The Spatiotemporal Evolution of Lias-Dogger deposits in the Fellat area (Middle Atlas Morocco)

ANJJAR Ahmed[1], BENJELLOUN Faiza[2], AIT HMEID Hanane[3]

Abstract— A series of sections are raised in the region of Fellat allowed the study of Lias-Dogger series in the SW ending of the Bekrit syncline. Like the other sectors of the Middle Atlas, the region studied is straddling the Causse and the pleated Middle Atlas. It is marked by the North Atlas accident. As it is structured in broad synclinal depressions and narrow anticlinal wrinkles. The lower and middle lias, predominantly carbonated, outcrop largely in the stable zones and in the unstable zones that form the major relief lines. As for the Toarcian and the Dogger, where different lithologies mix, whose dominant component is clay or marl, they are confined in the large synclinal structures. The Lias-Dogger sedimentation of the Bekrit syncline is organized according to a sequence with increasing bathymetry. It begins, during the lower Toarcian, by a facies of shallow mudflats, more or less close to shorelines. It passes abruptly into deposits of neritic platform and then evolves progressively towards an outer platform facies deeper and deeper during the Aalenian and early Bajocian. Laterally, the variations of thickness are important and the condensations are extreme on the paléoreliefs longitudinal (anticlinal ridges) and transversal (apex of blocks).The spatio-temporal evolution of the deposits of the Lias-Dogger in the Fellat sector, testifies to a device in "tilted block" which determines a deepening towards the West.

Index Terms— Biostratigraphy, Jurassic, Morocco, Middle Atlas, Sedimentology, Synclinal of Bekrit.

1 Introduction

Morocco belongs to the north-western part of North Africa.It comprises three structural domains [1] which, from North to South, are the Rifan, Atlas, Anti-Atlas and Saharan areas.

In the field of atlasic chains, the cover is formed of deposits mainly of Jurassic age; it is deformed in the pleated Middle Atlas and in the High Atlas. The domain of the atlasic chains, let us remember it, the High Atlas, the Eastern Meseta, the Middle Atlas and the North Eastern Morocco.

The boundary that separates, in the Middle Atlas, the subtabular causse of the folded domain corresponds to the north-atlasic average accident [2]. The most obvious materialization of this major structural line is morphological. Indeed, to the east of it stand the reliefs of the Middle Atlas chain, which generally dominate the high plateaus of Causse, located in the West.

In the pleated Middle Atlas, Meso-Cenozoic deposits are very thick. The general structural style is characterized by the existence of anticlinal wrinkles, superficial expression of basement accidents. They are distributed in the space in four directions: NE-SW dominant, NS, EW and NW-SE. They separate large synforms corresponding to the zones of sedimentary accumulation [3].

2 Materials and Methods

2.1 Geographical and Geological Framework

The studied region belongs to the Middle Atlas, more precisely to its southern part. It was long considered a dependency of the Tabular Middle Atlas (Causses of Al Hammam and Aïn Leuh). The structure, however, is more complex and is in fact a folded zone in large synclines and narrow anticlinal bands which marks the transition between the true tabular Causse and the anticline of Jbel Sidi Ali (Fig. 1).

The syncline of Bekrit spreads from SW to NE for about forty kilometers. It ends, in SW, with a well marked periclinal termination, where it is limited by the accident of Mermel which extends to Ouiouane and no longer to the south. While at the NE, it opens and passes imperceptibly into the syncline of Timahdit. The latter is almost entirely covered by quaternary basaltic effusions.

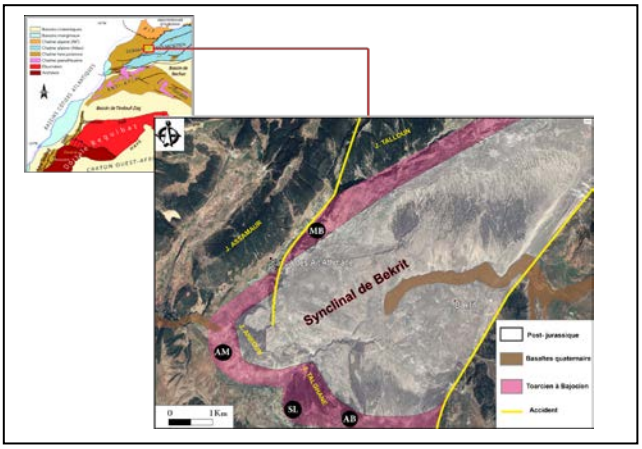

Fig. 1. Schematic Geological Framework of the Bekrit Syncline. MB: Ait Mbarek section; AM: Amzekattane section; SL: Selloum section; AB: Ait

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Bouziane section.

2.2 Methods and utilized terminologies

A series of raised sections in the Fellat region allowed the study of the Lias-Dogger series in the SW ending of the Bekrit syncline; they were closely sampled and allowed us to follow the spatiotemporal evolution of the Lias and Dogger facies. The lithostratigraphic division is realized, it follows the recognition and the definition of a certain number of formations. The study of the fauna and the microfauna is essential to date the deposits and to develop their chronostratigraphic subdivision according to charters. We have traced the different evolutions as we have inventoried the factors that governed them by using sequential stratigraphy and analysis as tools.

3 RESULTS AND DISCUSSION

3.1 Synthesis on research history and previous work

In the NW, the syncline is dominated by the lowered dome of Ain-Kahla, which separates it from the syncline of Afennirer. In the SE, it is limited by the north-Atlas accident which marks the contact with the dome of Aari Nessaa and the syncline of Bou-Angar.

A structural asymmetry, resulting from the tectonic play of the first pleated Middle Atlas wrinkle, is manifested between the very open NW flap and the SE flap, where the series are thinned [4].

The Bekrit syncline offers the most complete and best known stratigraphy of the study area.

H. Termier quickly described an NW-SE section from the Triassic of Ouiouan to the Cretaceous of the Ahroun. He reported the presence at the SW end of the syncline, Toarcian, Aalenian and Bajocian. He harvested a rich fauna in Jbel Selloum [5].

H. Echarfaoui established a sedimentological and micropaleontological study of the Lias-Dogger in the Bekrit Syncline and the Ouiouane Forest [6].

El Arabi and al. demonstrated that the Bekrit area, also called the Selloum block, was not a simple gulf terminating the Middle Atlas towards the SW, but a basin separated from the Middle-Atlas furrow by the high ground of Boulemane [7].

F. El Hammichi [4] studied the biostratigraphy and detailed sedimentology of the Lias-Dogger in this syncline.

3.1 Toarcien and Dogger deposits

Going from SW to NE, Lias and Dogger deposits change in thickness. The stratigraphic log we present is specific to the central Middle Atlas. It shows three types of deposits: sediments reduced from stable zones, those from subsidence regions where they are dilated and those from transition zones in which gravity structures and resedimentation phenomena are the rule (Fig. 2).

The Middle Lias of the stable zones is represented by limestones with large lamellibranchs (Megalodon, Cochlearites or Lithioris) which are, in general, totally dolomitized. On the other hand, in the sub-regions there are limestones limestone and marl-limestones with cephalopods, flint, sponges and coral reefs. In the latter case, the terminal Domérien may be composed of channeled marl.

Lower Toarcian is represented by cephalopod marls which form the continuity of the domed marl; they are laden with limestone and laterally pass to marl or red argillites.

The middle to upper Toarcicn, or even the Aalenian, is composed of nodular limestone in which oolithic and encrinitic limestones are interspersed; they are laterally framed by encrinites and cephalopodic marl-limestones. The Aalenian continues with lime limestones at Cancellophycus which are relayed by the marly-limestones at Cancellophycus (Laéviuscula area) and by the marls which show intercalations of trace limestones of Zoophycos (Zone of Sauzei). These different terms of the Toarcian, Aalenian and Lower Bajocian characterize the subsident zones; they diminish by going towards the stable zones at the level of which they are very small or incomplete[8].

The marls of Boulemane (Zones of Sauzei and Humphriesianum), very powerful subsidiary zones, load limestones in stable areas where they contain limestones, past marl red and evaporites. Their summit (Zone with Humphriesianum), more calcareous, is rich in intercalations of bioclastic limestones, channelized levels, small coralline bioconstrucriers in balls and past of red marl; Note that the frequency of bioclastic spraying, bioconstructions and red marl increases from subsidence areas to stable areas [9].

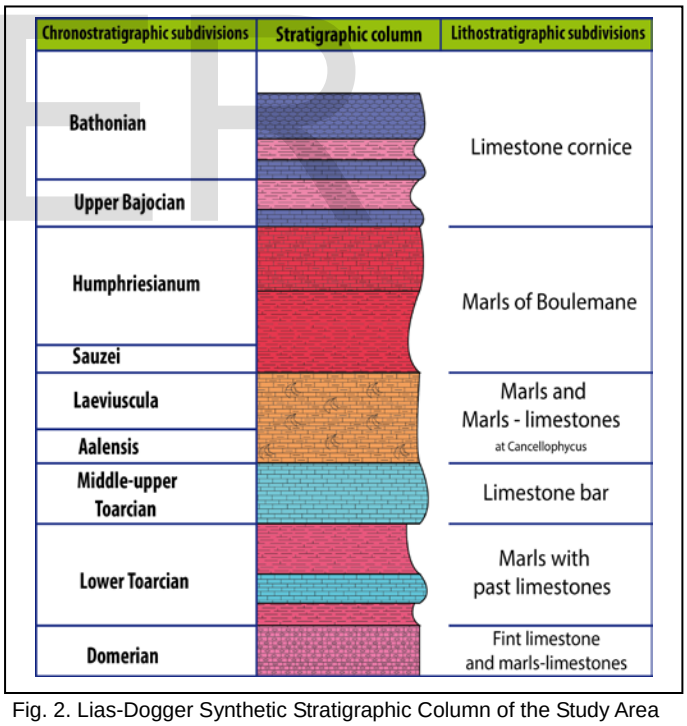

Fig. 2. Lias-Dogger Synthetic Stratigraphic Column of the Study Area

3.3 Spatiotemporal evolution

The evolution of the Middle Atlas in terms of geodynamics of the sedimentary basins was first applied to the central Middle Atlas [10], then to other parts of the central Middle Atlas [11]-[12]-[13]-[14]. Subsequently, it was generalized throughout the Middle Atlas [15] and to the entire field of Atlantic chains [16].

In the Lias and Dogger deposits of the Middle Atlas, several mesosequences formations are distinguished (Fig. 3). They are delimited by sedimentary discontinuities of regional ex-

tension whose materialization changes from one region to another. Some of this hiatus, which can amalgam sideways, are well dated; others, on the contrary, have a random age.

The vertical and horizontal sequences of these lithostratigraphic units, their geometry, their composition and their internal organization are governed by the aforementioned factors. The following work is related to sedimentation control factors or to some of them: [17]-[18]-[19]-[15]-[20]-[6]-[13]-[14]-[21].

During the Toarcian and the Dogger, the Middle Atlas is a deposit area framed by the residual platforms. The general physiography of this basin is inherited from the reactivation of the liasic structural framework. There are major wrinkles, oriented NE-SW and depocentres that are compartmentalized by submeridian and transverse wrinkles.

These paleogeographic and structural schemas, individualized since the Domérien, have changed over time. The remarkable durability of the deformation attests to the reactivation of the substratum, which is palaeogeographically determinant at different times. Note also that the deposits show significant changes of facies and significant power variations depending on whether one is at the right of a wrinkle, in the axis of a depocenter, or on the contrary, on the flanks of these structures.

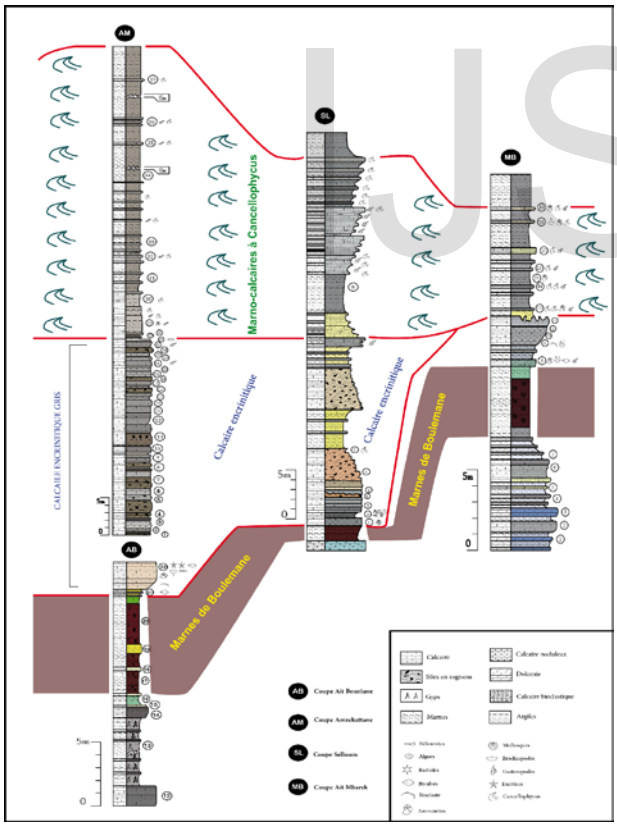

Fig. 3. *Correlations of the Lias and the Dogger of the Fellat Region*

At the scale of the Middle Atlas, the Jurassic deposits show notable spatiotemporal variations. In space, the faciological changes are mainly dictated by paleogeographic zonations. On the other hand, in time, intervene, also, the mobility of the substratum and the rate of the sedimentation. As for the climate and the variations of the sea level, they intervene in both cases.

On a regional scale, the correlations between the different lithostratigraphic units of Jurassic is possible. So the general evolution is under eustatic control. As for the other factors, which govern local developments, they can be assimilated to a background noise.

On the lithostratigraphic level, deposits of the Middle Atlas Jurassic can be grouped into three phases: a carbonate phase which is repeated three times in time; a marly phase which has reproduced itself twice; a phase, which consists essentially of evaporites, silicicoclastites and terrigenous detritics.

As early as the lower Tertiary-Toarcian begins the bedrock of the average Atlas basin, the bulk of whose filling is represented mainly by the aaleno-Bajocian deposits. This backfill, whose ultimate term is detrital, is composed mainly of marls (and / or argillites) and carbonates.

The Toarcian and Dogger deposits are organized into several lithostratigraphic units, which show a certain rhythmicity. They are identifiable and correlated at the scale of the whole basin. In addition, they recorded a significant synsedimentary deformation in relation with the reactivation of the structural framework, established since the Domérien.

Eustatism and climate are the main factors that controlled the nature and distribution of deposits as they guided the paleogeographic zonations. As for the rate of sedimentation and the mobility of the substratum, they intervene only locally: subsidence of depocenters, uptake of wrinkles and influence of borders.

REFERENCES

[1] A. MICHARD (1976) –Elément de géologie marocaine. Notes et Mém. Serv. Géol. Maroc, 252., 408p.

[2] G. COLO (1961-64) - Contribution à l'étude du Jurassique du Moyen Atlas septentrional. 2 volumes. Note et Mém. Serv. Géol. Maroc, n° 139-226p.

[3] F. BENJELLOUN (1994) : Evolution jurassique du Moyen Atlas central : contrôles tectono-eustatique et climatique de la dynamique sédimentaire. Thèse 3ème cycle, Fac. Sci. Rabat, 378p.

[4] F. EL HAMMICHI (2002) -Le Moyen-Atlas Sud Occidental (Maroc) Au Lias Dogger: Contexte Géodynamique, Biostratigraphie (Ammonites) et Évolution Paléogéographique. Thèse 3ème cycle, Université Mohammed V, Rabat, 269p.

[5] H. TERMIER (1936) - Etudes géologiques sur le Maroc central et le moyen-Atlas septentrional. Notes et Mém. Serv. Min. Géol. Maroc, Rabat, n°33, t. 2, pp. 743-1082.

[6] H. ECHARF AOUI (1991) - Etude micropaléontologique et sédimentologique du Lias-Dogger du synclinal de Bekrit (Causse moyen-atlasique, Maroc). Thèse 3eme cycle, Univ. Mohammed V, Rabat, 176 p.

[7] H. EL ARABI, B. OUAHHABI & A. CHARRIERE (2001) -Les séries du Toarcien-Aalénien du SW du Moyen-Atlas (Maroc) : précisions stratigraphiques et signification paléontologique. Bull.

[8] F. Benjelloun, B. Fedan, A. Anjjar, A. Lahrach, M. Boukhir, and A. Chaouni, "Apport De La Stratigraphie Séquentielle Dans L'évolution Jurassique Du Moyen Atlas Central (Maroc)," Eur. Sci. J., vol. 13, no. 21, pp. 155–171, 2017.

[9] B. FEDAN, F. BENJELLOUN, R. Du DRESNAY & M. CHARROUD (1994) –

Les formations de l'Aalénien et du Bajocien du Moyen Atlas (Maroc) dans leurs localités-types. Mise au point historique. Aalénian and Bajocian working groups meeting, Marrakesh 25-31 May 1994, Abstracts, pp.24-26.

[10] B. FEDAN, E. LAVILLE & A. EL MEZGUELDI (1989) - Le bassin jurassique du, Moyen Atlas (Maroc) : exemple de bassin sur relais de décrochements. Bull. Soc. Géol., France, (8), t.v., n° 6, pp.1123-1136.

[11] A. EL MEZGUELDI (1989) –Evolution structurale jurassique de la partie Nord du Moyen Atlas (Marco). Thèse 3ème cycle, univercité de Caen.

[12] M. CHARROUD (1990) - Evolution géodynamique de la partie sud-ouest du Moyen Atlas durant le passage Jurassique-Crétacé, le Crétacé el le Paléogène : un exemple d'évolution intraplaque, Thèse .3ème cycle, Univ, Mohammed v, Rabat, 232p.

[13] A. AKASBI (1993) - Le Moyen-Atlas nord-oriental au Dogger - Contexte géodynamique mésocénozoïque - Comparaison avec le bassin de Guercif et les Hauts-Plateaux. Thèse 3ème cycle en géologie, Univ. Med V, Rabat, 202 p.

[14] A. AKHSSAS (1993) - Le Moyen-Atlas nord-oriental au Lias - Contexte géodynamique mésocénozoïque - Comparaison avec le bassin de Guercif et les Hauts-Plateaux. Thèse 3ème cycle en géologie, Univ. Med V, Rabat, 202 p.

[15] B. FEDAN (1989) - Evolution géodynamique d'un bassin intraplaque sur décrochements : le moyen- Atlas (Maroc) durant le Mésa-Cénozoïque. Trav. Inst. Sci., Rabat, Série Géol. Géogr. Phys. 11°18, 144p.

[16] Ed. LAVILLE, & B. FEDAN (1989) - Le système Atlasique marocain au Jurassique : évolution structurale et cadre géodynamique. Sci. Géol. Mém., 84, pp. 3-28, Strasbourg.

[17] H. EL ARABI, A. CHARRIER, A. SABAOUI, B. OUAHHABI, S. KERCHAOUI, M. BOUTAKIOUT & M. LAADILA (1997) - Le Toarcien et l'Aalénien dans le Nord du Moyen-Atlas plissé (Maroc) : diversité de l'enregistrement sédimentaire et reconstitution du contexte paléogéographique. Bull. Soc. Géol. Fr., Paris, t. 170, n°5, pp. 629-641.

[18] K. BENSHILI (1989) – Lias-Dogger du Moyen Atlas plissé (Maroc), Sédimentologie, Biostratigraphie et Evolution paléogéographique. Docum. Labo. Géol. Lyon, n°106, 1989, 285p.

[19] S. ELMI, Y. ALMERAS & K. BENSHILI (1989) - Influence de l'évolution paléogéographique sur les peuplements au cours du Lias dans le Moyen-Atlas marocain. Sei. Géol. Mém., Strasbourg. 83, pp. 115-131, 2 fig., 3 pl.

[20] A. CHARRIERE (1990) - Héritage hercynien et évolution géodynamique alpine d'une chaîne intracontinentale : le Moyen-Atlas au SE de Fès (Maroc). Thèse d'Etat, Université Paul Sabatier, Toulouse III (Sciences).

[21] Z. BEJJAJI (1994)- Les foraminifères du Toarcien du Moyen Atlas Central(Maroc) Micropaléontologie et Paléoenvironnement. Thèse 3ème cycle, Université Mohamed V, Rabat, 231p.