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The origin of lofting rhythmites. Lessons from thin sections

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Introduction

Pliocene clastic shallow-marine sandstones constitute the main hydrocarbon reservoirs in the Columbus Basin, offshore Trinidad. These deposits have previously been interpreted as related to shelf-margin deltas during lowstand periods (Wood et al, 2000). Recently, a reinterpretation of main facies types and depositional geometries from core (Onyx-01) and seismic data in the offshore Onyx field favoured an origin associated to hyperpycnal discharges. Main facies types are massive to laminated sandstones related to long-lived and fluctuating turbulent flows. These deposits compose lens-shaped and elongate sandstone bodies lying over deep erosional surfaces. These bodies were interpreted as built-up by sustained hyperpycnal flows starting with acceleration, followed by a flow peak and an ending with a slackening period (Fig. 1) the last responsible of the infill of previous erosional (bypass) surfaces.

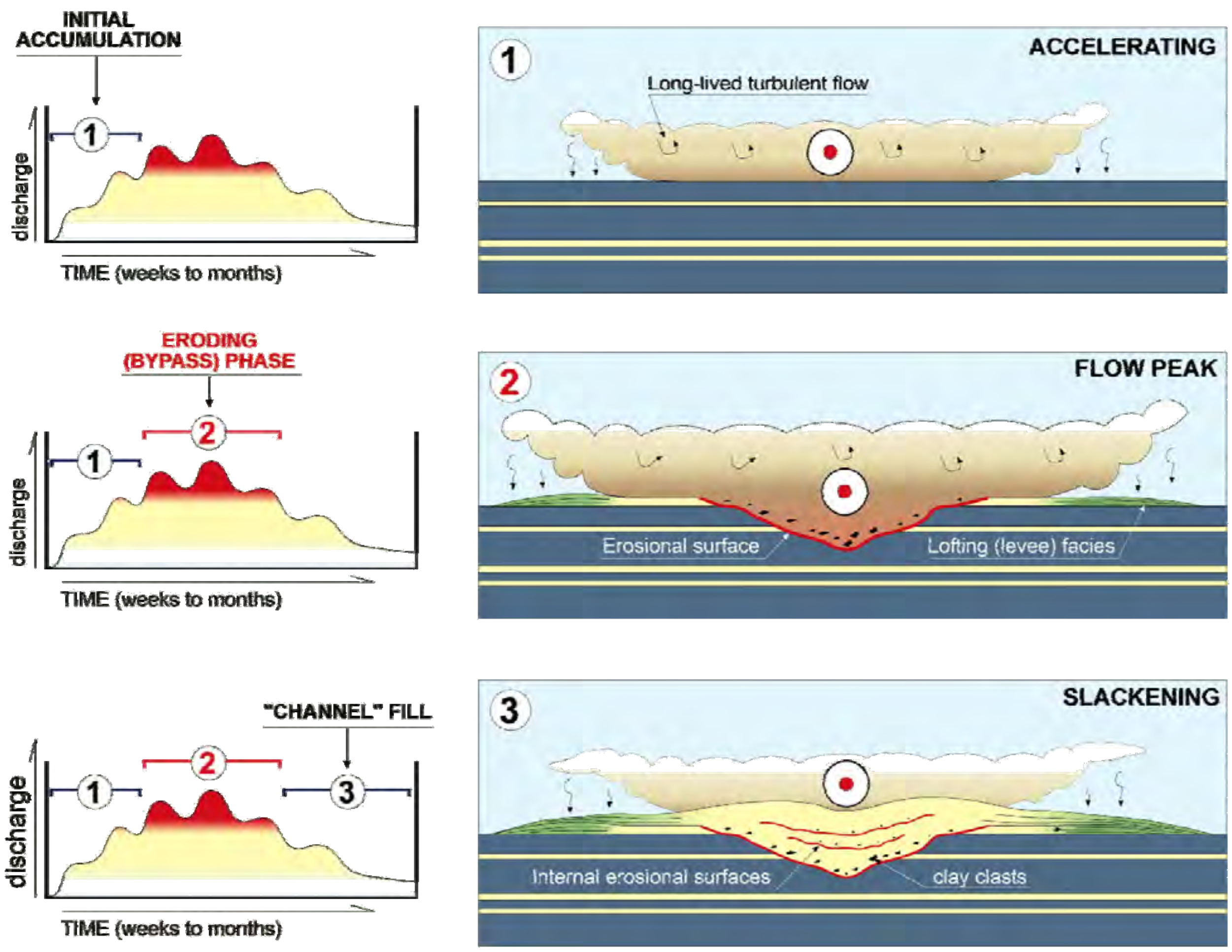

Figure 1. Depositional schema showing the origin of deep scoured hyperpycnal sandstone bodies. In 1 the arriving of the leading head starts the accumulation of sandstone deposits. In 2, the high velocity in the flow centre during the flow peak produces a basal erosional surface. In 3 during the flow slackening the hyperpycnal flow fills the previous erosional surface with sandstone accumulations. Modified from Zavala et al., 2006a.

Sandstone accumulations are interbedded with thin rhythmic sand-silts couplets with abundant plant material (Fig. 2) which were interpreted as lofting rhythmites (Zavala et al., 2006b). Individual levels are often up to 2 mm thick and show good lateral continuity. Silt/sandstone couplets and their intercalations integrate laminated and decimeter thick packages. These laminated packages lack or show rare and poorly diverse ichnofaunas. Lofting rhythmites appear isolated between mudstone successions or located in between or towards the top of massive to laminated tabular sandstone beds. Lofting rhythmites accumulate from a lofting plume, which is a typical feature of hyperpycnal inflows in marine environments. In this situation, the hyperpycnal discharge contains a fluid (freshwater) that is less dense than ambient sea water. Consequently, when the flow progressively loses part of its suspended load by deposition, the current will lift from the substrate through buoyancy reversal (Sparks et al., 1993; Kneller & Buckee, 2000), forming lofting plumes charged with fine-grained sediments, plant debris and micas. The recognition of lofting facies in marine environments is therefore extremely important, because it allows the diagnosis of a direct fluvial connection and a hyperpycnal origin for associated deposits.

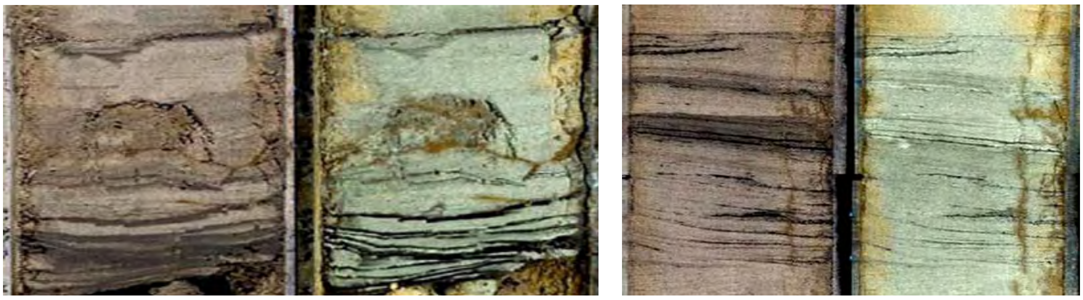

Figure 2. Examples of lofting facies from the Onyx-01 core. Dark levels are layers of carbonaceous materials.

Analysis of thin sections (Fig. 3) of lofting facies reveals new evidences related to the accumulation from lofting plumes, and allows the establishment of new diagnostic criteria for its recognition.

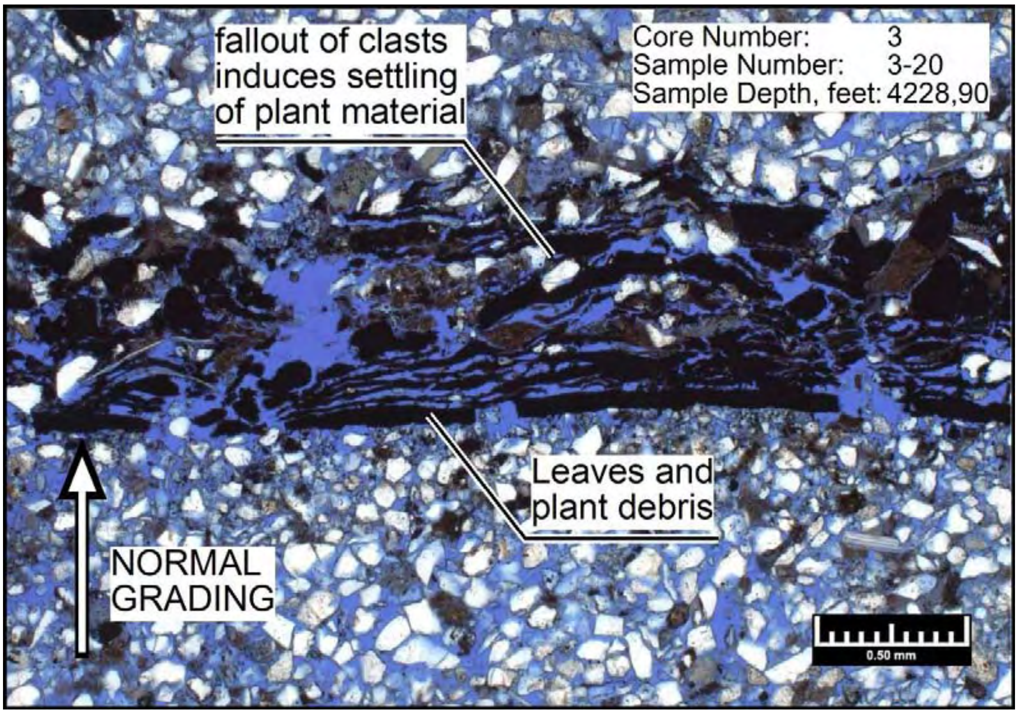

Figure 3. Thin section of lofting deposits. Fallout of clastic materials from suspension clouds are graded, and are followed by plant debris which remains in suspension until the next wave of clastic fallout, which forces the fallout.

Deposition of fine-grained materials from lofting plumes is very selective. The free fallout of clastic materials from suspension clouds is governed by the Stokes' law. The genetic analysis of the thin section of Fig. 3 allows to tract step by step the origin of lofting rhythmites. Fig. 4 shows an interpretation of its origin. In (A) a heterogeneous lofting cloud is introduced by a hyperpycnal wave, in a lateral position respect to the main flow. In (B) the free fallout of different grain-sized clastic materials results in a normally graded interval with silt and oriented micas on top. According to their low density, leaves and plant materials remain in suspension. A new suspension cloud is introduced by a new wave during the same hyperpycnal discharge. The free fallout of largest sand grains forces the deposition of leaves and plant fragments.

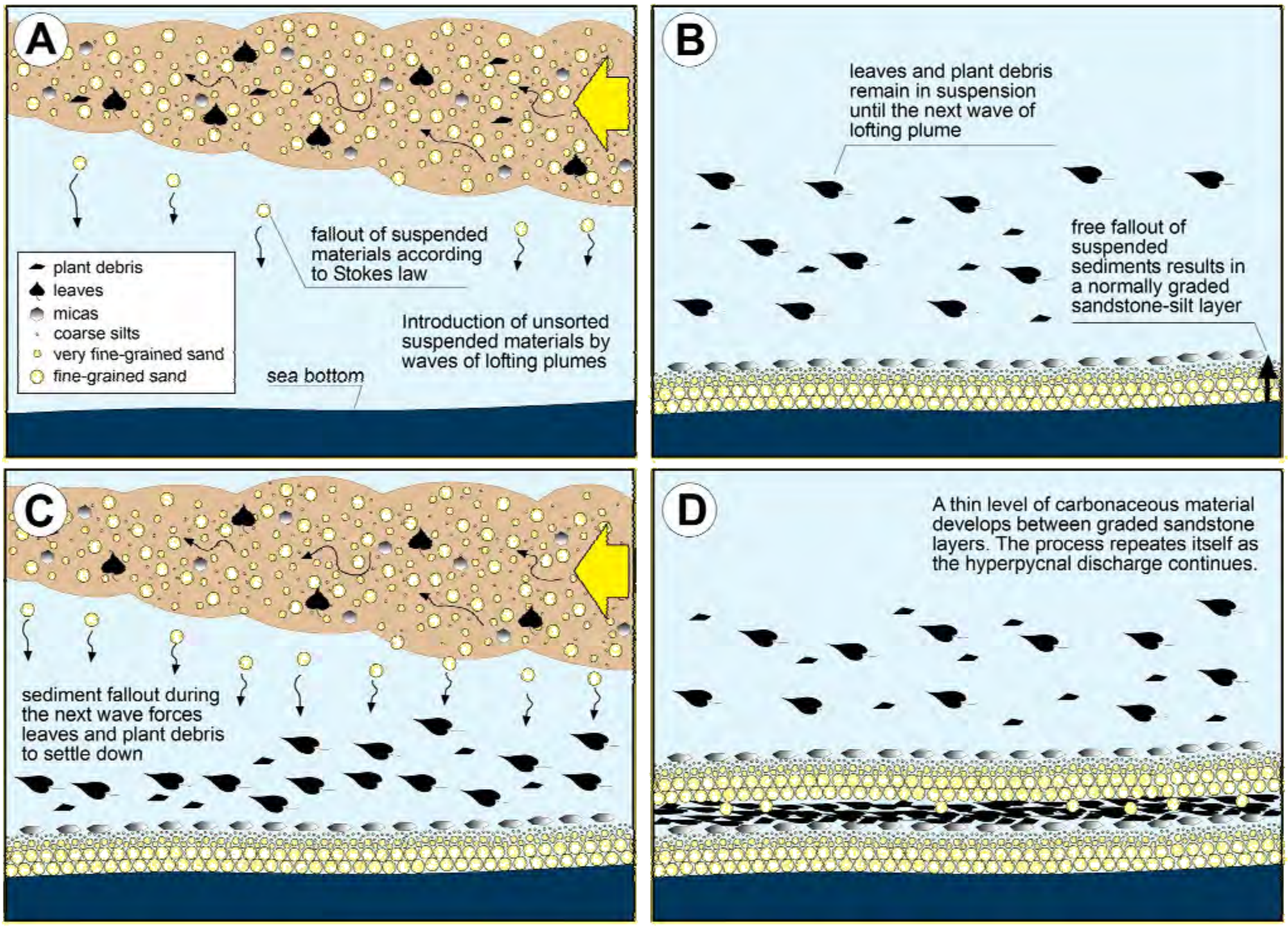

Figure 4. Lofting rhythmites are the result of the repeated aggradation of fine grained materials from suspension clouds related to the buoyant inversion of hyperpycnal flows.

Discussion

Lofting rhythmites are a diagnostic and useful feature for the recognition of hyperpycnal deposits in marine settings, since they provide a direct evidence of the buoyant inversion of a less dense fluid (in the case freshwater) in a saline environment. Additionally, lofting rhythmites provide a non-biological indication of marine and saline waters. The recognition of lofting rhythmites in core studies is very important because it allows predicting the existence of sandstone deposits at equivalent levels. This contribution provides for the first time a diagnostic key for the identification of lofting rhythmites using thin sections. Since lofting rhythmites are directionally oriented thin sections can provide also additional criteria to determine base and top in problematic intervals.

Acknowledgments

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