Lithostratigraphy and evidence of an extensive tectonic of Lower Permian age in the continental deposits of M’tal (Western Rehamna, Morocco)

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Abstract: In this study, a synthetic lithostratigraphic profile was established in the Permian basin of M’tal. It is made of a detrital series of approximately 450 m. Two formations could be identified: A basal conglomeratic with abundant matrix (Ouled Mira formation) overlayed by a sandstone-silts formation (Bir Enhass formation).

A systematic analysis of the synsedimentary fracturing reveals that this fault network and the opening of the M’tal basin was activated during East-Western extension.

Keywords: Lower Permian, Late-Hercynian, Tectonic, Geodynamic, Western Rehamna, Morocco.

I. Introduction

The Permian deposits are known in Moroccan Meseta and High Atlas. Those basins was studied in detail in the central Morocco ([11], [2], [3], [4], [5]), in the eastern and southern Rehamna ([11], [6], [7]) and in the High Atlas ([8], [9], [10]). The present study shows for the first time, the evidence of an extensive tectonic of probably lower Permian age in the basin of M’tal (Western Rehamna) (Fig. 1). Indeed, through the existing work, the late-hercynian geological history is slightly known between the westphalian and the deposit of the first terms of Permo-triassic in this region. During this period, multiple sedimentary and tectonic events have occurred. We will study particularly those events. This analysis is followed by a comparison with the similar events described in the other late Palaeozoic basins of Morocco.

![Fig. 1: Location of the M’tal basin in Moroccan Meseta.](image)

II. Location and tectonic features

The sedimentary basin of M’tal outcrops within a submeridian gutter of approximately 8 km in length and 3 km in width. It is located on the western extremity of the Palaeozoic Hercynian massif of Rehamna, approximately 100 km south from of El Jadida, on the road to Marrakech, near Jemaâ M’tal locality (Fig. 1). This basin is
situated parallelly to the submeridian (N176-170) M’tal Fault which marked the western margin of the basin. The fault, approximately 20 km in length, is located in the south of Jemâa M’tal locality at 500 m and skirts the road of Marrakech. The equivalent of these formations, in the basin of Mechraa Ben Abbou (southern Rehamna), is lower Permian [11]. Based on the analogy of the facies, the geological history and the geographical proximity, the deposits of the basin of M’tal can be assigned to the same age.

### III. Lithostratigraphic study

With an aim of specifying the detailed lithology of the various formations of the Permian basin of M’tal and of evaluating its thickness, as well as the conditions of deposits, four sections (A, B, C, D) was realised through the basin. Owing to these cross sections, a synthetic lithostratigraphic profile was established. It is made of a detrital series of approximately 450 m (Fig. 2). Two formations could be identified:

- A basal conglomerate with abundant matrix training whose pebbles are sometimes imbricated (Ouled Mira formation),
- A sandstone-silts formation (Bir Enhass formation).

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**Fig. 2 : Synthetic lithostratigraphic profil of the Permian basin of M’tal.**

**A. The conglomeratic formation of Ouled Mira (400 m thickness)**

It is observed in the North of the basin, organized in monoclinal strata of variable thickness which rest in angular unconformity on the folded and deformed Palaeozoic base (locations of the cross sections: see the map in Fig. 3), with intercalations of sandstone-silts levels towards the top. The dip of the layers of this formation is of approximately 30° towards NW. A detailed lithostratigraphic profile was established (Fig. 4).
Detailed section of Ouled Mira formation and Description of the facies:
Conglomerates: Of variable thickness (2 to 8 m) (Fig. 4), they are massive with joined to sub-joined pebbles, with imbricated pebbles who inform us on the direction of the currents which supply the detrital matter of the basin. The components are represented primarily by pebbles of quartzite, sandstone and some fragments of schist, angular to sub-angular resulting from the deposit of Palaeozoic substratum elements; the argillaceous-sandy matrix is less abundant. The benches of finer conglomerates are in the middle of the formation with variable thickness (10 to 30 cm).

Sandstones: They are presented in fine sandstone levels, seldom coarse to slightly microconglomeratic, of centimetric to decimetric thickness; their colors are red to brown. The texture is detrital, with sub-angular grains dispersed in calcitic or argillaceous matrix. The microscopic study shows that it is formed by:
- Angular to sub-angular Quartz. They occupy 50% of the rock.
- Feldspars represented primarily by plagioclases.
- Matrix, less abundant, is formed by a carbonated mudstone.

Fig. 3 : Geologic map of M'tal basin.
Sils: They are not very frequent and are presented in thin and discontinuous levels, resting on the sandstones facies or directly on the conglomerates.

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Fig. 4: Lithostratigraphic profile of the Ouled Mira formation.

**B. Sandstone-silts of Bir Enhass formation**

Of 60 meters thickness and red color, a detailed profile, of NW-SE direction, was realised (Fig. 5) along the Western outcrops of the basin. It corresponds to the top of the Permian of M’tal. It consists of terrigenous materials organized in centimetric to metric levels of sandstone and silts.

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Fig. 5: Lithostratigraphic profile of the Bir Enhass formation.
Description of the facies
Sandstones: We find two types: coarse sandstones and fine sandstones.

Coarse Sandstones: They are presented in levels from 1 to 4 m thickness, at a slightly erosive base. The granulometric sorting is good and one finds there only some dispersed gravels of quartz, quartzites or sandstones.

Fine Sandstones: They arrive directly on the precedents or interstratified in the silts. They are not very hardened, friable, with a little or not erosive base. The thickness varies from 20 cm to 80 cm, granulo-classified, they end in not very hardened silts.

Silts: They are most important in volume compared to the other facies, we frequently found them in the top of the fine sandstones, with levels from 2 to 10 m thickness. They have a variable colors red-brown, red-brick. The colouring of these silts depend on the presence of iron oxides.

IV. Environments of deposition
The massive conglomerates, with less abundant matrix, indicate a slight displacement by mass transportation (debris-flows) and correspond to gravity sliding. This type of sedimentation is often related to tectonic activity and/or to high reliefs. These facies can be observed preferentially near the eastern borders of the basin. The large size reached by some blocks suggests a close origin. On the other hand, channels with surrounding pebbles indicates a long transportation. The conglomerates of stratified contiguous coarse pebbles attest to an aqueous environment with channels. The abundance of coarse deposits indicates higher reliefs than during the lower Permian. The upper siltstones sandstone formation corresponds to channel deposits in a fluvial type environment. The red siltstones suggest deposition in a flooding plain.

V. The filling up of the basin
The occidental border of Permian basin of M’tal is a tectonic limit inherited from the pre-Permian substratum: the border fault of synchronal activity to the filling up of the basin: the basin side is formed of detritic sediment and flysch of the paleozoic.

The direction of the paleocurrent which was the origin of the transport and deposit of red continental molasses of M’tal was studied in the level of the outcrop favorable to such study.

The pebble imbrications observed in the conglomerates shows the dominance of N80° to N110° direction with the filling up direction to the east towards the west. The lenses observed in the land have the same result with the precedent.

The first levels of the filling up, wish are proximate, locate in eastern part of the basin. Towards the west and precisely towards the distal zones, the sedimentation relatively fines.

VI. Tectonic
The M’tal basin was affected by brittle late-Hercynian tectonic during which an important network of normal faults developed; the majority of them are synsedimentary faults (Fig. 6). This network corresponds probably to a late-Hercynian direction since it has an orientation close to that of the conglomeratic furrow of a lower Permian age.

This raises the question of the tectonic control of late-Hercynian faults during the formation of this collapse basin.

![Fig. 6 : Cross section showing the emplacement of normal faults.](image-url)
extension. The reactivation of the Hercynian faults, whose direction was compatible with the extensional stress field, could have played a determining role in the orientation and the localisation of conglomeratic furrow. Thus, these faults can be interpreted as: old brittle faults inherited from the Hercynian time, or faults formed during the development of the semi-graben during the lower Permian. Therefore, the dip of these faults is compatible with an extensive strain as hemi-graben, with a maximum stress $\sigma_1$ vertical (the axis number 3, Fig. 7), and a minimal stress $\sigma_3$ (the axis number 1) horizontal close to the direction of the East-West extension that could have dominated during the phase of sedimentation.

**Fig. 7:** Kinematic axes deduced from normal synsedimentary faults (Schmidt projection, lower hemisphere).

**VII. Conclusion**

The sediments of M’tal basin are detritic sediments (conglomerate, sandstone and silts) fluviatile generally red of intermediate zone at the base (with coarse element) and also of zone at the summit characterized by fine elements (down part of drainage pattern). They are organized into banks inclined towards the west of the basin, grano-decreasing on a thickness of almost ~ 500m. The enrichment of the basin in terrigenous element is attributed to the erosion of Palaeozoic basement. They are covered by Jurassic or recent plio-quaternary formations.

The Permian series of M’tal is subdivided on two formations:
- Conglomeratic formation of gritty intercalation. They are badly classified, its elements has variable size in less abundant matrix.
- A sandstone-silts formation (Bir Enhass formation).

Analysis of the tectono-sedimentary structures confirms that the sedimentation and the opening of the M’tal basin was controlled by accidents affecting the basement under an extensive regime of East-West orientation. A similar extension had been observed in the western High Atlas in the basins of the Ida Ou Zal and Ida Ou Ziki ([7], [12], [13]) during the same epoch. This local extension can be also generated under a transtensif mode as the Permian basins of Khenifra [1]. of Mechraa Ben Abbou ([11], [6]) and of Souss ([7], [8], [12], [13], [14]).

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