[PS]Coniacian Douleb Carbonate Member at Jebel Khsham El Artsouma, Central Eastern Tunisia; Reservoir Characterization and Subsurface Analogue*

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Abstract

The Coniacian series of central Tunisia are known as the Douleb limestone and constitute the dominant member within the Aleg Formation. It tested and produced oil in the eastern onshore and offshore Sfax area. Due to its heterogeneity and despite previous results, this reservoir is still presenting a challenge for explorationists. That is why the study of outcrop data is necessary for better understanding subsurface parameters. Sedimentological study and petrophysical analysis of two sections (Oued Mahloul (OM) and Oued Mahloul East (OME)) outcropping at Jebel Khsham El Artsouma (central Tunisia), provide more knowledge about the Coniacian Douleb reservoir. This member is composed of three distinctive units; (U1) lower alternations of bioturbated bioclastic/lumachellic carbonate and light green marls, (U2) middle oolithic dominant beige carbonate, and (U3) upper alternation of light grey carbonate and bioturbated marls. Limestone beds of these units are partially dolomitized at OM section and highly dolomitized at OME section. The main facies type is oolithic dominant, deposited in a shoal complex environment within a gentle slope ramp. Bioclasts increase in fore-shoal setting, however, back-shoal mud-coated grains and peloids are common. Oolithic sand bodies are oriented from northwest to southeast separating a restricted domain landward to the southwest and a storm influenced open platform toward the northeast. The Douleb limestone is made of shallowing upward sequences bounded topwards by aerial/subaerial surfaces outlining exposures/sub-emersion of a shallow ramp during regressive phases. In fact, initial petrophysical parameters were highly enhanced by early meteoric and burial diagenesis. Dolomotization and dissolution are spectacular processes giving a significant secondary porosity and permeability. A porosity vs. permeability cross plot showed that the OME section dolostones is a potential reservoir. The main pore types are: intercrystalline, molds of leached grains and vugs. The three units of the Douleb Member previously described in outcrop were encountered in drilled wells. Every unit was characterized by a distinctive diagraphic signature or log type. Their limits are marked by observable shifts in gamma ray and acoustic readings indicating a lithofacies contrast. In addition, sedimentological investigations showed a big similarity in reservoir parameters with studied sections. Indeed, the Coniacian of the Khsham El Artsouma outcrop could be a good candidate for subsurface analogue.

Acknowledgements

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AAPG International Conference & Exhibition 2014

Abstract

Sedimentological study and petrophysical analysis of two sections (Oued Mahloul "OM" and Oued Mahloul East "OME") outcropping at Jebel KhshamEl Artsouma, provide more knowledge about Coniacian Douleb reservoir.

This Member is composed of three distinctive units; (U1) lower alternations of bioturbated bioclastic/ lumachellic carbonate and light green marls, (U2) middle oolithic dominant beige carbonate and (U3) upper alternation of light grey carbonate and bioturated marls. Limestone beds of these units are partially dolomitized at OM section and highly Dolomitized at OME.

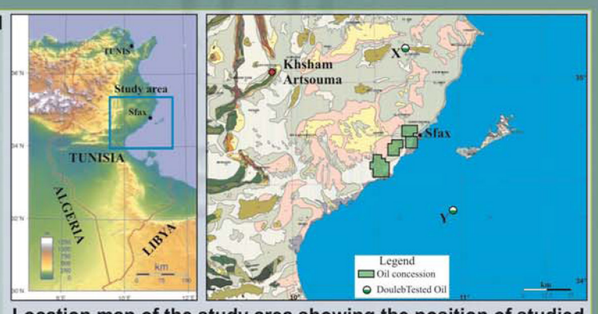
The main facies is oolithic dominant deposited in a shoal complex environment within a gentle slope Ramp. Bioclasts increase in fore-shoal setting however in back-shoal mud-coated grains and peloids are commons. Oolithic sand bodies are oriented from North West to South East separating a restricted domain landward to the South West and a storm influenced open platform toward the North East.

The Douleb limestone is made of shallowing upward sequences bounded at tops by aerial/ subaerial surfaces outlining exposures/ sub-emersion of shallow Ramp during regressive phases. In fact,initial petrophysical parameters of rocks were highly enhanced by early meteoric and burial diagenesis.

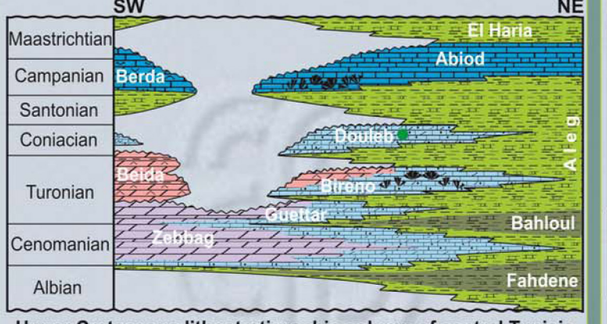
Dolomotization and Dissolution are spectacular processes giving a significant secondary porosity and permeability. Porosity versus Permeability cross plot showed that the OME section dolostones is a potential reservoir.

The main pore types are; inter-crystalline, molds of leached grains and vugs.

The three units of the Douleb Member previously described in outcrop were encountered in drilled wells. Every unit was characterized by a distinctive diagraphic signature or log type. Their limits are marked by observable shifts in Gamma ray and Acoustic readings indicating a lithofacies contrast. In addition, sedimentological investigations showed a big similarity in reservoir parameters with studied sections. Indeed, the Coniacian of Khsham El Artsouma outcrop could be a good candidate for subsurface analogue.



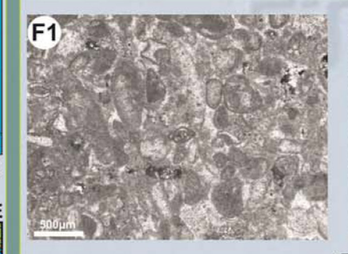
Location map of the study area showing the position of studied sections and oil producing concessions

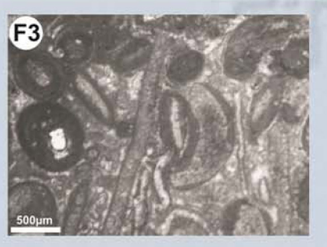


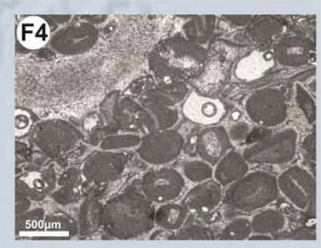
Upper Cretaceous lithostratigraphic column of central Tunisia

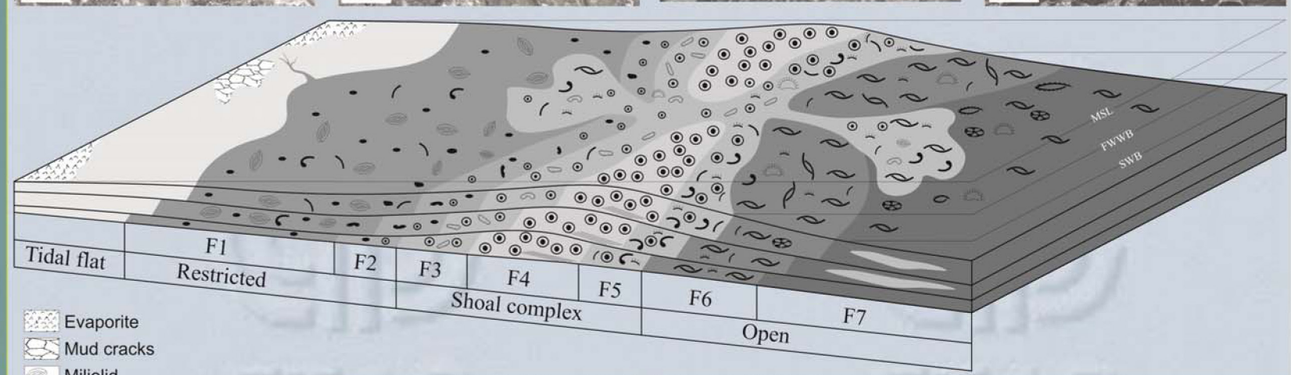
Platforml model

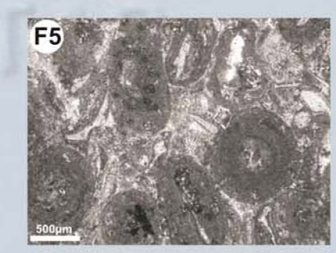
Referring to the studied sections, there is no evidence of dramatic lateral facies or thickness change. Oolithic dominant shoal limestones persist along a widespread area of about 50Km width. In fact, the platform was characterized by a gentle slope (lower than 1m/km). Referring to works of J.F. Read, 1982 and M. E. Tuker 1990 such morphology allowed us to propose a Ramp model for the Coniacian Douleb limestone of Tunisia. The platform dips toward the North and North East allowing the development of an inner restricted ramp Southward and open outer ramp Northward. These two domains are separated by a high energy NW SE trending oolithic sandbars.

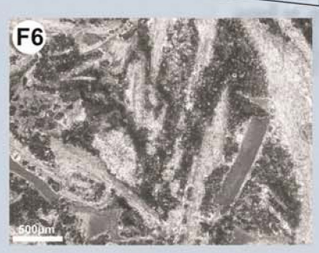


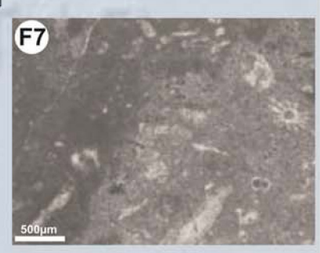




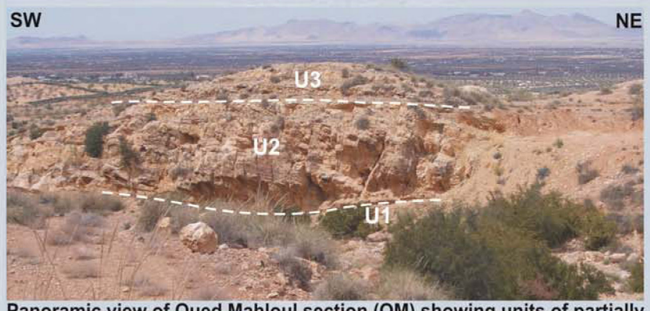






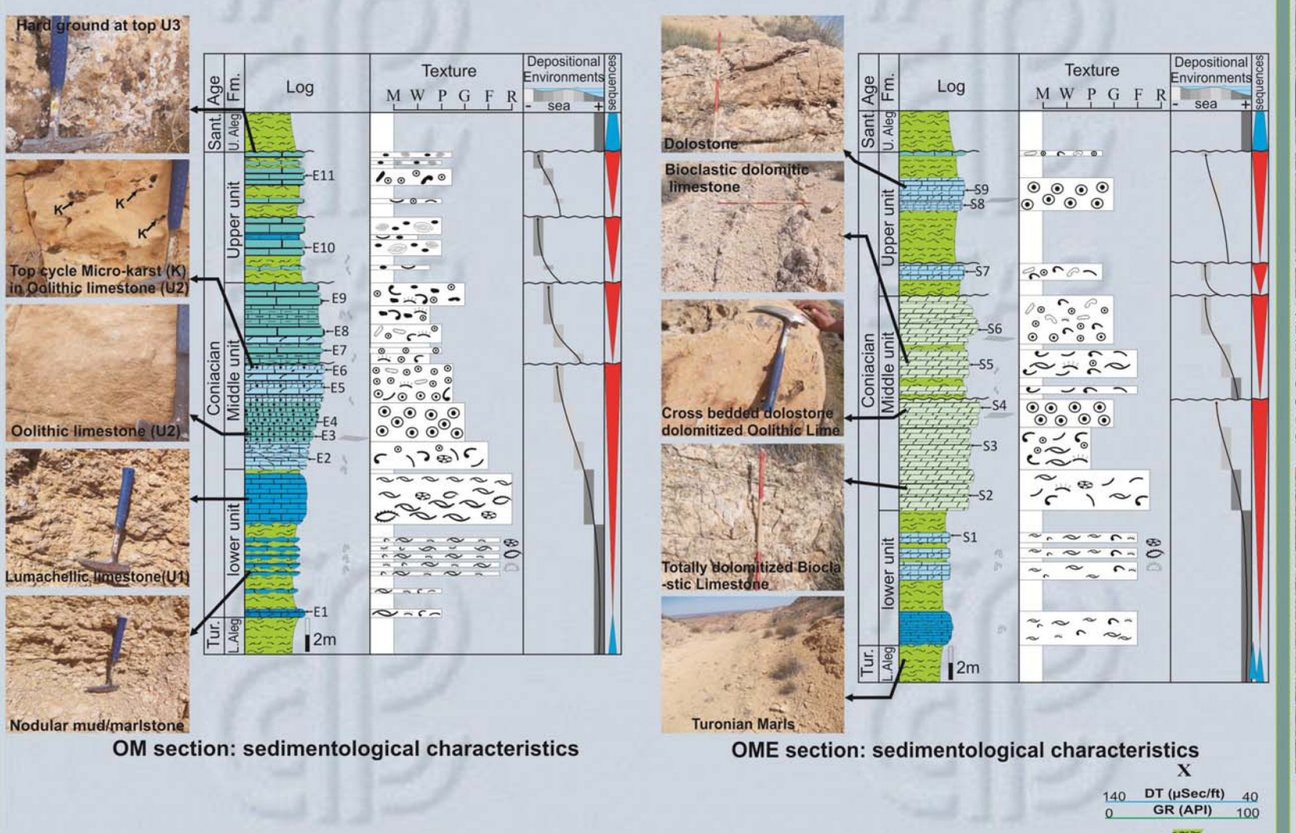


Outcrop /subcrop sections



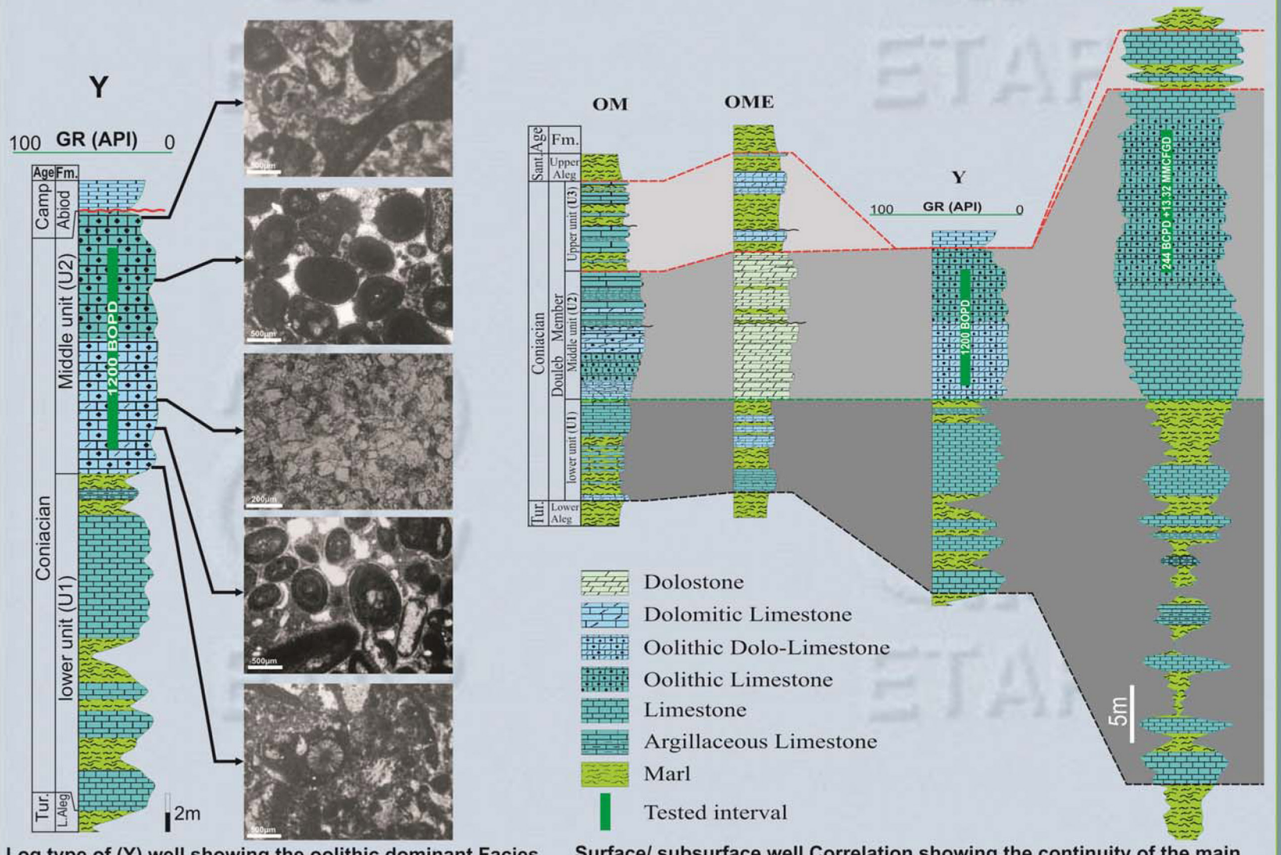
Panoramic view of Oued Mahloul section (OM) showing units of partially dolomitized douleb member carbonate (fractured unit U2 main reservoir)

Panoramic view of Oued Mahloul East section (OME) showing units of the totally dolomitized douleb carbonate member



OM section: sedimentological characteristics

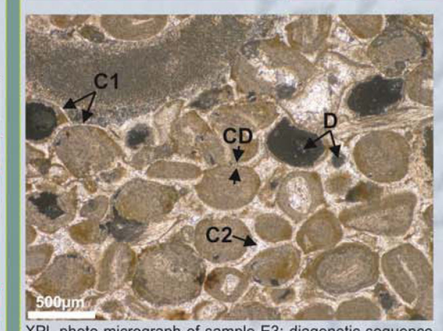
OME section: sedimentological characteristics



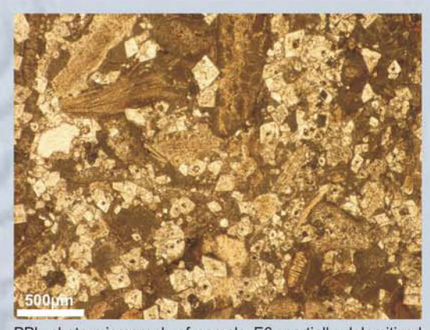
Log type of (Y) well showing the oolithic dominant Facies of the main reservoir unit U2 (samples taken from core & cuttings)

Surface/ subsurface well Correlation showing the continuity of the main reservoir unit (U2) witch tested Hydrocarbon in (X) and (Y) and the log character having cylinder shape of Gamma Ray and Sonic readings

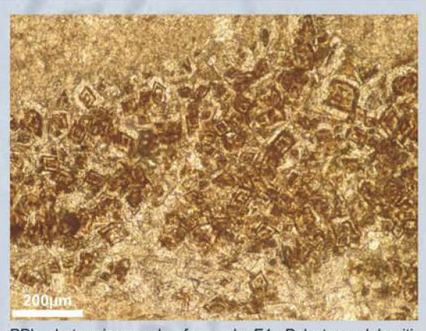
Diagenesis and petrophysics



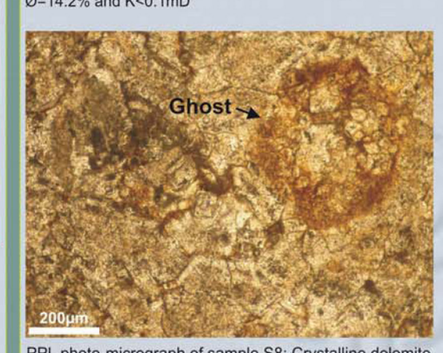
XPL photo-micrograph of sample E3: diagenetic sequence in an oolithic grainstone; early cementation C1 (light rim of isogranular calcite) , compaction/ dissolution CD witnessed by inter-penetrated oolithes and partly dissolved; second cementation phase C2 succeeding the compaction and late dissolution D; molds and vugs are the most common pores (black colored) major porosity is qualified as Secondary Ø=14.2% and K<0.1mD



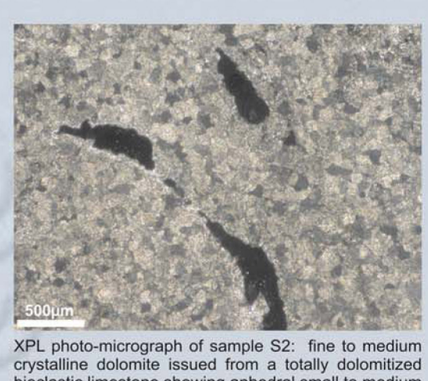
PPL photo-micrograph of sample E6: partially dolomitized bioclastic wackestone showing medium to coarse rhombic euhedral dolomite crystals (planar-e). Polystage of replacive dolomite indicative of an early burrial diagenesis and iron concentration in rhombs. the facies characterizes an open ramp setting with abundant micrite and floating bioclasts no observable pores Ø= 7.6% and K<0.1mD



PPL photo-micrograph of sample E1: Polystage dolomitization showing zoned sparry euhedral fine to medium crystals (planar-e) developed in a dolomicritic matrix. Iron rims and crystal size allow to propose an early burrial replacement of the original mud-supported facies.The enlargement of crystals during successive phases destroyed the created porosity Ø= 6.93% and K<0.1mD



PPL photo-micrograph of sample S8: Crystalline dolomite resulting from the dolomitization of an oolithic grainstone (oolithe ghost). Dolomite fabric is planar subhedral coarse crystals (planar-s) Ø= 8.87% and K<0.1mD.



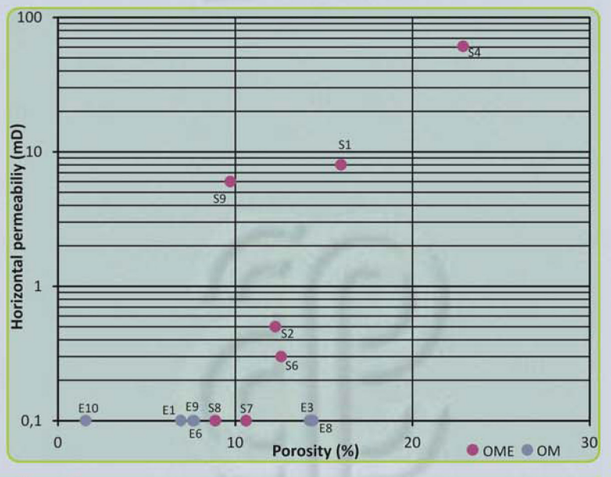
XPL photo-micrograph of sample S2: fine to medium crystalline dolomite issued from a totally dolomitized bioclastic limestone showing anhedral small to medium sized crystals with moldic and vuggy porosity (black colored) resulting from bioclast leaching and giving a significant secondary porosity and permeability Ø= 12.26% and K=0.5mD.

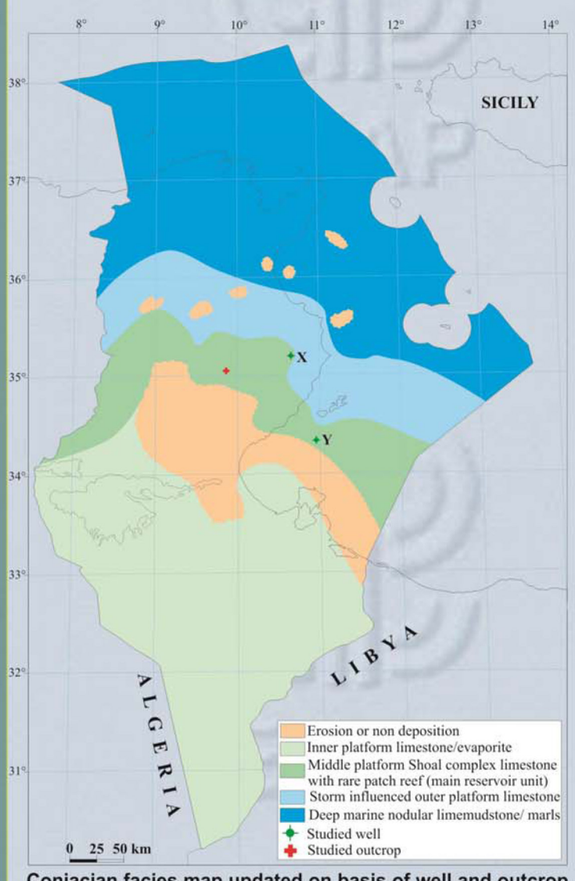
XPL photo-micrograph of sample S4: fine to medium crystalline dolomite resulted from the replacement of an original oolithic grainstone (fossilized cross bedding) showing intercrystalline and vuggy porosity (black colored) and trace of grain remnants (yellow-brown color). Porosity and permeability were clearly enhanced Ø= 22.86% and K=60.9mD.

The Douleb limestone is made of shallowing upward sequences bounded topwards by aerial/ subaerial surfaces outlining exposures/ sub-emersion of shallow Ramp during regressive phases. In fact, initial petrophysical parameters of rocks were highly enhanced by early meteoric and burial diagenesis.

Dolomotization and Dissolution are spectacular processes giving a significant secondary porosity and permeability. Porosity versus Permeability cross plot showed that the OME section dolostones (samples designed by pink points) is a potential reservoir with fair to good permeability and porosity. However, OM section (samples designed by blue points) shows a relatively low permeability. This Heterogeneity outlines the influence of diagenetic processes on the development of Douleb reservoir unit.

The main pore types are; inter-crystalline, molds of leached grains and vugs.





Coniacian facies map updated on basis of well and outcrop Data showing the extension of the potential reservoir facies

Conclusion

The Coniacian of Tunisia is made of oolithic dominant limestone deposited in a shoal complex setting within a gentle slope ramp.

Middle carbonate unit is the best reservoir formed by Grainstone /dolostones and it extends along a NW-SE prospective trend with an average of 50km wide.

The primary petrophysical parameters of reservoir rock were highly influenced by diagenesis. Dolomitization and Dissolution enhanced clearly the rock property by giving an inter-crystalline, moldic and vuggy secondary porosities

Outcrops of Khsham El Artsouma gave more data about the Douleb member and representing a good example for carbonate reservoir heterogeneity.

Compared to subcrop, studied sections are analogs of the coniacian of drilled sections especially in offshore Sfax area.

Facies Associations & depositional settings

Peloidal/ Milliolid rich Restricted inner Platform:

F1 Milliolid/ peloid limestone:

It is composed of abundant peloids associated with milliolids and bioclasts. The texture is packstone to grainstone with fine micritic matrix and cement occupying the inter-granular space. Some grains are partially recrystallized due to the impact of diagenesis. MF1 characterizes a restricted inner platform biota of large benthic foraminifera and high micritisation activity.

F2 Peloid/ Ooids limestone:

It is made by dominant peloids and Oolithes with occurrence of rare bioclasts. The texture is packstone to grainstone. It characterizes the shoal influenced part of inner platform marked by re-sedimentation of transported oolithes.

Oolithic dominated Shoal complex:

F3 Ooids/ mud coated grain limestone:

It's marked by abundance of Ooids and mud coated grain of partially micritized and recrystallized bioclasts. These later are issued from bivalves, echinoderm's plates, oysters and divert fauna transported by wave currents toward the inner platform. Texture is packstone to grainstone. The increasing amount of oolithes indicates a back shoal depositional settings.

F4 Oolithic limestone:

It is the main facies of **U2** and composed by well sorted Oolithes. Rare echinoderm's debris and bioclasts are common. It shows locally Cross and/or planar beddings suggesting a high energy conditions of sedimentation. Grains were cemented by an early iso-granular micro-sparite and tardy drusy sparite (Dunham, 1962). This facies is indicative of high energy shoal setting under shallow water conditions. It forms the main producing reservoir unit.

F5 Ooids/ Bioclastic limestone:

It is marked by increasing Shell and echinoderm debris within a micritic matrix associated to Oolithes. The matrix and grains were compacted and dolomitized. Texture is Packestone to Grainstone. The lack of high micritization and abundance of bioclasts proofs the fore-shoal open depositional settings of this facies.

Bioclastic storm influenced open Platform:

F6 Lumachellic lime-mudstone:

It characterizes the lower unit **U1** of Douleb member. It consists of graded shell debris associated with echinoderm and bryozoan. The texture is Rudstone when grain size exceeds 2mm if not it is packstone to wacke-stone. All elements are jointed together by a very fine partially dolomitized matrix. It was deposited in an open platform above the storm wave base

F7 Nodular lime-mudstone and marls:

It consists of white to creamy micritic nodular mudstone to wackestone with rare bioclasts and irregular Echinoderm in life position. Beds are intercalated within green muddy marls. This facies characterizes deep open platform below storm wave base.

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