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UPPER CRETACEOUS RESERVOIR ROCKS IN TATAOUINE AREA. SEDIMENTARY CHARACTERS AND SEQUENCE STRATIGRAPHY

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ABSTRACT

In Chenini section, located 20 km to the West of Tataouine, Upper Cretaceous series starting with siliciclastic deltaic facies and ending with shallow marine carbonates, are correlable at a regional scale, at least, in the whole Dahar. These facies are organised into third order sequences. The first sequence, Albian to Cenomanian in age, includes Chenini sandstones, Radhouane dolomites and the lower part of Kerker Formation. The second sequence, Cenomanian in age, includes the middle and upper part of the Kerker dolomites. The third sequence, Cenomanian to Turonian in age, is constituted of the Gattar dolomites; it starts on a transgressive surface marked by fossiliferous carbonates.

In terms of reservoir characters, intercrystal to vuggy pores are mainly developed in carbonates of Radhouane, Kerker and Gattar Formations, intergranular pores are mainly developed in the Chenini sandstones.

INTRODUCTION

In Tataouine area, Upper Cretaceous series associate carbonates, evaporites and siliciclastic deposits. In fact, well exposed outcrops show that these series start by Albian sandstones and end with Cenomanian-Turonian shallow marine carbonates. In terms of lithostratigraphic units, Albian sandstones constitute the Chenini Formation which is overlain by Upper Albian dolomites constituting the Radhouane Formation. The overlying carbonates and evaporites which are Cenomanian in age constitute the Kerker Formation. The summital facies which consist of dolomites containing rudists, constitute the Cenomanian-Turonian Gattar Formation. All these formations are easily correlable at a regional scale because of their large extension along the Dahar area and their continuity to Libya.

The main aim of this study will be to study the sedimentology and the sequence stratigraphy of the Albian-Turonian interval outcropping in Tataouine area. Petrographic analyses are also undertaken to identify the pore system in carbonates and in siliciclastic deposits.

GEOLOGICAL SETTINGS

The Dahar plateau extends from the Jeffara plain margin to Saharian erg. It is constituted of Mesozoic sedimentary series capped by Late Cretaceous carbonates (Fig. 1). The Dahar

plateau beds from a remarkable cliff line on 300 km of lateral extension, from their NE margin. They dip gently at about 1°W and SW, beneath the dunes of the Saharian Oriental Erg. In Chenini section, which located 20 km to the West of Tataouine (Fig. 1), Upper Cretaceous series which are represented by siliciclastic facies overlain by carbonates, are correlable at a regional scale, at least, in the whole Dahar and partly in Libya.

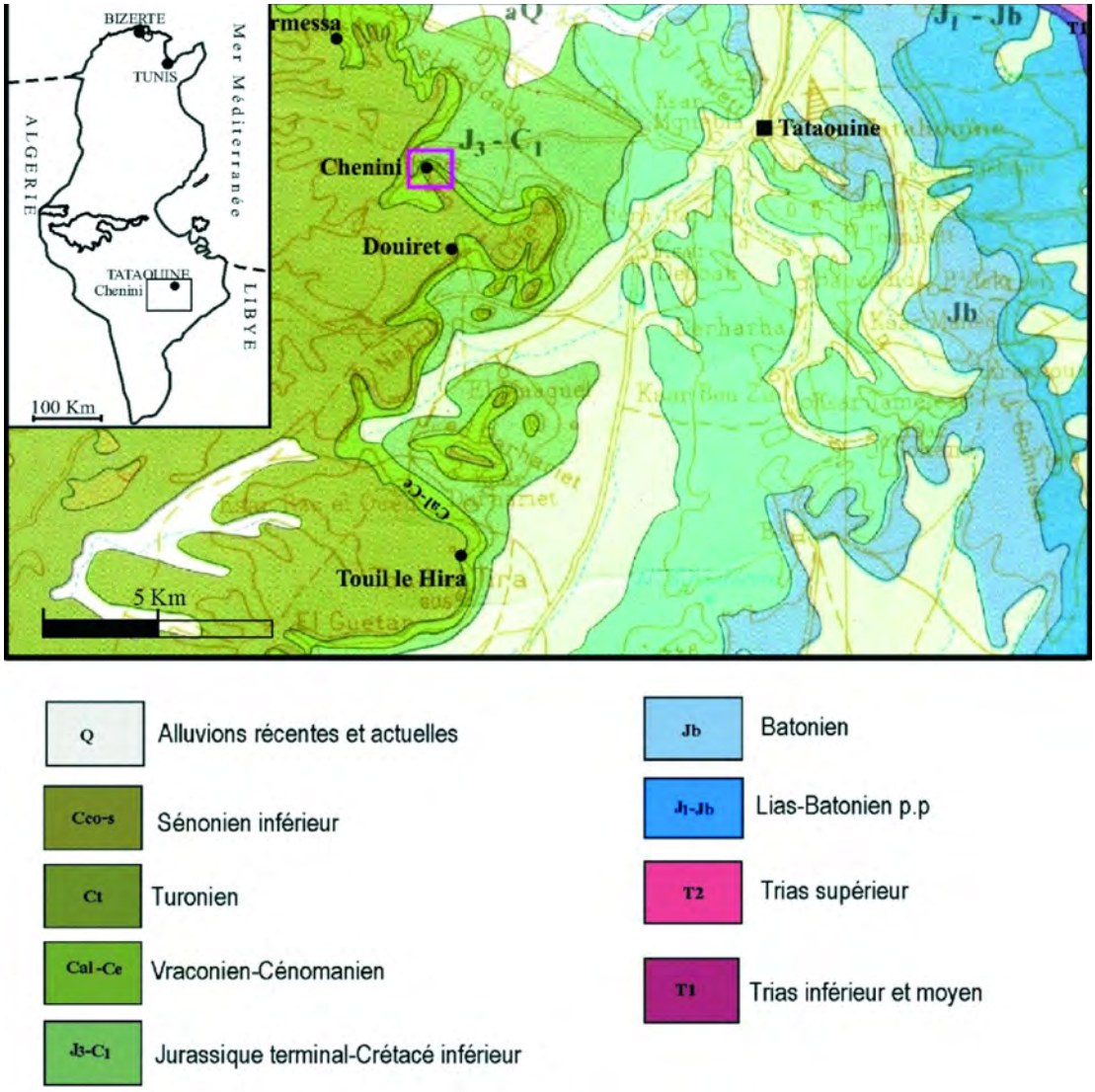


Fig.1: Localisation and geological map of Tataouine area.

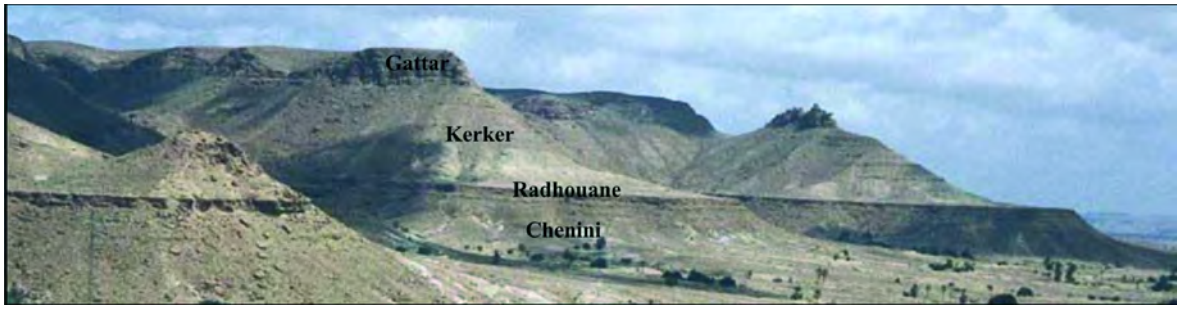
LITHOSTRATIGRAPHIC EVOLUTION OF THE UPPER CRETACEOUS IN CHENINI SECTION AND PALAEOENVIRONMENTS

In Tataouine area, Upper Cretaceous formations are represented by siliciclastic deposits overlain by carbonates locally interbedded with evaporites. From bottom to top, we distinguish the following formations (Fig. 2).

-The Albian Chenini Formation (Burollet, 1963; Tlig, 1978) which unconformably overlain, Aptian clays of the Douiret Formation, is mainly composed of sandstones containing Dinosaur bones and silicified wood fragments (8 m).

In detail, sandstones which consist of quartzarenites to quartzrudites, fossilise cross bedding and flaser bedding structures (Fig. 3) and are organized into fining up ward cycles suggesting subtidal channels probably dealing with a deltaic environment.

- The Upper Albian Radhouane Formation (Handoura, 2005) which well crops out only in Chenini area and to the North is constituted of sandy dolomites containing bivalve and gastropods fragments associated to phosphatic grains (18 m; Fig. 3). These sandy dolomites are organised into shallowing up ward cycles starting by bioturbated sandy and bioclastic dolomites and ending with laminate dolomites containing algal mats. Despite this transgressive aspect of these bioclastic carbonates, the palaeoenvironment which is also shallow marine consist of tidal flats to inner platform environment.



- The Cenomanian Kerker Formation (Bouaziz et al., 1985) which associates dolomites, clays, marls and evaporites (85 m) is subdivided into 3 units (K1, K2, K3; Fig. 3).

- The lower K_1 unit (30 m) starts with dolomites are interbedded with marls containing molluscan fragments and fish teeth. Dolomites which contain quartz, lithoclastes and locally gypsum nodules fossilise lenticular bedding and flaser bedding suggesting an subtidal environment.

Evaporites are mainly represented by massive to laminated gypsum beds. In K1 unit, the progressive vertical transition from carbonates to evaporites is the expression of a restriction of a shallow marine environment and its transitional evolution to a sabkha.

- The middle K_2 unit (7.5 m) consists of an alternation of dolomites and marls.

Marls contain molluscan fragments, phosphatic coprolites and lithoclastes. Dolomites which contain quartz grains, coprolites and lithoclastes are bioturbated fossilise wavy, lenticular and flaser beddings and locally exhibit stromatolithic laminations. In terms of palaeoenvironment, the Kerker K_2 unit is deposited in a tidal flat environment.

- The upper K_3 unit (47.5 m) is wholly composed of bioturbated massive dolomites admitting thin intercalations of marls. Dolomites which contain bivalve and gastropod debris associated to benthonic foraminifera locally show stromatolithic lamination. The summital part of these dolomites shows bivalve borings corresponding to emergence surfaces which laterally change to desiccation breccia, correlable at a regional scale.
- The Upper Cenomanian to Turonian Gattar Formation (Pervinquière, 1907; Burollet,

1956), which consists of a correlable dolomitic series (45 m), is subdivided into 3 units (G1, G2, G3; Fig. 3).

The lower G1 unit (5m), consists of dolomitic limestones containing brachiopods and echinoderm debris.

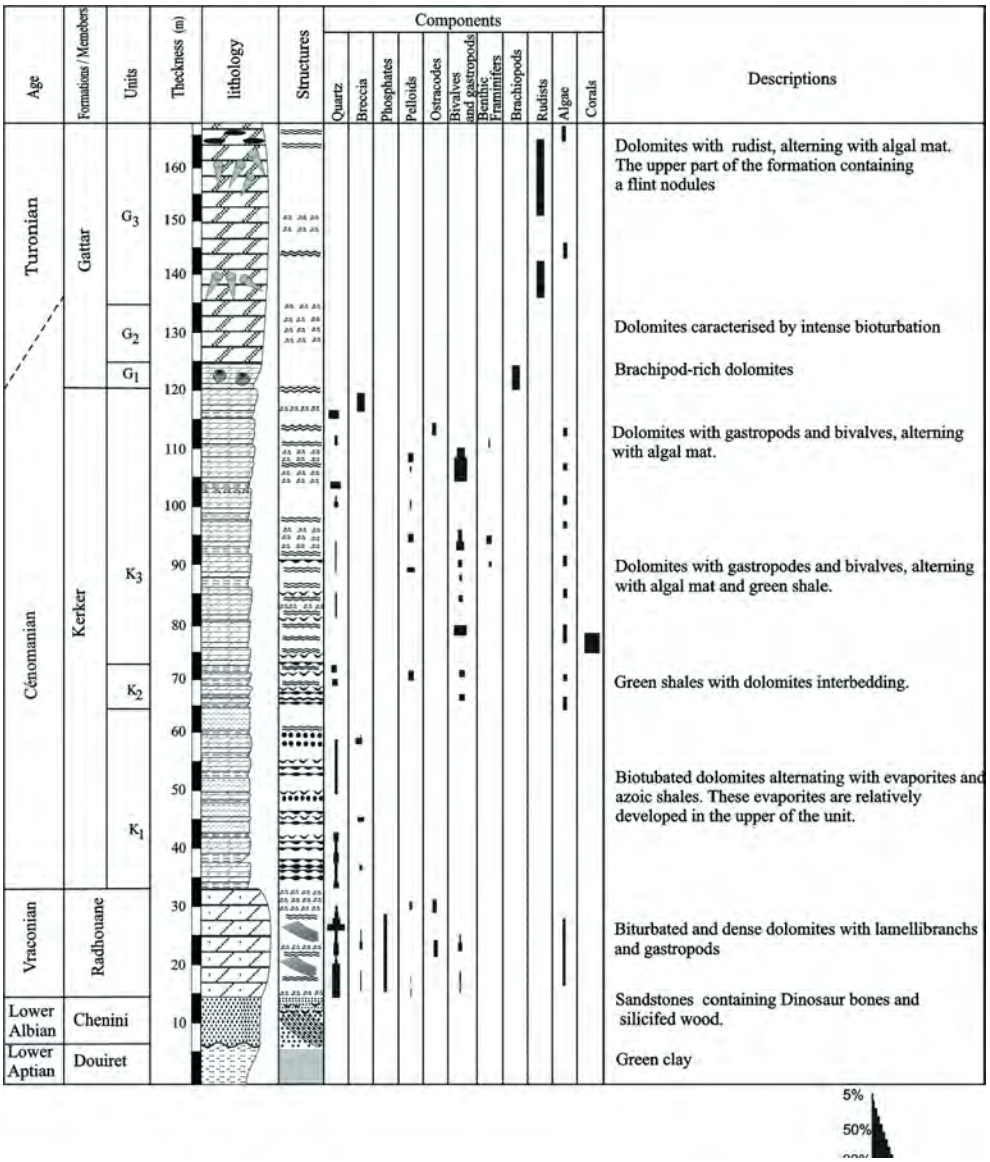


Fig.3 : Vertical evolution of facies in Upper Cretaceous of Chenini section

- The middle G2 unit (10 m), consists of highly bioturbated dolomites.
- The upper G_3 unit (30 m), consists of rudist-rich dolomites interbedded with laminated dolomites showing stromatolithes. The upper part of G3 exhibits flint nodules.

In terms of palaeoenvironment, the transgressive brachiopod-rich carbonates of the Gattar Formation suggest a relative deepening of the environment which corresponds to a regionally extended platform occupies the whole South of Tunisia and the North Western part of Libya.

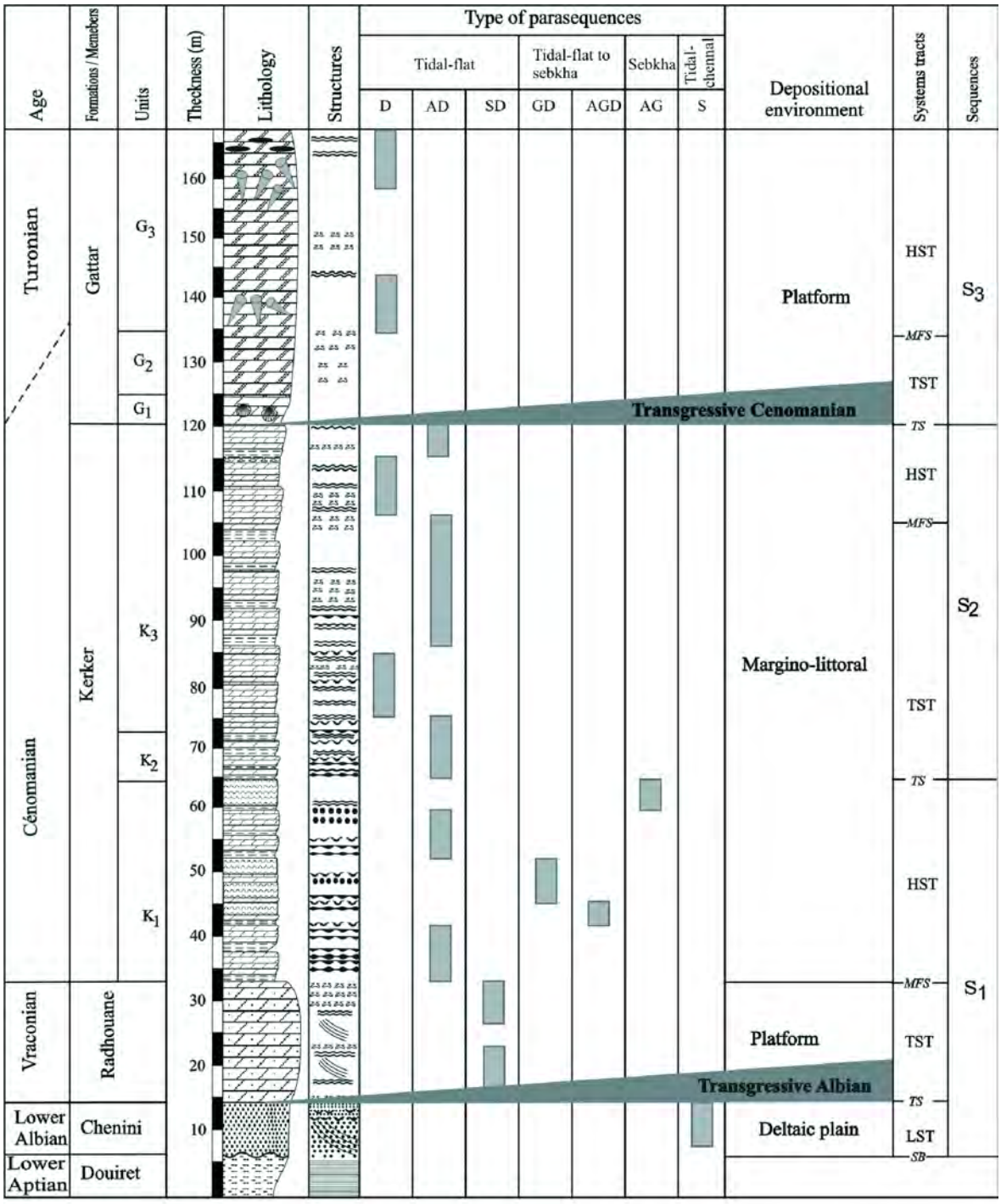


Fig.4: Upper Cretaceous sequences, cycles, parasequences and System Tracts in the Tataouine area (Chenini section).

HST: Highstand System Tract. TST : Transgressive System Tract. mfs : maximum flooding surface. LST : Lowstand System Tract.

TS: Transgressive Surface. SB : Sequence Boundary.

D: Dolomites. AD: Argillaceous dolomites. AGD: Clays-Evaporites-Dolomites.

GD: Evaporites-Dolomites. S: Sandstones. AG: Clays-Evaporites. SD: Sandy dolomites.

The evidence of entire to fragmented rudists suggests a platform biostromal origin of the Gattar carbonates.

SEQUENCE STRATIGRAPHY

During the Late Albian, the vertical transition from sandstones to carbonates is expressive of a regional transgression coinciding with the deposition of bioclastic carbonates. Other eustatic fluctuations were identified within the whole Upper Cretaceous series in Tataouine area. At least, three sequences (S1, S2, S3; Fig. 4) are distinguished.

1. The first S1 sequence includes the Chenini sandstones, the Radhouane dolomites and the K1 first unit of Kerker dolomites and evaporites.

S_1 which is limited by a sequence boundary (SB) on top of the Douiret clays, coinciding with an erosional base, includes fining upward cycles starting with coarse grained sandstones and ending with siltstones.

The abrupt change to bioclastic dolomites deals with a transgression surface (TS) coinciding with the base of the Radhouane Formation constituting a transgressive system tract (TST). The maximum flooding surface (MFS) is marked by highly bioturbated dolomites rich in micritised bioclasts. This MFS coincides with the base of the first unit (K1) of the Kerker Formation. The whole K1 unit is organised into two to three terms cycles starting by clays and ending with supratidal dolomites and /or evaporites. The K1 unit constitutes a high stand system tract (HST).

2. The second sequence S2 includes K2 and K3 units of the Kerker Formation. It consists of a type 2 sequence starting on transgressive surface (TS) underlined by the occurrence of fossiliferous marls and dolomites directly deposited on evaporites. The transgressive system tract (TST) which includes the whole K2 and the lower and middle part of K3, is composed of bioturbated dolomites and marls fossilising bivalves, gastropods, benthonic foraminifera, peloids and stromatolithes. These facies are organised into tidal flat cycles (Fig. 5). The MFS corresponds to clearly fossiliferous beds mainly containing molluscan fragments and peloids. The high stand system tract, including the upper part of K3 unit, is organised into emersive clayey dolomitic cycles (Fig. 5).

3. The third sequence (S3) which includes the whole Gattar dolomites starts up on a transgressive surface (TS) underlined a carbonatic bed rich in brachiopods and echinoderms, directly deposited on an emergence surface (hard ground or desiccation breccia). The TST includes the fossiliferous dolomitic unit (G1) and the bioturbated dolomites of G2 unit. The MFS corresponds to a highly bioturbated bed. The HST which is formed by the whole G3 unit is dominated by massively bedded rudist-rich dolomites admitting the intercalation of thinly bedded stromatolithic laminated dolomites.

PORE SYSTEM

In terms of reservoir aspects, the main reservoir intervals are formed by the Chenini sandstones, the Radhouane sandy dolomites, the Kerker dolomites and the Gattar carbonates. Reservoir aspects are enhanced by diagenetic modifications such as solution features.

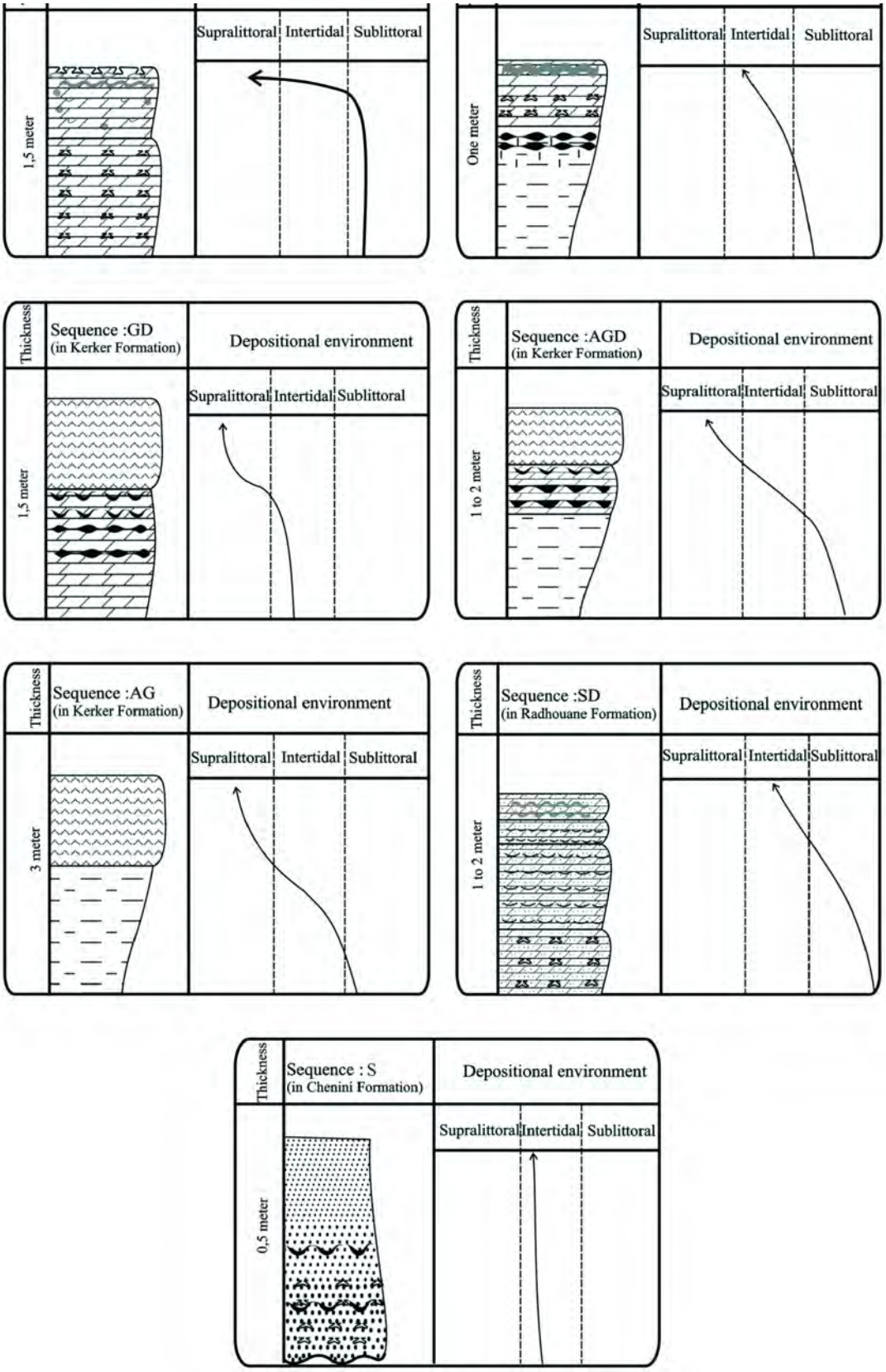


Fig. 5: Cycles and parasequences identified in Chenini area.

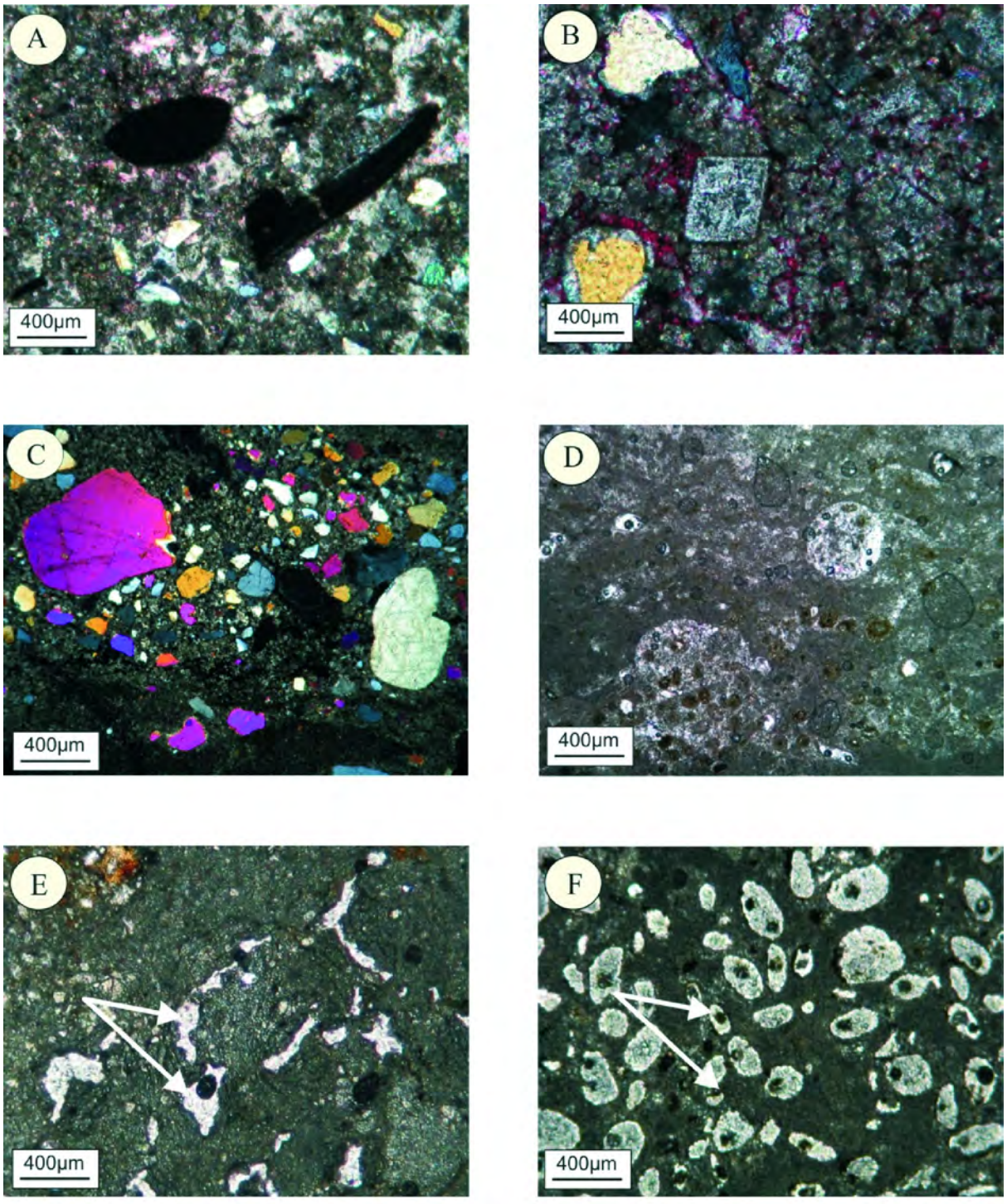


Fig.6: Pore system.

A: Intragranular porosity in the dolomites of Radhouane Formation. B: Intercrystal porosity in the Kerker Formation. C: Intergranular porosity in Radhouane Formation. D: Intergranular porosity in the dolomites of Kerker Formation. E: Vuggy porosity (arrows) in the dolomites of Gattar Formation. F: Vuggy porosity (arrows) in the dolomites of Kerker Formation.

especially affecting Kerker and Radhouane carbonates. Dolomitisation which is more common is responsible of the creation of intercrystal to vuggy pores (Fig. 6).

CONCLUSIONS

The identified sedimentary patterns reflect platform evolution from a probable deltaic plain during the Lower Albian to a shallow marine environment during the Cenomanian, to a platform during the Late Cenomanian-Lower Turonian interval.

A high-resolution sequence stratigraphic framework has been adopted to interpret the deposition history in response to relative sea-level changes, and to subdivide the series record into three sequences based on the identified boundary discontinuities, including transgressive surface (TS) and maximum flooding surface (MFS). The lower sequence, Albian to Cenomanian in age, limited by a sequence boundary, includes Chenini sandstones, Radhouane dolomites and the lower part of the Kerker shales, dolomites and evaporites the second sequence, Cenomanian in age, limited by a type 2 sequence boundary, includes the middle and the upper part of the Kerker dolomites. The upper sequence is constituted of the Gattar dolomites. It starts on a transgressive surface marked by fossiliferous carbonates especially rich in brachiopods.

The petrographic study in Chenini section leads to the identification of the following porosity types:

- Intercrystal pores in Radhouane and Gattar Formation.
- Vuggy pores in Kerker Formation.

On the whole, the Upper Cretaceous (Albian to Turonian) outcrops in Tataouine area, exhibit interesting possibilities of facies in terms of reservoir properties. In fact, siliciclastic and carbonatic reservoirs are largely extended; however, source rocks are not obvious in the studied sector and have to be identified in deeper horizons (Jurassic and/or older facies).

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