ISSN: 234-5197
Impact Factor: 3.765

INTERNATIONAL JOURNALOF RESEARCH SCIENCE & MANAGEMENT

GEOLOGICAL AND STRATIGRAPHIC STUDY OF THE MIDDLE OUERRHA, TAOUNATE (RIF, MOROCCO)

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DOI: 10.5281/zenodo.1291888

Keywords: Bedrock; Salt red marl; Triassic; Stratigraphy; prerifaine chain; faults.

Abstract

The study area is located in the central Rif, region of the middle Ouerrha. Its bedrock is essentially composed of blue marls of the upper Tortonian, a schistose series of Cretaceous and red salt marl of the Triassic.

The goal of our work will focus on the study of geological and pedological formations, as well as the study of stratigraphy, making a detailed inventory of the material reworked in it. Then establishment of structural maps of Taounate region; for a new lithological, paleogeographic and structural interpretation of the prerifainechaine.

The morphostructural analysis of the study area was conducted to highlight the relationship between the basement structures and their influence in the establishment of the current tectonic structures including the reactivation of ancient faults.

Introduction

The Rifain domain has undergone violent tectogenesis with metamorphism and charriage. It contains allochtones or rooted units, and detached or slipped units. The study area is part of the external rif, it is subdivided in three sets, the prerif, the mesorif and the intrarif.

The external Rif knew a great extension of the Triassic formations and its close connection with the upper cretaceous.The field study and the analysis of the geological maps have shown that the triassic complex is generally in the state of sedimentary Klippes in the Cretaceous sediments.

A structural mapping of the Taounate region and a detailed description of the different geological layers, as well as the pedological classes of two zones, Hammam and Twansa located NE and SW respectively, allowed to understand the main features of the study area.

Study area

The external Rif is a very complex domain, it is constituted of three sets from the inside to the outside, NE to SW:

- **Intrarifaine zone:**
  - **Ketama zone:** outcrop in the central Rif, affected by two phases of schistosity and two metamorphisms (Upper Oligocene-Lower Miocene and Upper Miocene) [1]. This unit would be superposed on the Mesorif during the first phase.
  - **Tangier zone:** slightly deformed, it is considered the cover of the unit of Ketama, it is considered the cover of the unit of Ketamaranging from Cenomanian (marl and marly limestone) to lower Miocene [2] and [3].
- **Mesorifaine zone:** It is located immediately north of Ouerrha, Characterized by clay-sandstone deposits of Callovo-Oxfordian [4] and [5], andcalcarenite of Middle Miocene [6]. Massifs of gabbroshave been observed in central Mesorif in the east of Taounate [7].

- **Prerifaine zone:** is the southernmost part of the rifaine chain. This is a very complex formation with their predominant marlyfacies from the lower Cretaceous [8], [9] and [10]. The internal Prerif is formed a stack of overlapping and pleated series including rocks of Jurassic and Lower Cretaceous detached from the Paleozoic bedrock of the African plate. The overlapping front of the prifain domain has been identified in the Atlantic Ocean, in the western extension of the Jebha accident.

The external domain is grouped by a major sinister accident, located in the Eastern Rif where it is oriented NE-SW to ENE-WSW about forty kilometers east of Al Hoceima Bay. It separates the intrarifine unit of Ketama from the Mesorifan massif of Temsamane. This accident divides towards the South in two accidents of which the most important can extend until Taounate.

Geographical setting

The study area with semi-arid climate, is located in the north of Morocco, in the Sebou watershed and precisely in the Ouerrha basin (Fig. 1), central part of the Rifaine chain, region of Moyen Ouerrha. It is part of the sector Taounate-Ain Mediouna (Fig. 2). This region is between the Senhaja-Rheddou massif in the east and the Tabouda-Tafrannt ridge in the west and covers an area of approximately 438 Km², 35 Km² long and 13 Km² wide on average. It is between latitudes 34 ° 25 'and 34 ° 37' North and longitudes 4 ° 25 'and 4 ° 44' West. The region shows a monotonous relief consisting of a multitude of hills to the south with a very low altitude of 214 m and mountains to the north, which can reach the 1628 m of altitude.

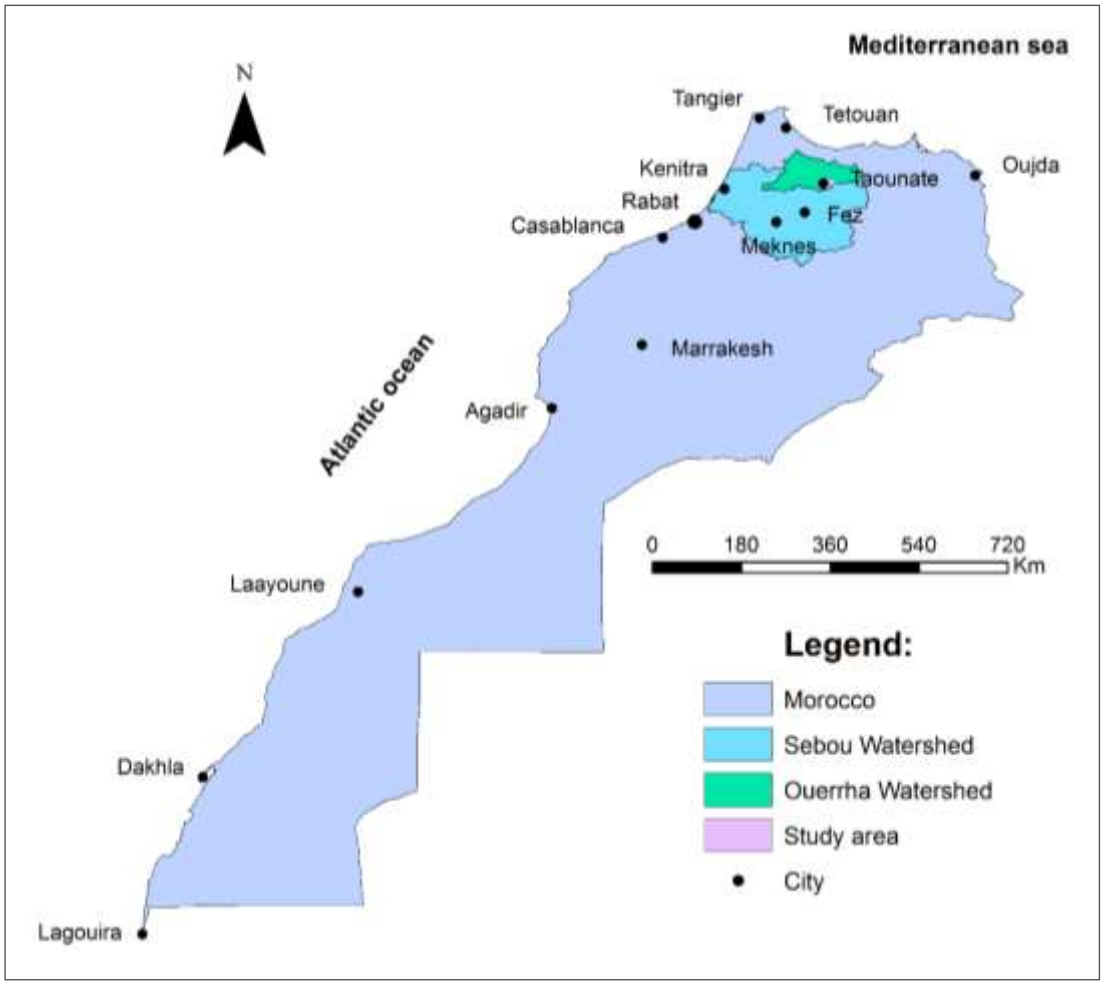

Figure 1: Location of the Ouerrha watershed.

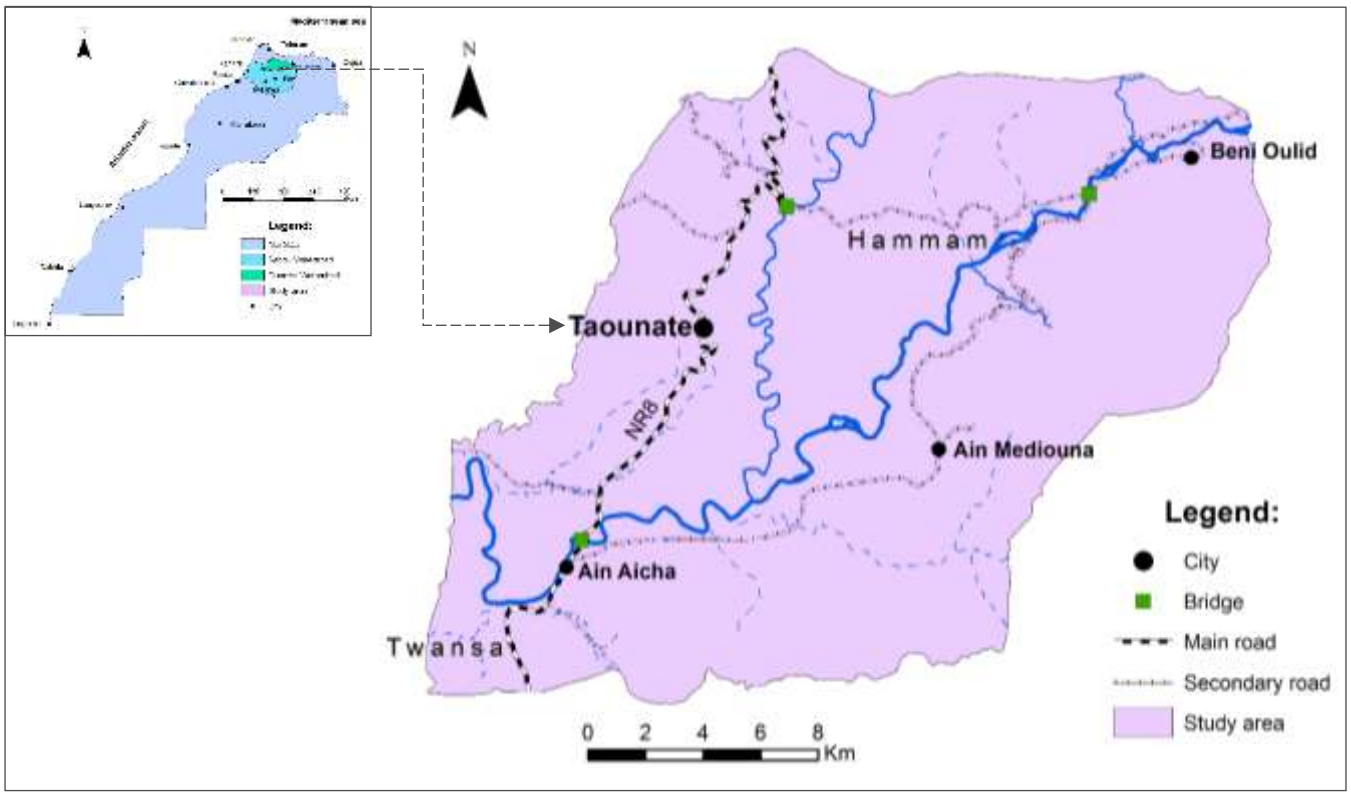

Figure 2: Location of the Taounate Study Area.

Sedimentological context

Stratigraphically the study area corresponds to a chaotic marly matrix, with microfossils and elements of all sizes, sometimes covering surfaces of several hundred meters interstratified in Miocene blue marl (Fig. 3).

These elements are composed of maro-gypsifer of Trias (Fig. 4), have origin from different external Rif nappes [11].

The prerifainenappes consisting essentially of detritic and turbiditic clays and Triassic evaporites carried on the Middle Mesozoic and Miocene foreland [12].

Due to the extreme abundance of reworked elements from Upper Cretaceous to Lower Miocene, which represents the initial material of the water table makes it very difficult to determine the exact age of the prerifainenappe.

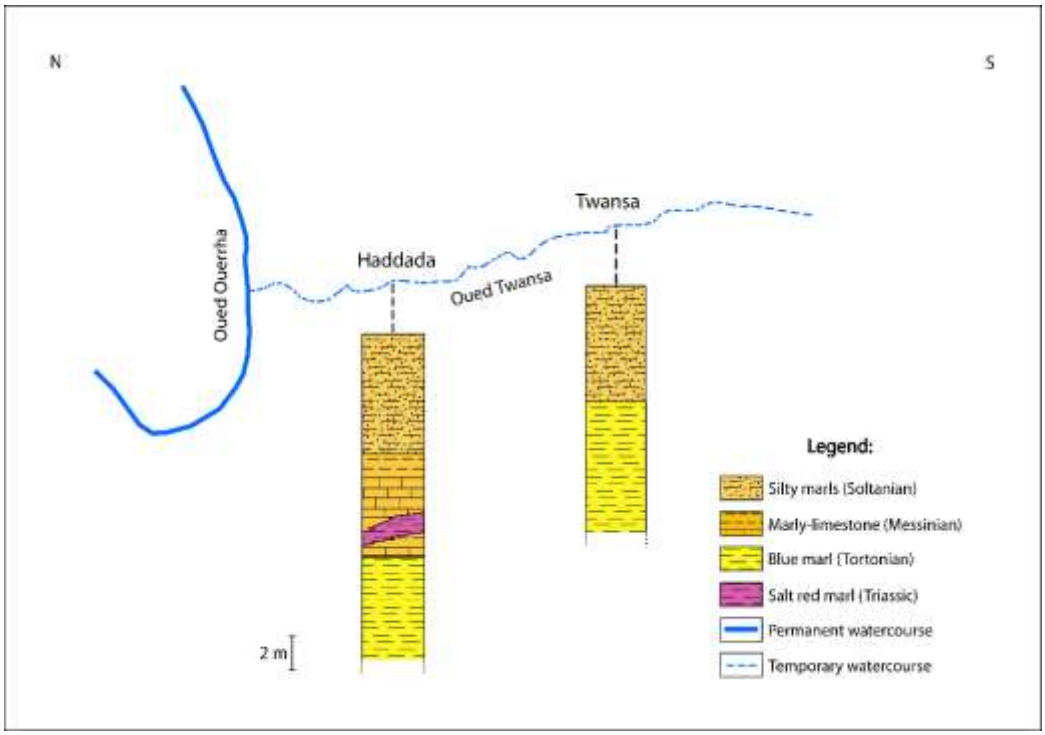

Figure 3: Stratigraphic logs at the Twansa area.

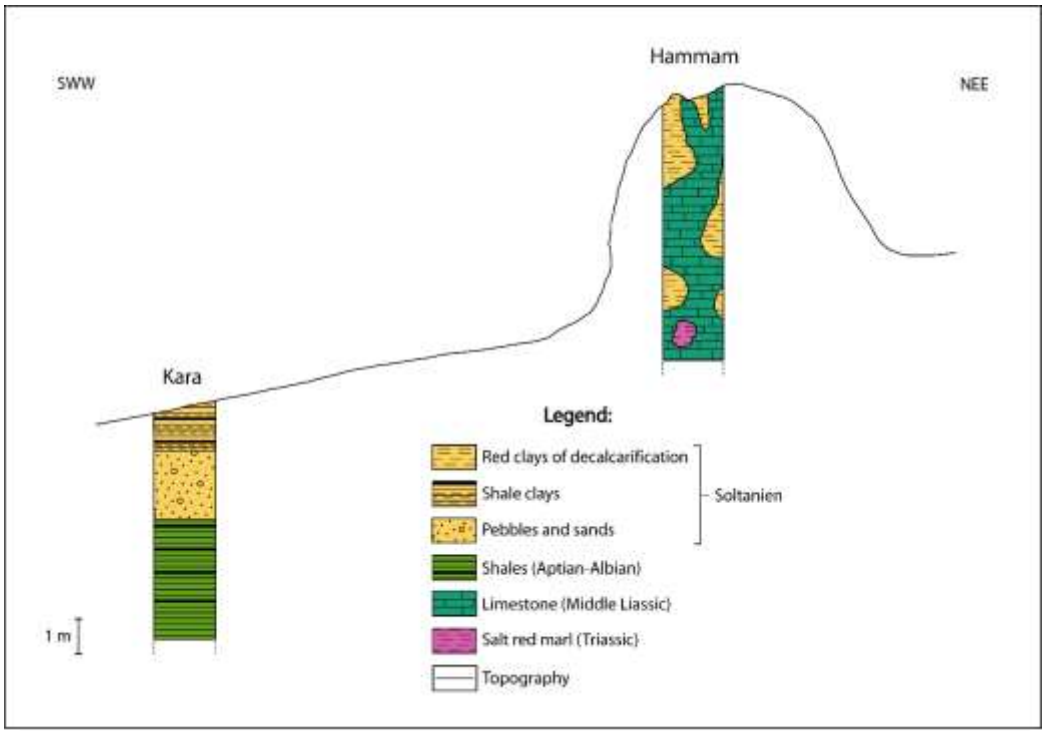

Figure 4: Stratigraphic logs at the Hammam area.

Cartography of middle Ouerrha

Geological mapping

Geological studies in the Rif started early of the 20th century, with the arrival of Luis GENTIL in 1904 [13]. Before this, the research carried had an aspect general [14].

The first works are those of Daguin (1927) [15], then Marcais (1937-1942) [16], [17] and [18]. They distinguished two domains in northern Morocco (the Rif North and the Prerif South), since the Rif is carried on the southernmostPrerif.

The rifaine chain, northernmost part of Morocco, belongs to the alpine building, betico-rifo-tellian from the western Mediterranean. It is separated from the Cordilleras by the Strait of Gibraltar. In the Taounate region (Fig. 5), the geological formations of detail are complex; we could distinguish several geological systems:

- **Triassic:** formed essentially by salt red marls and gypsum (Fig 6). It could be qualified the Allochthonous Triassic because it is never known in place. This chaotic Triassic has been the subject of various tectonic and palaeogeographic interpretations, around the western Mediterranean, especially in the Betic Cordillera in Andalusia [19], as polygenic gypsum matrix breccia of sedimentary origin.
- **Jurassic:** the formations are largely developed under two main facies, dolomitic limestones of the Liassic that form large massifs, and a schisto-sandstone flysch of Callovo-Oxfordian.
  - **Lower Lias:** dated by Eodiademalacosteii [20], it consists of a thick calacreo-dolomitic series (Jbel Kiel), whose discontinuous outcrops appear clearly under softer posterior series.
  - **Middle Lias:** formed mainly by limestones and dolomites, by the presence of Ammonites at the summit of the limestone series which follows the dolomites [21].
  - **Lower Lias-Upper Bajocian:** it constitutes a reduced series based on the Domerian, This is limestone and marl-limestone, the Toarcian provided rich deposits of Ammonites in the marls, especially at the Senhadja unit level.
  - **Dogger:** in the Bathonian, he begins a powerful series of shale-sandstoneflysch, monotonous almost azoïque in almost the whole chain, except in the Eastern Rif [16].The age of the flyschcan only be determined by comparison of facies. This is Bathonian at the base and Tithonic at the summit (Upper Jurassic). The basics of this sandstone-pelitic formation is not known in the studied region, the summit is marked by Cretaceous transgression.
  - **Malm:** Tithonic, including Kimmeridgian, finishes the Jurassic by a limestone episode whose faciesvariesa zone to another, these fine limestones often contain Calpionella and Apticus [21],The outcrops of these limestones are rare and irregularly distributed when they exist.
- **Cretaceous:**
  - **Lower Cretaceous:** characterized by marls and marl-limestone, in the Aptian-albian the terrigenousdetritic character of the sedimentation is accentuated and corresponds to the flysch of Albo-Aptian. This mesorifanfacies is most often dark pelitic with intercalation of marly clear levels, rare lenticular quartzite sandstone bars are interpreted as fills of lateral channels [22].
  - **Upper Cretaceous:** it includes a thick series of Inocerames marl and marl-limestone. The greenish to yellowish marls of the Senonian contain in places gray limestones balls, their size varies from centimeter to meter [14]. The chaotic gypsiferous material described above is intercalated at many points in these marls.
- **Eocene:** the lower and middle Eocene are presented in the form of white flint marls, these outcrops are rare and discontinuous. These outcrops are rare and discontinuous, since in the area of Taounate-AinMediouna, only one Eocene point is known at the level of Douar Bab Ouennder.
- **Miocene:**
  - **Lower Miocene:** often qualified as ante-nappe by a detrital marl-sandstone series whose outcrops are also widely dispersed. Their sedimentation continues until the end of the Middle Miocene [23]. These tertiary formations are poorly developed in the region studied; they are relatively quite thick (more than 1000 m).
  - **Upper Miocene:** these blue marl formations, of conglomerates and molasses, constitute thick transgressive series on secondary lands and fill all the collapsed basins of Middle Ouerrha. It is

qualified post-nappeand normally surmounts the lower Miocene or rests directly in unconformity on any ante-Miocene series subrifaine [14].

- **Quaternary:** Quaternary evolution is reflected in the course of the great wadis,by a developed system of seven terraces, the oldest corresponds to Villafranchienne (q_6) sometimes deformed, then Regreguian (q_5), Saletian (q_4), Amirien (q_3), Tensiftian (q_2), Soltanian (q_1) and Rharbian (A). In the basin of Middle Ouerrha the clearing of the marl tortoniennes was important. The flattening of the Taounate Ridge derives from the Pontian surface. It is observed moreover that constructed forms extend below high topographies, as alluvial materials, or as deposits of local origin, which prolong the Villafranchian formations.

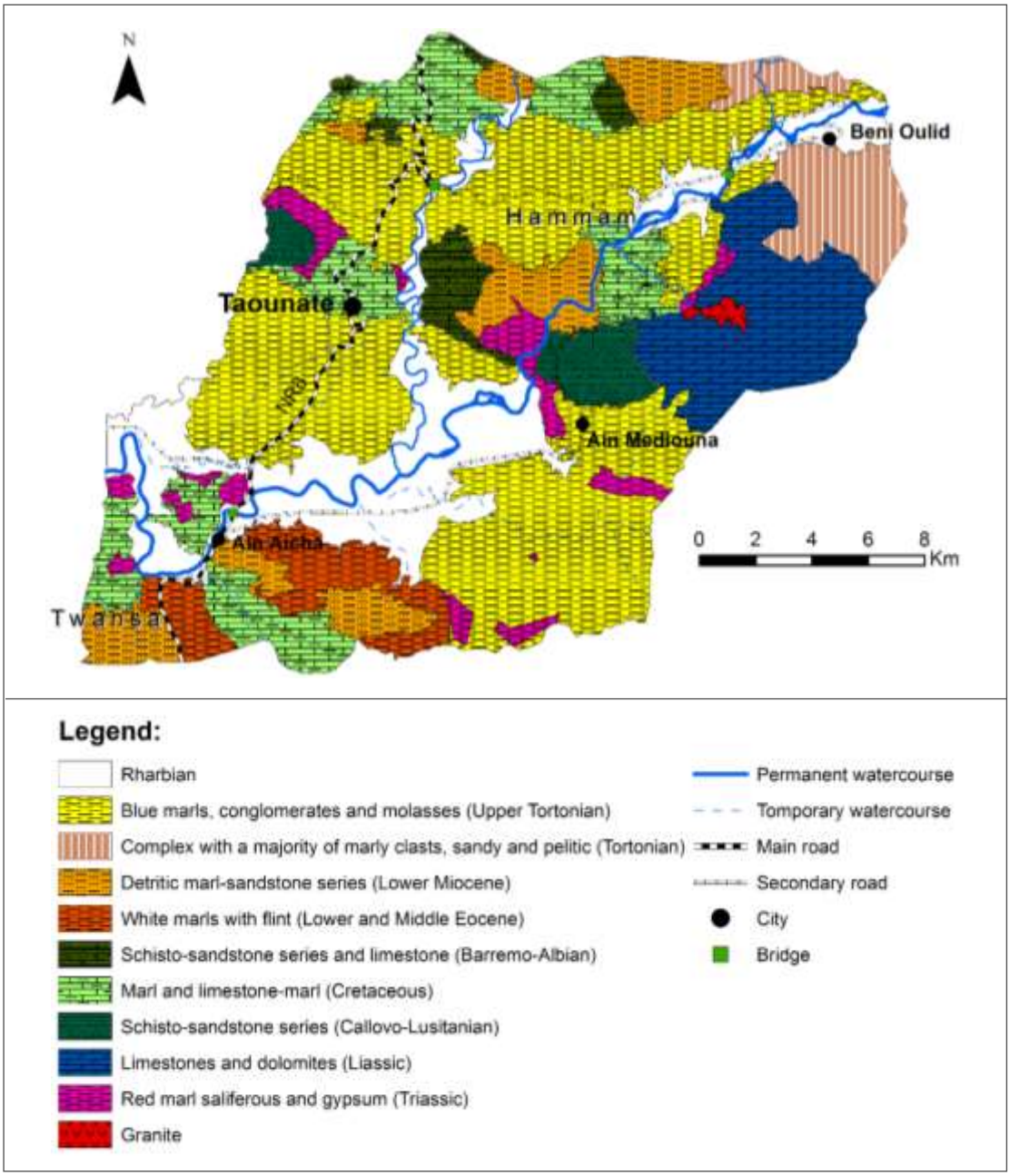

Figure 5: Structural geological scheme at 1/50.000 of the Taounate region.

Fig.6: Blue marl bleached with salt at the Twansa area.

Soil mapping

The detailed soil mapping and pedological general plan of the Taounate region at 1/50.000 (Fig. 7) was carried out during this study. The distribution of soils comes essentially from the alteration of the rocks immediately underlying, present in the Rif in the form of marls, sandstone and especially flyschs. The characteristics of these soils are highly dependent on the source rock from which they come (texture, reaction, fertility, permeability, porosity, etc.) and this in the relief areas [24].

Hill soils are superficial and eroded; they consist of a low silty-gravel layer based on the rock in place. On soft rocks, its thickness is maintained by plowing, which attacks each year the upper layer of rock in place. In some places, solifluction deposits exist especially above 800 m. They have a calmer relief and a pedogenesis influenced by the different climates and vegetations they have known since their establishment. These deposits cover the oldest rocks with a thick layer with a softer relief. These soils are generally calcareous brown or forest soils of a fairly acidic type.

The recent alluvium and colluvium are regosols and do not show any differentiation of profiles. Older allvions have sometimes been tirsified in relation to a marly origin of alluvium and often rubefied with acidification.
The erosion of the Rif soils are in a very bad situation because of their often impermeable nature and the very unfavorable rains regime, on slopes strong to very strong.

The semi-arid soils of the Mediterranean slope are eroded mainly in ravines and gullies, which contribute a lot to supply the solid flow of the fluvial waters.

The different series of soils encountered mostly in the study area, on the mares prérifaines belong to the following groups:

- Poorly developped soil no climatic, alluvial, colluvial or erosion contibution, on fine texture material, based on marl;
- Vertisols external drainage, with an angular structure on at least the upper 15 cm, Modal to vertic, on Quaternary alluvium or colluvium;
- Complex formed by the association of poorly developed soils of regosolic erosion on limestone marl, and modal brown calcareous soils, locally vertic, and eroded on marls limestone, slightly melanized;
- Complex formed by mineral soils of erosion, lithosols, poorly developed soils of erosion regosolic shallow and colluvialcontribution moderately deep on flyschs;
- Raw mineral soil no climatic, erosion on Jurassic sandstone limestone, gneiss and ophites (lithosols) and on marls or flyschs (regosols); or alluvial contribution on coarse alluvium of the wadis beds;
- Soil iron sesquioxideswith calcic reserve from balanced texture to fine based on sandstone or limestone slab sometimes with rocky outcrops (fersiallitic);

- Calcareous brown soils calcimagnesic with carbonates on marls limestone, marls sandy or fluvio-lacustrine formation;
- Brown soil of intergrades of temperate climates, acidic and vertic, on material of fine texture, based locally on schists;
- Isomhumic with saturated complex evolving under a fresh pedo-climate during the rainy season on clay alluvium of medium terraces (vertic);
- Hydromorphic soils slightly humiferous at pseudogley, on quaternary material of balanced texture to fine;

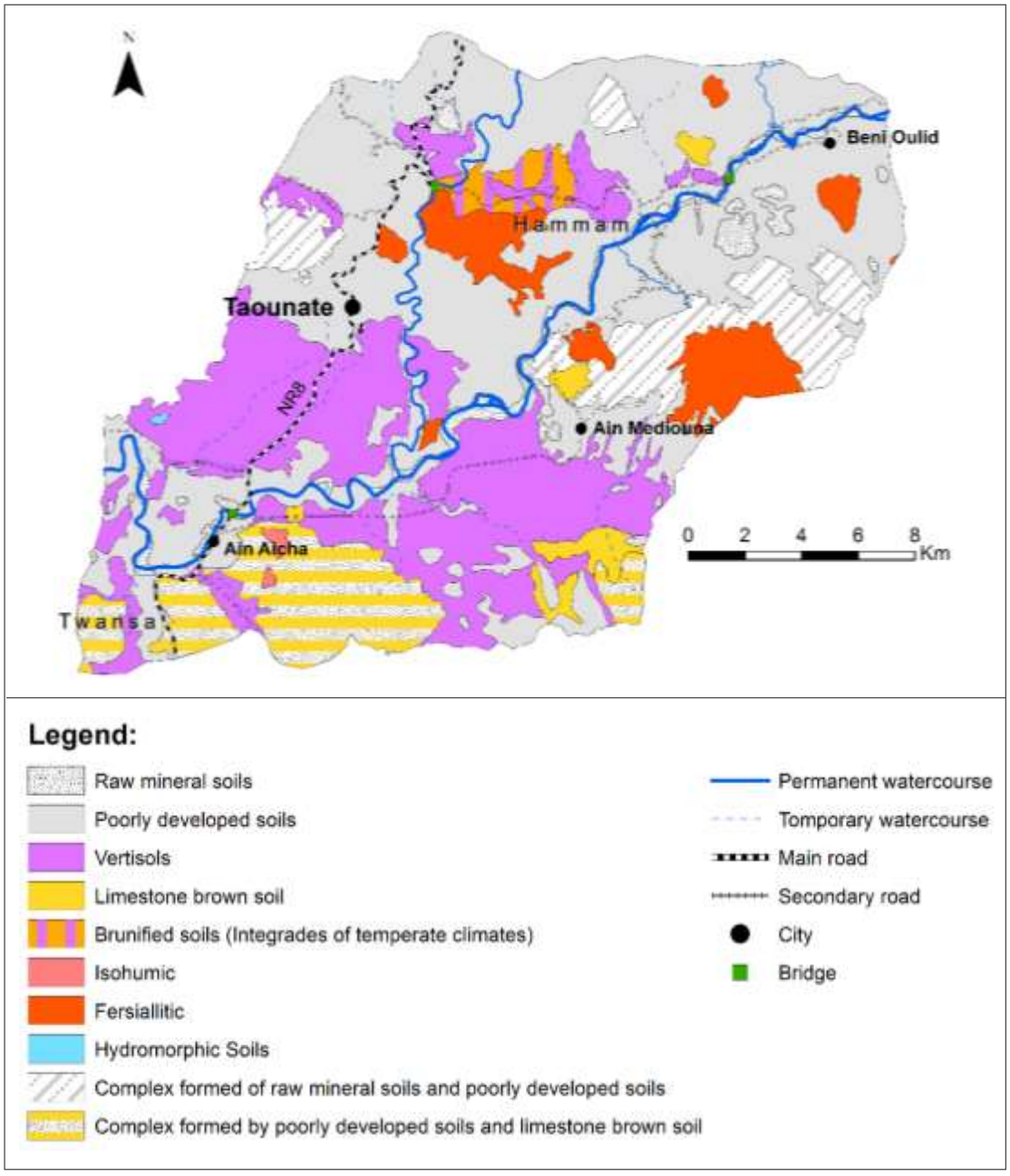

Figure 7: Structural soil scheme at 1/50.000 of the Taounate region.

Conclusion

The detailed observation of the lithology of the formations present in the Taounate region identified the general history of deposits of sedimentary formations, where the intramontane basins (post-napes) that are developed later in the western part of the external Rif, bordering the major accidents of the chain. In this case, it is the

Taounate basin,it includes two formations:

- The formation of Taunate of Tortonian-Messinian age, composed of marine marls with sandstone intersections, surmounted by continental conglomerate deposits of Plio-Quaternary agefollowing the Messinian erosion and the Miocene-Pliocene compressive phases;
- The formation of AinMediouna of Upper Tortonian age, formed by continental red conglomerates, overheated by deposits of conglomerates and marine sandstones.

The triassic complex of olistostromic nature outcrops exclusively in the outer rif, it changes from one region to another according to the local geological context. The origin of these gypsum masses can be at the origin of the resedimentation of these to the Senonian (Upper Cretaceous) which gives it the character of a sedimentary breach with gypsum matrix. Posteriorly the spatial distribution of these polygenic breach with gypsum matrix was conditioned by the replay of ancient tectonic accidents at Tortonian-Messinian (Late Miocene).

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