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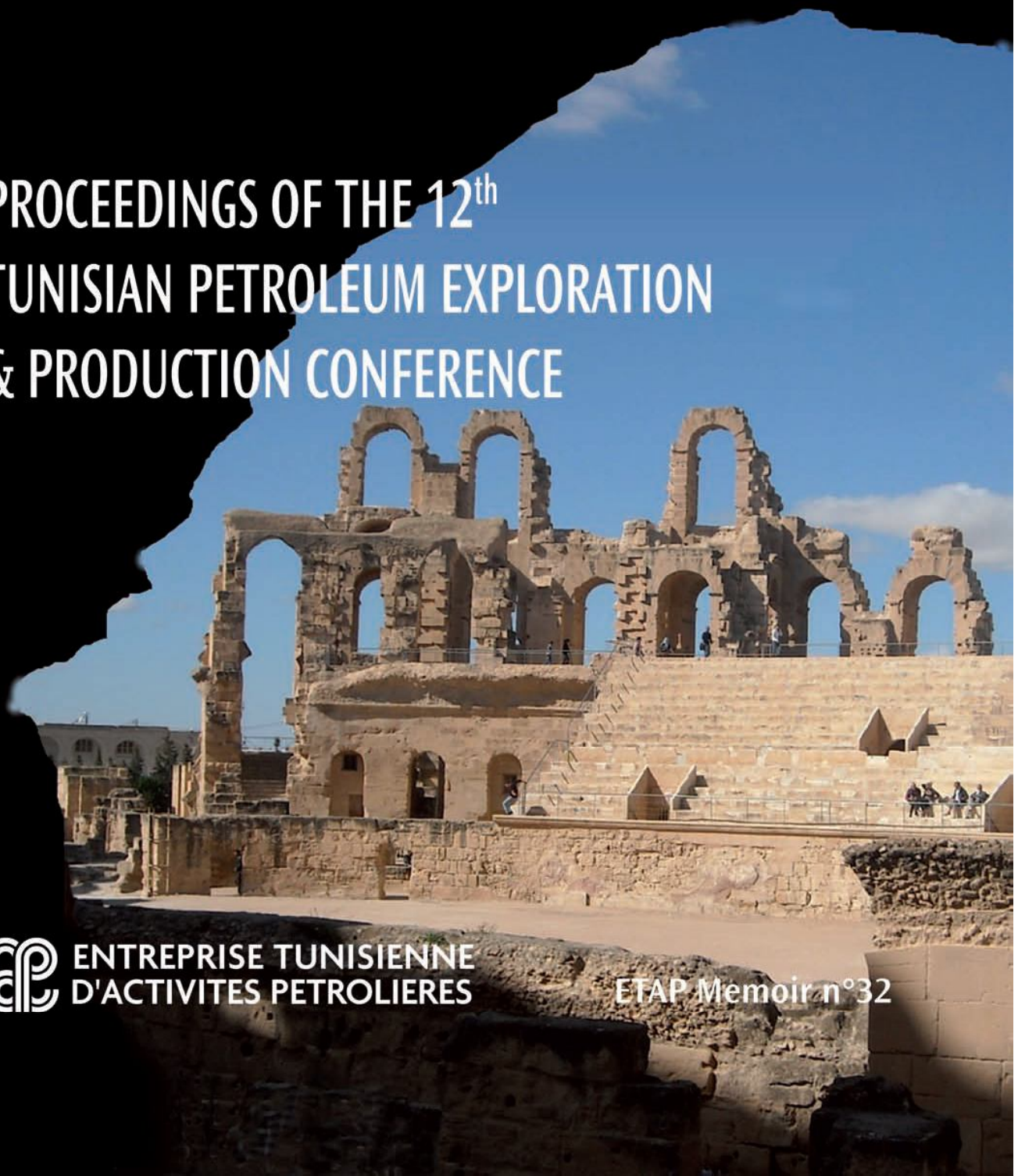

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OUTCROPS-SUBSURFACE LITHOSTRATIGRAPHIC CORRELATIONS OF THE BIRENO CARBONATIC RESERVOIR IN CENTRAL TUNISIA

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ABSTRACT

The present study targets the Bireno reservoir in central-eastern Tunisia where it produces oil and gas in several fields such as Gremda, Rhemmoura, El Aïn, Guebiba, El Hajeb and Mahares. The Bireno reservoir which is Early to Middle Turonian in age, mainly consists of carbonates deposited in a shallow marine environment.

A total amount of 233.25m of core from two producing wells in the Sfax area (well A and well B) was described in detail. On the basis of outcrop observations and log signature of subsurface wells, the present study proposes a new layering of the Bireno reservoir. The four distinguished units are partly correlable with the three units already identified in the Fej Atroument type section of Jebel Bireno and also perfectly correlable with the BG Tunisia subdivision (1993).

INTRODUCTION

The Bireno carbonatic reservoir, Early to Middle Turonian in age, is the most successful play in the central – eastern Tunisia (Sfax area), producing oil in several fields such as Gremda / El Ain, Rhemoura and Guebiba. It tested oil in many wells around the area, especially in Sfax onshore and offshore vicinity; Salloum-1 well (1848bopd), and Jawhara-1 well (276bopd).

In central - western Tunisia, the sedimentary characters of the Early to Middle Turonian Bireno carbonates reservoir were studied in several outcrops (Touir et al., 2010; Troudi, 1998; Zagrarni, 1999; Negra et al., 2002, 2008; Zagrarni et al., 2008). The Fej Atroument section which is well exposed at the Jebel Bireno could be considered as the most representative section of the Bireno Member at least in west-central Tunisia. In relation with the paleogeographic setting, during the Early to Middle Turonian interval, the typical Bireno facies are well correlable in central Tunisia. However, in central-eastern Tunisia, where the Turonian Bireno reservoir is buried, the regional evolution of facies was uncertain regarding the lack of a regional facies model. The latter could be established by means of integrated study of outcrops and subsurface including cores, thin sections and logs data. The first results of this study constitute the aim of the present work.

GEOLOGICAL SETTING

The study area is located in central-eastern Tunisia, neighbouring the Sfax city and many oil fields (Fig.1). Structurally, this zone was characterized by the NW-SE (N 140) trending fault systems and the presence of volcanism activities. In this area, the principal outcropping series are Mio-Plio-Quaternary in age, whereas all the overlying lithostratigraphic units are only founded in subsurface.

The Early to Middle Turonian Bireno Member forms the main reservoir target in the Sfax area. This member is included within the Aleg Formation (Early Turonian - Early Campanian). Generally limited by two shaly units; the Annaba Member at its base and the Lower Aleg at its top which forms the cap rock. The Bahloul Formation (Late Cenomanian-Early Turonian) characterized by a good geochemical attributes, constitute the major source rock for the Bireno Turonian reservoir.

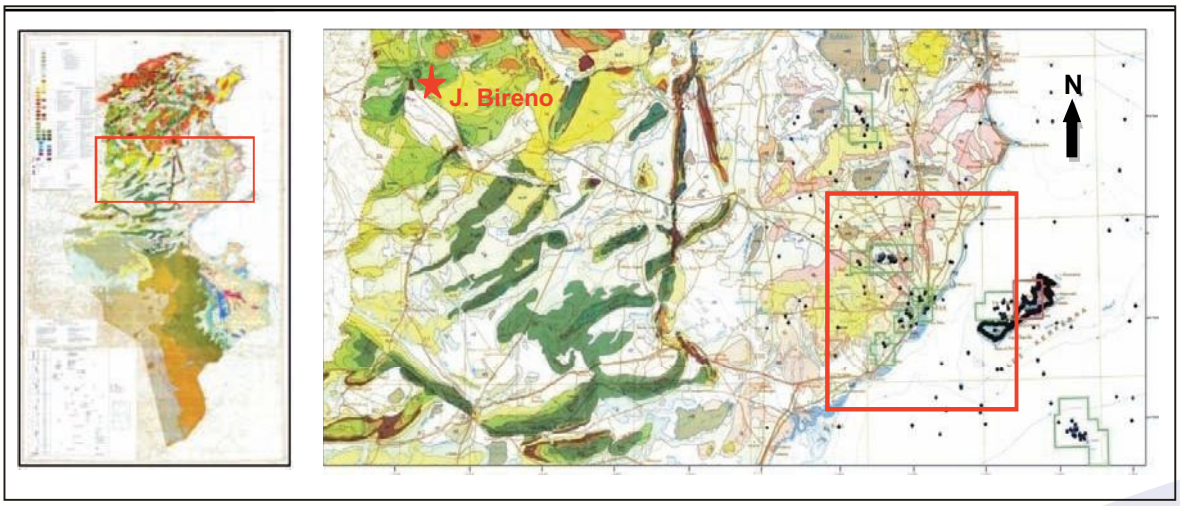


Figure 1: Geological Map of central Tunisia (Onshore and Offshore). The studied area is approximately 200Km from outcrop of Bireno Member in Jebel Bireno at Fej Atroument section.

MATERIAL AND METHODS

A total amount of 233.25m of core from two producing wells in the Sfax area (well A and well B) was described in detail. This cored interval was distributed into two main intervals covering the BU4 and BU3, which represented proven reservoir units within the Bireno reservoir. The BU2 and the upper most part of BU1 were cored only into well B. The top and the base were not cored within the two wells. The core is 12 cm wide, which makes it easy to see sedimentary structures and small-scale lateral variations in facies. The core was logged bed by bed at a cm-scale, records lithological characteristics (color, texture and composition) together with sedimentary structures, relative hardness, grain characteristics, visible porosity and fractures. A considerable Knowledge which was gained from the outcrop analogue (at the Fej Atroument section in Jebel Bireno) was the most reliable way to learn about common rock types, depositional environments and lateral facies variations, in order to correlate the lithostratigraphic subdivision established in surface to that in subsurface.

OUTCROPS LITHOSTRATIGRAPHIC SUBDIVISION

At surface, the Early to Middle Turonian carbonate interval outcrops extensively in several atlasic structures of central-west Tunisia. The type section chosen to be used as a

guide for this interval subdivision was the Fej Atroument section in Jebel Bireno. In this locality, according to Troudi 1998, the Bireno carbonate Member was subdivided into two lithologic units (Lower Bireno and Upper Bireno) separated by a regional unconformity correlative with Haq's SB 90.5 Ma (Abdallah et al., 2000) and the top of Bireno reservoir is marked by a transgressive regional mark rich in planktonic and calcispheres. In 1999, Zagrarni has subdivided the Bireno Member intro three lithologic units. The first unit (B1), called Lower Bireno, starts with bedded wackestones-packstones, rich in calcispheres, scarce planktonic foraminifera, echinoid debris and scattered red algae and benthic fauna. The calcisphere limestones are directly overlain by bioclastic packstones rich in rudist debris (Zagrarni, 1999, Negra et al., 2002). The second unit (B2), called Middle Bireno, is predominantly constituted of marls and calcisphere-rich bedded limestones admitting the frequent intercalations of massively bedded bioclastic grainstones. The latter are rich in peloids, red algae, lithoclasts and scarce ooids. The third unit (B3), called Upper Bireno, starts with bioclastic limestones rich in rudist fragments and showing cross beddings. These bioclastic limestones are directly overlain by the main rudist lithosome (Skeleton et al., 1991; Negra et al., 2002). The rudist lithosome consists of a massively bedded lensoid body showing clustered rudists in vertical growth position. Laterally, toward the NE, the rudist lithosome changes to bedded onlapping packstones containing rudist debris and debris foraminifera, suggesting a slight deepening of the depositional environment. The upper Bireno ends with bedded dolomites, overlain by conglomeratic and bioclastic to micritic limestones. The latter was capped by an emersion surface directly sealed by pelagic marls.

SUBSURFACE LITHOSTRATIGRAPHIC SUBDIVISION

In subsurface, according to BG Tunisia study, concerning fields around the Sfax city (onshore), the Bireno reservoir was subdivided into four major units (Fig.2). The following units are distinguished from base to top: Lower Shelf Margin (LSM), Lower Peritidal (LP), Upper Shelf Margin (USM) and Upper Peritidal (UP). In fact, each "BG unit" corresponds to one unique type of depositional environment (shelf margin or peritidal).

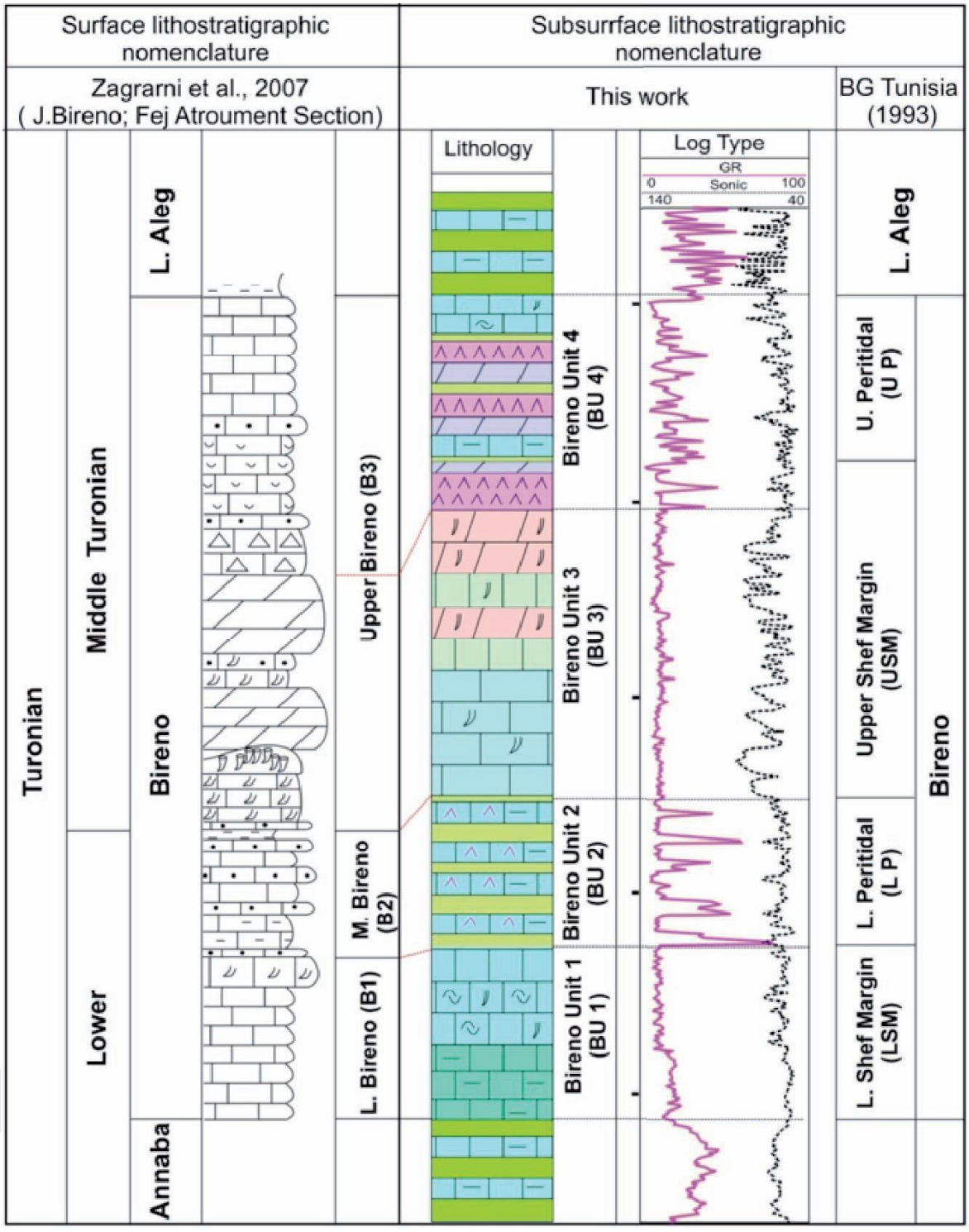
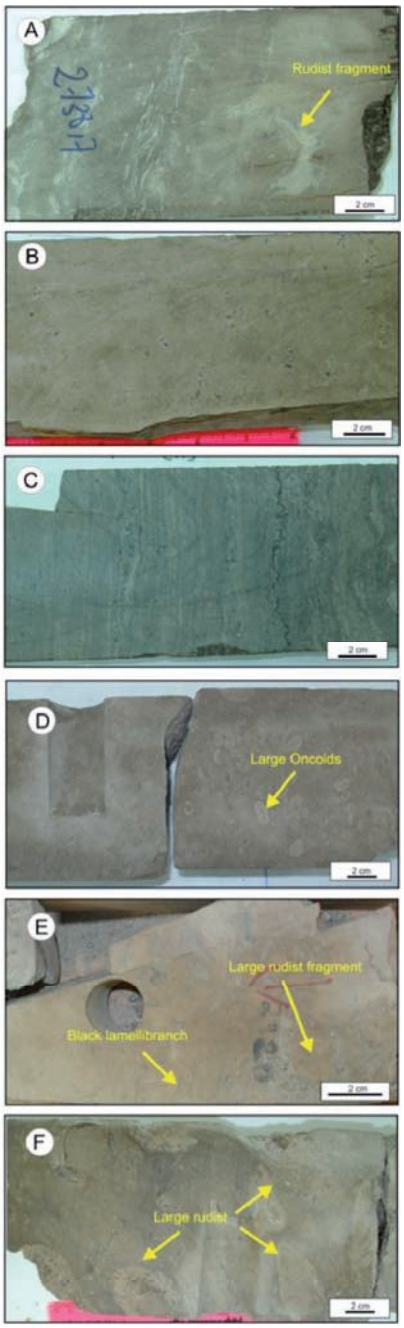


Figure 2: Integrated Bireno lithostratigraphic subdivision combining the Fej Atroument outcrop nomenclature with the Sfax area Bireno log type.

Because this approach appears rather interpretative, we propose in the present work a descriptive approach in which the subdivision of the Bireno Reservoir is based both on E-Log signature and facies types and their succession. This apparently more objective approach is easier to use and could be proposed as a guide for other correlations. On the whole, four major units were identified within the Bireno reservoir. From the base to the top, we distinguish: the Bireno unit 1 (BU1), the Bireno unit 2 (BU2), the Bireno unit 3 (BU3) and the Bireno unit 4 (BU4). The Bireno unit 1 (BU1) and the Bireno unit 3 (BU3) were predominantly carbonatic units with a low GR tool reading. However, the Bireno unit (BU2) and the Birenounit.



A-Bioclastic limestone with large rudist fragment within the top of BU1 (well B, core 11)

B- Oncoidal limestone within BU2 (well B, core 11)

C- Beige to yellow anhydritic thin layer within the dolomite of BU2 (well B, core 11)

D- Oncoidal limestone within lower part of BU3 (well B, core 10)

E- Rudist floatstone within the BU3 (well A, core 3)

F- Rudist rudstone within the BU3 (well B, core 9)

Plate 1. Core photo showing lithofacies within Bireno Reservoir in the Sfax area.

unit 4 (BU4) appear more shaly. The Bireno unit 1 (BU1) was represented by fine-grained bioclastic limestones, slightly argillaceous in their lower part and slightly dolomitised and contain few rudist debris in their upper part (plate 1A). Only it upper most part was cored within well B. The Bireno unit 2 (BU2) has the highest impulse rates and can, therefore, easily be distinguished from all units. Thin claystone layers between limestones show needle-like gamma ray spikes. This unit was cored only within well B. It is composed of interbedded dark grey claystones and light grey to beige limestone, slightly argillaceous, locally rich in large oncoids, peloids, thin skeletal debris and foraminifera (plate 1B). Thin and rare layers of anhydrite are present (plate 1C). The presence of shaly interbeds diminished the reservoir quality of this unit. The Bireno unit 3 (BU3) appear the most clean limestone unit. This unit consists of rudist floatstone (plate 1E) and locally rudstones (plate 1F) including large fragments of rudists, large black lamellibranchs with occasional foraminifera and oncoids (plate 1D). It is slightly dolomitised and frequently encountered within the lower part and the upper most part of BU3. The unit UB3 shows an important visible porosity and it was a proven unit within Bireno reservoir which tested oil in well A and B. The upper unit (BU4) appears the most heterogeneous unit composed of dark claystone, bioclastic dolomitised limestone, algal dolomite and evaporites. Evaporite beds, metric in thickness, were generally present. When they exist, they underline the lower part of the BU4 unit. In that case, the evaporite layers could be used to calibrate cores with Wire-line Logs and also as indicators of the BU4 unit. According to this observation, the limit between UB3 and BU4 was slightly modified. The upper most part of the Bireno Unit 4 (BU4) was not cored. The top of this unit was represented by a sharp shift corresponding to an abrupt transition to the Lower Aleg argillaceous limestone Member. This shift could correspond to the discontinuity immediately overlying the emersion surface observed in outcrops (Zagrarni et al., 2007).

CONCLUSIONS

On the basis of log signature, four major units called, respectively from base to top, Bireno Unit 1 (BU1), Bireno Unit 2 (BU2), Bireno Unit 3 (BU3) and Bireno Unit 4 (BU4), were identified in the Bireno reservoir of the Sfax area subsurface (Onshore and Offshore).The Bireno unit 1 (BU1) was represented by a fine-grained bioclastic limestone, slightly argillaceous in its lower part and locally dolomitised and containing few rudist debris in its upper part. The BU1 represents a potential unit with a good reservoir characterization (average porosity 20 to 28%). The Bireno unit 2 (BU2) have the highest impulse rates and can, therefore, easily be distinguished from all units. The limestone of (BU 2) was slightly argillaceous and locally rich in nodular anhydrites which decrease its reservoir properties (porosity less than 12%). The Bireno unit 3 (BU3) appears the most clean limestone unit, generally, composed by rudist/molluscan floatstone-rudstone limestone associated with foraminiferal and algal limestone and dolomite. This unit was a proven reservoir which tested oil in well A and well B (average porosity between 10 and 14%). The upper Bireno unit (BU4) appears the most heterogeneous units with different lithologies; dark claystone, bioclastic dolomitised limestone, algal dolomite and evaporites. This unit was a proven reservoir which tested oil in well A and well B (average porosity between 10 and 14%). According to outcrop observations and subsurface features, the top of this unit coincides with a sharp shift that could be the expression of an emersion surface directly overlain by transgressive series.

The four identified units are also correlable with the three units of the Fej Atroument type section: the Bireno Unit 1 (BU1) is correlable with the Lower Bireno (B1), the Bireno Unit 2 (BU2) to the Middle Bireno (B2), the Bireno Unit 3 (BU3) and the Bireno Unit 4 (BU4)

to the Upper Bireno B3. The discontinuity (emersion surface) onlapped by the transgressive pelagic marls, constitutes in all cases the summital boundary of the Bireno reservoir.

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