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THE ABIOD FORMATION IN THE ENFIDA AREA: PARTICULAR SEDIMENTARY FEATURES AND RESERVOIR PROPERTIES IMPLICATIONS

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Abstract

In the Enfida area located in northern central Tunisia, the Abiod Formation which is represented by an only one carbonatic member shows frequent variations in thickness and facies. From North to South, the four sections respectively surveyed in Jebel Bou Safra, Mdheker, Garsi and Fadhloun show that the whole thickness of Abiod Formation changes from 80 m (in Jebel Bou Safra and Garsi) to 110 m (in Jebel Mdheker and Fadhloun). In addition, the Abiod Formation locally includes several intercalations of resedimented limestones which are interbedded within the thinly bedded micritic chalky limestones (classic Abiod facies). Resedimented limestones are only identified within subsident areas such as the Jebel Mdheker and Jebel Fadhloun in which the Abiod Formation is relatively thick.

The resedimented facies are expressed by relative coarse-grained siliciclastic and bioclastic sediments showing graded bedding and corresponding to turbiditic and/or tempestitic sequences. They are identified within subsiding and thick series preferentially deposited in depressed areas. On contrary, on highs, Abiod Formation facies are clearly thinner and do not include resedimented sediments. Rapid variations in thickness and facies appear to be insured by NW-SE normal faults. Highs occupying the Jebel Bou Safra and Garsi areas correspond to horsts while depressed areas occupying Jebel Mdheker and Fadhloun could correspond to grabens and/or half-grabens.

The main source of resedimented sediments could correspond to the highs and horsts immediately neighbouring the "depressions". Quartz grains and/or bioclasts are transported from highs to depressions on slopes as suggested by the frequent identified slump marks. Resedimentation processes occur during tectonic and/or seismic instabilities related to Upper Cretaceous tectonic and/or volcanic events.

In terms of reservoir properties, the coarse-grained resedimented facies constitute particular layers in which porosity and permeability are higher than those of the micritic chalky limestone. Relative porous and permeable resedimented bioclastic deposits could constitute conduits favouring fluids circulation within the Abiod fine-grained carbonates.

Introduction

Following our first results concerning the rapid changes in thickness, sedimentary characters, diagenetic features and reservoir properties within the Abiod carbonates in Grombalia area (Melki et al., 2004), we undertake a similar approach to analyse the Abiod carbonates in other sectors located slightly more to the South, in Enfida area. As demonstrated in Grombalia area, tectonic movements expressed by an intense fracturing of carbonates and the existence of frequent normal faults, generally N140 in mean direction, appear, at a first glance, responsible of the paleotopography compartimentation into horsts, grabens, half grabens.

In addition, Abiod limestones which are classically known as thinly bedded chalky limestones admit the intercalation of frequent massive beds formed of relatively coarse-grained limestones. Petrographical analyses show that, comparatively to thin-bedded chalky limestones, massive beds consist of resedimented carbonates in which porosity and permeability appear relatively.

Plate

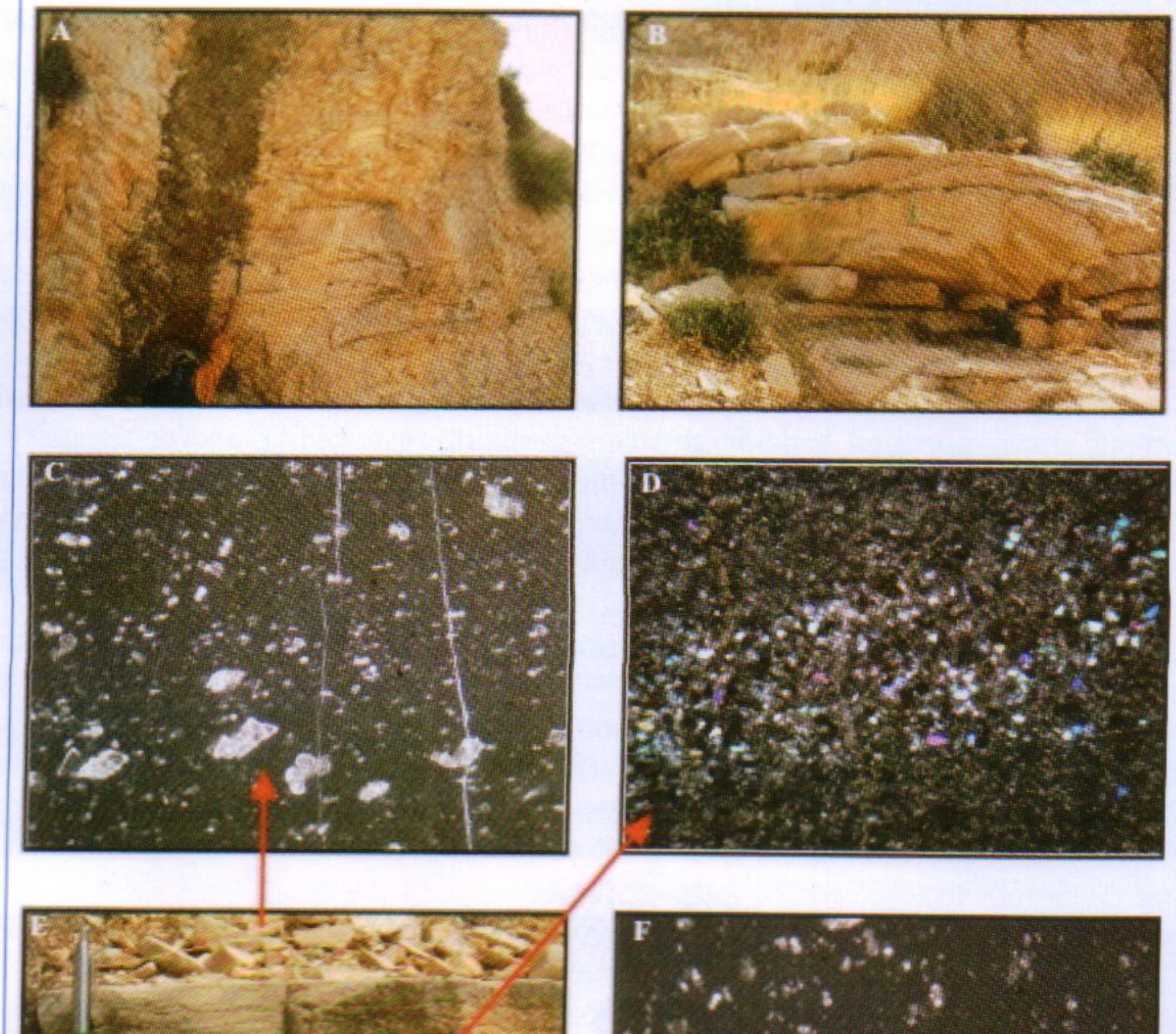

Plate: Campanian Abiod Formations facies in Enfida outcrops

A: Outcrop view showing slump marks in Abiod limestones at Jebel Mdheker section.

B: Detailed view showing folded limestones underlying and overlying by non-deformed series, suggesting syn-sedimentary folding (on slopes).

C and F: Photo-micrograph showing the texture and composition of the white thin bedded chalky limestones, corresponding to wackestones rich in pelagic microfauna.

D: Photo-micrograph showing the texture and composition of the resedimented grey limy bed, corresponding to a packstone containing well sorted subangular to subrounded quartz grains.

E : Resedimented grey limy bed intercalated within white thin bedded chalky limestones. more developed. However, porous resedimented carbonates appear closely linked to relatively depressed and subsiding areas. In terms of lateral extension, subsiding areas are not very extended. Outcrops show that the maximum of subsiding areas is about 4 km.

In subsurface, the relatively small size of the discovered oil and gas fields (Zinnia, etc.) neighbouring Grombalia and Enfida areas (Lansari et al., 2006) could confirm our outcrop studies. In fact, the small size of hydrocarbon fields and prospects could reflect rapid variations in sedimentary characters and reservoir properties in relation with synsedimentary tectonic activities.

Geographical and geological setting

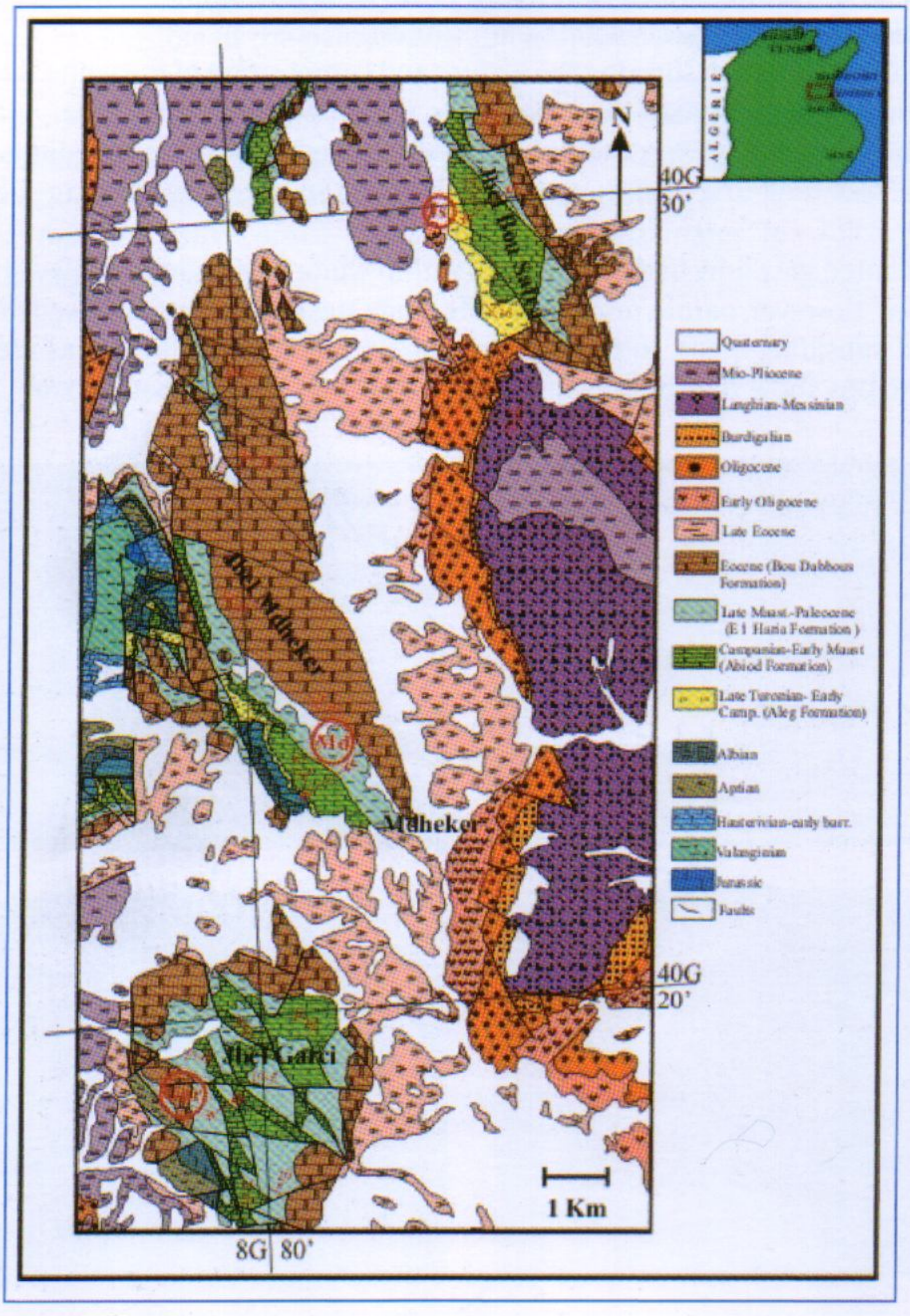

Fig. 1: Geological map of Enfida and location of studied area (Bajanik et al., 1974)

The Enfida area which is located about 100 km to the South-East of Tunis City (fig. 1) corresponds to a series of folded and faulted structures such as the Jebel Fadhloun anticline whose core is formed of Campanian Abiod limestones. In Jebel Mdheker, the Campanian-Early Maastrichtian Abiod carbonates which conformably overlie Late Turonian-Early Campanian Aleg marls' are directly overlain by the Late Maastrichtian-Paleocene El Haria shales.

Vertical Evolution of Abiod Facils

A synthetical lithostratigraphical section surveyed in Jebel Mdheker (Md section) shows from base to top the following facies (fig. 2)

– The Aleg marls exhibit at their upper part, frequent intercalation of intensely fractured limestones beds, expressing a transitional change from Aleg marls to Abiod limestons.

– Abiod Formation, is represented by an only one carbonatic member, about 130 m in thickness and showing varied facies. According to changes in structures and compositions, three units, at least, are identified

Unit I (20 m) is formed of thinly bedded (centimetric) highly fractured and bioturbated white pelagic limestones corresponding to wackestones rich in planktonic foraminifera.

Unit II (45 m) is marked by the intercalation of two massive beds formed of grey-coloured and relatively coarse-grained limestones. The first bed (Md12; 10 cm in thickness) wich is directly overlain by thinly bedded white pelagic limestones, consists of a packstone rich in bioclastic fragments (40%) associated to planktonic (40%) and benthonic microfauna (20%). The planktonic foraminifera, which are obviously badly preserved, suggest reworking and resedimentative processes. The second bed of grey-coloured and coarse-grained limestones (Md19; 15 cm in thickness) wich are partly composed of quartz grains, consist of packstones rich in planktonic foraminifers (40%) associated to benthonic foraminifers (15%), bioclastic debris (35%) and subangular to subrounded well sorted quartz grains (20%).

Unit III (65 m) is formed of thinly bedded white pelagic limestones admitting the intercalation of 3 additionnal beds of grey-coloured, coarse-grained limestones (third, fourth and fifth beds). The third grey_coloured limy bed (Md26; 30 cm in thickness) consists of grainstone rich in well sorted and relatively well preserved planktonic foraminifers (70%) associated to bioclastic debris (20%) and benthonic foraminifers (10%). The fourth grey-coloured limy bed (Md36; 20 cm in thickness), consists of a nodular limestone showing lithoclasts containing badly preserved components corresponding to planktonic (60%) and benthonic (10%) foraminifers associated to bioclastic fragments (30%). The fifth grey coloured limy bed (Md39; 20 cm in thickness), rich in well sorted, more or less fragmented planktonic foraminifers (70%) associated to bioclastic debris (20%) and benthonic foraminifers (10%). The fifth grey limy bed is directly overlain by thinly bedded white chalky limestones. Vertically, limestones progressively change to the Maastrichtian-Paleocene El Haria marls and shales.

Lateral Evolution Of Facies

Along a North-South trend from Jebel Bou Safra to Jebel Fadhloun, the Abiod Formation exhibits obvious changes in thickness and facies (fig. 3). In fact, a North-South correlation shows that thickness and facies are comparable in Jebel Fadhloun and Jebel Mdheker in which the Abiod Formation is relatively thick (110 to 130 m) and includes grey beds of resedimented coarse-grained limestones. However, in Jebel Bou Safra and Jebel Garci, the Abiod Formation wich is thinner (80 m) does not include resedimented carbonates.

Lateral facies changes appear linked to tectonic movements expressed by normal faults predominantly showing NW-SE trands. These distensive faults are responsible of a compartimentation of the paleotopography in horsts, grabens and probably half-grabens. Subsiding grabens and half-grabens area (such as Jebel Mdheker and Jebel Fadhloun) receive a relatively thick pelagic sedimentation episodically interrupted by the resedimentation of reworked deposits at least partly derived from highs and transported on slopes.

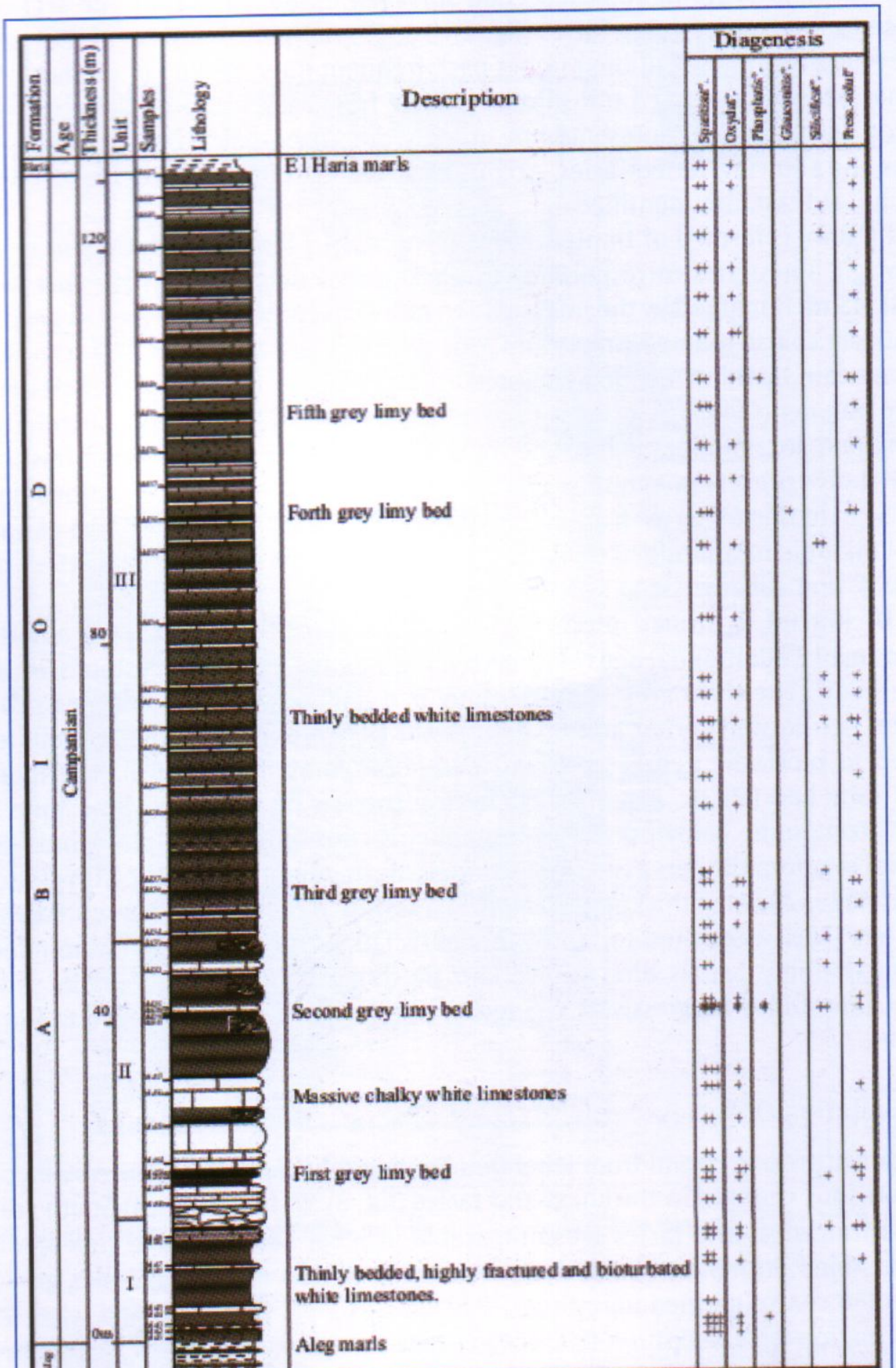

Fig. 2: Vertical evolution of Abiod Formation in Jebel Mdheker (Enfida area, Md section)

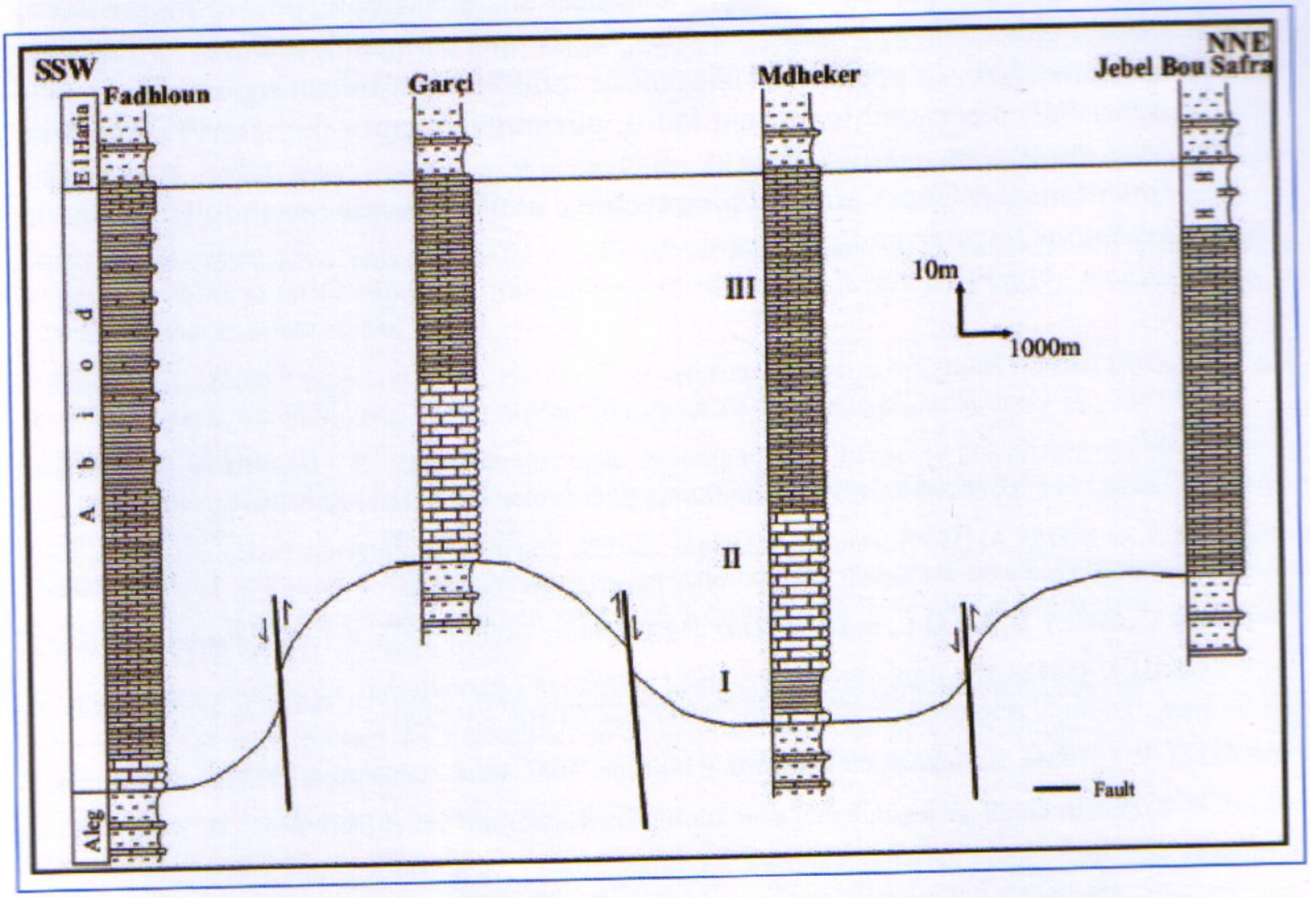

Fig. 3: Lateral evolution of Abiod ormation in Enfida area

Reservoir aspects

Commonly, the thinly bedded chalky limestones constituting the Abiod Formation are impermeable (< 0,1 Md; Negra et al., 1992). However massively bedded and relatively coarse-grained limestones deposited in highs (Jebel el Ghorfa South; Melki et al., 2004) or constituting resedimented beds in depressed areas (Jebel Mdheker for example) appear relatively more porous and permeable. In fact, petrographical studies show that coarse-grained limestones especially in Grombalia area (Jebel el Ghorfa South; Melki et al., 2004) are preferentially affected by solution and, locally, by dolomitisation-dedolomitisation features. Such diagenetic modifications enhance the reservoir potential of the Abiod limestones.

Conclusions

The 5 identified grey limy beds intercalated within the Abiod pelagic limestones are characterised by particular textures and compositions.

In terms of reservoir properties, the intercalation of grey-coloured coarse-grained limestones within the chalky limestones of the Abiod Formation could enhance the reservoir potential of the Abiod in Enfida area. In fact, as shown in other areas in outcrops (Maknassy area; Negra, 1994; Negra et al., 1992) or subsurface (Sidi el Kilani field; Ben Brahim, 1993; Lansari et al., 2006), coarse-grained limestones which are relatively porous and permeable could act as conduits for diagenetic fluids during early or burial diagenesis. When diagenetic fluids contain sufficient quantities of Mg, dolomitisation, for example, transforms the initial impermeable pelagic chalky limestones into porous and permeable dolomites (Negra et al.,1994; Negra, 1994). In addition to diagenetic modification, fracturing which is highly intense apparently associated to ancient faults, obviously enhance the reservoir potential of the Abiod limestones in Enfida area.

Resedimentation episodes are following tectonic and/or seismic instabilities related to Upper Cretaceous tectonic and/or volcanic events.

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