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Research Article

Paleoenvironmental indicators of Liassic deposits in the Ait Ourir basin area (example from Tafilalt, High Atlas of Marrakech)

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Abstract – This study aims to determine the indicators of emersion in the Liassic deposits of the Tafilalet basin, located in the Ait Ourir region, to characterize different structures and gain a better understanding of the paleoenvironment. The Liassic series of Tafilalet exhibits a variety of geological features, including dissolution breccias, carbonate-filled vacuoles, parallel laminations, dessiccation cracks, stromatolithic limestone, teepee structures, tidal channels, as well as fossil traces such as Skolithos, Arenicolite, Planolite, and Diplocraterion.These diverse elements suggest favorable environmental conditions for intertidal to supratidal zones. Dissolution breccias indicate processes involving the dissolution of evaporites, while carbonate-filled vacuoles reveal periods of emersion and sedimentation in specific environments. The identification of fossil traces like Skolithos, Arenicolite, Planolite, and Diplocraterion provides crucial information about the fauna and flora during the Liassic period, allowing for a more comprehensive reconstruction of the paleoenvironment. These data significantly contribute to the study of the geological evolution of the region during the Liassic period. In summary, this study provides important insights into the geological and environmental processes that shaped the Tafilalet basin during the Liassic period.

Keywords – Tafilalet Basin, Emersion İndicators, Stromatolithic Limestone, Teepee Structures, Skolithos, Tidal Channels, Paleoenvironment, Liassic Period.

INTRODUCTION:

The Ait Ourir region is characterized by its geological diversity, particularly from a Mesozoic-Cenozoic sedimentological perspective, attracting the attention of numerous researchers. This area represents a unique subject of study due to its stratigraphic significance (Lakhlili.M.2023) .In this study, the emphasis is on the investigation of the Tafilelt Basins, which is a syncline characterized by a different panoramic view compared to other basins in Ait Ourir from a structural and sedimentological perspective. This study will be conducted on the two silty-clayey units with evaporites and carbonato-

evaporitic deposits from the Liassic series of the Tafilet Basin to determine its paleoenvironment based on various sedimentological, paleontological, and ichnological indicators.

1. Geographical Setting and Geological

[5]This geological section is located within the Ait Ourir basin, specifically in the Tafilelt basin, positioned to the northwest of the Jbel Sour syncline (Bah,O,1993). These two geological entities are separated by basalt formations dating from the Upper Triassic, through which the Oued Touama has carved its course. The Lias, characterized by silty layers and carbonate beds, overlays the red clayey formations of the Triassic series. Additionally, this geological sequence is capped by the red continental sedimentation of the Dogger. This geological configuration provides a unique opportunity for study to comprehend the evolution and geological history of the region, offering significant insights spanning different geological periods from the Upper Triassic to the Dogger. However, the primary focus of this study lies in investigating the paleoenvironment of the Lias in the Tafilelt basin.

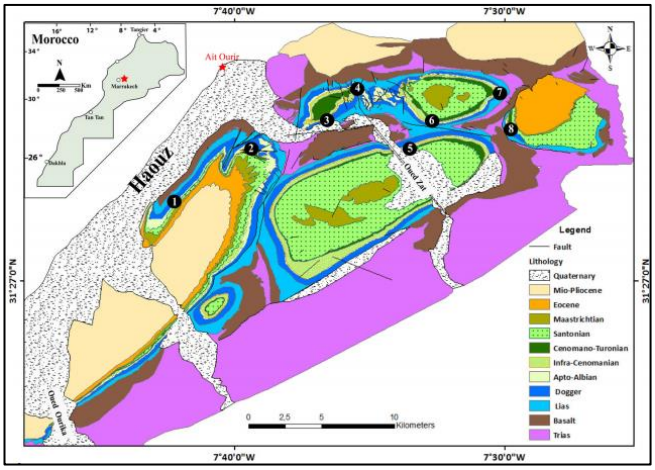

Figure 1::Location of the study area, location of thesection(Hadach Fatiha)

Paleoenvironmental indicators of Liassic

The Liassic series of Tafilalet is primarily characterized by the presence of red clayey silt deposits associated with secondary gypsum. It is also composed of alternating metric layers of dolomitic limestone and interbeds of clayey silt. The detailed study of this geological section reveals various elements that play a crucial role in determining the paleoenvironment of this series.

In the western part of the section, there is an abundance of tidal channels, accompanied by teepee structures within stromatolithic limestones. Furthermore, features such as desiccation cracks, conglomerates, laminations parallel to dolomicrite levels, marbling phenomena, and dissolution breccias are clearly identified. These geological evidences provide significant clues for reconstructing the paleoenvironment.

A careful observation also reveals the presence of Skolithos-type ichnofacies, including fossil traces such as Arenicolite, Diplocraterion, and Planolite, in certain dolomitic limestone beds. These indicators of ancient biological activity add an additional dimension to our understanding of the geological history of the Liassic series of Tafilalet, providing valuable insights into the sedimentary processes and environmental interactions that have shaped this region over time.

Chenaux de marrés

[7]The Liassic series of the Tafilelt syncline is marked by the presence of structures that refer to specific sedimentary features formed by tidal movements in a coastal environment. These tidal channels result from regular fluctuations in sea level caused by tides, i.e., the ebb and flow of seawater, which generate water currents in preferential directions.

Tidal channels are typically represented as linear depressions or curved channels in sedimentary deposits. They are often filled with sediments transported by tides, such as sands and silts. These geological structures provide important information about past paleoenvironmental conditions, especially variations in sea level and marine current dynamics.

The study of tidal channels in sedimentary sequences allows geologists to reconstruct ancient coastal environments, understand the interactions between marine processes and sedimentary

deposits, and infer details about paleogeography and tidal dynamics in bygone eras.

Stromatolites

This type of structure is well pronounced in the basins of the Ait Ourir region, such as the Albian formations (Hadach, F. 2015), and, of course, in the Liassic series, which is the focus of this study. They consist of small decimeter-thick levels, almost 50 cm in whitish and sometimes yellowish color.

Stromatolites are rocky structures formed by bacterial activity in shallow aquatic environments, such as lagoons, coastal basins, and estuaries, where sunlight is abundant, and conditions favor the growth of cyanobacteria. These structures often date back to ancient geological periods and provide valuable insights into the paleoenvironment, particularly in intertidal areas like tidal flats or estuarine plains.

Teepee structures

[6]We have identified this type of structure associated with stromatolithic limestones, which result from the water escape during the dehydration process. Teepee structures serve as indicators of specific paleoenvironmental conditions, often linked to periods of drought where the withdrawal of water from sediments leads to the formation of these characteristic fissures. These structures can be observed in ancient sedimentary rocks and are valuable for understanding past climatic conditions and variations in water levels over time (Hadach, F. et al., 2015).

Mud cracks

Almost throughout the Liassic series in the Ait Ourir basins, the presence of desiccation cracks on the surface of carbonate beds characterizes the geological formations. These cracks manifest as polygonal structures forming a network of fissures that develop on the surface of a material due to exposure to sunlight, leading to the loss of water through the evaporation process from the saturated sediment. Desiccation cracks are frequently observed in coastal environments, mudflats, intertidal zones, and other areas prone to water level fluctuations. These environments often undergo periods of wetting and drying due to tides, seasonal changes, or climatic cycles, with this type of structure indicating a confined setting (Hadach, F., Algouti, Ahmed, 2015).

Parallel lamination

We have previously encountered these structures in carbonate beds, especially in dolomicrite (Mudstone), in the Jbel Sour basin (Lakhlili, M. 2023), and the same applies to the Tafilelt basin. In the Liassic series of Tafilelt, there are small parallel beds ranging from a few millimeters to a few centimeters in thickness. These beds can provide insights into the environmental conditions during sediment deposition. For instance, parallel lamination in fine carbonate mud may indicate a calm environment.

Cargneule

This type of structure characterizes the Lias of the Tafilalet basin. It manifests through the dissolution of evaporites, particularly salt. Evaporites form through the evaporation of water in environments such as salt lakes, salt marshes, and evaporation basins, where salt concentration increases as water evaporates.

[4]The process of evaporite dissolution occurs when acidic water circulates and permeates the evaporitic deposit. In this case, ions dissolved in the water chemically react with evaporitic minerals, causing their dissolution and leading to the formation of dissolution cavities (Algouti, A. et al., 2022). This process can be influenced by factors such as temperature, pressure, the chemical composition of water, and the duration of interaction between water and evaporites. The presence of this structure provides a more effective insight into the paleoenvironment from intertidal to supratidal settings (Algouti, A. et al., 2022).

Dissolution breccia

[6]Clearly observable in the carbonate beds of the Liassic series in Tafilalet, dissolution breccia exhibits dissolution voids and is characterized by a more pronounced disorganization than dissolution stratification. It involves a more or less complete replacement of the original appearance by a

predominantly brecciated facies. These carbonate breccias mainly consist of slightly angular fragments of dolomitic limestone. Numerous voids, some reaching several centimeters, are present. The smaller voids form true "birds-eyes" or "fenestrae" (Hadach, F. et al., 2015).

[4]It is important to note that these are small-scale structures arranged parallel to the stratification, often elongated and with irregular edges. They characterize the intertidal to supratidal environment and form either by the trapping of gases released through bacterial actions or by the swaying of water, or by the contraction of carbonate mud during its emersion (Algouti, A. et al., 2022).

Skolithos association

[10]The Liassic carbonates in Tafilalet reveal the presence of traces of marine organisms, specifically of the Skolithos type. Among them, Arenicolite is a identifiable fossil trace characterized by a pair of closely spaced circles on the limestone stratification plane, usually in the form of a U. Additionally, Planolite is a fossil trace preserved in a limestone bed, displaying a subcylindrical to cylindrical morphology of centimetric size. It appears as a single burrow manifested as lines or small pieces on the surface of the limestone layer, without apparent branching and exhibiting some oxidation (Lakhlili, M. et al., 2023).

Furthermore, the presence of Diplocraterion has been noted, which are U-shaped tubes highlighting the succession of deposition and erosion periods (GOLDRING, 1964). This bioturbation generally indicates a lower to infralittoral coastal environment. In general, the presence of Skolithos and Diplocraterion suggests a lower to infratidal coastal environment under conditions of moderate to relatively high energy [13](Seilacher, 1967; Frey and Pemberton, 1989; Seilacher, 1980)**.**

Conclusion

En conclusion, les observations géologiques et paléontologiques réalisées dans la cuvette de Tafilalet révèlent un paléoenvironnement complexe et dynamique au cours de la période liasique. La série liasique de Tafilelt présente des caractéristiques distinctives, notamment la présence de brèches de dissolution, de vacuoles carbonatées, de laminations parallèles, de fentes de dessiccation, de calcaire stromatolithique, de structures en teepee, de chenaux de marée, et de traces fossiles telles que Skolithos, Arénicolite, Planolite, et Diplocraterion. Toutes ces informations nous permettent de conclure que les conditions environnementales étaient associées aux zones inter à supratidales.

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