

Lithofacies of very fine sand are characterized by high concentration in zirconium, barium, chromium and copper. Boron is present in low concentration but always appears. High values of TiO<sub>2</sub> are present and niobium is scarce, but highly concentrated in these samples. Values of gallium and cesium are similar to loessial samples. The silica average is 72.59 %.

Lithofacies of mud layers are characterized by a little height boron concentration. The values of zirconium, barium chromium and copper are high but minor that very fine sand values. Gallium and cesium are higher than very fine sand. The silica value is constant and differs from mudrock and very fine sand. They are the lowest (66.43 % average).

Lithofacies of mudrock layers are very similar to mud layers. However, significant differences in silica values mark the contrast (76.61 % average). Other study indicate that this lithofacies are tempestites (TORRA 2000).

These results shown clearly that different lithofacies can be geochemically recognized in this sequence. This fact should be very useful in order to identify underground beds in future drill-holes and regional correlation at the 'Chaco-Paranense intracratonic basin'.

TORRA, R. (1998): Estructuras sedimentarias marinas diagnósticas en las arenas de la Formación Ituzaiingó (Mioceno Medio), entre Itatí y Empedrado, Provincia de Corrientes, Mesopotamia de Argentina. - Revista del Instituto de Geología y Minería, **12** (1): 75-86.

TORRA, R. (1999): Ituzaiingó Formation. A Key for the Interpretation of the Upper Tertiary Stratigraphy, Mesopotamia-Chaco Paraná Basin, Argentina. - Revista Ciência e Natura. Universidade Federal de Santa Maria, Santa Maria. 'in press'

TORRA, R. (2000): Reinterpretación sedimentológica y edad de las Formaciones Paraná, Ituzaiingó, Toropí, Yupoí y Puelches (Mioceno medio), Mesopotamia de Argentina. - Revista Brasileira de Geociencias. 'in press'

### **Paleocurrents analysis in siliciclastic arenaceous sediments (sandy beach lithofacies) as a marker to paleoenvironmental systems, Northeastern Argentina**

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The Ituzaiingó Formation Sands is a significant sedimentary unit that scarcely outcrops in ravines and gullies near the Paraná river at the northeastern Mesopotamia region of Argentina. Several researchers studied it since 1848 to 1995. They concluded, upon paleontological basis, that the sandy-muddy lithofacies are of fluvial origin and Pliocene to upper Pleistocene in age. The fossils used as an indicator are of broad biochron, overall Cenozoic age. Two unconformities were proposed both on top and bottom of this unit, without determine exactly its potency (HERBST 1971, HERBST & SANTA CRUZ 1985, 1995, JALFIN 1988).

Recent studies concluded that none unconformities are present. The contact between sand and mud is conformable, resembling a lithofacies change. Fossil fauna is not representative and contacts were not observed until the present study (TORRA 1997a, b, 1998a, h, c).

I made, since 1994 to 1999, a detailed sedimentologic study about paleocurrents (over 450 measurements) on the planar cross stratification and tangential-sigmoidal cross-stratification, which are always present in the sandy lithofacies, both ferricretized (reddish) and non ferricretized (white) ones plagued of diagnostics internal intertidal-to-subtidal structures.

I found it a repeated simple and unequivocal bimodal bipolar design along more than 1,000 km at the Mesopotamia region, Northeastern Argentina. Recent bibliography, accept that bimodal bipolar design indicates more than one direction of the flow currents (i.e. reversal

flows as tidal currents). Previous studies considered these sediments as deposited like a fluvial system (i.e. a "braided platee" in JALFIN 1988).

After the study of the design of the paleocurrents roses, I proposed a shallow marine intertidal to subtidal environment system for these sandy-muddy sediments, roughly 230 meters in thickness at depths. This was texturally study by means of logs of most hydrogeologic drill-holes (TORRA 1999).

The age proposed is Middle Miocene synchronous with the 'Paranense Sea transgression deposits' (RASÄNEN et al. 1995, TORRA 1997a, b, 1998a, b, c, 1999).

HERBST, R. (1971): Esquema estratigráfico de la Provincia de Corrientes, República Argentina. - Revista Asociación Geológica Argentina, **24** (2): 221-243.

HERBST, R. & SANTA CRUZ, J.N. (1985): Mapa Litoestratigráfico de la Provincia de Corrientes. - D'Orbignyana, **2**: 1-51.

HERBST, R. & SANTA CRUZ, J. N. (1995): Mapa Geológico de la Provincia de Corrientes. 1: 500.000. - Ed. por Secretaría de Minería. Dirección Nacional del Servicio Geológico, Ministerio de Economía y Obras y Servicios Públicos, Buenos Aires.

JALFIN, G. (1988): Formación Ituzaiingó (Plio-Pleistoceno) en Empedrado, Provincia de Corrientes: un paleorrio arcuoso entrelazado tipo "platte". Actas. - II Reunión Argentina de Sedimentología, **1**: 130-135, Buenos Aires.

RASÄNEN, M. E., A. M. LINHA, J.C.R. SANTOS & F. NEGRY (1995): Late Miocene Tidal deposits in the Amazonian foreland basin. - Nature, **269**: 368-390.

TORRA, R. (1997a): Genesis and Age of the Ituzaiingó Formation Sands, Northeastern Argentina: a preliminary note. - 18<sup>th</sup> Regional European Meeting of Sedimentology, Abstracts, 339, Heidelberg.

TORRA, R. (1997b): Reconnaissance of Tidal Bundles by means of the Fast Fourier Transformations. Ituzaiingó Formation Sands (Miocene), Northeastern Argentina. - Memorias. I Congreso Latinoamericano de Sedimentología, **1**: 315-321, Isla de Margarita

TORRA, R. (1998a): Architectural Analysis of the Ituzaiingó Formation Sands (Miocene), Northeastern Argentina, South America. - Geocongress '98, Geological Society of South Africa, 178-181, Pretoria.

TORRA, R. (1998b): A Brief Stratigraphy and Paleogeography of the Miocene Sea at the Mesopotamia Region, Northeastern Argentina, South America. - Geocongress '98, Geological Society of South Africa, 79-81, Pretoria.

TORRA, R. (1998c): Paleocurrent Analysis Applied to Resolve Depositional Environment System. The Case of the Ituzaiingó Formation Sands (Miocene), Corrientes Province, Argentina, South America. - 15<sup>th</sup> International Sedimentological Congress, 768, Alicante.

TORRA, R. (1998d): A New Age (Miocene) and a New Environment Depositional System for Pelitic Toropí and Yupoí Formations, Corrientes Province, Argentina, South America. - 15<sup>th</sup> International Sedimentological Congress, 767, Alicante.

TORRA, R. (1999): Avances en el conocimiento del Terciario Superior de la Llanura Chaco-Pampeana. - IV Reunión de Comunicaciones Científicas y Tecnológicas, Universidad Nacional del Nordeste, Actas, **VI**: 93-96, Corrientes.

### **Spatial relation between tempestites (typical non-tidal offshore sand bodies deposits) and beteroolithic succession in shallow marine littoral environment. The case of the Ituzaiingó, Toropí and Yupoí Formations (Middle Miocene), Northeastern Argentina**

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The Toropí and Yupoí Formations are stratigraphic units created in order to solve the presence of mixed silty-very fine sandy mud soft sediment beds (typical "mudrocks" as proposed by TORRA 1998a, 1999a, b). They are outcroppings in a large region of the Mesopotamia Argentina (about 117,000 km<sup>2</sup>), always overlying Miocene marine sediments (i.e. Ituzaiingó Formation). The

structural relation between them is conformable, and none autoctonous fossil or microfossil remains were founded before 1999 into the Toropí and Yupofí tempestites Formations.

The Toropí and Yupofí Formations were interpreted as continental (fluvial) in origin long time ago (HERBST 1971, HERBST & SANTA CRUZ 1985). They argued the presence of vertebrate fossil fauna remains of Pleistocene to Holocene age (HERBST & SANTA CRUZ 1985). The Toropí and Yupofí Formations have a maximum thickness of about eight meters averaging four meters (TORRA 1998b, 1999a, b).

Recent studies proposed that those vertebrate fossil fauna remains are alloctonous (TORRA 1998a, b). The interpretation was that the fossil remains are always in surface layers and that they were swamped into mud beds on Holocene times (11,500 BP, TORRA 1998c).

The sandy-muddy Ituzaingó Formation is a typical heterolithic succession beneath these horizontal mixed silty-very fine sandy beds of flat-lenticular forms. The fact is that marine heterolithic succession (Ituzaingó Formation) and the supposed continental Toropí and Yupofí Formations layers are in a quite concordance (TORRA 1999b).

The origin proposed for Toropí and Yupofí Formation is non-tidal offshore sand bodies deposits (formerly very fine sandy-silty mud bodies) deposited under the action of marine storm currents (i.e. tempestites or marine storm deposits).

The geochemical signatures of eight mayor molecules and fifteen trace elements carried out on Ituzaingó, Toropí and Yupofí Formations, confirmed that the sequence is in a fully agree with previous sedimentological thesis (TORRA 2000a, b).

HERBST, R & SANTA CRUZ, J.N. (1985): Mapa Litoestratigráfico de la Provincia de Corrientes. - D'Orbignyana, **2**: 1-51.

TORRA, R. (1998a): A Brief Stratigraphy and Paleogeography of the Miocene Sea at the Mesopotamia Region, Northeastern Argentina, South America. - Geocongress '98 Geological Society of South Africa, 79-81, Pretoria.

TORRA, R. (1998b): A New Age (Miocene) and a New Environment Depositional System for Pelitic Toropí and Yupofí Formations, Corrientes Province, Argentina, South America. - 15<sup>th</sup> International Sedimentological Congress, 767, Alicante.

TORRA, R. (1998c): El Estudio de los Sedimentos del Cuaternario de la Provincia del Chaco y Regiones Aledañas. - III Reunión de Comunicaciones Científicas y Tecnológicas. Universidad Nacional del Nordeste. - Actas, **4**: 197-200, Resistencia.

TORRA, R. (1999a): Avances en el conocimiento del Terciario Superior de la Llanura Chaco-Pampeana. IV Reunión de Comunicaciones Científicas y Tecnológicas. - Universidad Nacional del Nordeste, Actas, **VI**: 93-96, Corrientes.

TORRA, R. (1999b): Ituzaingó Formation. A Key for the Interpretation of the Upper Tertiary Stratigraphy, Mesopotamia-Chaco Paraná Basin, Argentina. - Revista Ciência e Natura, Universidade Federal de Santa Maria, Santa Maria, (in press).

TORRA, R. (2000a): Reinterpretación Sedimentológica y Edad de las Formaciones Paraná, Ituzaingó, Toropí, Yupofí y Puelches (Mioceno Medio), Mesopotamia de Argentina. - Revista Brasileira de Geociencias, Brasília, (in press).

TORRA, R. (2000b): Geochemistry of a Tidal Transgressive Heterolithic Succession: The Ituzaingó Formation (Middle Miocene), Argentina. - Chinese Journal of Geochemistry, **19** (1): 1-7.

### Petrographical characterization of the Ituzaingó Formation Sands (Middle Miocene), Northeastern Argentina

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The Ituzaingó Formation is a wide succession of sand and mud beds. They appear in the left margin of the natural slopes, ravines and gullies of the left margin of the Paraná and Paraguay rivers at

the Mesopotamia region.

The outcrops of the northern beds are extremely characterized by a predominance of a very fine, well sorted, white sands. They have several internal structures such as tidal bundles, reactivation surfaces, herringbone cross-stratification, rhythmic tidal beddings, flaser beddings and bipolar cross-stratification. The sequence has a very simple arrangement of sigmoidal pattern (TORRA 1998, 1999).

Twenty-nine selected samples were picked up from the Corrientes province outcrops' (northeastern Argentine). In this way, twenty-nine thin-polished sections were made out. They were studied using standard polarizing microscope methods.

The results show a great predominance of well rounded to rounded quartz grains in form, generally uniform in size and spherical appearance (0.15-0.06 mm in average). The percentage is over 95 % quartz. About 85 % are monocrystalline quartz grains with few visible fluid inclusions and not undulose extinction. The other 15 % were polycrystalline grain-sutured quartz grains (metamorphic grains?). Packing is largely cubic and highly porous. Neither cement nor matrix material is present into unaltered sand beds. Both, the very well sorting and rounded grains point out a 'superature' texture sand very frequent in beach environments. There are no significant quantities of feldspars and lithics grains. Very scarce microcline is present, generally characterized by cross-hatch twinning. The main translucent resistates minerals are tourmaline, muscovite, rutile, zircon, kyanite, staurolite, chalcedony and garnets.

Opaque minerals are mainly rounded magnetite grains, which is always present. Sometimes magnetite grains appear in quantities of about more than 3-5 in percentage. The significant ferritization processes are present in some of upper beds of the Ituzaingó Formation derived from magnetite oxidation. This phenomenon stamped typical reddish to yellowish tones into the sand layers. It is possible that forces of oxidation caused break out of pure quartz grains, which are fully cemented by ferric oxides. Ilmenite and titanomagnetite are inferred to be present based on significant geochemical anomalous values in titanium (TORRA 2000).

In accord with the classification of DOTT (1964), the arenaceous lithofacies of the Ituzaingó Formation may be classified as a 'quartz arenite'.

DOTT, R.H. (1964): Wacke, graywacke and matrix-what approach to immature sandstone classification? - Journal of Sedimentary Petrology, **34**: 625-632.

TORRA, R. (1998): Estructuras sedimentarias marinas diagnósticas en las arcas de la Formación Ituzaingó (Mioceno Medio), entre Itatí y Empedrado, Provincia de Corrientes, Mesopotamia de Argentina. - Revista del Instituto de Geología y Minería, **12** (1): 75-86.

TORRA, R. (1999): Reinterpretación sedimentológica y edad de las Formaciones Paraná, Ituzaingó, Toropí, Yupofí y Puelches (Mioceno Medio), Mesopotamia de Argentina. - Revista Brasileira de Geociencias, 'in press'

TORRA, R. (2000): Geochemistry of a Tidal Transgressive Heterolithic Succession: The Ituzaingó Formation (Middle Miocene), Argentina. - Chinese Journal of Geochemistry, **19** (1): 1-7.

### Holocene fluvial reorganizing drainage pattern at the right margin of the Paraná-Paraguay rivers, Northeastern Argentina

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The right margin of the Paraná-Paraguay fluvial valley is frequently run around for a most number of young, low volumes, incision rivers at the Chaco-Pampeana region.