

Biostratigraphy and correlations of the Devonian of the Moroccan Meseta : a synopsis

أحمد الحسني والمصطفى بنفريكة

Ahmed EL HASSANI & El Mostafa BENFRIKA

Mots-clés : Moroccan Meseta, Devonian, biostratigraphy, carbonated platform

ملخص

البيوستراتغرافيا ومقارنات الدفوني الهضبة الأطلسية : دراسة تحليلية. عرفت الهضبة الساحلية تغيرا في نمط الارساب خلال الديويني بالتوقف النهائي للمؤثرات الصحراوية التي ميزت الباليوزويك الأسفل لتتعرض بتكوينات رصيف قاري كاريوناتي ملائم لتطور المرجان. وقد عرف هذا الرصيف امتدادا كبيرا بحيث شمل ما بين الساحل حاليا ومنطقة ولما شرقا وامتد حتى منطقة الرحامنة والجيبلات الغربية في الجنوب. وخلاف ذلك تميز النظام الارسابي بالهضبة الشرقية بمجموعة فتاتية تكونت من الغرب نحو الشرق تشمل توضعات حطامية صنف ميكروكنكولوميرا ورصيص وفليش وكلس رصافي من الديويني الأسفل والأوسط، تأخذ شكل كتل منقولة ضمن فيزي، منطقتي زكارة وجردة تشبه كتل الهضبة الساحلية. أدى اختلاف هذه الخصائص إلى التمييز بين أربع مناطق أساسية خلال الديويني بهضاب المغرب : - كتلة السهول بالشمال (منطقة قارية وقتئذ) تغلف هوامشها الجنوبية مجموعات الرباط - تيفلت المرجانية وهي ذات نحو امتداد نحو بهرة إيموزار جنوب فاس - رصيف كاريوناتي بالهضبة الغربية. - رصيف ثان بالجنوب الشرقي قد يناسب هضبة وهران. - اخدود عميق شمالي شرقي - جنوبي غربي تطور بين الرصيفين، استقبل ارسابات البحر و الفتاتات.

RESUME

Biostratigraphie et corrélation du Dévonien de la Meseta marocaine : Synthèse. Les couches dévoniennes reposent en concordance sur les terrains du Silurien. Au Dévonien, la Meseta marocaine connaît un changement du type de sédimentation. Les influences sahariennes qui avaient caractérisé le Paléozoïque inférieur vont cesser définitivement et sont remplacées, notamment en Meseta occidentale, par la formation d'une plate-forme carbonatée, où se développeront des récifs. L'extension de cette plate-forme est importante; elle se fait depuis la côte atlantique actuelle jusque dans la région d'Oulmès à l'Est. Vers le Sud, elle se développe dans les Rehamna du Nord et dans les Jebilet occidentales. En revanche, dans la Meseta orientale le régime sédimentaire est caractérisé par un ensemble turbiditique constitué de l'Ouest vers l'Est par des dépôts détritiques à grauwackes, microbrèches et microconglomérats ; des flyschs et des calcaires récifaux du Dévonien inférieur et moyen, sous forme d'olistolites dans le Viséen de Zekkara et de Jerrada, rappelant de ce fait ceux de la Meseta occidentale. Ces différents caractères ont amené à différencier dans le Maroc mésétien au Dévonien quatre zones principales:

- le bloc des Schoul au Nord (zone émergée à cette époque), en bordure sud de laquelle se trouvaient des ensembles récifaux de Rabat à Tiflet, et extension dans la boutonnière d'Imouzzer (au Sud de Fès).

- une plateforme carbonatée en Meseta occidentale à l'Ouest,

- une deuxième plateforme, située au Sud-Est, qui correspondrait à la Meseta oranaise,

- un sillon profond de direction NE-SW, développé entre les deux plateformes et où se déposent des sédiments pélagiques et détritiques.

ABSTRACT

The Devonian series lies with conformity on the Silurian formations. During the Devonian, the Moroccan Meseta has undergone a change in the type of deposition. The Saharian influence, which characterized the Lower Paleozoic, stopped and replaced, especially in the western Meseta, by the development of a carbonated platform with reefs. This platform extended from the present-day Atlantic coast, to the area of Oulmes eastwards. To the South, it developed in the northern Rehamna and the western Jebilet. In contrast, the depositional regime in the eastern Meseta is characterized by a turbiditic set, composed, from west to east by detrital deposits with wacks, microbreccia and microconglomerates, flyschs and reefal limestones of the Early and Middle Devonian, in the form of olistolites in the Viséan of Zekkara and Jerrada areas, similar to those of the western Meseta. These different characters have led to differentiate in the Moroccan Meseta four main zones during the Devonian:

- the Schoul block to the North (an emerged area at this time), on the southern border of which reefal formations existed and extended until the Imouzzer inlier (South of Fes).

- a first carbonated platform in the western Meseta to the West.

- a second platform located to the Southeast, which would corresponded to the Oranian Meseta.

- a deep trough trending NE-SW developed between the two platforms, where deposits are pelagic and detrital.

PRESENTATION

The Devonian strata of the Moroccan Meseta is outlined with a conformity on Silurian outcrops. Sedimentation is continuous from the Silurian to the Late Devonian, where another cycle began.

In the Moroccan Meseta, the Lower and Middle Devonian formations outcrop in Paleozoic structural zones (PIQUE & MICHARD, 1989). The Devonian formations are characterized by facies changes which determined several paleogeographic areas. In the northeastern Meseta, these outcrops are located essentially on the high areas surrounding the Devonian-Dinantian basins.

In the eastern part of Central Morocco, they are represented in the allochthonous transition Azrou-Khenifra zone. In the eastern Meseta, Lower and Middle Devonian outcrop in several inliers, and are affected by deformations of Late Devonian / Intra-Viséan age.

The Devonian formations also outcrop in the Paleozoic massif of Rehanna (Mechra Ben Abbou and Oulad Abbou areas), and in the Jebilet and the "old massif" of the High Atlas.

WESTERN MESETA

CENTRAL MOROCCO

The Devonian series outcrops mainly on the edge of the Sidi Bettache Devonian-Carboniferous basin (PIQUE, 1979). Its northern part is bounded by the Rabat-Tiflet area, oriented E-W. To the west, Devonian series outcrop in two sub-meridian lines of Benslimane and Cherrat as well as to the South in the ENE to NE trending area of Zaer. The two last areas extend to the south-west, respectively by the Mdakra and Khatouat outcrops. Towards the east, they can be observed in the northern Central Morocco (Oulmes area) and in Azrou-Khenifra area.

Rabat-Tiflet area

Lower and Middle Devonian

It is in the region of Rabat, on the right bank of the Bou Regreg river, that the early Devonian strata rest in conformity on the late Silurian one.

The first studies are those of LECOINTRE and DELEPINE (1933), who recognized the Devonian in Khaloua gorges. Later, COGNEY (1957), discovered several Paleozoic faunas in Rabat area, set the stratigraphic succession, and dated the Coblentian and Eifelian.

The Devonian stratigraphy was later refined by ALBERTI (1966-1977), who precised the Lochkovian-Praguian boundary and gave a detailed

description of the Devonian formations.

Studies undertaken by EL HASSANI (1990) permitted the rising of several sections and comparing of facies and thickness in Rabat-Tiflet area. The typical section at Bled Dfa (Bou Regreg right bank) offers a continuous succession from the Lochkovian to the Late Emsian. It consists of platy limestones alternating with black shales conformable on those of the Late Silurian. These limestones are bituminous and include terrigenous debris (quartz). Bioclasts are represented by Lamellibranchiata, Ostracoda and mainly Graptolites (*Monograptus uniformis* and *Monograptus microdon*). The Lochkovian is 60 m- thick. The Praguian is constituted by grey-blue nodular limestones with Tentaculites, Brachiopods and Echinoderms. These limestones are 40 m- thick and contain in their upper part centimetric shaly joints. Early Emsian is represented at the base by cherty limestones, then thick layers of dolomites and recrystallized massive limestones with Lamellibranchiata and Crinoids. The transition to the Late Emsian is marked by an alternation of limestones and black shales with *Anarcestes lateseptatus* Beyrich (EL HASSANI, 1990). Late Emsian corresponds to black shales so-called "schistes carton" by LECOINTRE (1926), with locally some layers of nodular limestones. These shales contain Trilobites (*Phacops* sp.).

The Givetian is not known in Rabat area, but in Tiflet it is characterized by reef limestones with *Favosites cervicornis* and *Cyathophyllum heterophyllum*. In El Khaloua canyon, Givetian is limited to a tectonic lens in Bou Ghachoua syncline (LECOINTRE & DELEPINE, 1933). The Givetian is also found in the form of blocks in the Satour Late Famennian conglomerates and in the northern border of Sidi Bettache basin. Givetian is exposed south of Tiflet river (BENFRIKA, 1994) where blue limestones yielded Conodonts (*Polygnatus varcus*, *P. rhenanus*, *Icriodus brevis*,...).

Other Lower and Middle Devonian exposures are located on the two banks of Bou Regreg river (Ain Dick, Bou Ghachoua,...), in the sides of Sidi Mohammed Ben Abdellah dam (Grou river) and in the Tiflet river valley. In general, we find the same lithological successions for the different levels, except few differences concerning lateral variations of facies.

- At El Mograne (right bank of Grou river), the Lochkovian is characterized by limestones with coarse to middle grain size associated to a benthic fauna suggesting a seaside deposit. This area is considered by ALBERTI (1969) as a shoal more elevated in comparison with Rabat area and that of Tiflet, where the Lochkovian facies indicate a relatively deep-sea.

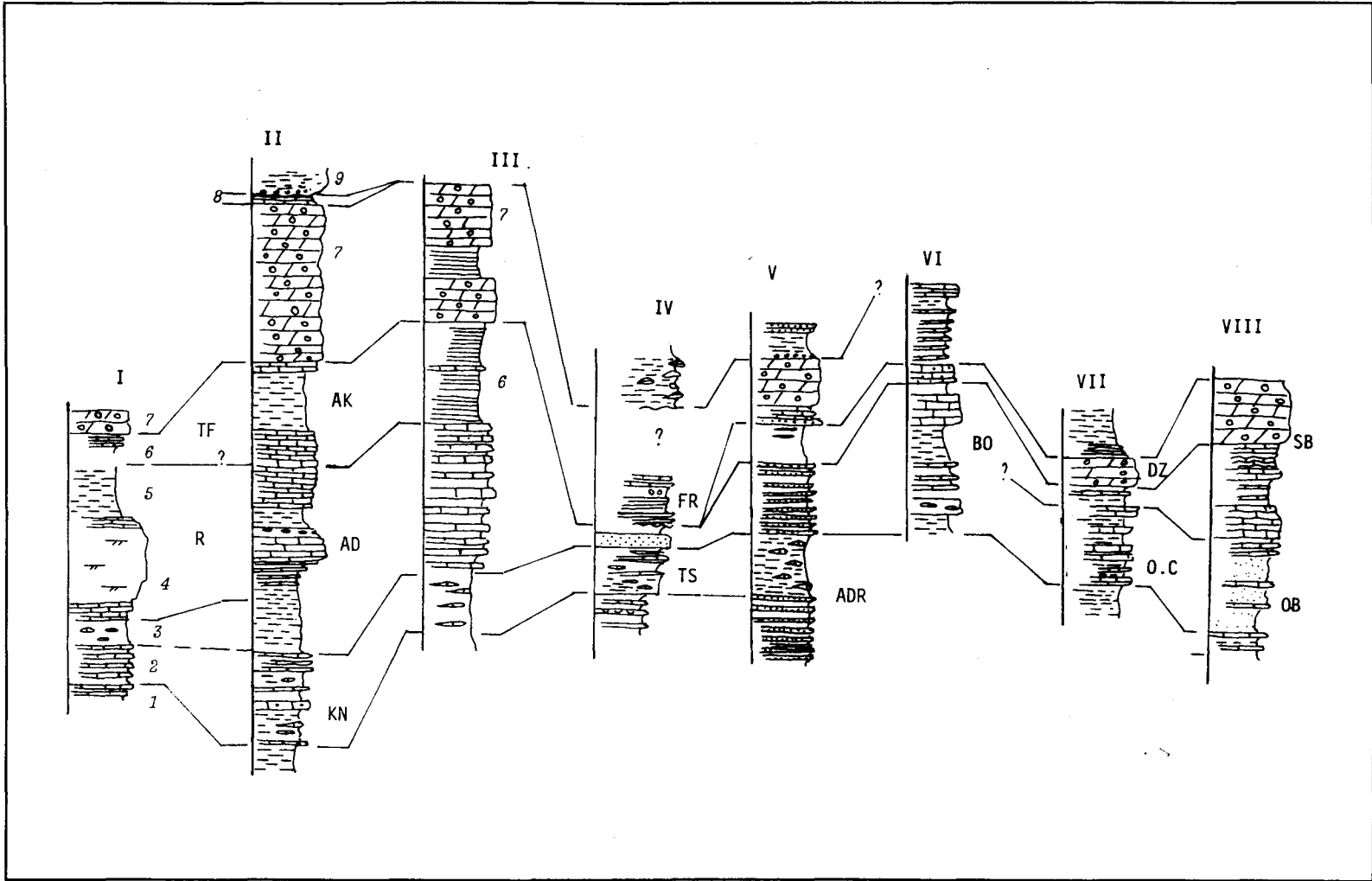


Figure 1 : Devonian correlations in the western Meseta.

I. Rabat-Tiflet area (EL HASSANI, 1990 & BENEFRICA, 1994), II. Oued Cherrat area (CHALOUAN, 1977 & ZAHRAOUI, 1991); III. EL Attamna (Fadli, 1990); IV. Zaer (CHEKIRI, 1991), V. Oulmes area (TAHIRI, 1991); VI. Azrou-Khénifra zone (BOUABDELLI, 1989); VII. Oukad Abbou area (BEN BOUZIANE al; 1993); VIII. Mechra ben Abbou area (EL KAMEL, 1987).
 1. Late Silurian; 2. Lichkovician; 3. Praquian; 4. Early Emsian; 5. Late Emsian; 6. Eifelian; 7. Givetian; 8. Frasnian; 9. Famennian.
 AD. Ain Dakhla; ADR. Ain Dram; AK. Ain Khira, BO. Bouechot; DZ. Douar Zrahna; FR. Friine; KN. Kef Nzaha; OB. Oulad Barka; OC. Oued Cheguigua; R. Rabat; SB. Sidi Boutalaa; TS. Tsili; TF. Tiflet.

- Variations are also noted in the Early Emsian, which is laterally perireefal limestones in Rabat, subreefal limestones and brecciated in Tiflet, whereas in El Mograne the Emsian is partly terrigenous with sandy limestones. These facies persists Lochkovian environment.

On the other hand, the transition from Early to Late Emsian is abrupt in Rabat, with platform carbonates overlain by shales of a deeper and relatively calm environment. However, in Khaloua canyon, the same sedimentation of carbonated platform persists during the Late Emsian.

Mobile carbonated platform

The mobile character of the environment of deposition is encountered in Early Lochkovian. It is materialized by small syndepositional faults with centimetric displacement in the Lochkovian and Praguian, which become decimetric to metric in the Emsian (EL HASSANI, 1990).

Structures related to slumping are observed in Lochkovian and Praguian (Bled Dfa section). Nodular limestones in the Praguian and partly in the Emsian suggest slope deposits governed by mobility of the sea floor. Local variation of thickness of the Emsian layers in Grou river and lateral shift of facies are witnesses of early extensional movements that are responsible for local shoals favorable to develop a carbonated sedimentation.

Late Devonian - Tournaisian

The Early and Middle Devonian formations are overlain by Late Devonian - Early Carboniferous sequences.

+ Chabet Guenfoudia

In Chabet Guenfoudia, a small tributary of Grou river (located some 50 km SE of Rabat), the following succession is found above the Early Devonian clays and limestones :

- gritty mudstones and red-brick shales with microbreccia graded-bedding layers. Size of these elements is variable, from a millimeter to several tens of meters in length.

- thin to large micaceous and microconglomeratic sandstones with floating plants. Shelly limestones contain *Schizophoria* sp., *Productinae* (?*Marginatia* sp.), *Spirifer tornacensis* of Tournaisian age.

- shales and sandstones with desorganized layers (wildflysch).

- greenish lava flow (spilitic basalt).

- green chaotic sandstones, with sandy blocks and grey limestone fragments without an apparent order in a greenish-grey clayed matrix.

- conglomerates with perfectly rounded boulders.

This section, about 500 m thick, is interrupted by a fault. Similar outcrops are followed to the East, reaching the area of Tiflet. The sequence ends by shallow-water arenites and small reefal constructions of Tournaisian age.

+ Ain Hallouf

Ain Hallouf section is situated 12 km south of Rabat. It's base is unknown, and it is composed, from base to top, of :

- pyroclastic materials : sandstones and acidic tufa.

- graywackes and conglomerates ; graywackes are lithic and feldspathic in thick layers, sometimes with a graded bedding. Conglomeratic layers are lenticular. Shale layers associated with conglomerates yielded *Phacops granulatus*, *Dictyodendron* sp., *Platyclymenia protracta*, etc... of Late Famennian. Graywacke layers are affected by intense synsedimentary deformations : folds and shearing indicating reworked unconsolidated material.

- litharenites : sandstones with less abundant matrix, containing quartzitic and phylladic micropebbles and showing oblique laminations.

- Jbel Akala quartzites lenticular layers which correspond to littoral sandy barriers.

This Late Devonian series is 400 m- thick and covered by "Goniatites schists" of Akrech river that represent the Tournaisian. Ain Hallouf formations are interpreted by IZART (1990) as a debris-flow (thick conglomerates with abundant matrix without apparent bedding), turbidites (conglomerates with imbricated pebbles, sandstones and sandy-shales), border channel (quartzites) and finally basin facies (shales and sandstones).

Ben Slimane and Cherrat areas

The Devonian formations of these areas outcrop discontinuously in two north-south shear zones, and are well studied since LECOINTRE (1926). These studies were carried out with an essential stratigraphic goal (DESTOMBES & JEANNETTE, 1966 ; HOLLARD, 1967 ; CHALOUAN, 1977 ; PIQUE, 1979 ; FADLI, 1983 and ZAHRAOUI, 1991).

Ben Slimane area

Sections studied by ZAHRAOUI (1991) in Chabet Hamira, south of Benslimane offer, despite a tectonic complexity, different Early Devonian stages. The presence of Middle Devonian is probable.

The Early Devonian is characterized by a detrital formation that overlies sandy-shales of Late Silurian age. It is represented by a turbiditic sequence (sandstones and pelites). In the lower part, *Monograptus*

uniformis is found in micaceous shales alternating with thin sandstone layers. These sandstones show synsedimentary fold structures and Bouma turbiditic sequences. In the higher part, this series displays more sandy and quartzitic layers with rare sandy-limestone lenses.

These levels are assigned to the Praguian. The Emsian corresponds to a carbonated series separated from the detrital formation by a fault. It consists of cherty and griottic limestones, then Conodont (Belodella) limestones and finally thin limestone layers included in a shale series attributed by ZAHRAOUI (1991) to the Eifelian.

The only levels of Late Devonian - Tournaisian west of Cherrat river area, are Strunian quartzites which form Ben Slimane "Sokhrates" (rocks in Arabic) and which can be found, northwards, near the Cherrat river mouth. West of Ben Slimane area, these quartzites lay on the Devonian series of the "coastal block" or are separated from the Bouznika Cambrian schists by a fault (PIQUE, 1979). To the east, they are covered by limestones and sandy-shales of Late Viséan (ZAHRAOUI, 1991).

Oued Cherrat area

Here, the outcrops are of better quality than in Ben Slimane area. They follow a north-south shear zone and are limited by two faults : they are in contact with Ben Slimane Famennian-Tournaisian formations to the west ; and with the Famennian-Tournaisian formations of Sidi Bettache basin to the east.

The stratigraphic succession is disturbed by several internal faults; however, a synthetic succession can be constructed from the partial sections.

Early Devonian (Fig. 2 & 3)

In Kaf Nzaha section, the Lochkovian is characterized by shallow water deposits (shales and limestones) which lay on Late Silurian limestones, sandy-limestones and pelites with Trilobites, Crinoides, Lamellibranchs and Orthocera.

The Praguian outcrops at the base of Ain Dakhla section, where it is represented by :

- thin sandy-shales layers containing Trilobites (*Phacops*),

- a lower carbonated unit with bioclastic limestones and ferruginous and channelized limestones, that indicate a stirred environment upon a sedimentary discontinuity,

- an upper carbonated unit represented by nodular limestones attesting for an instability of the sea-floor.

The return to a shallow water environment is characterized by carbonated deposits with Bryozoa (*Fenestella*), Trilobites and algae (*Palaepordella lam-*

matonensis).

The Emsian corresponds to a reefal facies announcing the tendency towards the development of a shallow carbonated platform (Fig. 2). These facies are well exposed in Ain Aliliga section, with dolomitic and siliceous limestones (100 m thick), with organic debris and Polyps (CHALOUAN, 1977).

Sequential analysis of Ain Dakhla section (ZAHRAOUI, 1991), show that each of the two units corresponds to a Early Devonian filling up sequence. This filling is accomplished in the Middle Devonian.

Different Early Devonian sections studied and compared to each other in Cherrat river banks show several lateral changes of facies in relation with non-homogeneous bathymetry governed by instability of the sea-floor (sedimentary discontinuities and synsedimentary gliding).

Middle Devonian

The Eifelian is restricted to the southern part of Cherrat area. It is represented at Sokhrat Ben Brahim by dark shales containing some carbonate lenses. This series reduces to 20 m of thickness in the Ain Kheneg Nmer section and is overlain by limestones with Lamellibranchs, Goniatites and Conodonts of Late Eifelian age (CHALOUAN, 1977).

The Givetian is a carbonated formation, and the typical section is situated at Ain El Khira, along the ravine going down to Kef Nzaha. This section, 100 m thick, is constituted by a carbonated succession which contain at the base *Stringocephalus* sp. then *Stromatoporoids*, Corals,...(LEHMAMI & al., 1995). Presence of pseudo-algae (*Kettneramina* sp., *Bisphaera elegans*, *Parathuramina* sp., *Irregularina* sp., *Bisphaera* sp., "*Grimosphaeroides*" *grandisporus*) and Conodonts assemblage attest for a Middle Givetian age.

Late Devonian - Tournaisian

In the Cherrat valley, on the Givetain limestones of Sokhrat Chleuh lie few meters of bioclastic limestones with *Manticoceras*, of Early Frasnian age. The El Brijat formation laying directly on the Givetian limestones, is composed by (CHALOUAN, 1977):

- conglomerates attributed to Early Famennian, with non-sorted and angular elements,

- sandy shales rich in detrital elements upward (150 m),

- breccias, the clastic components of which are Devonian limestones; the matrix contains Late Famennian Conodonts (*Spathognathodus costatus*, *Icriodus cornutus*, *I. expansus*, etc...). To the west, on the left bank of Cherrat river, these levels lay directly on Ain El Aliliga Emsian limestones.

- sandy-shales alternation (300 m).

- conglomerates with carbonate matrix and mostly Devonian reef limestones elements.

- green shales (500 m) with breccia-conglomerate layers, the elements of which are mostly limestones. Laterally, these shales contain *Syringothyris cuspidata* and *Spirifer tornacensis* of Tournaisian age (LECOINTRE, 1926).

- dark limestones;
- phyllitic-shales (650m), with alternation of quartzitic and limestones thin layers.
- shales and sandstones (500m) with andesitic flow. The latter levels belong to the Tournaisian.

Comparison of Benslimane and Cherrat zones shows thickness and facies variations of the Early Devonian series:

- 400 m in Benslimane and 200 m in Cherrat,
- predominance of detrital sedimentation in Benslimane which seems in continuity with the Late Silurian facies, and carbonates with reefal tendency

(Emsian) in the Cherrat zone.

The two zones show differences in bathymetry, which seems to be controlled by sea-floor motions inducing a more active subsidence in Benslimane zone (trough), and uplift tendency in Cherrat zone (shoal), where an insular platform developed during the Givetian. This platform, of exclusively carbonated sedimentation, is devoid of terrigenous elements was bounded to the west by Benslimane trough and to the East by an open sea.

Khatouat and Mdakra zones

The Devonian formations in these two zones were first identified by LECOINTRE (1926), TERMIER (1936) and re-studied in detail by FADLI (1990).

The Devonian outcrops in four areas : Al Gara, Al Attamna (southern prolongation of Cherrat zone), Sibara and the southern part of Khatouat.

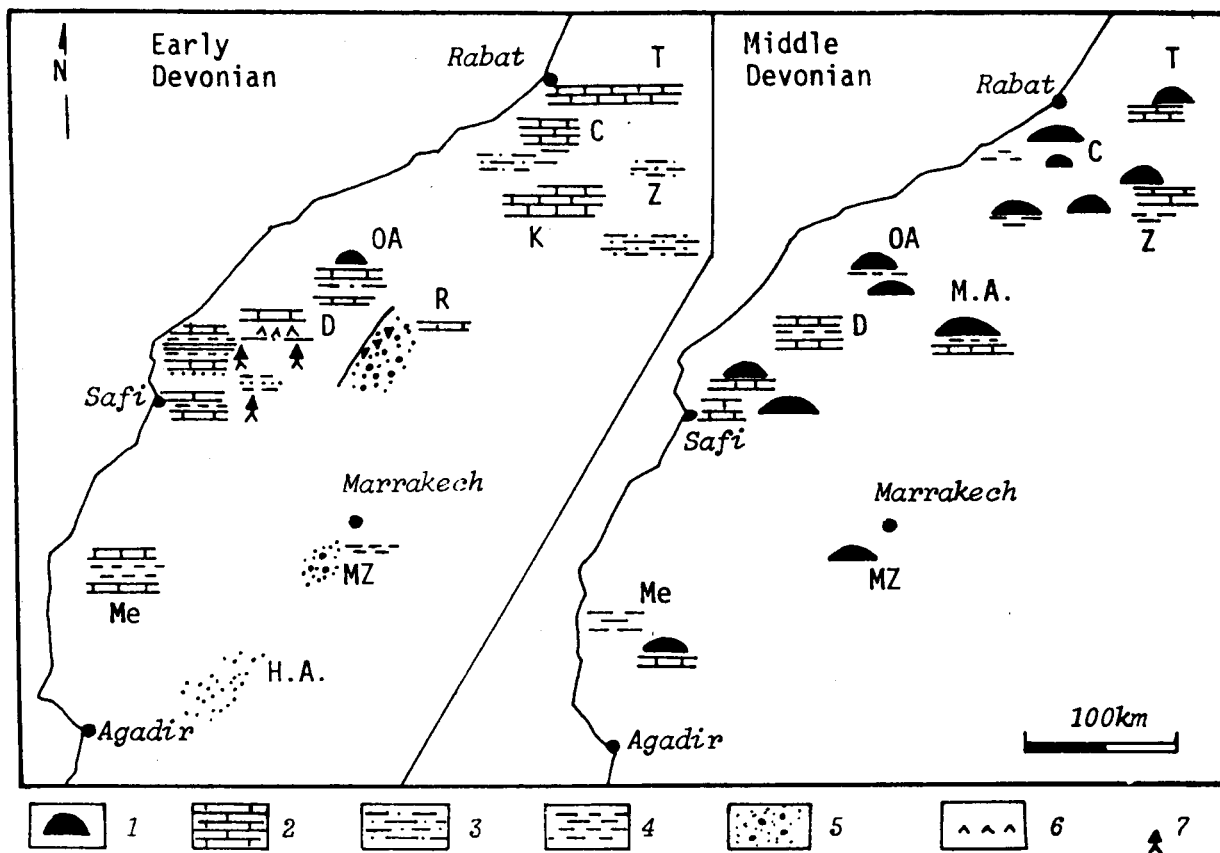


Figure 2 : Facies distribution in the western Meseta (after ZAHRAOUI, 1991).

1. reefs ; 2. limestones ; 3. sandy shales ; 4. shales ; 5. conglomerates and olistolites ; 6. volcanic rocks ; 7 bore holes. T. Tiflet ; C.Cherrat ; Z. Zaer ; K. Khatouat ; OA. Oulad Abbou ; R. Rehamna ; D. Doukkala ; MZ. Mzoudia ; Me. Meskala ; H.A. High Atlas.

Early and Middle Devonian (Fig. 2 & 3)

The Early Devonian formations display a homogenous facies constituted by mudstones with lenticular muddy limestone layers. In Al Gara area (oued Ahmeur), this series contains *Cleistopora geometrica* of Praguian age and is overlain by bioclastic and siliceous limestones of Emsian age.

The same succession is found in Al Attamna area, but with reduced thickness of Emsian limestones which becomes perireefal and conglomeratic with bioclastic and muddy limestone intercalations.

The important differences observed both vertically and laterally in the Eifelian allow distinction of two paleogeographic areas:

- In the western part (Al Gara, Sidi Daoud), the Emsian is composed by shaly deposits with Eifelian Goniatites.

- In the eastern part (Khatouat), the Early Devonian formations are not exposed. The Eifelian is represented by shales with bioclastic, locally conglomeratic, limestone intercalations (Khezzan El Ma, Sibara). Some limy blocks, with Polyps, could be re-sedimented in the Eifelian at El Menzeh and oued Ateuch (FADLI, 1990).

The Eifelian also outcrops in the North-South zone of El Attamna between Khatouat and Mdakra, where it is differentiated by its reefal and perireefal limestones.

In the Givetian, a homogenous sedimentation was established, with reefal limestones in Mdakra, Khatouat and El Attamna, where reefal limestones are more developed (200 m).

The Frasnian, rarely exposed, was identified in Beni Sekten area (Al Gara) by TERMIER & TERMIER (1951). It consists of shales with nodular limestones intercalations (not more than 50 m thick), and is overlain by Famennian conglomerates with sandy limestone elements.

Late Devonian and Tournaisian

Five formations are defined in Khatouat and Mdakra zones by FADLI (1990):

- the Fouizir Formation (800 m) overlies Middle Devonian limestones and contain: Late Devonian Acritarcha (*Micrhystridium* sp., *Unellium pyriforme*,... MARHOUMI, 1984) and *Dzieduszyckia crassicostata* of Famennian age.

This formation is composed by thin sandstones, breccias with heterometric calcareous elements (called Biar Setla conglomerates by TERMIER, 1936) and graywackes. Biar Setla formation, well known in

other areas of western Meseta, is a cliff rockfall of Middle Devonian material and resulting from the repartition of chaotic products collapsing downward slope in debris flows and shifting laterally to proximal turbidites.

- the Chabet El Baya Formation: (400 m) is situated in Mdakra area to the west of Fouizir Formation and its base is unknown. It is a shaly complex containing conglomerate layers with rounded and joined limy pebbles. At the top, sandstones and quartzites with cross-bedding contains Famennian Acritarcha (RAUSCHER, in FADLI, 1990) and is considered as a lateral shift of the Fouizir Formation.

- the Bir En Nasr Formation: (500 m) overlays Fouizir Formation in the Khatouat zone, and is composed by green shales and gray sandstones alternation containing Foraminifera, spores and plant residues of Late Famennian, Strunian and perhaps Tournaisian age(?). This formation is interpreted as a shallow, but subsiding, platform deposit. The material input from emerged terrains is located to the east and north-west.

- the Souk Jemaa Formation: (400 m) is the equivalent of Bir En Nasr Formation in the southern Khatouat and is dated, with certainty, of Late Famennian - Tournaisian (FADLI, 1990). It is composed of shallow-water deposits (sandstones with convolutes and hummocky stratifications) reworked by storms. The source of detrital elements is the Sokhrate area (SSW of Zaer granite), which represents an emerged land at this time.

- the M'Garto Formation (600 m) is the western lateral facies of Bir En Nasr Formation, but it is more shaly. It is composed by green shales alternating with thin sandstone graded layers showing horizontal laminations mostly with convolutes.

The Famennian-Tournaisian paleogeographic reconstruction of Khatouat and Mdakra zones depends on the correlation of these formations (Fig. 3C). The chaotic character of the greatest part of Fouizir Formation results from two emerged terrains bounded by faults in the eastern and western parts of Khatouat (Cherrat and Zaer terrains). The Mdakra zone, west of Cherrat, is characterized by a calm sedimentation on a clayey platform (Chabet El Baya Formation). Then, follows the flooding of Cherrat high which allowed communication of the two marine sedimentation areas (Khatouat and Mdakra). The subsiding Khatouat zone is rapidly filled by detrital deposits from the southern part of Zaer ground, while the probably deeper Mdakra zone was filled by distal thin debris.

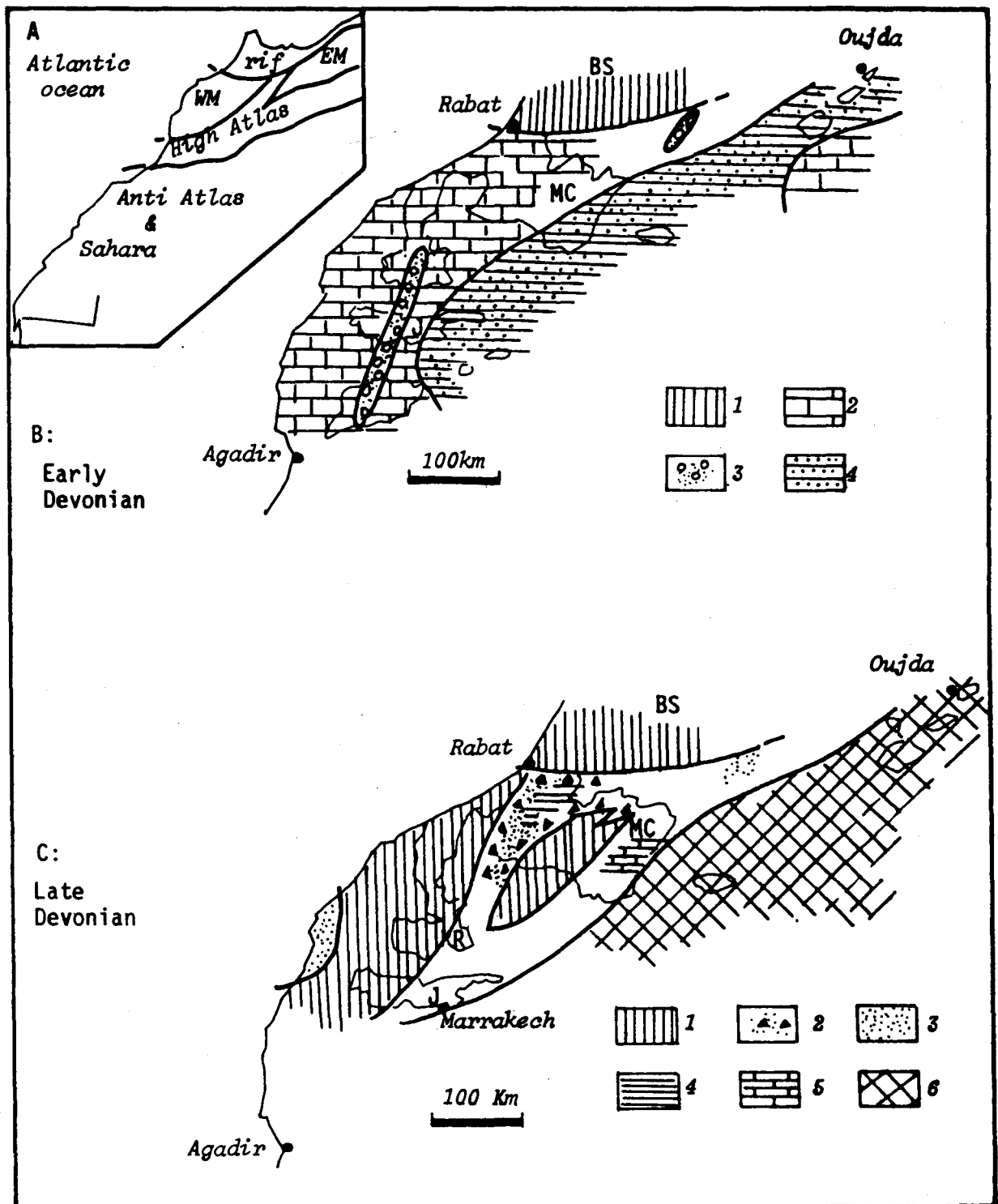


Figure 3 : Devonian paleogeographic maps in the Moroccan Meseta (after PIQUE & MICHARD, 1989, Modified).

BS : Schoul block ; MC : Central Morocco ; R : Rehamna ; J : Jebilet.

A : General situation, WM: Western Meseta ; EM: Eastern Meseta.

B : Early Devonian, 1. emerged land ; 2. shelf limestones and shales ; 3. continental redbeds ; 4. turbidites and pelagic facies.

C : Late Devonian, 1. emerged land ; 2. olistostromes, mudflows and proximal turbidites ; 3. sand ; 4. shales ; 5. pelagic limestones ; 6. covariscan belt.

Zaer Zone

The Devonian is exposed in the northwestern limb of Khouribga-Oulmes anticlinorium, along the ENE to NE Zaer fault strip (ZAHRAOUI, 1991). This zone extends from Sibara (SW) to the south of Tiddas (NE). Early and Middle Devonian deposits appear mostly within Famennian-Tournaisian Formations as tectonic lenses or redeposited blocks. These outcrops are folded and affected by regional metamorphism, to which a contact metamorphism is superposed in the northwestern edge of Zaer granite.

Early Devonian

In the northwestern edge of Zaer granite, an Early Devonian age is assigned to shales and sandy-quartzite facies in which are recrystallized and flattened limestones. Bryozoa and Orthocera traces can be detected. Observation of different outcrops, dislocated by a N70 fault zone, show lateral shift of facies on a short distance in the same series.

The Tsili area, in the eastern part, is constituted of the Sidi El Ghazi shales and sandstones of Early Devonian age. These shales, which contain decimetric to metric lenses of a conglomerate with sandy and limy elements, overthrust Silurian deposits to the south and are overthrust by the Famennian-Tournaisian formations to the north.

Different outcrops, described by CHAKIRI (1991) in the oued Grou and Bou Regreg banks, are composed of:

- Lochkovian greywackes and shales (50 m) and shales with limy balls,
- Praguian limestones (75 m), similar to Atichina outcrops (CAILLEUX, 1974),
- Early Emsian quartzites with Brachiopods (20 m).

Despite metamorphism, it is possible to reconstruct partly the Early Devonian paleoenvironment. Several authors suggest relative subsiding zones separated by limy shoals, or emerged terrains which are a terrigenous deposit source (TERMIER, 1936; GENDROT & AL., 1969; PIQUE, 1979; FADLI, 1983 & 1990; ZAHRAOUI, 1991).

Middle and Late (?) Devonian

The transition from the Early to Middle Devonian is not observed in this area. Middle Devonian deposits only occur as resedimented blocks within the Famennian-Tournaisian Formations. Outcrops are partly reconstructed by ZAHRAOUI (1991), in spite of their fragmentary character and Conodonts lead the author to accept a Givetian age in two points:

- In Koudiat Cherif (northern border of Zaer granite), where Eifelian limy shales are overlain by dolo-

mitic limestones which contain *Polygnatus linguiformis linguiformis*.

- In Jbel Friine (Tsili outcrop) where the calcareous series contains *Polygnatus xylus*.

Facies analysis of several blocks shows that they initially belonged to a shallow carbonated platform with reefal tendency (lagoon, back-reef and fore-reef facies).

Oulmès zone (northern central Morocco)

This zone is well known from several biostratigraphic studies (TERMIER, 1936; COGNEY, 1967; ALBERTI, 1966-1977), based on macrofauna (Goniatites, Tentaculites and Trilobites). These studies were partly integrated in a previous synthesis (HOLLARD, 1967) and in the environmental reconstructions (ELLOY, 1972). The Conodonts (LAZREQ, 1983 & 1992) gives some biostratigraphical precisions, and TAHIRI (1991) retraced paleogeographic reconstructions from analysis and distribution of facies. Bioevents and comparison of facies were also proposed (TAHIRI & al., 1992).

Lower Devonian

The most typical Lower Devonian section is in Ain Dram area, 5 km SE of Tiliouine (LAZREQ, 1983; TAHIRI, 1991). It is constituted by:

- 20 m of Lochkovian, with shales and micaceous graywackes alternating, with thin convolutes and current ripples. It is dated by *Paranowackia intermedia*.

- 50 m of Praguian shales with limy balls, which contain *Reedops browni*, Crinoids and *Nowackia acuria*.

- 30 m of Early Emsian constituted by an alternation of black limestones (with Trilobites, *Nowackia zlichovensis* and *Polygnatus grombergi*) and shales with calcareous nodules which are laterally replaced at Moulay El Hassane outcrop by 100 m of shales, graywackes and quartzites.

- 70 m of Late Emsian represented by quartzites alternating with convoluted and laminated shales and limestones, with *Nowackia barrandei*. Some slumping structures are also observed in this series.

Middle Devonian

The typical section is located in Ain Jemaa (10 Km to the East of Tiliouine) and it is constituted by:

- Ain Jemaa member: 80 m of shales with calcareous nodules. This member is dated as Early Eifelian by the presence of Trilobites, Goniatites, Tentaculites and Conodonts. Nodular limestones with Conodonts, Trilobites and Tentaculites of Middle and Late Eifelian are exposed at the top of this member.

- Bou Sif member: 100 m of Givetian bioclastic limestones with slumps, dolomites and reefal limestones. This member contains Echinodermata, Tetracorallia, Stromatoporoids, Amphipora,...

This section shows lateral variations of facies and thicknesses. Ain Jemaa member consists of 80 m of shales and limestones in the western part (Taliouine) and 50 m of graywackes and shales in the Eastern part (Moulay El Hassane). Bou Sif member is unknown in Moulay El Hassane section while it is represented to the North by 10 m of shales and limestones alternating. These variations are explained by the existence of the North-South-trending Oulmes fault (TAHIRI, 1991).

Late Devonian-Tournaisian

In the NE part of Khouribga-Oulmes anticlinorium, the Late Devonian series of Taliouine is transgressive on the Middle Devonian karstified limestones. The typical section, located at Moulay El Hassane sanctuary, is composed of:

- alternation of limestones and shales (25 m) which contain Tentaculites, Brachiopoda, Lamellibranchiata, Trilobites, Echinodermata and Conodonts (TAHIRI & LAZREQ, 1988 and TAHIRI, 1991). COGNEY (1967) also found *Manticoceras cf cordatum* Sandberger, of Early Frasnian.

- black shales (100 m) with graywacky and psammitic intercalations. The middle part contains some layers of limestones, where COGNEY (1967) found *Cheiloceras cf verneuilli* Munster, and Brachiopoda (*Plectorhynchella roemeri* Dames) of Early Famennian age.

- alternation of psammitic graywackes and micaceous black shales (60 m) attributed to Late Famennian (COGNEY, 1967).

Azrou-Khénifra zone

In this zone, the Devonian strata crop out within the Dinantian formations of Azrou-Khenifra foreland basin. Olistolitic units and synsedimentary nappes derive from the internal zones at the Eastern part of this basin (ALLARY & al., 1971 ; BOUABDELLI, 1982-1989 ; FAIK, 1988 ; LAZREQ, 1992 ; WALLISER & al., 1995). Autochthonous and allochthonous formations are distinguished in this area.

Autochthonous Formations (Fig. 1)

They outcrop in Bouechott area (west of Mrirt) and Bou Trou-Al Açama (25 Km SW of Azrou).

The lithostratigraphic succession of Devonian rocks is as follows: Silurian black shales overlain by

pelites and nodular limestones (Emsian) ; the Lochkovian purple pelites have been here tectonically squeezed; the Eifelian to Givetian sediments are mostly detrital (pelites) with sandy, nodular and cherty limestones; Late Tournaisian basal conglomerates and red greywackes unconformably overlie Devonian strata and show variations in thickness and grain-size distribution along a NE-SW direction (BOUABDELLI & al., 1989).

The typical Bouechott Emsian-Givetian section is constituted by :

- greenish sandy pelites with thin limy layers,
- nodular limestones (25 m) intercalated by sandy limestones. Nodular limestones yield Tentaculites, Orthoceras, Ostracods, Conodonts and Crinoids.

- green to dark shales (150 m), with rare calcareous layers. In the lower part, these shales show considerable amounts of Tentaculites.

- alternation of sandy limestones with cherts and sandy pelites with Tentaculites, Ostracodes and some Conodonts. This level is dated as Late Emsian.

- greenish sandy pelites and nodular limestones with Goniatites, Tentaculites, Lamellibranchiata and Conodonts of Eifelian age.

- purple pelites (150 m) with calcareous intercalations, containing Tentaculites, Trilobites, Ostracoda and Conodonts of Givetian age.

The Devonian section is more complete in Bou Trou Al Açama area (BOUABDELLI, 1982 ; HABIBI, 1988). Indeed, the section (500 m thick) is constituted by a lower detrital sequence and an upper carbonated sequence:

- Bou Trou quartzites with lateral variations of thickness (20 to 30 m). This member contains Trilobites (*Opisthoparia*) and Graptolites attributed by MORIN (1957) and Huvelin (1970) to Late Silurian - Early Devonian.

- sandy pelites and sandstones (150m) with brecciated sandy layers where solitary Corals and shells are reworked. Conglomeratic lenses with bioclastic elements are observed at the top of these levels. Finally, quartzite layers (20 m) with graded-bedding and cross-bedding end this member which represent the Lochkovian-Emsian (?).

- reddish sandstones and sandy pelites (90 m) where HABIBI (1988) found Trilobites (*Phacopidae*) of Late Praguian-Emsian.

- alternation of limy sandstones and limy pelites (100 m) with shaly calcareous nodules where Tentaculites and Encrinus are found.

- Cherty limestones (20 to 50 m) with dark oncholithic limestones in the Upper part. This member contains Givetian Conodonts (*Polygnathus linguiformis*).

- greyish griottic limestones (30 m) alternating with yellow marly layers. This member contains Tentaculites, Brachiopods Gasteropods and Conodonts (*Scaphignathus velifer*, HABIBI, 1988), and is overlain by sandy limestones and encrinitic and bioclastic limestones. According to the paleontological elements, this member is attributed by the authors to the Famennian.

Allochthonous Formations

These formations belong to thrust slices (ALLARY & al., 1971 ; BOUABDELLI, 1989 ; WALLISER & al., 1995). The most typical and complete sections are Touchchent (12 km to the SW of Mrirt) and Bou Nebdou (SW side of Gara de Mrirt).

Bou Nebdou section (HOLLARD & MORIN, 1973 ; TERMIER & al., 1975, 1977 ; BEN SAID, 1979 ; FAIK, 1988 ; BOUABDELLI, 1989) is composed of :

- greenish sandy pelites with some sandy calcareous layers which contain Dacryoconadiae of Early Emsian (WALLISER & al., 1995).

- sandy limestones with cherts (10 m) overlain by pelites and limestones (50 m) which contain *Anarcestes lateseptatus* of Late Emsian and Eifelian (BEN SAID, 1979).

- grey nodular limestones and marls (20 m) overlain by greenish pelites (50 m) of Givetian age.

- grey *Manticoceras* limestones (10 m) with variable thickness of the individual beds (6 to 30 cm). The sequence is constituted by three Frasnian levels with dark micritic limestones alternating with black shales. They contain a rich pelagic and some necto-benthic fauna, mainly *Manticoceras*, *Orthoceras*, *Tentaculites*, *Conodonts*, small *Bivalves*, *Ostracodes* and *Trilobites*.

The Famennian is represented by *Cheiloceras* griotte limestones with variable thickness (5 to 30 cm). They are micritic limestones with bioclasts, alternating with mudstone levels. Some thick mudstone layers contain interbedded nodular limestones. Beds overlying the *Cheiloceras* limestones are typical griotte and have an undulating appearance. They are composed of pink and purple nodules.

REHAMNA (OULAD ABBOU AND MECHRA BEN ABBOU) : Fig. 1 & 2.

Devonian formations are largely represented with variable facies in these zones, and are studied by several geologists, but there still exist some biostratigraphic difficulties, caused by the complexe structure.

Early Devonian

The transition from the Silurian to the Devonian in the eastern Rehamna is progressive. The Early Devonian formations begin by coarse clastic deposits: conglomerates and red sandstones containing vegetal traces, which attest for the proximity of an emerged land, considered as a source of these detrital sediments. These are overlain by shales including bioclastic limestones and red sandstones. From the Lochkovian to the Praguian, sediments accumulated under shallow marine conditions in the western part near an emerged land, to open marine environments in the Eastern part, toward Mechra Ben Abbou "basin".

The western ridge of this "basin" shows several traces of synsedimentary tectonics: quartzitic, sandstone and limestone blocks in a shale matrix, and synsedimentary faults. This ridge is also characterized by terrigenous sediments supplied from eroded reliefs by torrents (EL KAMEL, 1987).

Middle Devonian

During the Late Emsian, the depositional environment changed, as the detrital deposits of Lower Paleozoic are essentially overlain by carbonated sediments.

During the Late Emsian-Givetian, marine basement uplift or/and sea-level decrease allowed development of a carbonated platform. This reefal ecosystem started at Oulad Abbou during Emsian and extended to Doukkala area. It is organized on reef belts including fringing reefs, reef barriers, surrounding terrigenous marginal basin (RABATE, 1976). This paleogeographic configuration is completed by the presence of an emergent land (shoal): "môle d'Imfout" which is considered as the detrital source for the marginal basin. Mechra Ben Abbou carbonated platform should have been bordered to the West by a reefal complex eroded at present.

At the end of the Givetian and the beginning of the Frasnian, reefs migrated to the East and particularly developed in the Mechra Ben Abbou "basin" (Fig. 2). Carbonates in this area are represented by Eifelian-Givetian reefal limestones, which are the equivalent of Foum El Mejez limestones, attributed to Givetian-Early Frasnian. This reefal migration from the west to the east is also found in other Mesetan areas (oued Cherrat: GENDROT & al., 1969). It should be the result of marine basement uplift associated probably to the fall of sea-level. It is attested by the increasing surface of "môle d'Imfout" (emerging) at in the same time sea withdrawal to the East. These occurrences are rela-

ted to general emersion of the Western

Rehamna during the Late Frasnian and probably the Early Famennian.

Late Devonian

The Rehamna, emerging from Late Frasnian to Early Famennian, are transgressed by the Famennian sea. Foug El Mejez graben, developed in the Western part of the Rehamna, received deltaic deposits. They are relayed by fine shaly facies in the northern extension of Sidi Bettache basin. Coarse clastic facies located at the top of the Famennian formation is the result of the progradation to the North of a deltaic system. Neritic conditions developed during the Strunian. After this lateral accretion, shoals bordering Famennian basin were partially submerged. Foug El Mejez basin, where the sedimentation rate was more important than subsidence, was filled. At the same period, Sidi Bettache basin was still subsiding and received chaotic material and volcano-clastics on the ridges; while, in the center, there were fine detrital deposits. The Late Devonian of Oulad Abbou area is represented by shaly and pelitic facies with fauna of an open marine environment.

In the western Rehamna, the Foug El Mejez formation is 300 m thick (HOLLARD & al, 1982). It is represented by sandstones and silts including quartzitic thick layers which contain *Buchiola* and *Cyrtospirifer verneuilli*. This formation is overlain by Late Famennian/Tournaisian sandy carbonates which are transgressive on Middle Devonian karstic limestones in the Nahilat area. Progressive unconformity by Strunian sandstones and Late Famennian pelitic sandstones of Foug El Mejez is related to block tilting.

Toward the northwest, the chaotic and channelized Bled Mris formation containing quartzitic blocks, is attributed to Late Devonian (PIQUE, 1972). Characteristic sequences of these deposits are developed in the western margin of Sidi Bettache basin. The Foug El Mejez formation should probably be the equivalent of Cherrat formation, however, sediments are folded and metamorphosed in central Rehamna and make correlations difficult between the two areas.

JEBILET

The Devonian formations, exposed mainly in eastern Jebilet (Bou Marhara, Smaha,...) and in Western Jebilet (Jbel Ardouz and Skhirat), and correspond to allochthonous or para-autochthonous series (HUVELIN, 1977; TAHIRI, 1982). They belong to different sedimentation provinces; the eastern part shows formations identical to Eastern Central Morocco

(Azrou-Khenifra zone) and Ait Tamellil zone (High Atlas), the western part is similar to Mechra Ben Abbou Formations (Rehamna).

The Eastern Jebilet allochthonous Formations are as follows :

- siliceous shales and pelites (50 m) with Graptolites of Late Silurian-Lochkovian,
- green shales (50 m) with *Bivalvia*,
- sandy micaceous lutites with limy nodules where Tentaculites are found, and griottic limy lenses (50 m) with slumping marks. *Phacops (Reedops) intermedia* Barrande of Praguian age was found by HUVELIN (1977),
- shales with bioclastic calcareous intercalations (15 m) with Tentaculites,
- sandy flysch (20 m) containing some conglomeratic lenses where are included calcareous elements with Tentaculites,
- green pelites (150 m),
- flyschoid series (400 m) which contain some sandy calcareous layers with Middle Devonian Conodonts.

The western Jebilet Formations outcrop in Skhirat Unit and mainly in Mzoudia (Jbel Ardouz).

The Devonian of Mzoudia corresponding to thrust slices are synthesized by TAHIRI (1982) as follows:

- shaly sandstones Formations with red conglomerates (48 m) attributed to Early Emsian,
- a calcareous Formation (grey-blue, dolomitic, shaly, cherty, reefal and Goniatic limestones), brown dolomites and marly limestones. This Formation is attributed in its lower part to the Eifelian (KERGOMARD, 1970) and to the Frasnian in its upper part (HOLLARD, 1967).
- sandy quartzitic Formation of Late Famennian (HOLLARD, 1967).

WESTERN PART OF THE HIGH ATLAS PALEOZOIC INLIER

The Devonian sequences in the allochthonous Ait Tounart nappe are dated from Lochkovian to Late Frasnian times (CORNEE & al., 1990). Thick siliciclastic deposits occur during Lochkovian time while Praguian-Frasnian rocks are mainly made of a thin carbonated sequence. These Formations are close to those of similar age, known in northwestern Morocco.

EASTERN MESETA

From Taza to Oujda, the eastern Meseta is a subsiding domain during Devonian time, characterized by a flyschoid sedimentation which distinguishes it from the western Meseta (Fig. 3).

The Early and Middle Devonian formations outcrop in western Tazekka, Debdou, Mekkam,

Boudoufoud and Beni Snassene areas. In general, Devonian facies of these regions are mainly detrital and fine grained (flyschoid sedimentation). Their age was confirmed by palynological dating (MARHOUMI, 1984 ; HOEPFFNER, 1987) as Early Devonian (Beni Snassene), Early to Middle Devonian (Emsian-Eifelian: Tazekka and probably Boudoufoud), Middle to Late Devonian (Givetian-Frasnian : Debdou, Mekkam).

Homogeneous sedimentation is observed in all these regions: alternation of grey or green mudstones and cross-bedded siltstones with slumps. These levels are interrupted by rough graywacky and arenitic sediments (turbidity currents).

The Devonian of Western Tazekka is mainly constituted by a micro-brecciated and arenitic Formation with plant debris (oued Bou Ayach Formation, HOEPFFNER, 1987). The Bou Ayach Formation (320 m) is composed of :

- black shales of Lochkovian,
- gray shales and sandstones with slumps,
- rhythmic settling of shales and convoluted sand stones,
- alternation of graywackes and black shales,
- massive graywackes,
- alternation of graywackes and pelites,
- massive graywackes,
- alternation of graywackes and pelites with plant debris (4 to 5 cm long), particularly abundant, which are observed in some sandy shales and in thin graywacke layers.

Palynological investigations were undertaken by HOEPFFNER (1987) in three shaly levels ; they contain Chitinozoa, Acritarcha and spores of Early to Middle Devonian.

The Devonian does not outcrop to the East, but HOEPFFNER (1987) outlined, within the Carboniferous series, some exotic blocks of Devonian reefal limestones coming from the East or the South-East.

MIDDLE ATLAS BASEMENT

In the basement of the Middle Atlas (Immouzer du Kandar outcrop, South of Fes), Conodonts succession (Emsian to Early Frasnian) permits to date the sedimentary and paleogeographic evolution of this region and to enhance the similitudes with the North-Eastern part of Moroccan central Meseta (CYGAN & al., 1990). The stratigraphic section is as the following :

- Ain El Beida shales, with several Praguian-Emsian Trilobites.
- Chabat Jenanat polygenic conglomerate which becomes upwards coarse graywacky sandstones with Brachiopods (BRICE & al., 1983) and Lycophytes.

- Carbonated Devonian series:
 - * lenticular and bioclastic limestones with Crinoids,
 - * nodular limestones (12m) with Cephalopodes, Tentaculites and Conodonts. These limestones are "Orthoceratitico-Rosso" and "Goniatitico-Rosso" type. In the Middle part micritic limestones contains *Agoniatites* sp. and *Anarcestes lateseptatus* Beyrich.
 - * lutites and siltites with plant (25-30 m) with terrestrial influences (vegetal remains).
 - * bedded limestones (1 to several meters) with Tentaculites. It corresponds to black micrite showing regularly Conodonts and accumulation levels of Tentaculites shells.
 - * decametric lenses of reef breccias with non-sorted elements constituted by fragmented organisms (solitary Madreporaria, Stromatoporoids,...) and lithoclastic fragments (bioclastic limestones and micrites with Tentaculites).
 - * lutites with pebbles (20 to 30 m thick) and sometimes conglomeratic or gravel levels. Neretic fauna (Brachiopoda of Frasnian age) is included at the base and the top of the series.
 - * limestones and marly calcareous (40 to 50 m thick) which contain in the middle part a fossiliferous level with Famennian IV/V Brachiopoda (BRICE & al., 1983).
 - Thick flyschoid formation of Famennian-Tournaisian age.

CONCLUSION

The Devonian is a key-period in the sedimentary and tectonic evolution of Central Morocco. At that time was set the paleogeographic configuration and the earliest hercynian movements. The Early Devonian sedimentation continues conformably the Late Silurian one and it is characterized by calcareous material in relation with decrease of terrigenous supply from the West African craton and a climatic warm up.

Three paleogeographic zones are distinguished in the Moroccan Meseta (Fig. 3) :

1- western carbonated platform zone (western Meseta) : in detail this platform is not homogeneous; it was subdivided during early and middle Devonian in several sedimentary areas with various material and corresponding to calcareous ridges or deep shaly grooves with rare calcareous alternations. Reefal constructions are observed at the border of some emerged areas.

2- transition zone corresponding to eastern part of central Morocco massif, characterized by different facies in the allochthonous and autochthonous sections.

3- turbiditic zone (eastern Meseta), with turbiditic and pelagic sedimentation coming from emerged areas.

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Authors address:

Ahmed EL HASSANI
Département de géologie,
Institut Scientifique
B.P. 703 Rabat-Agdal

El Mostafa BENFRIKA
Département de Géologie
Faculté des Sciences, Ben Msik,
Casablanca