Abstract

Introduction

The lower Eocene Metlaoui Group contains proven economic petroleum reserves onshore and offshore Tunisia and Libya and is still an exploration target (e.g. Bishop, 1988). Since the Ypresian deposits located in Tunisia crop out in very good conditions and are well documented (see e.g. Moody and Grant, 1989, Loucks et al., 1998), they constitute a very good example of a carbonate ramp model applicable to a hydrocarbon field.

The studied area is located in central Tunisia (Fig. 1). The Kef El Guitoune corresponds to the western flank of the Djebel Ousselat, which culminates at an altitude of 900 m, 35 km east of Kairouan. Numerous active hydrocarbon fields are located in the vicinity, such as Sidi El Itayem or Sidi Behara onshore Tunisia and Ashtar, 40 km southeast of the Kerkennha Islands (respectively SIT, SB and AST in Fig. 1).

The studied El Garia Formation was deposited as a broad belt oriented northwest to southeast, deepening to the northeast into the Tethyan Sea (Moody and Grant, 1989). This formation belongs to the Metlaoui Group and presents a carbonate ramp separating the basinal deposits of the Bou Dabbous from the evaporitic Faid Formation and the gastropod-rich carbonate of the Ain Mermotta Formation. The sedimentation of the Ypresian formations in the area of the Djebel Ousselat is controlled by the structural context. The west-east distension generated a north-south horst and graben structuration. The nummulitic bodies are mainly restricted to the borders of the graben (Bishop, 1988).

The Djebel Ousselat study is part of a Ph.D. thesis, the aim of which is to evaluate these outcrops as an analog to a Tunisian oil field. The results presented in this paper concern the facies and the production/removal equilibrium of the carbonate sediments. They are based on 19 sections and 2 transects described during 2 distinct missions. The second mission was directly linked to this Ph.D. work, while the first one was part of an ARTEP project (Vennin, 1997).
Observations

Two main groups of facies are to be distinguished in the Djebel Ousselat, on the basis of the carbonate texture and of their lateral evolution:

The forebank environment presents a gradual facies evolution characterized by the increase in size and the abundance of the nummulite debris and shows a very good faunal zonation (mud-rich facies in Fig. 2 to 4). A schematic lateral distribution of the main large foraminifers is presented in Fig. 3. The bioclastic content allows us to distinguish several zones. The basin facies consists of fine-grained sediment with abundant planktic foraminifers, mostly globigerinids, and no or very scarce entire nummulites. When entire and large foraminifers appear, nummulites are present, but the typical forms are operculinas and heterosteginas. This facies could be compared to the operculina-rich environments described by Arni (1963) as forebank facies for the Syrte basin, in Libya. Laterally, the large foraminifers become more and more abundant with the apparition of flat and large discocyclinids, associated with flat, small or large, nummulites. All these facies changes are gradual and slow, and the general trend is very easy to observe.

By contrast, the so-called nummulitic bank, which consists of coarse-grained sediments, poor in muddy matrix and nummulitoclasts, shows more irregular and abrupt variations (rudstone to coarse packstone, grain-supported or mud-poor in Fig. 2 to 4). According to previous studies (e.g. Louks et al., 1998), abundant large and robust tests occur at the top of the paleo-high, while more small but robust nummulites are present in the backbank environment. This kind of deposit shows frequent rapid vertical changes of facies such as, for instance, packstones with only small tests overlain by rudstones with large and robust nummulites.

The relationship between these two main facies can be observed along the cliffs of the Kef El Guitoune (Fig. 2). Two isochronous horizons were followed in the field and were carefully adjusted through the sequential interpretation of 5 sections. The mud-rich deposits are observed towards the north, while the coarse facies crops out to the south. The latter group forms a poorly stratified sedimentary body with a high intra- and interparticle primary porosity (between 40 and 70%, Loucks et al., 1998) and scarce compaction features. Two main observations can be done:

- The transition between the coarse facies part and the mud-rich environment is very sharp. The vertical part of the cliff, corresponding to the coarse part, disappears laterally after 20 m.
- The thickness of both units is constant along the cliff, suggesting a similar sedimentation rate during the time lag separating the two isochronous horizons.
Fig. 3 Three stages sedimentologic model influenced by a storm event, equilibrium between carbonate production and removal of particles.

Interpretation

A three-stage sedimentologic model is proposed on the basis of the above observations:

- During the fair-weather stage (Fig. 3A), the ramp probably corresponds to a wide seagrass environment. Changes in the shape and size of the large foraminifers are probably the result of the association with algal symbiots (Hallock and Glenn, 1986) and of the need for light. The very flat tests are almost always deeper than the robust ones. The same morphological adaptation has been described for other organisms such as corals (Ross, 1972, Lathuilière, oral comm.). Therefore, the carbonate bioproduction is expected to be more important in the upper part of the ramp or on paleotopographic highs, where the water is warm and the luminosity is still high.

- During a storm event, currents affect all sediments above the storm wave-base (Fig. 3B). Erosive features appear due to vortex currents (erosive pockets and potholes, Aigner, 1982). A very important amount of particles are suspended, generating a selective winnowing of the small nummulites and debris (Aigner, 1985).

- After a storm, the water, charged with suspended particles, flows down due to its density (Fig. 3C). This density current generates a selective removal of the particles (Aigner, 1985). A part of the carbonate production is therefore redistributed, down dip into the fore- and backbank environments.

The successive storm events create the stacking of the coarse deposits (Fig. 4). This unit presents chaotic variations due to the hydrodynamic conditions disturbing the sediment, and records exclusively the catastrophic events. In the Kef El Guitoune cliff, the stacking of the coarse layers tends to create a massive aggrading coarse-textured body. The lateral change in facies is very sharp and may correspond to the mean storm wave base. The homogenous lateral thickness demonstrates that if the carbonate production is more important in shallow water, an important amount of particles are exported down dip the slope. Therefore, the nummulites banks have to be considered as the result of a winnowing and their shape tends to be linked to the substratum.
morphologies. Conversely, the forebank deposits facies are not strongly affected by storms. Thus, the original faunal distribution is preserved, even if an important amount of fine material in the form of suspended particles is added to it during storm events.

**Fig. 4** Stacking pattern of storm events, the model compared to the Kef El Guitoune’s deposits.

**Acknowledgements**

My sincere gratefulness goes to TOTAL FINA and the ARTEP for their financial support. I would like to thank the TOTAL FINA Carbonate Department, and particularly Loutai Machhour. Special thanks are due to ELF for all the documents put at my disposal. I am also very thankful to all the geologists who participated in the ARTEP mission, and especially to Emmanuelle Vennin (MNHN), Frans Van Buchem (IFP) and Michel Rebelle (ELF).

**References**


