Genetic model of deposition for the Miocene of the Gulf of Lions (western Mediterranean) from seismic stratigraphy and well log correlation

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Abstract

The occidental part of the Gulf of Lions passive margin (western Mediterranean) was chosen by the GDR Marges Golfe du Lion (a French research group on the continental margins) to conduct the first correlations between the post-rift Miocene sedimentary formations of the onshore domain and their extension on the adjacent continental shelf. The correlation between the two domains lay on an existing correspondence between seismic profile, offshore and onshore well logs, in terms of stacking pattern, biostratigraphy and geometries. This communication is based on the study of 11 offshore drillings and industrial offshore seismic lines. We present in this communication the first results of a seismic stratigraphy study and well log correlations for the offshore Miocene of the Gulf of Lions margin.

Introduction

This study supports the interpretation of numerous industrial and high-resolution seismic profiles taken in the Gulf of Lions by the petroleum industry (RM96 LIGO et HR Total profiles) and by IFREMER (Marion and Calmar campaigns). These data were provided by Total and IFREMER within the GDR marge framework.

Seismic profiles analysis methods apply the principle of the sequence stratigraphy.

In the case of the Miocene of the Gulf of Lions, this method lays on the stacking pattern of the offlap break (Homewood *et al*., 1999).

Seismic stratigraphy of the Miocene megasequence across all seismic sections shows a set of 6 sequences characterized by a stacking pattern and their limits (downward shift surfaces and maximum flooding downlap surfaces) which correlate globally.

Four sequence boundaries correspond with downward shift surfaces and are clearly identifiable by the seismic profiles. These surfaces correlate with major sequence limits when we tie the wells logs interpretation to our seismic interpretation.

First Results

Seismic velocities for time-to-depth conversion of seismic data were derived from average values of transit time on the sonic log from eleven industrial bore holes. The order of the seismic sequence remains conjectural, due to insufficient stratigraphic correlations. In any case, it appears that the surfaces separate sequences of equivalent order as follows:

Unit 0 is characterized by a group of reflections that onlap the normal faults scarps or overlap the summit of tilted blocks of the acoustic substratum (pre-rift basement, fig. 1). The top of this unit, which has been drilled, is Oligocene-Aquitanian in age. However, the stratal pattern within the sequence does not show a characteristic geometry of a classical syn-rift unit (divergent reflections, progressives unconformities).

Unit 1 is constituted by a set of sigmoid progradations that stack vertically towards the sea. The aggradational offlap is used to follow the palaeo-border of the Miocene platform during the Burdigalian. This sequence is very thick on the continental shelf, and the seismic facies within the sequence show horizontal, parallel reflectors, quite continuous and of high amplitude, confirming the aggradation (fig. 1).

The upper limit of unit 1 is a downward shift surface (surface B, fig. 1), identified on the palaeo-platform border by a downward shift of the first aggradation onlap of unit 2 (fig. 1). Surface B has a chronostratigraphic value and its post-Burdigalian-Langhian age is estimated from biostratigraphic data from drilling samples (Cravatte *et al*., 1974).

Unit 2 is apparently onlapping the Langhien palaeo-talus border, and is formed by three reflections of high amplitude and low frequency (fig. 1), showing an aggrading (slightly retrograding?) geometry.

The stacking patterns of the offlap break of unit 2', showing an aggrading-prograding architecture of the prisms, and the geometries within unit 2, confirm that unit 2 corresponds with an upper lowstand prograding wedge beneath a highstand system track (unit 2') at the border of the palaeo-platform. Therefore the T surface is a downlap surface prograding on a maximum flooding surface between sequence 2 and 2' (fig. 1).

Core samples from Prism 2', show a regressive tendency towards the top of the sequence (Tortonian lagunal and shoreface deposits – Cravatte et al., 1974). This prism is truncated at the border of the palaeo-talus by an erosive surface (surface C, fig. 1).

On surface C, a 3rd prograding unit is a prism (unit 3, fig. 1) characterized by steep clinoforms (oblique progradation), whose upper limit is an erosive toplap (surface D, fig 1). Its equivalent on the platform is a by-pass surface, associated with erosion.

A second major erosional surface at the top of prism 3 cuts across this last unit and lay emphasis on an important messinian paleo-canyon (paleo-Aude, Lofi, 2001, fig. 2). The infilling of this canyon is illustrated by chaotic seismic facies on high resolution seismic sections (unit 4, fig. 2) and is characterized by non-continuous, low-frequency high-amplitude reflections on the conventional seismic profiles (unit 4, fig. 1). In the deep basin of the Gulf of Lions, salt is gradually replaced upsection by this chaotic seismic unit, which overlies the Messinian erosion surface, and which is interpreted as Messinian detritus (Lofi, 2001; Dos Reis, 2000). Accordingly, we interpret surface D to be the incised Messinian surface.

Conclusions

The analysis of the seismic profiles of the Gulf of Lions allows us to identify four units from the lower Burdigalian. Those sequences are characterized by their lower and upper limits, which have been defined as downward shift surfaces, and/or by the stacking pattern of the offlap breaks.

Geometric analysis near surface A shows evidence of a regression between the Aquitanian and the Burdigalian. Calibration is given by core samples and well logs, of the onshore bore holes of Elne and Canet, where a contemporary continentalisation is described (Duvail et Le Strat, 2000).

Surface B also corresponds with a downward shift. Calibration is given by paleontological and sedimentological data from offshore drillings by Cravatte et al. *et al*. (1974); according to those stratigraphic studies we have conferred a post-Burdigalian-Langhian to pre-Messinian age to this surface.

Surface C is located between surface B and surface D. The latter cuts across the entire geometric system. This last erosive surface constitutes the base of unit 4, which is interpreted to be constituted by the products of Messinian erosion. By this fact, the surface D can only have been formed during the Messinian crisis. Therefore, surface C is considered genetically linked to a post-Langhian and pre-Messinian crisis event.

We have gathered a set of observations that suggest a link between this forced regressive event and a pre-Messinian and post Langhian-Serravalian tectonic uplift and gravitational collapse of the entire Gulf of Lions margin (Duvail and Le Strat (2000, 2002) ; Mauffret *et al*., 2001 ; Camus, 2001; Séranne *et al*., 2002 ; Aunay and Le Strat, 2002; Lofi, 2002; Duvail *et al*., 2003; Gorini *et al*. (submitted to Marine and Petroleum Geoloy); Duvail *et al*. (submitted to Marine and Petroleum Geology). The seismic profiles have revealed that in the area of our study, the Late Miocene platform is offset by a number of normal structures associated with extension dating from the latest Miocene - earliest Pliocene (fig. 1, Mauffret *et al*., 2001). The cause of this post-rift extension has yet to be clearly identified, but it is thought to be associated with uplift in the east of the Pyrenees (Alberes and Canigou massifs, Duvail and Le Strat, 2000; Clauzon and Rubino, 2001; Duvail *et al*., 2001). If this latest Miocene extension could have been caused by gravity-driven destabilization of the platform associated with base-level lowering at the onset of the Messinian salinity crisis (Gorini *et al.*, 2003) the regressive prism 3 could be associated with a former Tortonian uplift of the margin.

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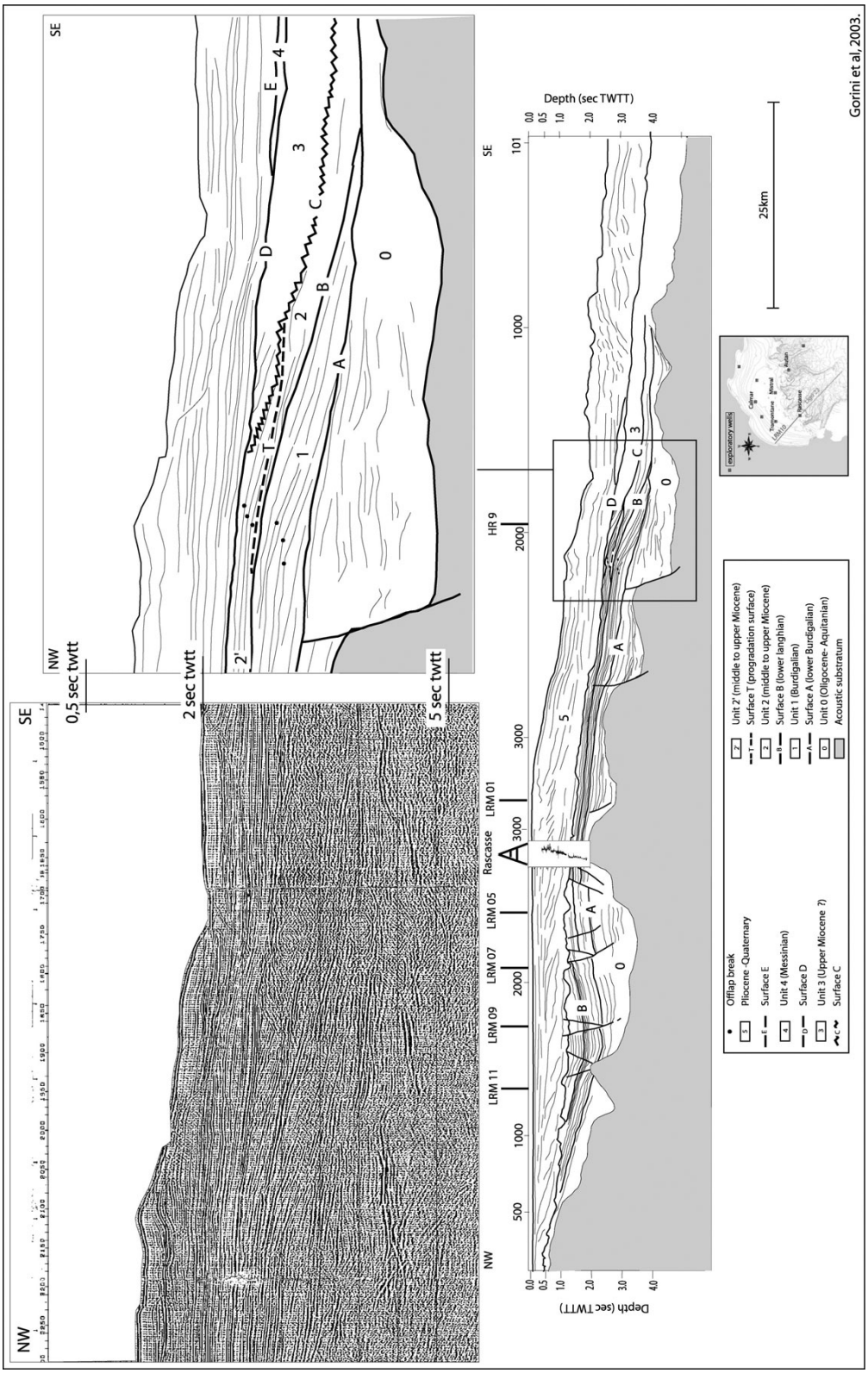

Figure 1 – Seismic profile showing the seismic sequences identified in the Gulf of Lions Miocene post-rift sedimentation

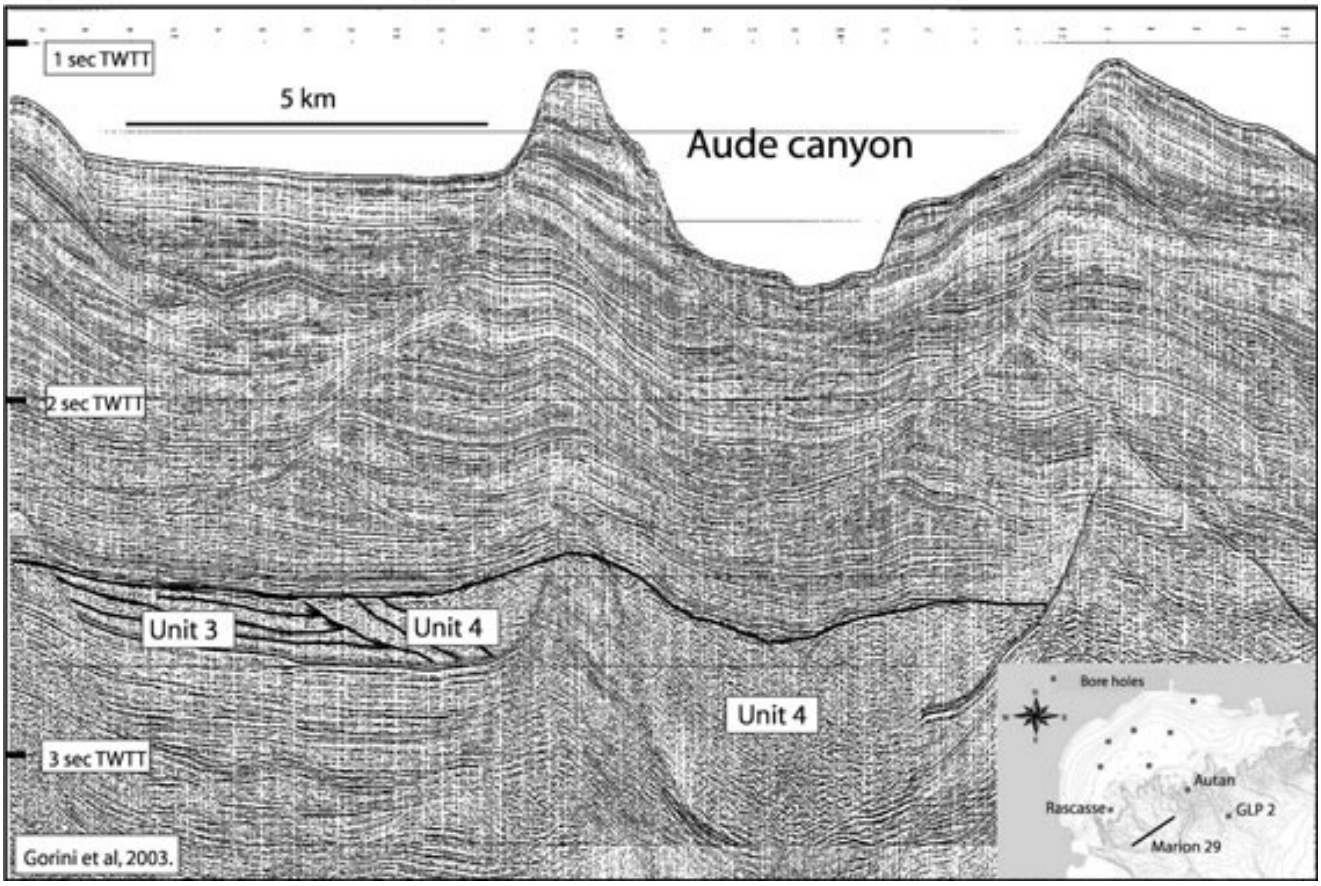

Figure 2 – High resolution seiscmic profile showing the contact between Units 3 and 4.