

# Corumba Meeting 2013: The Neoproterozoic Paraguay Fold Belt (Brazil): Glaciation, iron-manganese formation and biota, an IGCP Workshop and Field Excursion on the Ediacaran system

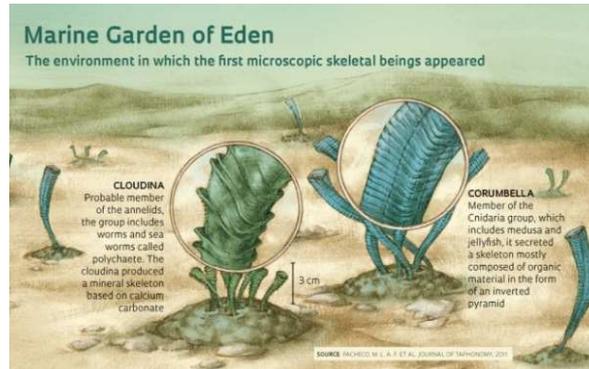
4 – 9 August 2013, Corumbá, MatoGrossodoSul, Brazil

Neoproterozoic sedimentary basins in Brazil, including glaciogenic deposits of Cryogenian and Ediacaran affinity, occur on the São Francisco, Rio de la Plata, and Amazonia cratons. Detailed correlation of these units, however, is complicated by the tectonic traffic that resulted in the intervening mobile belts, dearth of radiometric constraints, and the lack of continuous (and uncovered) outcrop in temperate and tropical environments. Nonetheless, many of the Ediacaran sections are richly fossiliferous containing important lagerstaette of the earliest biomineralizing organisms on Earth, including *Cloudina* and *Corumbella*.

A science news article written by Ricardo Zorretto published by *Pesquisa FAPESP* about life's early armor, including quotes from many of the participants in the Corumba Meeting 2013 is available at: (<http://revistapesquisa.fapesp.br/en/2012/09/11/life-protected-by-armor/>)

To evaluate the stratigraphic context of the Ediacara biota in the southern Paraguay Belt in the context of the global subdivision of the geological period, an IGCP Workshop and Field Excursion was held on 4-9 August, 2013 in Campo Grande and Corumbá. These events were organized by Prof. Dr. Detlef Walde of the Universidade de Brasília along with his colleagues, and were sponsored by the Subcommission of Ediacaran Stratigraphy (an arm of the International Commission on Stratigraphy), Geological Survey of Brazil (CPRM), Petrobras, Brazilian Society of Geology (Brasília), Universidade Federal de Mato Grosso do Sul (UFMS), VetriaMineração, and IGCP project 587 ["Of Identity, Facies and Time: The Ediacaran (Vendian) Puzzle" led by Patricia Vickers-Rich, Mikhail A. Fedonkin, James G. Gehling, Guy M. Narbonne, and Alan J. Kaufman].

After an opening ceremony at the Universidade Federal do Mato Grosso do Sul (UFMS) in Campo Grande, the group travelled to Corumbá, Mato Grosso do Sul for the workshop and field activities along the margin of the Amazonia craton. The city of



Corumbá lies along the banks of the Paraguay River at the border of the Pantanal wetlands and is adjacent to the Urucum Massif of high grade iron and manganese ore (in the Jacadigo Group), as well as fossiliferous limestone (Corumbá Group) atop glaciogenic deposits. While the structural relationship between the ore deposits of the Jacadigo Group (including a dropstone-laden diamictite horizon) and the Ediacara fossils of the Corumba Group (including *Cloudina* and, of course, *Corumbella*) is complex, these rocks document terminal Neoproterozoic climatic and biological events in a peri-Gondwanan position.

Keynote lectures on the geology, chemistry, and paleontology of the Paraguay Fold belt were presented on Monday, August 5<sup>th</sup> at the Nacional Palace Hotel in Corumbá. Carlos Alvarenga and Milene Figueireo discussed the geology and chemostratigraphy of the North Paraguay Fold Belt on the Amazonia craton, while Paulo Boggiani and Detlef Walde provided an integrated picture of the sedimentology and paleontology of the



South Paraguay Fold Belt in the Corumbá region. An integrated summary of the Ediacaran system along the margin of the Amazonia craton from Brazil to Argentina was presented by Claudio Gaucher concluding the first day of the workshop.

On August 6<sup>th</sup> a keynote lecture to open the morning session was transmitted over the internet by Shuhai Xiao.

He proposed a new subdivision of Ediacaran time based on paleontological and geochemical observations from South China. Continuing the focus on South China, a second keynote address by Bernd-Dietrich Erdmann provided a critical review of Ediacaran/Cambrian boundary sections on the Yangtze Platform. Additional presentations during the Tuesday session included those related to new discoveries of Ediacara biotas worldwide or new spectroscopic techniques to study them, as well as those focused on geochemical indicators of oceanic and atmospheric redox conditions. The final keynote address was presented by Alan J. Kaufman who discussed how to solve the Cryogenian stratigraphic puzzle based on integrated stratigraphic approaches to correlation of strata within and between sedimentary basins.

Field investigations associated with the workshop focused on the geology and paleontology of the carbonate-dominated Corumbá Group, which contains a unique archive of biomineralized Ediacara fossils, and the economic deposits of iron-bearing rocks of the Urucum Massif (Jacadigo Group). The relationship between these units – both of which contain glacial deposits – is well constrained despite limited stratigraphic contacts. The stratigraphic relationship of the Corumbá and Jacadigo groups is likely confused by zones of syn-sedimentary graben faults and differential weathering of iron-formation and carbonate-dominated strata. While detrital zircon U-Pb measurements

suggest a minimum age of around 700 Ma for the Jacadigo Group, a recent  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  determination on cryptomelane from the Urucum has been used to suggest middle Ediacaran age for the iron-formation (Piacentini et al., 2013). It has been argued, however, that this age reflects a metamorphic rather than a sedimentary constraint. Comparison with broadly equivalent strata worldwide suggests that iron-formation facies are generally related to pre-Ediacaran rifting and glacial events.

The Corumbá Group in the southern Paraguay Fold Belt conformably overlies the Puga diamictite, interpreted to be glacial in origin due to its heterogeneous composition as well as its juxtaposition immediately beneath a texturally and isotopically anomalous cap carbonate. Whether the Puga diamictite near Corumbá is isochronous with the glacial deposit of the same name in the northern Paraguay Fold Belt, however, remains uncertain. Based on chemostratigraphic trends and the fossil assemblages in overlying strata, Spangenberg et al. (2013) suggest that the Puga in the southern part of the fold belt accumulated during the Ediacaran Gaskiers glaciation (ca. 580 Ma). In contrast, the Puga diamictite in the north is loosely constrained by a Pb-Pb age of its cap carbonate to be related to the older Marinoan (ca. 635 Ma) ice age (Babinski et al., 2013). In the southern fold belt the Puga diamictite is overlain by the Cerradinho, Bocaina, Tamengo, and Guaicurus formations (Corumbá Group), which have a composite thickness of over 600 meters. The fossil assemblages known from these units include planktonic acritarchs, vendotaenids, benthic skeletal fossils and putative soft-bodied cnidarians.

On August 7<sup>th</sup> participants in the field trip observed the Tamengo and Guaicurus formations at Laginha Mine (Votorantim-Cimento) south of the city of Corumbá. Here a carbonate breccia at the base of the fossiliferous Tamengo Formation is overlain by laminated marine mudstone and marl, as well as laminated micrite and grainstone; all facies are variably enriched in organic matter and pyrite. A karst surface – potentially hiding the Ediacaran-Cambrian boundary – separates the faulted black to grey Tamengo carbonates with olive-grey transgressive marine siltstone of the overlying Guaicurus Formation.

In the afternoon, the field party drove further south to the VetríaMineração Mine in the south part of the Urucum Mountains to observe freshly exposed surfaces of iron-



formation – believed to have a hydrothermal source – and glacial facies within the Santa Cruz Formation of the Jacadigo Group. We observed an iron-cemented diamictite with dropstones clearly truncating sedimentary laminations developed in an arkosic wedge between laminated iron-formation facies (see image to left). Similar glacial indicators are preserved in Sturtian-aged (ca. 720 Ma) iron-formations worldwide, including the Rapitan Formation in the Mackenzie Mountains of arctic Canada and the Chuos Formation in Namibia, but are atypical of younger Marinoan or Gaskiers aged deposits. Thus either the Santa Cruz iron-formation is a remnant of an older rifting phase and the Ar-Ar age records a metamorphic event, or it is a deposit unique to Upper Cryogenian (Marinoan) or Ediacaran time. Supporting the latter, the Puga diamictite beneath the Bocaina Formation has been reported to contain iron-formation facies with dropstones. In Ediacaran strata of Uruguay, the Las Ventanas Formation comprises lithologies similar to the Urucum Formation, including a rift-related depositional environment and glacial deposits bracketed between U-Pb SHRIMP ages of  $590 \pm 2$  Ma and  $573 \pm 11$  Ma (GaucherandPoiré, 2009; Oyhançabal et al., 2009), thus related to the Gaskiers ice age.

On the morning of August 8<sup>th</sup> the field party searched for *Corumbella* at Walde's discovery (1982) site in the Tamengo Formation at Sobramil Port on the Paraguay River. A gigapan image of the discovery outcrop was created (see <http://www.gigapan.com/gigapans/138155>) for teaching and outreach purposes. The port is used to load

ores onto boats, so manganese-rich samples from a discrete horizon the base of the Santa Cruz/Band' Alta Formation (Jacadigo Group) beneath iron-formation facies (exposed only in mines) were available for collection and study; the switch from manganese to iron deposition most-likely reflects changing redox conditions in the depositional basin.

In the afternoon, strata of the Tamengo and Guaicurus formations were observed at Corcal Quarry, including *Cloudina* and *Corumbella* fossils and a potential volcanic ash layer was observed that was collected for new geochronological investigation, where previous U-Pb SHRIMP dating yielded age of  $543 \pm 3$  Ma (Babinski et al. 2008). At the nearby Universidade do MatoGrosso do Sul in Corumbá, a second gigapan image was taken of a large boulder containing a remarkable graveyard of *Cloudina* fossils (see <http://www.gigapan.com/gigapans/137987>).

On August 9<sup>th</sup> participants visited CacimbaEcopark along the Paraguay River in the GeoparkBodoquena-Pantanal (<http://www.geoparkbodoquenapantanal.ms.gov.br/>), to further evaluate facies variations in the Tamengo Formation, including the development of evaporate laminations and



veins, and to search for *Corumbella* and rare *Chuarias* specimens. In the afternoon, some of the participants in the meeting took a boat trip on the Paraguay River to observe the flora and fauna of the Pantanal wetland, as well as outcrops along the river bank. Everyone assembled in the evening for a delightful farewell concert by the InstitutoMoinho Cultural Group (<http://www.moinhocultural.org.br/>). The orchestra is composed of Brazilian and Bolivian children between the ages of 10 and 18. Its primary goal is to give them through musical education stronger cultural ties and potential future professions. The concert that entertained the international workshop participants was given in recognition of DetlefWalde's Corumbá citizenship award.

In all, forty-seven geologists participated in the IGCP 578 sponsored Corumbá Meeting



**Participants in the Corumba Meeting 2013 at Cacimba Ecopark: (left to right) Rony Barroso, Maria Somália, Joana Rodrigues, Sonia Agostinho, Patricia Vickers-Rich, Márcia Machado, Paulo Boggiani, Carlos Abreu, Chuanming Zhou, Juliana Leme, Heyo Van Iten, MileneFigueiredo, Sandra Gabas, Beatriz de Paula, Thomas Fairchild, Weigo Sun, Maria Cristina Lanza de Barros, Rafael Oliveira, Alan Kaufman, Ricardo Paiva, Aguinaldo Silva, Edi Guimarães, DetlefWalde, Bernhard Buhn, Bernard Erdtmann, Thais Tobias, Edna Facincani, Christian Valdivia, Douglas Galante, Marcello Guimarães, OtonLeonardos, Claudio Gaucher, Luana Pereira, Mirian Pacheco, MatheusDenezine, Bruno Becker, Victor Dias, Silvio Yuji, and Frank Stolzenberg; not shown: Les Kriesfeld, David Elliot, Rodrigo Adorno, Carlos Alvarenga, Lucieth Vieira, Evelyn Sanchez, Dermeval do Carmo, and HuimingBao.**

2013. The logistic support for the conference, field excursions, and transportation to and from Campo Grande were excellently handled by staff at the Universidade do MatoGrosso do Sul in both Campo Grande and Corumbá, and the Universidade do Brasilia. Special thanks to Evelyn Sanchez who oversaw the team, including Aguinaldo Silva, Dermeval do Carmo and his students, especially MatheusDenezine and Ricardo Paiva, who took great pains to accommodate all of the needs of the national and international participants. This event was only possible thanks Vetria, VotorantinCimento, Corcal, Sobramil and city government of Corumbá.

As a whole, Corumba Meeting 2013 was a scientifically enlightening and socially enjoyable experience. The program with abstracts and field guide are available at the following website: (<http://corumbameeting2013.wix.com/corumbameeting>).

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