de 2019

Citation / Cómo citar este artículo: Warren, L.V. et al. (2019). Calibrating the Ediacaran-Cambrian transition in the SW Gondwana. Estudios Geológicos 75(2): e118. https://doi.org/10.3989/egeol.43593.573

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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 northeastern 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% δ^{13}VCPDB and $^{87}Sr/^{86}Sr$ ratios of 0.708604 (Warren *et al*., 2019). The consistent positive $\delta^{13}C$ plateau in the entire stratigraphic succession and the $^{87}Sr/^{86}Sr$ 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±13 Ma and 2590±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 ± 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 ± 15 Ma and a minimum of 498 ± 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±10 Ma and 565±10 Ma provided a "concordia" age of about 545±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 ± 19 Ma), it would indicate deposition in the late Cambrian. Considering the regional deformation of Itapucumi

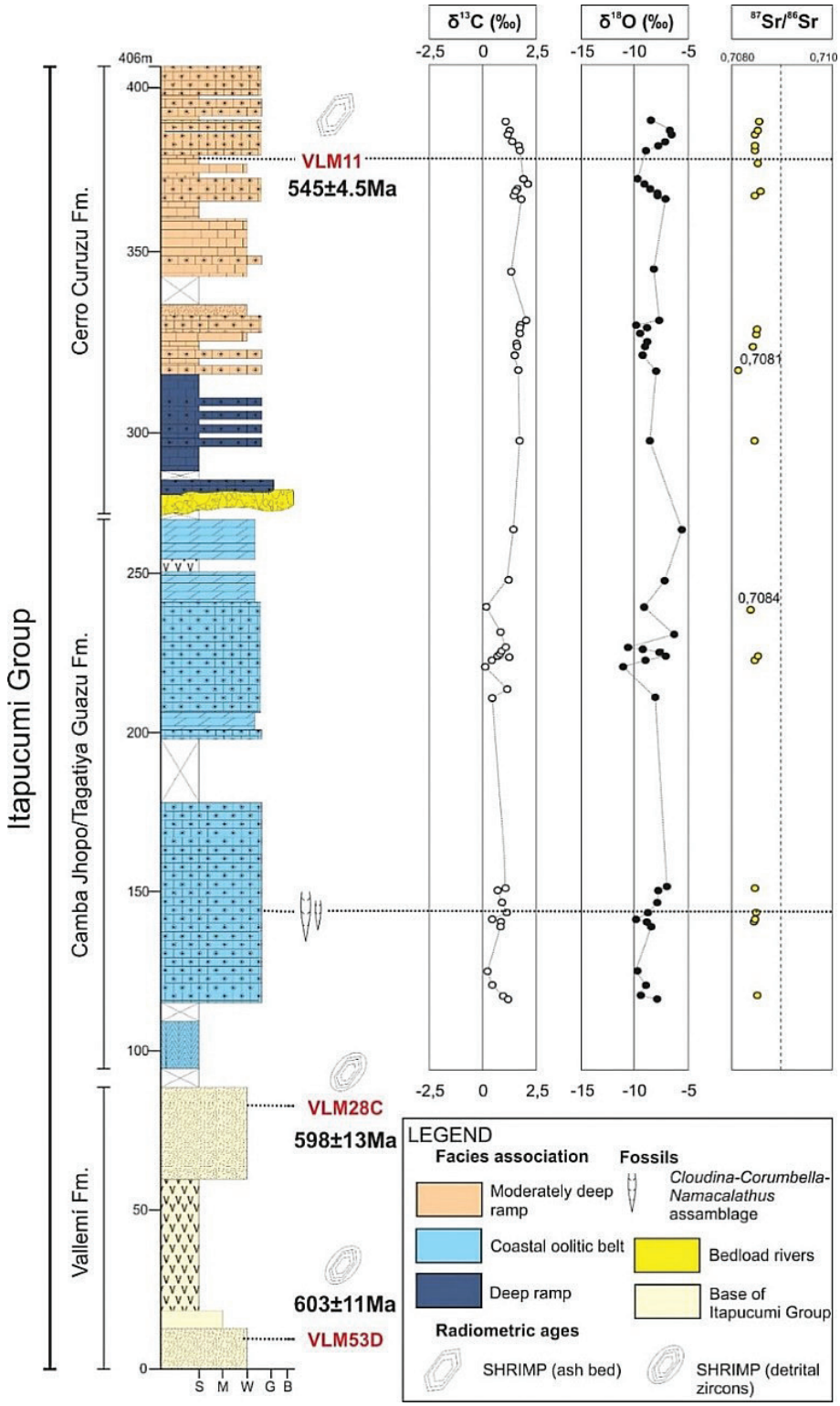

Figure 1.—Composite stratigraphic column and high-resolution chemostratigraphic (C, O and Sr) data of the Itapucumi Group. The main facies associations, Ediacaran skeletal fossils and SHRIMP ages are marked.

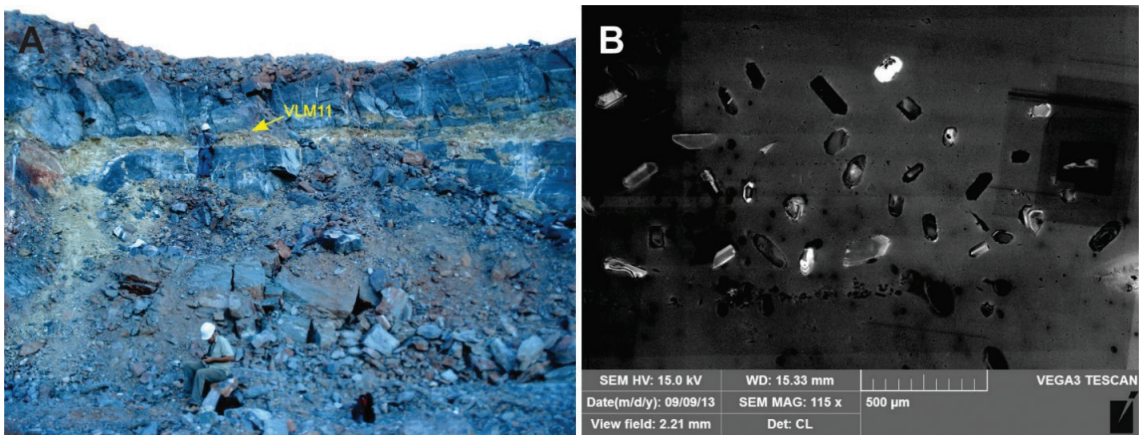

Figure 2.—A. Tuff bed stratigraphically located at the upper part of the Cerro Curuzu Formation, Itapucumi Group, northern Paraguay. B. Cathodoluminescence images of detrital zircons from the tuff bed shown in A (sample VLM11). Note the predominance of euhedral zircon grains.

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, palaeontological and isotopic framework, are presented here. A total of 12 volcanic zircon grains presenting early Cambrian to Ediacaran ages varying between 537±10 Ma and 565±10 Ma provided a "concordia" age of about 545±4.5 Ma, placing the deposition age of the top of Itapucumi Group close to the Ediacaran-Cambrian transition.

ACKNOWLEDGEMENTS

This research was sponsored by FAPESP (grants 2010/19584-4 and 2018/26230-6).

References

Cordani, U.G.; Teixeira, W.; Tassinari, C.C.G.; Coutinho, J.M.V. & Ruiz, A.S. (2010). The Rio Apa Craton in Mato Grosso do Sul (Brazil) and northern Paraguay: Geochronological Evolution, Correlations and Tectonic Implications for Rodinia and Gondwana. American Journal of Science, 310: 981–1023. https://doi.org/10.2475/09.2010.09

Linnemann, U.; Ovtcharova, M.; Schaltegger, U.; Gärtner, A.; Hautmann, M.; Geyer, G.; Vickers-Rich, P.; Rich, T.; Plessen, B.; Hofmann, M.; Zieger, J.; Krause, R.; Kriesfeld, L. & Smith, J. (2019). New high-resolution age data from the Ediacaran-Cambrian boundary indicate rapid, ecologically driven onset of the Cambrian explosion. Terra Nova, 31: 49–58. https://doi.org/10.1111/ter.12368

Tohver, E.; Trindade, R.I.F.; Solum, J.G.; Hall, C.M.; Riccomini, C. & Nogueira, A.C. (2010). Closing the Clymene Ocean and bending a Brasiliano belt: Evidence for the Cambrian formation of Gondwana, southeast Amazon craton. Geology, 38 (3): 267–270. https://doi.org/10.1130/G30510.1

Warren, L.V.; Quaglio, F.; Simões, M.G.; Gaucher, C.; Riccomini, C.; Poiré, D.G.; Freitas, B.T.; Boggiani, P.C. & Sial, A.N. (2017). Cloudina-Corumbella-Namacalathus association from the Itapucumi Group, Paraguay: increasing ecosystem complexity and tiering at the end of the Ediacaran. Precambrian

Research, 298: 79–87. https://doi.org/10.1016/j.precamres.2017.05.003

Warren, L.V.; Freitas, B.T.; Riccomini, C.; Boggiani, P.C.; Quaglio, F.; Simões, M.G.; Fairchild, T.R.; Giorgioni, M.; Gaucher, C.; Poiré, D.G.; Cáceres, A.A. & Sial A.N. (2018). Sedimentary evolution and tectonic setting of the Itapucumi Group, Ediacaran, northern Paraguay: from Rodinia break-up to West Gondwana amalgamation. Precambrian Research, 322: 99–212. https://doi.org/10.1016/j.precamres.2018.12.022