ISOTOPIC AND DIAGENETIC CONSTRAINTS OF THE NEOPROTEROZOIC VILLA MONICA AND LOMA NEGRA FORMATIONS, TANDILIA SYSTEM, ARGENTINA – FIRST RESULTS

Gómez Peral, L.[1,2]; Poiré, D.G.[1]; Strauss, H.[3] and Zimmermann, U.[2]

1. Centro de Investigaciones Geológicas, CONICET-UNLP,1 N° 644, 1900 La Plata, Argentina. poire@cig.museo.unlp.edu.ar
2. Department of Geology, RAU University, Auckland Park 2006, Johannesburg, South Africa. uz@na.rau.ac.za
3. Geologisch-paläontologisches Institut, Westfälische-Wilhelms-Universitäti Münster, Corrensstrasse 24, 48149 Münster, Germany

Keywords: Carbonate rocks, stable isotopes, diagenesis, Upper Precambrian, Tandilia system

INTRODUCTION

The objective of this case study in Argentine Neoproterozoic successions is twofold. On one hand we want to add stable isotope data combined embedded in a diagenetic study to correlate these outcrops with similar lithologies of the Neoproterozoic world-wide.

The Tandilia System is a 350 km long, northwest-southeast orientated orographic belt, located in the Province of Buenos Aires (Fig. 1), which is comprised by an igneous metamorphic basement and a Neoproterozoic to Lower Palaeozoic sedimentary cover. In the Olavarría area, this Neoproterozoic sedimentary succession is composed of the Villa Mónica, Cerro Largo and Loma Negra formations (Sierras Bayas Group) and the Cerro Negro Formation (Poiré, 1993; see Fig. 2). These lithostratigraphic units were grouped into four depositional sequences: Tofoletti (I), Malegni (II) Villa Fortabat (III) and La Providencia (IV) sequences (Spalletti and Poiré, 2000).

The Neoproterozoic rocks are not affected by metamorphism, nearly undeformed and overlying unconformably basement rocks.

The oldest depositional sequence (Tofoletti, 52 m thick; Fig. 2) is equivalent to the Villa Mónica Formation, and shows two sedimentary facies associations: (a) quartz-arkosic arenites at the base and (b) dolomites including shallow marine stromatolitic dolomites and shales at the top. The dolomites and shales facies association (36 m thick), is composed by laminated stromatolitic dolomites, interdolomitic green shales and supradolomitic red shales with associated mudstones. Eight sedimentary facies have been recognized along these vertical sections. The dolostones of the Villa Mónica Formation support a very good assemblage of stromatolites, which is composed of *Colonella* fm., *Conophyton ?resotti*, *Conophyton* fm., *Cryptozoon* fm., *Gongylina* fm., *Gymnosolem* fm., *Inzeria* fm., *Jacutophyton* fm., *Jurusonia nisvensis*, *Katavia* fm., *Kotuikania* fm., *Kussiella* fm., *Minjaria* fm., *Parmites* fm., *Parmites* cf. *cocrescens* and *Stratifera* fm. (Poiré, 1993). An 800-900 Ma age for the stromatolite assemblage of Villa Mónica Formation has been suggested by Poiré (1987, 1989, 1993), based on world-wide stromatolite biostratigraphy (e.g. Semikhatov, 1986).

The 793 ± 32 Ma radiometric age (Cingolani and Bonhomme, 1988), for the diagenesis of Villa Mónica Formation coincide with the proposed age of the stromatolites by Poiré (1993).

The second depositional sequence (Malegni, 75 m thick; Fig. 2) consists of a basal succession composed of chert breccia, fine-laminated glauconitic shales, and fine-grained sandstones, followed by cross-bedded quartz arenites which are in turn covered by siltstones and claystones. This sequence represents a shallowing upward succession from subtidal nearshore to intertidal flat deposits. A depositional age of older than 730 Ma has been interpreted by Rb-Sr analyses on whole rock samples (e.g. Kawashita et al., 1999).

The youngest pre-Vendian depositional sequence (Villa Fortabat; Fig.2) is a 40 m thick unit composed almost exclusively of brownish (lower section) and black (upper) micritic limestones, originated by suspension fall-out in open marine ramp and lagoonal environments.

On top of the Sierras Bayas Group a regional unconformity is recognised (Barrio et al., 1991). This surface has been related to a eustatic movements. Meteoric dissolution of the carbonatic sediments is interpreted as a karstic surface on which residual clays and brecciated chert have been accumulated.

The Vendian Cerro Negro Formation (La Providencia depositional sequence; Fig. 2) appears on top of the above described unconformity. It is a more than 100 m thick unit characterised by claystones and heterolithic fine-grained sandstone-claystone intercalations, mainly formed in upper to lower intertidal flats. The lower part is composed by marls and mudstones (Fig. 2). Through radiometric dating on whole rock samples with Rb-Sr a depositional age older than 730 Ma could be established (Kawashita et al., 1999).

DIAGENESIS AND C-O ISOTOPES

The dolomites of the Villa Mónica Formation show a complex diagenetic history. The early diagenetic dolomite mosaic has grown from primitive LMC (protonuclei), placing them in the field of secondary dolomites. Later, different cements filled voids and fractures, and could be differentiated in three principal stages:

(1) Dolomitic cement constituted by macrosparitic rombohedral crystals of dolomite, partly with an iron-rich nuclei, and sizes between 200 to 750 µm, coating the pore walls.

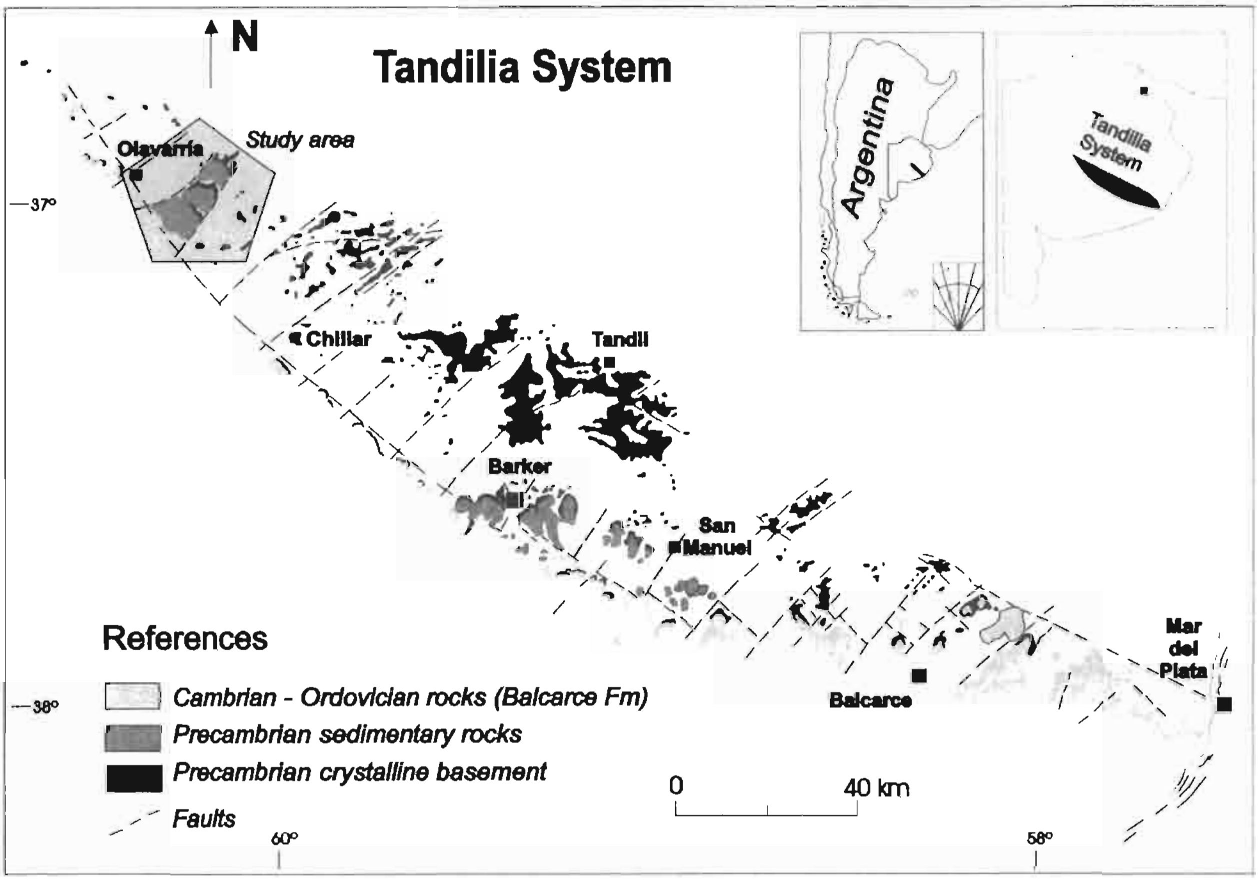

Figure 1. Location map (after Poiré et al., 2003).

(2) Silica cement which covers the porewalls in a geode form, closing partly or completely the pore space.

(3) High-Mg-calcite cement grew as anhedral to euhedral macrosparitic crystals.

These cements are filling voids and fractures up to 15 cm in diameter, and their origin have not been determined yet.

The limestones show homogeneous micritic to sub-sparitic calcite with a xenotopic texture. Microprobe analysis shows that crosscutting veins are filled by sparitic to sub-sparitic calcite and very fine-grained chert. While, irregular stylolites are filled by illite, chlorite and different Fe-oxides. The following diagenetic processes are interpreted:

(1) Chemical dissolution that generates veins and cavities.

(2) Cementation of voids and cavities by calcite cements.

(3) Pressure solution which produces the irregular stylolites and their mineralogical components.

(4) Silicification by the precipitation of silica gels along the veins and as replacement of carbonate crystals.

However, the silicification processes have affected more intensively the upper section (black micritic limestone) than the lower section (brownish micritic limestone).

Using CL two different classes of veins could be classified. One generation (< 250μm wide) shows a very low orange luminescent calcite, and a second generation (±30 μm wide), which crosscuts the first, and contains bright yellow luminescent calcite. The veins are mostly vertical to the stratification and could reflect extensional conditions probably caused by diagenesis.

The carbonate rocks of the Loma Negra Formation (Fig. 2) contain a TOC (total organic carbon) value between -0.15% and 0.35%, TIC (total inorganic carbon) between 8.41% and 11.30%, TC between 8.42% and 11.58%. $\delta^{13}C_{Carb}$ between +2.77 and +4.54‰, and $\delta^{18}O_{Carb}$ between -14.13 and -7‰. These data are only slightly different from preliminary values measured by Valencio (1985). The $\delta^{13}C_{org}$ lies constantly between -27.1 and -28.1‰.

The dolomites of the Villa Mónica Formation show TOC value between 0.37% and %1.22, TIC between 3.97% and 11.89%, and TC between 4.34% and 12.79%.

In a $\delta^{13}C_{Carb}$ - $\delta^{18}O_{Carb}$ diagram (Fig. 3) from Loma Negra Formation it is possible to distinguish three fields, according to the kind of rock analyzed: brownish micritic limestones, ii) black micritic limestones, and iii) red marls.

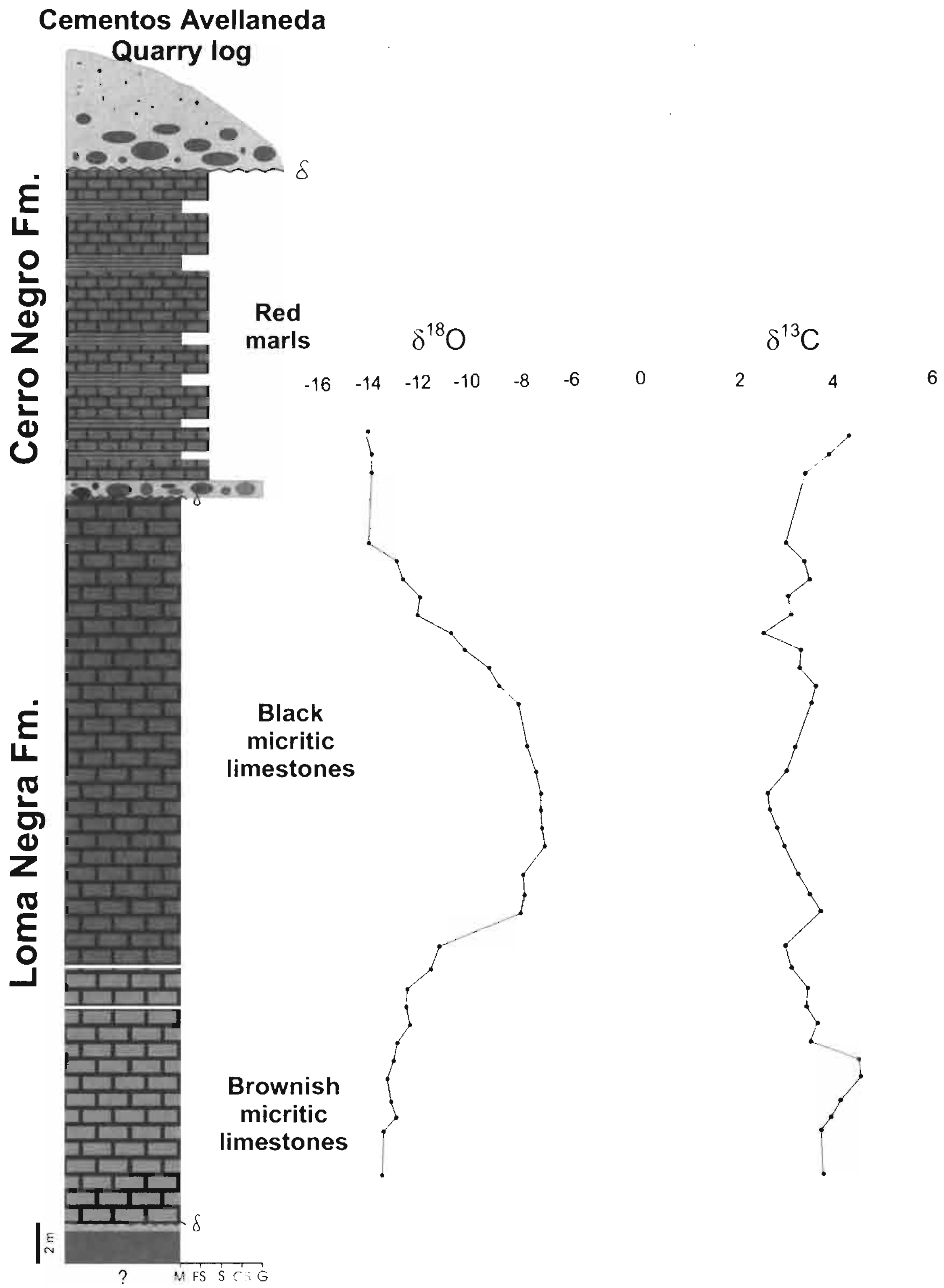

Figure 2. Stratigraphic framework and $\delta^{13}C_{Carb}$ - $\delta^{18}O_{Carb}$ (°/oo PDB) isotope curves from the Cementos Avellaneda quarry, Olavarría.

DISCUSSION

In figure 2, the C-O isotopic values are correlated with the stratigraphic framework: Loma Negra Formation and its transition to Cerro Negro Formation.

First, preliminary stable isotope data from the upper cycle (Loma Negra Formation) shows that the $\delta^{18}O_{carb}$ (‰) values are all negatives but in the middle part of the profile the curve shows a less negative excursion. The curve of $\delta^{13}C$ show very low fluctuations, however, it is possible to observe an increase (peak) in the brownish micritic limestones and two negative peaks in the black micritic limestones.

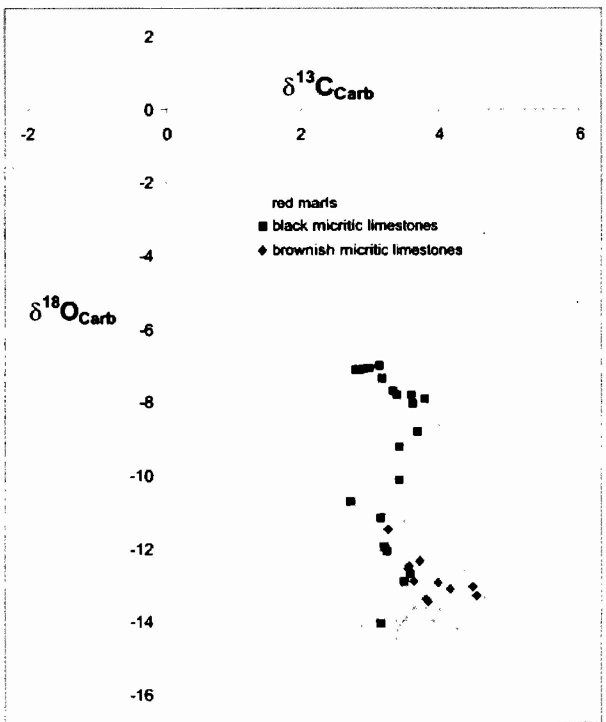

Figure 3. $\delta^{13}C_{Carb}$ versus $\delta^{18}O_{Carb}$ (‰ PDB) plot of samples from Loma Negra Formation and its transition to Cerro Negro Formation.

These $\delta^{13}C_{Carb}$ - $\delta^{18}O_{Carb}$ values are quite similar to those from Sete Lagoas Formation, Bambuí Group, Brazil (Santos et al., 2000), Polanco Formation, Arroyo del Soldado Group, Uruguay (Kawashita et al., 1999) and the Upper Proterozoic successions in Namibia (Kaufman, 1999), which were part of the South-western Gondwana margin during the Upper Proterozoic.

Further investigation on C-O isotopes of the lower cycle (Villa Mónica Formation) and the major and trace element geochemistry of the carbonates and the siliciclastic sedimentary record as well as detailed microprobe analysis on single grains will give more insight in the complex diagenetic history and the source areas for the clastic rocks. C-O-S data for the whole group and combined with a provenance analysis of the clastic record will complete this study in the near future to correlate the section with those in Brazil, Uruguay and southern Africa.

REFERENCES

Barrio C.A., Poiré D.G. y Iñiguez M.A., 1991. El contacto entre la Formación Loma Negra (Grupo Sierras Bayas) y la Formación Cerro Negro, un ejemplo de paleokarst, Olavarría, prov. de Bs. As. Revista de la Asociación Geológica Argentina XLVI(1-2): 69-76.

Cingolani, C. and Bonhomme, M.G., 1988. Resultados geocronológicos en niveles pelíticos intercalados en las dolomías de Sierras Bayas (Grupo La Tinta), provincia de Buenos Aires. Actas Segundas Jornadas Geológicas Bonaerences :283-289.

Kaufman, A.J., Hayes, J.M., Knoll, A.H. and Germs, G.J.B., 1991. Isotopic compositions of carbonates and organic carbon from Upper Proterozoic successions in Namibia: stratigraphic variations and the effects of diagenesis and metamorphism. Precambrian Research 49: 301-327.

Kawashita, K., Gaucher, C., Sprechman, P., Teixeira, W. And Victória, R., 1999. Preliminary chemostratigraphic insights on carbonate rocks from Nico Pérez terrane (Uruguay). Actas II South American Symposium on Isotope Geology :399-402.

Kawashita, K., Varela R., Cingolani C., Solían E., Linares, E., Valencio, S. A., Ramos, A. V. and Do Campo, M. 1999. Geochronology and Chemostratigraphy of "La Tinta" Neoproterozoic Sedimentary rocks, Buenos Aires Province, Argentina. Actas II South American Symposium on Isotope Geology :403-407.

Poiré D. G., 1987. Mineralogía y sedimentología de la Formación Sierras Bayas en el Núcleo Septentrional de las sierras homónimas, partido de Olavarría, provincia de Buenos Aires. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Tesis Doctoral 494 (unpublished).

Poiré D. G., 1989. Stromatolites of the Sierras Bayas Group, Upper Proterozoic of Olavarría, Sierras Septentrionales, Argentina. Stromatolite Newsletter XIV:58-61.

Poiré, D.G., 1993. Estratigrafía del Precámbrico sedimentario de Olavaria, Sierras Bayas, Provincia de Buenos Aires, Argentina. Actas XII Congreso Geológico Argentino y II Congreso de Exploración de Hidrocarburos II: 1-11.

Poiré, D.G., Spalletti, L.A.and Del Valle, A,.2003. The Cambrian-Ordovician siliciclastic platform of the Balcarce Formation (Tandilia System, Argentina): facies, trace fossils, palaeoenvironments and sequence stratigraphy. Geologica Acta 38(1): 41-60.

Santos, R. V., Alvarenga C. J. S., Dardenne M. A., Sial A. N., Ferreira V. P. 2000. Carbon and oxygen isotope profiles across Meso-Neoproterozoic limestones from Central Brazil: Bambuí and Paranuá groups. Precambrian Research 104: 107-122

Semikhatov, M.A. 1976. Experiences in stromatolite studies in the USSR. In M.R. Walter (Ed.), Stromatolites. Elsevier :337-357, Amsterdam.

Spalletti, L. A., Poiré, D. G., 2000. Secuencias silicoclásticas y carbonáticas del Precámbrico y Paleozoico inferior del Sistema de Tandilia, Argentina. II Congreso Latinoamericano de Sedimentología y VIII Reunión Argentina de Sedimentología, Guía de Campo, 39 pp.

Valencio S., Linares, E. and Panarello, H. O., 1985. Composición isotópica del carbono y oxígeno de rocas carbonáticas de las Sierras Septentrionales de la Provincia de Buenos Aires. Evidencias de cambios post-deposicionales. . (Tandil). Comisión de Investigaciones Científicas, Actas I Jornadas Geológicas Bonaerenses I: 51-67. La Plata.