BANDED IRON FORMATION (BIF) ASSOCIATED WITH GLACIAL SEDIMENTS OF THE PUGA FORMATION (MARINOAN) IN THE SERRA DA BODOQUENA (MATO GROSSO DO SUL, BRAZIL)

Boggiani, P.C. [1], Piacentini, T. [1]; Fairchild, T.R. [1]; Yamamoto, J.K. [1]; Campanha, G. A da C. [1]; Sá, F. R de[1], Zuquim, M. de P.S. [1]

1. Instituto de Geociências, Universidade de São Paulo, Rua do Lago, 562, São Paulo, SP, Brazil. CEP 05508-080. E-mails: boggiani@usp.br; thirby@ig.com.br, trfairch@hotmail.com, jkyamamo@usp.br, ginaldo@usp.br.

Keywords: BIF, Marinoan, glaciation, Puga Formation, Paraguay Belt

INTRODUCTION

Banded iron formation (BIF) associated with glacial deposits has been described in late Neoproterozoic deposits around the world. The importance of this association has increased recently due to its implications for understanding global changes during Neoproterozoic glaciations and its significance with respect to the Snowball Earth hypothesis.

BIF associated with diamictite of the glaciogenic Puga Formation (Marinoan) is reported here for the first time in the Serra da Bodoquena (Paraguay Mobile Belt) in a stratigraphic context different from that of known deposits of the Jacadigo Group, e.g. those at Morro do Urucum, near Corumbá, Mato Grosso do Sul (MS).

THE OCCURRENCE OF BIF

Banded iron formation was recently discovered by Wladimir Dalletezze (Mineração Horii) in a recently opened trench on the São Manoel Farm (541 082 7 - 715 923 UTM) near Bodoquena (MS). The BIF occurs as a bed about 40 cm thick, which dip of N45E, over a distance of about 200 m overlying, massive diamictite with ferruginous matrix. In a few places laminated diamictite overlies the BIF. During deformation the silica was partly remobilized, leaving a massive, fine, black ironstone. In some parts, however, typical ferriferous/siliceous banding is evident. Isolated blocks of granite occur within the BIF, but tectonic overprinting makes observation of the relationship between the clasts and original lamination difficult.

Diamictite with ferruginous matrix was also found about 20 km to the south, between the Ceita-Core and Certeza farms, but without BIF.

Chemical analyses show that the BIF is 46.17 % SiO_2, 45.65% Fe_2O_3, 4.53 % Al_2O_3 and 1.97% K_2O (due to the high content of feldspar clasts). A 5-cm-thick bed of concentrated magnetite is 97.52 % of Fe_2O_3, due to removal of silica during deformation. MnO is practically nil. Concentration of Ba and F are 366 ppm and 586 ppm in the BIF and 74 ppm and 1 461 ppm, respectively, in the massive magnetite.

The diamictites of the Puga Formation, in this part of the Serra da Bodoquena, crop out in the cores of anticlines. Dolostones of the Bocaina Formation (Corumbá Group – Ediacaran) overlie the Puga Formation in erosional contact in the west. Deformed glaciomarine sedimentary rocks of the Puga Formation (Alvarenga & Trompette 1992), originally mapped as the Cuiabá Group (Corrêa *et al.* 1979, Araujo *et al.* 1982), stretch extensively to the east.

The Puga Formation is considered Marinoan in age (ca. 630 Ma) primarily because the diamictites underlie the Corumbá Group, near whose top occur the Ediacaran metazoan fossils *Cloudina* and *Corumbella.* There are no reliable radiometric data from these units.

Cap carbonates above diamictites of the Puga Formation have been described at two widely separated locations, both within cratonic cover, one, to the south, at Puga Hill (Boggiani & Coimbra 1996, Boggiani *et al.* 2003), beneath carbonate rocks of the metazoan-bearing Corumbá Group, and much further north, at Mirassol do Oeste, Mato Grosso (Nogueira *et al* 2003; Trindade *et al.* 2003, Alvarenga *et al* 2004;) where metazoan-bearing carbonates correlatable to the Corumbá Group are unknown.

RELATIONSHIP OTHER FERRIFEROUS UNITS

In South America, Neoproterozoic BIF's have been described in Uruguay and in the Urucum Massif (Corumbá, Brazil), where it is mined. In Uruguay, the BIF occurs in the lower siliciclastic units of the Arroyo del Soldado Group (Gaucher *et al.,* 2003, 2004), in which no glacial features have been observed.

The glacial origin (Urban *et al.* 1992) of the ca. 300 m-thick BIF`s from the Urucum Massif (Dorr II 1945, Almeida 1948) above four layers of manganese 0.5 to 4-m-thick, has been questioned by Trompette *et al* (1998) and Dardenne (1998), who argue that the "dropstones" immersed in the BIF`s may be the result of debris flows in a turbidite context, because there are no breaks in the lamination under the clasts and because all blocks are apparently derived locally from the granitic basement exposed near the Urucum Massif. Based on the results of oxygen isotope analysis, Trompette *et al.* (1998) attribute the genesis of Urucum BIF`s to hydrothermal fluids.

In the northern Paraguay Mobile Belt, there are

references to BIF's in the Poconé (Da Rosa *et al*. 1997) and the Nova Xavantina regions. The thickness of successions of alternating hematite and chert is generally around 2 m but may reach 50 m. That at Poconé is associated with diamictite (mapped as part of the Cuiabá Group), a possible distal equivalent of the Puga Formation, and that at Nova Xavantina, with a metavolcanosedimentary sequence (Pinho 1990, Dantas & Martinelli 2003).

Little is known as to the relationship between these occurrences and that in the south (São Manoel farm) other than that the northern occurrences are hematitic and the southern ones, predominantly magnetitic and apparently unassociated with metabasic rocks.

DISCUSSION

The presence of fine BIF at the São Manoel Farm suggests a sudden stop in the terrigenous sedimentation of the glacial Puga Formation. Given the lack of current-generated structures and the possibility that the isolated clasts represent dropstones, chemical precipitation of iron and silica may have occurred in relatively deep water with coarse sediment provide by icebergs.

The relationship between reported metabasic rocks and the BIF's and ferruginous sediments of Puga Formation is unclear.

The genesis of BIF`s is presently under discussion, with diverse hypotheses as to the supply of iron, mechanism of precipitation, primary vs. secondary origin, the genesis of banding, and the influence of biological processes (Trendall & Blockley 2000, Trendall 2002, Beukes & Gutzmer 2004). The São Manoel BIF adds more fuel to this debate and together with the Urucum deposit should be carefully compared with others possibly associated with Late Neoproterozoic glaciation, such as those in the Rapitan Group of Canada (Young 1976) and in the Damara Supergroup of Namibia. Deposition of these better studied examples of BIF has been related to anoxic, iron-rich ocean bottom water within the Snowball Earth scenario and subsequent major transgression following glaciation. This hypothesis must be weighed against the possibility of deposition related solely to rift-proceses, as pointed out by Young (1976) and Trompette *et al.* (1998).

CONCLUSION

The new occurrence of BIF in the Puga Formation is important for at least two reasons: first, because it seems to be related to the late Neoproterozoic Puga glaciation, within a context that may be distinct from that responsible for the classical Urucum deposit of the Jacadigo Group; and, second, because it invites stratigraphic comparison with similar deposits in northern parts of the Paraguay Fold Belt.

ACKNOWLEDGMENTS

The authors are thanked to CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) for their research fellowships and grants. This work is a contribution to Project IGCP 478 (Neoproterozoic-Early Palaeozoic events in SW-Gondwana) and has been financed by FAPESP (Proc. 04/01233-0).

REFERENCES

Almeida, F.F.M. de 1948. Origem dos minérios de Ferro e Manganês de Urucum. *Boletim da Divisão de Geologia e Mineralogia*, DNPM, 119: 1-58.

Alvarenga, C.J.S. de & Trompette, R. 1992. Glacially influenced sedimentation in the later Proterozoic of the Paraguay Belt (Mato Grosso, Brazil). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **92**:85-105.

Alvarenga, C.J.S. de; Santos, R.V.; Dantas, R.V. 2004. C-O-Sr isotopic stratigraphy of cap carbonates overlying Marinoan-age glacial diamictites in the Paraguay Belt, Brazil. *Precambrian Research*, 131: 1-21.

Araújo *et al.* 1982. Folha SF-21- Campo Grande, 1- Geologia. Projeto RADAMBRASIL, Rio de Janeiro, v.28, p.9-124.

Beukes, N.J. & Gutzmer, J. 2004. Distribution, Genesis and Palaeocological Significance of Iron Formation Through Time. In: 1st Symposium on Neoproterozoic-Early Paleozoic Events in SW-Gondwana, Extend Abstracts, IGCP-478, Second Meeting, Brazil, p. 6-7.

Boggiani, P.C. & Coimbra, A.M. 1996. The Corumbá Group (Central South America) In The Context of Late Neoproterozoic Global Changes. *Anais da Academia Brasileira de Ciências,* Resumo das Comunicações, **68**(4): 595-596.

Boggiani, P.C.: Ferreira, V.P.; Sial, A.N.; Babinki, M.; Trindade, R.I.F.; Aceñolaza, G.; Toselli, A.J.; Parada, M.A. 2003. The cap carbonate of the Puga Hill (Central South America) in the context of the post-Varanger Glaciation. In: IV South American Symposium on Isotope Geology, Short Papers, Salvador, Brasil, v. 1, p. 324- 327.

Corrêa *et al.* 1979. Geologia das regiões Centro e Oeste de Mato Grosso. Projeto Bodoquena. Departamento Nacional de Produção Mineral-DNPM/CPRM. Série Geologia Básica no 3, 111p., mapa geológico esc. 1:250 000.

Da Rosa, Á, A. S.; Pinho, F.E.; Gheler, W.L. 1997. Formações ferríferas no Grupo Cuiabá, Neoproterozóico (?), MT. In: Simpósio de Geologia do Cento-Oeste, *Anais...* Cuiabá, MT, p. 99-102.

Dantas, E.L. & Martinelli, C.C. 2003. Nd isotopes from the Araés Metavocano-sedimentary sequence in the Paraguay Belt, Nova Xavantina, Mato Grosso, Central Brazil. In: In: IV South American Symposium on Isotope Geology, Short Papers, Salvador, Brasil, v. 1, p. 168-169.

Dardenne, M. A. 1998. Modelo Hidrotermal Sedimentar Exalativo para os Depósitos Fe-Mn da Região de Corumbá, Mato Grosso do Sul. In: 40º Congresso Brasileiro de Geologia, 1998, Belo Horizonte. Anais, 1998. p. 152-152

Dorr II, J.V.N. 1945. Manganese and iron deposits of Morro do Urucum, Mato Grosso, Brazil. *Bull. U.S. Geol. Surv.*, **946A,** 47 p.

Gaucher, C.; Boggiani ,P.C.; Sprechmann, P.; Sial, A. N.; Fairchild, T.R. 2003. Integrated correlation of Vendian to Cambrin Arroyo del Soldado and Corumbá Groups (Uruguay and Brazil): palaeogeographic, palaeoclimatic and palaeobiologic implactions. *Precambrian Research 120(3-4):241-278.*

Gaucher, C.; Sial, A.N.; Blanco, G. Sprechamann, P. 2004. Chemostratigraphy of the Lower Arroyo del Soldado Group (Vendian, Uruguay) and Palaeoclimatic Implications. *Gondwana Research*, **7**(3): 715-730.

Nogueira, A. C.R.N., Riccomini, C., Sial, A. N., Moura, C., Fairchild, T. 2003a. Soft-sediment deformation at the base of the Neoproterozoic Puga cap carbonate (southwestern Amazon Craton, Brazil): Confirmation of rapid icehouse-greenhouse transition in snowball earth. *Geology.*, **31**(7):613-616.

Pinho, F.E, 1990. Geoquímica do depósito de ouro de Nova

Xavantina – leste do Estado de Mato Grosso. In: Congresso Brasileiro de Geologia, 36, Natal, RN, Anais..., v. 3, p. 1316-1330.

Trendall, A.F. 2002. The significance of iron-formation in the Precambrian stratigraphic record. In: Precambrian Sedimentary Environments: A Modern Approach to Ancient Depositional Systems. Special Publication n.33 of the IAS, (W. Alteramann and P. L. Corcoran eds.), Blacwell Science, p.33-66.

Trendall, A.F. & Blockley, J.G. 2000. Precambrian iron-formation. In: The Precambrian Earth: tempos and events. Developments in Precambrian Geology, 12, (P.G.. Eriksson, W. Alteramann, D.R.. Nelson, W.U. Mueller, O.Catuneanu eds.), Elsevier, p. 403-421.

Trindade, R.I.F. ; Font, E.; Dágrella-Filho, M.S.; Nogueira, A.C.R.; Riccomini, C. 2003. Low-latitude and multiple geomagnetic reversals in the Neoproterozoic Puga cap carbonate, Amazon craton. *Terra Nova,* **15**(6):441-446.

Trompette, R.; Alvarenga, C.J.S. de; Walde, D. 1998. Geological evolution of the Neoproterozoic Corumbá graben system (Brazil). Depositional context of the stratified Fe and Mn ores of the Jacadigo Group. *Journal of South America Earth Sciences*, **11**(6):587-597.

Urban, H.; Stribrny, B.; Lippolt, H. 1992. Iron and manganes deposits of the urucum district, Mato Grosso do Sul, Brazil. *Economic. Geology*, **87**: 1375-1392.

Young, G.M. 1976. Iron formation and glaciogenic rocks of the Rapitan Group, Northwest Territories Canada. *Precambrian Research*, 3:137-158.