AAPG HEDBERG CONFERENCE
"Sediment Transfer from Shelf to Deepwater - Revisiting the Delivery Mechanisms"
March 3-7, 2008, Ushuaia - Patagonia, Argentina

Integrating Sedimentologic and Ichnologic Data in Characterization of Hyperpycnal Flow Deposits of Cretaceous Fluvio-Dominated Deltas (Austral Basin, Southern Argentina)

Luis Lucas Saccavino[1], Luis Buatois[2], Carlos Zavala[3]

[1] Petrobras Energía SA, cc181, Neuquen, Argentina.
[2] Department of Geological Sciences, University of Saskatchewan, SK S7N 5E2, Canada.
[3] GEoil Technology, Av Principal C. Marinamar, Apto 2-01, Anzoategui, Venezuela.

Introduction

The Austral Basin is one of the most important petroleum basins of Argentina. The aim of this study is to provide sedimentologic and ichnologic data that help to reinterpret the depositional mechanisms and sedimentary environments of the Upper Cretaceous reservoirs of the Magallanes Formation in the Campo Boleadoras-Estancia Agua Fresca area. The role of hyperpycnal flows in sedimentary dynamics is underscored. Integration of standard facies analysis with ichnologic data provides more robust depositional models. With very few exceptions (e.g. Carmona et al., 2006; Ponce et al., in press), the ichnology of hyperpycnal deposits has remained largely underexplored. Our study is based on the analysis of 8 well cores and well logs in an area of 200 km^2.

Geologic Setting

The Austral Basin, also known as Magallanes Basin, is located in the southernmost region of South America and hosts up to 8000 m of rift (Triassic to Middle-Upper Jurassic), post rift (Upper Jurassic to Lower Cretaceous) and foreland (Upper Cretaceous to Cenozoic) deposits. During this latter stage, the establishment of a fold and thrust belt resulted in the formation of a foredeep in the foreland basin. Sediment was sourced from uplifted areas in Central Patagonia and the Río Chico High located towards the northwest. Clastic wedges prograded towards the basin center leading to a southeastern migration of the depocenters and forming a series of sedimentary cycles controlled by regional tectonics.

Clastic wedges prograded from the north and northwest, and shoreface and deltaic deposits (Anita Fm.) accumulated during the Campanian-Early Maastrichtian. Offshore mudstone and thin-bedded sandstone (Palermo Aike Fm.) interfinger with the sandstone tongues towards the southeast. This succession is capped by the D3 unconformity. The Calafate sequence (Magallanes Fm., Upper Maastrichtian-Danian) occurs above this unconformity. During the rest of the Paleocene, the area was uplifted and the unconformity D4 was formed. Deep incisions were carved, leaving erosional remnants that favor formation of stratigraphic traps. Glauconite wackes accumulated during the Eocene transgression, forming the seal.

Sedimentary Facies and Trace Fossil Distribution

Lower Maastrichtian deposits in the study area are stacked forming a coarsening-upward succession reflecting a prograding deltaic system (Fig. 1). The bulk of these deposits consists of coarse- to fine-grained sandstone that are either structureless or display a subtle parallel lamination that is commonly delineated by abundant plant remains.

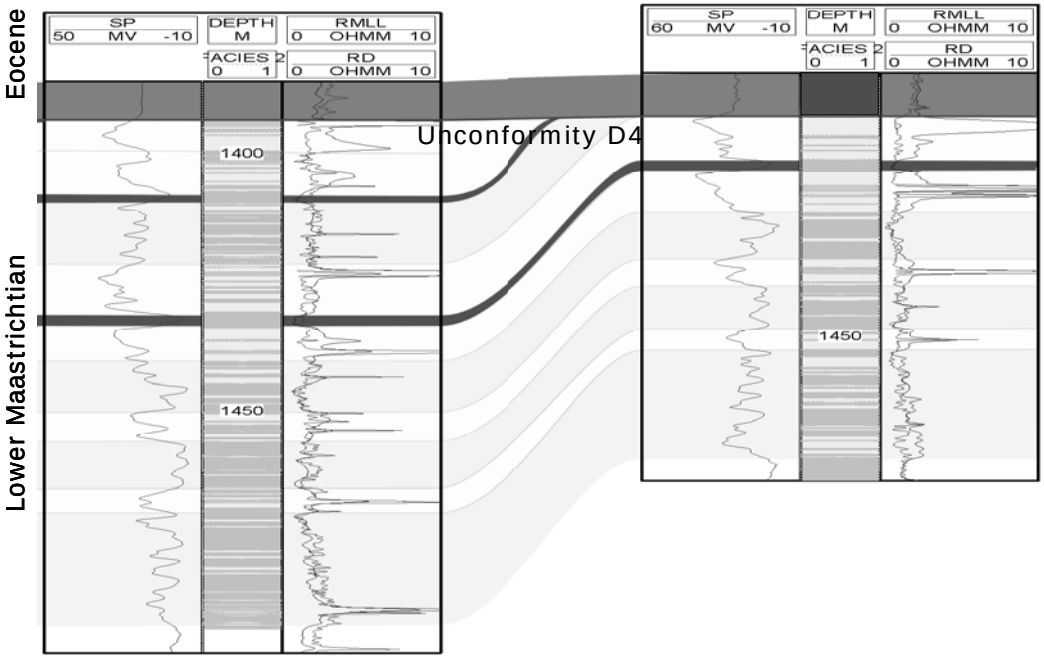

Figure 1 - Generalized stratigraphy of the studied succession

Hummocky cross-stratification occurs locally. Gradual changes in grain size are common (Fig. 2). Erosive-based, pebble conglomerate layers that contain mudstone intraclasts and bioclasts occur at the base of very coarse- to coarse-grained sandstone units.

Vertical grain size changes reflect flow fluctuations, while the concentration of plant remains indicates phytodetrital pulses, which is consistent with high fluvial discharges. These deposits are interpreted as the result of turbulent flows of fluctuating energy and high suspended sediment concentrations. Associated pebble conglomerate layers may indicate sand by-pass. This is also suggested by sandstone beds with asymptotic cross-stratification that may reflect fill of localized topographic lows.

The dominant ichnogenus in these deposits is *Thalassinoides*. Burrow systems contain both horizontal and vertical segments. Burrow walls are well defined and mud lined while burrow fill is laminated and passive. Bioturbation is commonly restricted to the top of sandstone beds and suites are typically monospecific, although *Ophiomorpha, Skolithos, Diplocraterion* and *Palaeophycus* are present locally. These bioturbated deposits are commonly interbedded with non-bioturbated structureless sandstone units. In terms of archetypal ichnofacies, the *Thalassinoides* assemblage belongs to the *Skolithos* ichnofacies.

The *Thalassinoides* assemblage records opportunistic colonization in sand-rich hyperpycnal deposits. Sandstone beds are erosive-based, massive and burrowed at the top.

Characteristics of the ichnofauna (low ichnodiversity, dominance of dwelling burrows) and its presence at the top of massive beds suggest rapid emplacement during times of decreased sedimentation rate. However, the pervasive laminated fill may reflect relatively high sedimentation rates most likely due to suspension fallout of fine-grained material. Low ichnodiversity and presence of synaeresis cracks are consistent with stress due to dilution of marine salinity, specifically freshwater input during hyperpycnal discharges.

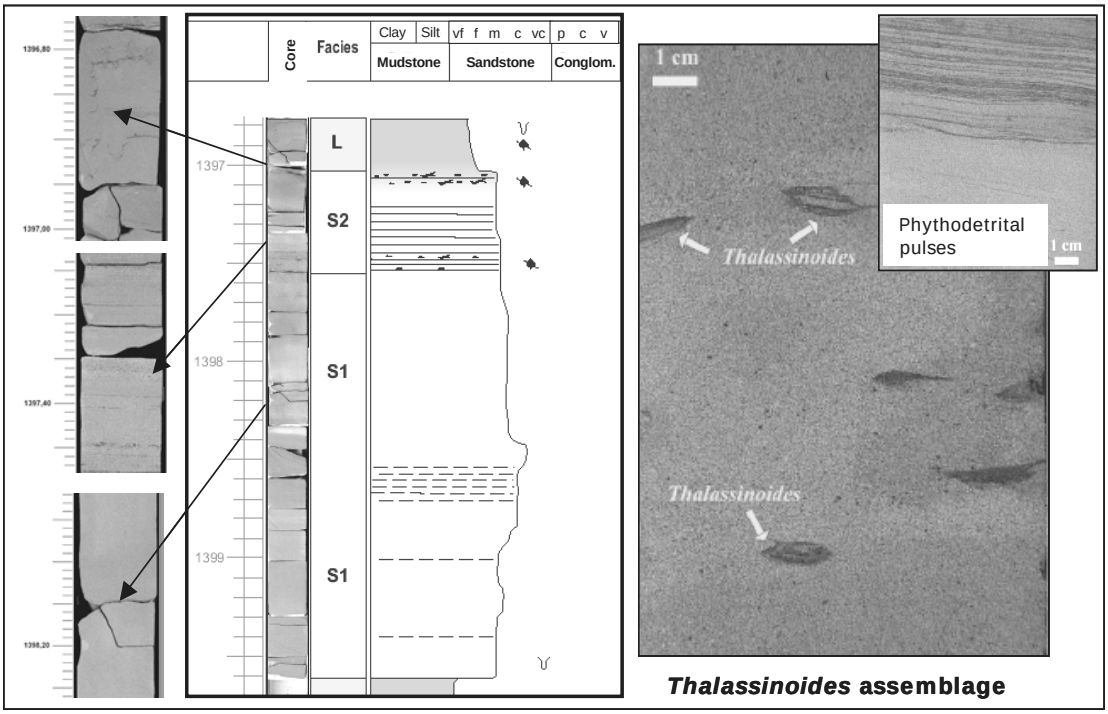

Figure 2 - Sedimentology and ichnology of sand-rich deposits

Interbedded dark grey massive or parallel-laminated mudstone and thin to very thin very fine- to fine-grained sandstone accumulated during times of quiescence between flows. Synaeresis cracks and plant remains are common. Degree of bioturbation is low; *Planolites* and *Teichichnus* are commonly the only ichnogenera identified. Locally *Thalassinoides* may occur. The *Planolites-Teichichnus* assemblage represents a depauperate *Cruziana* ichnofacies (Fig. 3a).

Hyperpycnal sand-rich deposits are interbedded with finer-grained deposits that display features suggestive of open marine conditions formed during fairweather. These deposits consist of silty very fine-grained sandstone with hummocky cross-stratification and wave ripples interbedded with light grey mudstone. Sandstone beds are commonly bioturbated at the top, where *Thalassinoides, Teichichnus, Skolithos* and *Asterosoma* tend to occur. Mudstone intervals are dominated by *Terebellina* and *Phycosiphon* (Fig. 3b), the latter forming the background ichnofabric. Accessory components are *Planolites, Palaeophycus, Teichichnus, Thalassinoides, Zoophycos* and *Shaubcylindrichnus*. The *Terebellina-Phycosiphon* assemblage illustrates the *Cruziana* ichnofacies.

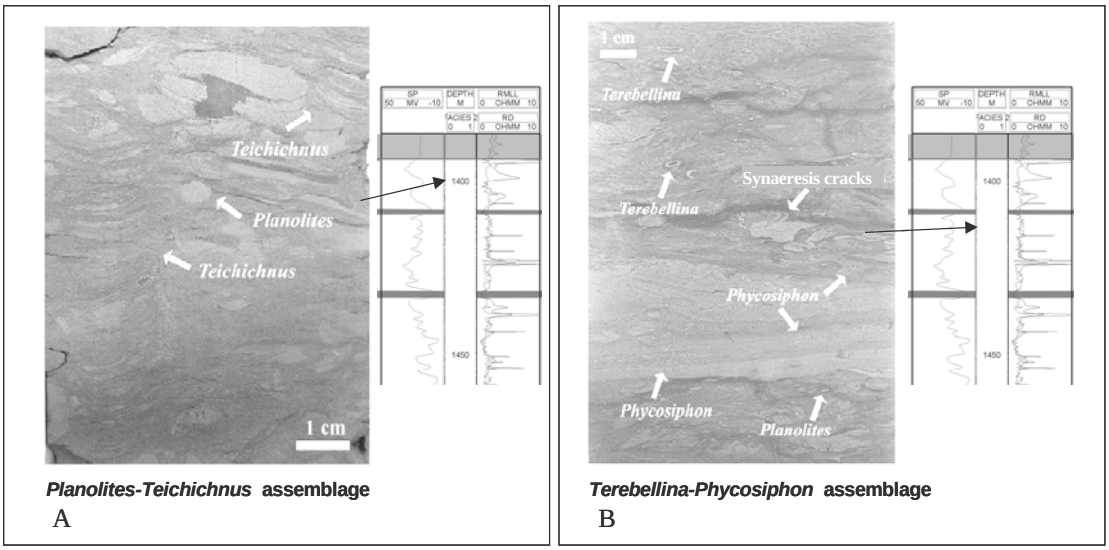

Figure 3 – Sedimentology and ichnology of mud-rich deposits

Depositional Environment

The studied succession is interpreted as formed in a shallow-marine setting affected by sustained turbulent flows linked to a coeval fluvial system. Deposits accumulated forming lobes that filled topographic lows, occasionally allowing by pass of sand-rich flows into more distal areas. High rates of sedimentation and freshwater discharge from a prograding fluvio-dominated delta were among the most important stress factors that affected the benthic fauna. The *Thalassinoides* assemblage records opportunistic colonization of sandstone deposits. The *Planolites-Teichichnus* assemblage occurs in associated finer-grained prodelta deposits that were formed lateral to the hyperpycnal sand-rich lobes under suspension fallout. During times of reduced sediment suply, material was reworked by wave processes and hypopycnal conditions were dominant. The *Terebellina-Phycosiphon* assemblage typifies this situation and reflects stable conditions that allowed intense bioturbation and the establishment of a moderately diverse benthic fauna.

References

Carmona, N.B., Ponce, J.J., López-Cabrera, M.I. and Olivero, E.B. 2006. Distribución y diversidad de trazas fósiles en hiperpicnitas: implicancias etológicas y comparación con patrones de trazas fósiles en turbiditas clásicas. 9º Congreso Argentino de Paleontología y Bioestratigrafía. Córdoba, Argentina. Resúmenes: p. 279.

Ponce, J.J., Olivero, E.B., Martinioni, D.R. and López C., M.I. in press. Sustained and episodic gravity flow deposits and related bioturbation patterns in Paleogene turbidites (Tierra del Fuego, Argentina). In: Bromley, R., Buatois, L.A., Mángano, M.G., Genise, J. & Melchor, R. (Eds.), Sediment-Organism Interactions: A multifaceted ichnology. SEPM Special Publication 88.