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UPPER CRETACEOUS AND LOWER EOCENE HYDROCARBON PROSPECTS IN GROMBALIA AREA. LATERAL EXTENSION AND RESERVOIR PROPERTIES

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ABSTRACT

In Tunisia, the Grombalia area constitutes an interesting site providing hydrocarbon prospects. Oil and gas were discovered in several fields such as in Zinnia, El Menzah and Belli (Moody et al., 1990 ; Ben Brahim, 1993 ; Touati et al.,1994 ; Loocks et al., 1996 ; Fourati et al, 1998). The lateral extension of Upper Cretaceous and Lower Eocene prospects and reservoir properties could be in relation with sedimentary characters and tectonic activity during this period. Outcrop studies have been carried out to focus on sedimentary characters of Abiod and Bou Dabbous carbonates (Burollet, 1956 ; Fakhfakh-Ben Jemia, 1996), especially, the linkage between diagenesis, fracturing and reservoir properties (Negra et al., 1991).

Concerning the structural setting, the Grombalia area is dominated by a distensive tectonic system mainly expressing horsts, half grabens and grabens and a faulting system globally oriented North-South to North West to South East (Turki, 1988 ; Ouahchi et al., 1993). Tectonic activities could be responsible, at least partly, of the irregular paleotopography which is obvious since the Lower Cretaceous. In fact, in Jebel El Ghorfa, Campanian Abiod limestones are unconformably overlying Aptian shales. The irregular paleotopography is mainly expressed by the existence of highs surrounded by relatively depressed areas. The most spectacular high occupies the southern part of Jebel El Ghorfa in which thickness of both Abiod and Bou Dabbous Formations are very reduced (about 4m, each). In this area, Abiod and Bou Dabbous Formations are constituted of massively bedded micritic limestones which consist of packstones (Dunham, 1961) rich in planktonic foraminifera (Negra et al., 2000 ; Mardassi, 1998 ; Mardassi-Hafsia, 2004). In addition, the Abiod Formation top exhibits a bored hard ground suggesting an early lithification of Abiod micritic limestones, probably in relation with an emersion of this sector during Upper Cretaceous (Melki, 1999).
From Jebel El Ghorfa South (constituting a high), to North, South West and South East, lateral changes in thickness and facies are variable. It means that changes which are progressive to North are, in contrast, rapid, sometimes abrupt to South West and South East. The progressive or abrupt changes appear closely related to a variable inclination degree of slopes. To the North, progressive changes of thickness and facies rather deal with a relatively gentle slope. In fact, massively bedded micritic limestones progressively change to thicker well bedded banks admitting frequent intercalations of argillaceous limestones and marls. In contrast, to South West and South East, the Abiod Formation is obviously thicker (90m). It fossilises slump marks which rather deal with steeper slopes.

Diagenesis is mainly represented by cementation, solution, dolomitisation-dedolomitisation, silicification, compaction, phosphatisation (Zaier et al., 1998 ; Beji-Sassi, 1999).

— Cementation significance varies in relation with the deposition environment (Purser, 1980 ; Negra et al., 1994). On highs, the hard ground characterising the top of the Abiod limestones, suggests an early lithification of Campanian limestones. The frequency of burrowing features immediately beneath the hard ground, could be in relation with a low sedimentation rate. The evidence of micritic internal sediment within foraminifera chambers, identified, both, in Abiod and Bou Dabbous limestones, may confirm the early stage of lithification. The sparitic mineralogy of the cementing crystals could be related to meteoric water influences during emersion (Negra, 1986 ; Negra, 2003).
— Solution, dolomitisation-dedolomitisation processes in Abiod and Bou Dabbous limestones are local and preferentially occur neighbouring highs. They appear responsible of the development of a visible porosity within foraminifera chambers and also between micritic grains and nanofossils. In addition, dolospar crystals partly infill microfractures, especially in Bou Dabbous limestones.
— Other diagenetic processes, such as compaction, silicification and phosphatisation tend to close certain pores such as foraminifera chambers.

On the whole, in terms of reservoir potential, despite the local enhancing of porosity by solution and dolomitisation-dedolomitisation processes, fractures which appear the most potential pores, insure the interconnection between all types of pores (Negra et al., 1992). Fracturing appears less developed on highs which are occupied by relatively thick massively bedded limestones. Toward basins, fracturing is more developed because limestones are thinly bedded and admit frequent intercalations of argillaceous limestones and marls.

I. INTRODUCTION

Outcrop studies of Upper Cretaceous (Campanian) and Lower Eocene (Ypresian) carbonates, undertaken in Grombalia area, (in Jebel El Ghorfa), show rapid variations in thickness, sedimentary characters, diagenetic features and reservoir properties. On the other hand, hydrocarbon fields neighbouring Grombalia area, such as El Menzah, Zinnia, Belli, consist of “small sized” prospects. A relationship could exist between the size of prospects and the size of basins and highs elaborated during Upper Cretaceous-Lower Eocene period. The present outcrop studies will demonstrate that rapid variations of sedimentary characters and reservoir properties of the Abiod and Bou Dabbous Formations are, at least partly, related to an irregular Upper Cretaceous paleotopography constituted of highs and basins.

II. GEOGRAPHIC AND GEOLOGIC SETTING

The Abiod and Bou Dabbous Formations in Grombalia area, about 40 km to the South East of Tunis, outcrop in Jebel El Ghorfa which constitutes a synclinal structure (Bujalka et al., 1971). The core of the latter is formed of Upper Eocene marls (Souar Formation and Reneich Member). A series of sections were surveyed along the eastern flank of Jebel El Ghorfa, in Sidi Hamdan (fig. 1). This syncline structure is highly affected by a distensive tectonic mainly expressed by frequent faults oriented N140. Certain faults appear occurring during Upper Cretaceous-Lower Eocene interval (Turki, 1988 ; Ouahcli et al., 1993).

The studied sector is characterized by frequent unconformities. The main is identified

between Aptian marls and Campanian Abiod carbonates (Turki, 1988). Other discontinuities appear within the Abiod, the El Haria and the Bou Dabbous Formations. Concerning the paleogeographic setting, the Upper Cretaceous paleogeography is dominated by the existence of islands, platforms and basins (Negra, 1994). The most developed island corresponds to Kasserine-Sidi Bouzid island (Negra, 1994). Smaller islands occur in Central Tunisia and less common in Northern Tunisia, such as in Grombalia area. Neighbouring this island, Abiod and Bou Dabbous Formations exhibit series condensation processes expressed by reduced thickness (2 m for the Abiod, 7m for the El Haria and 2m for the Bou Dabbous Formations). In addition, Abiod and Bou Dabbous limestones are massively bedded and are characterized by relatively shallow marine facies.

III. MAIN SEDIMENTARY CHARACTERS OF ABIOD AND BOU DABBOUS FORMATIONS

A– Sedimentary characters of Abiod Formation

A series of twelve sections surveyed along the South Eastern flank of Jebel El Ghorfa syncline shows rapid variations in thickness and facies. In the Southern part (in Sidi Ghilane section), Abiod Formation which is very reduced in thickness (only 2m ; fig. 2), is unconformably overlying Aptian marls. It starts by massively bedded limestone showing frequent phosphatic grains and mainly consist of packstones rich in planktonic foraminifera associated to bioclastic debris. The summital part of the Abiod limestones is frequently bioturbated ; the top of the Abiod Formation consists of an encrusted surface showing millimetric to centimetric organic borings. Later on, it will be demonstrated, by means of diagenetic features, that this hard ground probably corresponds to an emergence surface. Laterally, along 1 km to the North, thickness and facies change progressively (fig.3). In fact, to the North, the Abiod thickness reaches 30 m. In addition, the massive limestone laterally changes to well bedded micritic limestone in which decimetric limestone banks are separated by thin (centimetric) marly intercalations. Limestone banks consist of wackestones mainly composed of planktonic foraminifera. In terms of deposition environments, progressive lateral change in thickness and facies suggest relatively deepening and opening toward the North. The Southern part (Sidi Ghilane area) is acting as a high during the Campanian sedimentation.

B- Sedimentary characters of El Haria and Bou Dabbous Formations

The El Haria Formation appears following the same changes, in thickness and facies, occurring in the Abiod Formation. To the Southern part of Jebel El Ghorfa, the El Haria Formation, 7 m thick, is mainly constituted of marls. To the North, the El Haria Formation, clearly thicker (about 30m), shows limy facies represented by bedded coarse grained packstones rich in planktonic and benthonic foraminifera, associated to bioclastic debris. The limy facies is particular and uncommon in El Haria Formation. It suggests a shallowing at least to the Southern part of Jebel El Ghorfa. The lateral change of facies within El Haria Formation is, at least partly, in relation with the existence of numerous discontinuities as illustrated by angular unconformities between limy beds of El Haria Formation and the overlying Bou Dabbous banks. The Bou Dabbous Formation also shows rapid variations in thickness and facies as previously demonstrated in the Abiod and El Haria Formations. In fact, in the Southern part of Jebel El Ghorfa (Sidi Ghilane section), the Bou Dabbous formation, 2m in thickness, starts with massively bedded limestone ravinating the underlying El Haria marls

and carbonates (fig.4). In fact, the relatively coarse-grained limestones consist of packstones rich in phosphatic and glauconitic grains, fish teeth, lithoclasts, associated to planktonic and benthic foraminifera and bioclasts (Ben Ismaïl K. et al., 1996). One kilometre to the North, the massive limestone which is obviously thicker (65m) progressively changes to well bedded limestone organised into centimetric to decimetric banks admitting centimetric marls and argillaceous limestone intercalations. The bedded limestone consist of wackestones and packstones containing planktonic foraminifera and radiolarians (De Wever et al., 1994). As shown during the Campanian period, the lateral change in thickness and facies deals with a clear deepening and opening of the deposit environment during the Ypresian. The Jebel El Ghorfa South (Sidi Ghilane area) is still acting as a high during the Lower Eocene.

IV- DIAGENESIS - RESERVOIR ASPECTS

Diagenetic modifications appear to follow the deposition environment changes. In fact, the diagenetic modifications identified on highs are different from those occurring in “basins”. Similar diagenetic modifications both affect the Abiod and Bou Dabbous limestones on highs, such as in Jebel El Ghorfa South (Sidi Ghilane ; Plate, photos A, B). Toward basins, diagenetic features change also in Abiod and Bou Dabbous limestones. In fact, the Jebel El Ghorfa South is characterized by solution features (Plate, photos C, D, E, F) which are locally associated to dolomitisation.
These diagenetic modifications induce the development of secondary porosity mainly intraparticular (Choquette et al., 1970), occurring within foraminifera chambers (Plate, photo C). A matrix porosity is also expressed by intergranular pores which are obvious between nanofossils, especially coccoliths (Plate, photos D, F).<

The solution features and the associated porosity are obvious in Abiod and Bou Dabbous limestones. To the North, the main diagenetic features consist of pressure solution, and cementation processes (Loreau, 1972 ; M’Rabet et al., 1986 ; Negra et al., 1988) which, in contrast, lead to an occlusion of primary pores. However, fracturing which appears more common in “basins”, insures the interconnection between all pore types.

V. CONCLUSIONS

In Grombalia area, Abiod and Bou Dabbous sedimentation is controlled by Cretaceous (Aptian) paleotopography which is expressed by the existence of “small” highs (horsts, partly) and basins (half grabens and grabens).
Reservoir properties within Abiod and Bou Dabbous Formations, which are obviously under the control of sedimentary characters and diagenetic modifications, clearly change from highs to basins. On the whole, the “small size” of Upper Cretaceous and Lower Eocene discovered prospects around Grombalia area is, at least partly, in relation with the small size (few kilometres) of basins.

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Plate: Campanian Abiod and Lower Eocene Bou Dabbous Formations facies in Grombalia outcrops

Photo A: Photomicrocraph showing well preserved planktonic and benthonic foraminifera whose chambers are filled with micrite, Abiod Formation in Jebel El Ghorfa South.

Photo B: Photomicrograph showing intragranular cementation within foraminifera chambers. Abiod Formation in Grombalia area (Sidi Ghilane).

Photo C: Photomicrograph showing intragranular porosity in foraminifera chambers (arrows) Abiod Formation in Jebel El Ghorfa South (Sidi Ghilane).

Photo D: SEM photo showing a loosely packed structure formed of disintegrated coccoliths and matrix porosity (arrow) Abiod Formation in Grombalia area.

Photo E: Photomicrograph showing a globigerinids rich packstone in which an intraparticular porosity is obvious (arrow). The Bou Dabbous Formation in south Jebel El Ghorfa.

Photo F: SEM photo showing a loosely packed to coalescing structure constituted of anhedral to subhedral micritic grains, with an intergranular porosity. The Bou Dabbous Formation in Grombalia area.

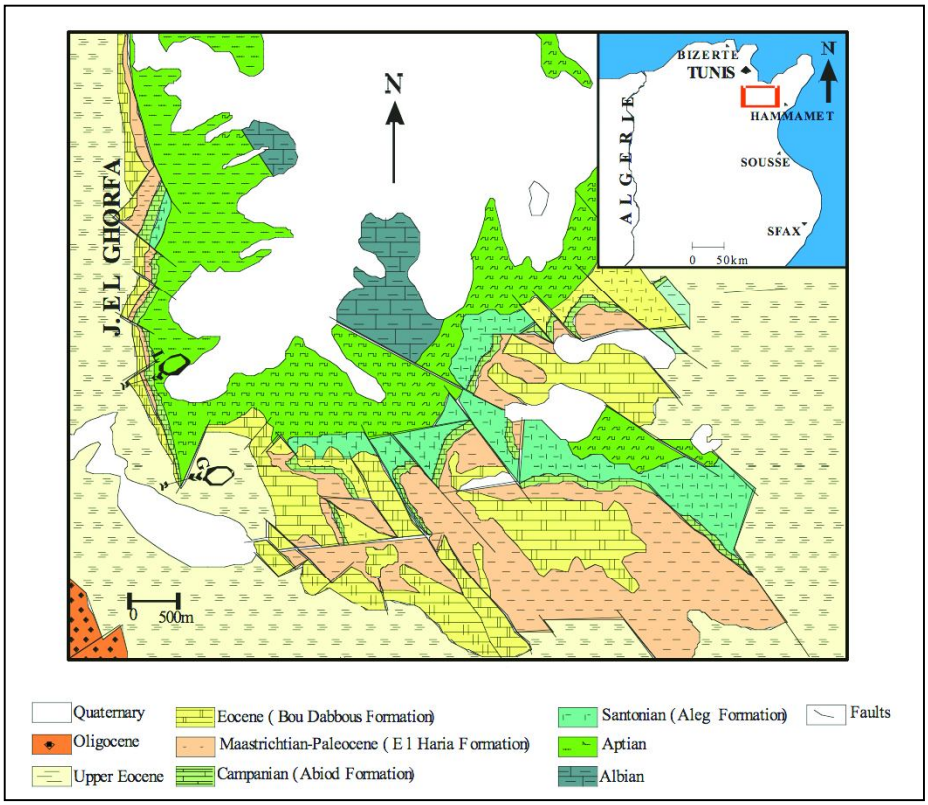

Figure 1: Location map of the studied sections, from "La feuille de Grombalia" map, 1/50000 (Bujalka et al., 1971)

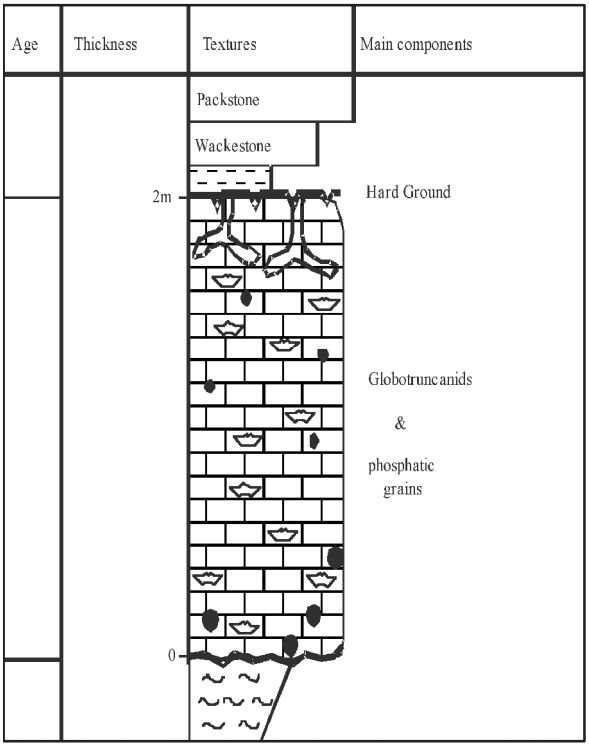

Figure 2: Vertical evolution of Campanian Abiod facies in Jebel EL Ghorfa South

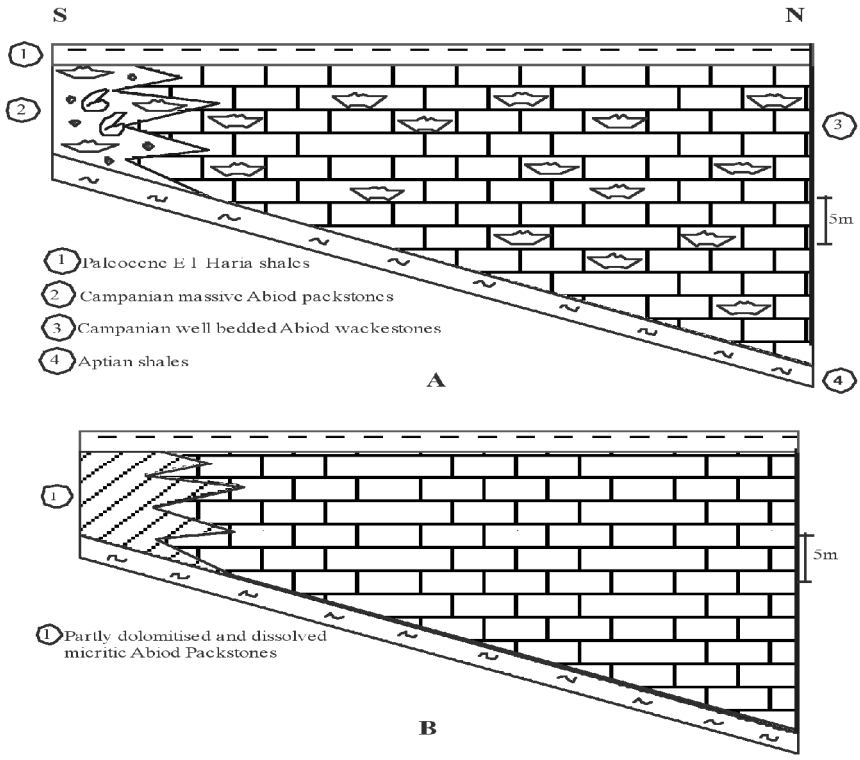

Figure 3: Lateral evolution of facies (A) and diagenetic modifications (B) within the Abiod Formation in Jebel EL Ghorfa outcrop

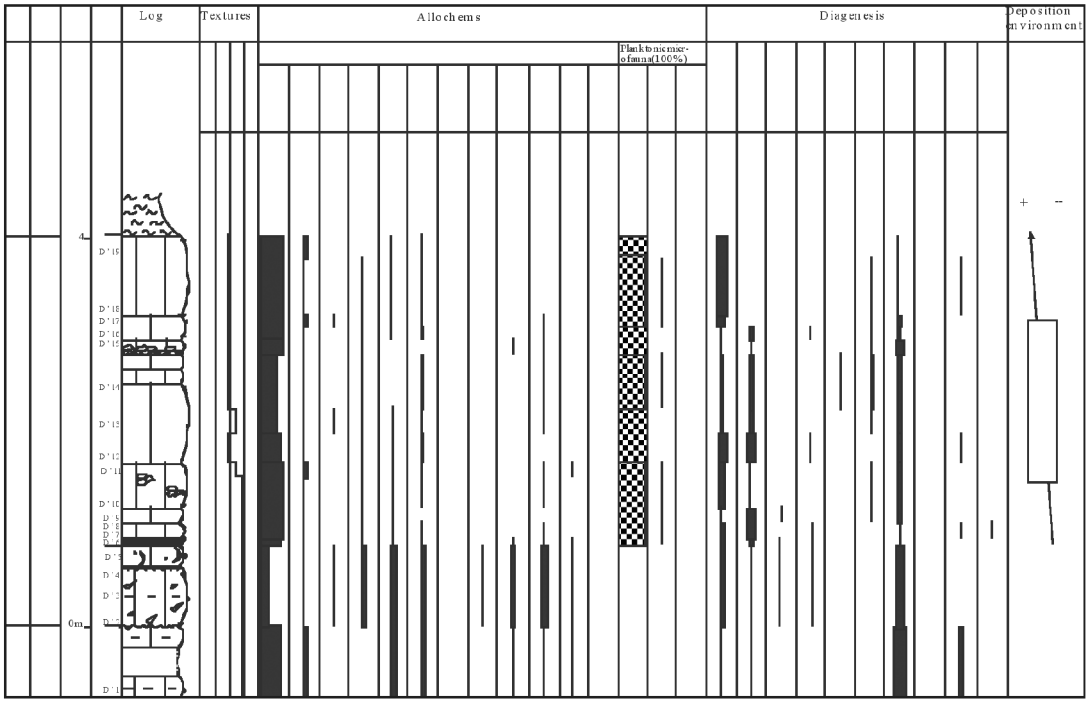

Figure 4: Vertical evolution of facies in Jebel EL Ghorfa section (Section D)

PLATE I

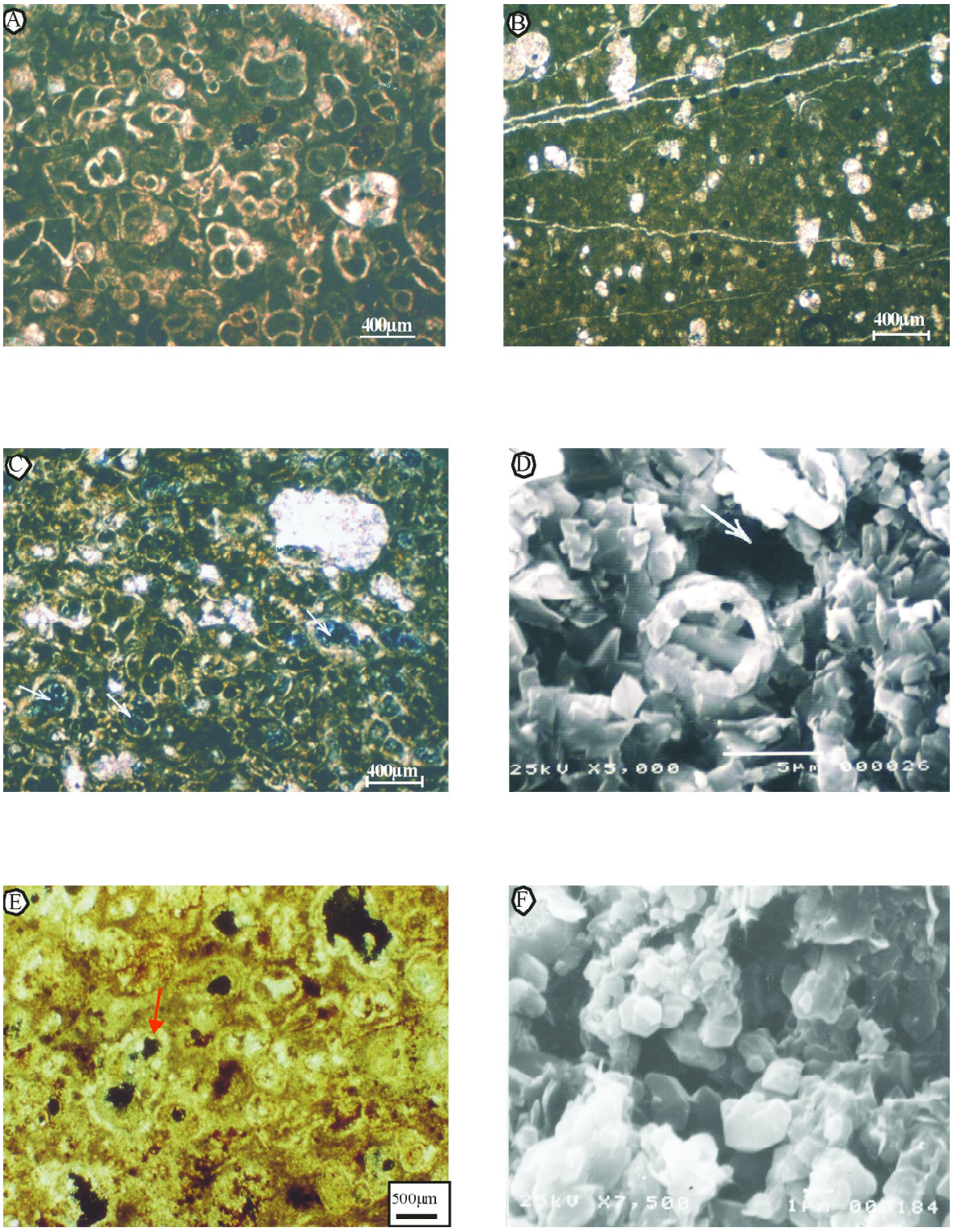

Plate1 : Campanian Abiod and Lower Eocene Bou Dabbous Formations facies in Grombalia outcrops