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Research Article

Sedimentological study of a Quaternary fluvial-estuarine deposit at the mouth of the Tensift River, Souiria Laqdima, Morocco.

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Abstract – The study was carried out on a Quaternary fluvial-estuarine deposit situated in the Souiria region, at the mouth of Tensift. This region is part of the coastal meseta and is located 30 kilometers south of the Moroccan city of Safi on the Atlantic coast of Morocco.

An investigation was conducted on samples obtained from a stratigraphic log to analyze them physicochemical and mineralogical properties. This involved using techniques such as X-ray diffraction, calcimetry, and petrographic examination of thin sections. The objective was to assess the changes in mineral, clay, and carbonate content along the log.

The log consists of successive layers arranged in a vertical sequence: summit marl, marly sandstone, alternating layers of sandstone and conglomerate, laminated sandstone, and finally massive sandstone.

The proportion of calcium carbonate progressively rises from the lowermost section to the interface between sandstone and conglomerate, when it experiences a marginal decline.

The presence of clayey, non-clayey, and carbonated minerals, including smectite, kaolinite, vermiculite, illite, diopside, anorthite, aragonite, dolomite, and calcite, was confirmed using X-ray diffraction analysis. Certain minerals present provide indications of a calm, non-agitated coastal setting and a hot and dry ancient climate.

The examination of thin sections of the samples ''Alternating sandstone and conglomerate'', 'Laminated Sandstone'', and ''Massive sandstone'' through petrographic analysis indicated the occurrence of quartz, biotite, modified volcanic fragments, iron oxide, and bioclasts, namely algae, suggesting a shallow setting, along with gastropods and ostracods.

Keywords – Stratigraphic Log, Quaternary, XRD Analysis, Carbonates, Petrographic Analysis.

I. INTRODUCTION

This research project focuses on investigating a Quaternary fluvio-estuarine deposit located at the Tensift river mouth in the Souiria Laqdima region. This region is situated on the Atlantic coast of Morocco, specifically on the Moroccan coastal meseta [1]. It is positioned approximately 30 km south of Safi and 60 km north of Essaouira. In order to achieve this objective, we conducted a field

expedition to the study site with the purpose of gathering samples, doing a geological assessment of the area, and subsequently performing analyses on the acquired samples using Calcimetry, X-ray diffraction, and thin sections.

The initial phase of this research endeavor involves presenting a comprehensive analysis of our study region from both a geographical and geological perspective. This will include a detailed account of the stratigraphic log, followed by an examination of the physico-chemical or mineralogical properties using techniques such as XRD and Calcimetry. Lastly, we will create thin sections of the collected samples and provide a methodology and interpretation for each technique employed.

II. Matherial and Method

We have chosen a method that involves collecting samples from each layer of the fluvial-estuarine deposit at the mouth of the Oued Tensift (as shown in the stratigraphic log in figure 2). Subsequently, we conducted sedimentological analyses, specifically X-ray diffraction, calcimetry, and petrographic analysis using thin sections. The diagram below illustrates the employed methodology (Fig 3).

A. Study area

The study area has a predominantly flat or slightly undulating terrain, with peaks seldom surpassing an altitude of 500 m. The region is bordered to the north by the Doukkala plains (located in the El Jadida province), to the northeast by the Rehamnas plateaus, to the southeast by the Chichaoua plateaus, to the south by the Essaouira province, to the south by the city of Essaouira, and to the west by the Atlantic Ocean (Fig. 1) [1].

The research area is situated in the Doukala Abda basin, which is a part of the Moroccan coastal meseta. This basin is known for its tabular sedimentary layer consisting of secondary and tertiary deposits. The primary bedrock in this area has been pierced and heavily folded by the Hercynian orogeny, as documented by [2], [1] and [3].

The geological formations observed in the research region span from the Jurassic to the Quaternary period and exhibit a diverse spectrum of lithological properties [4] and [1].

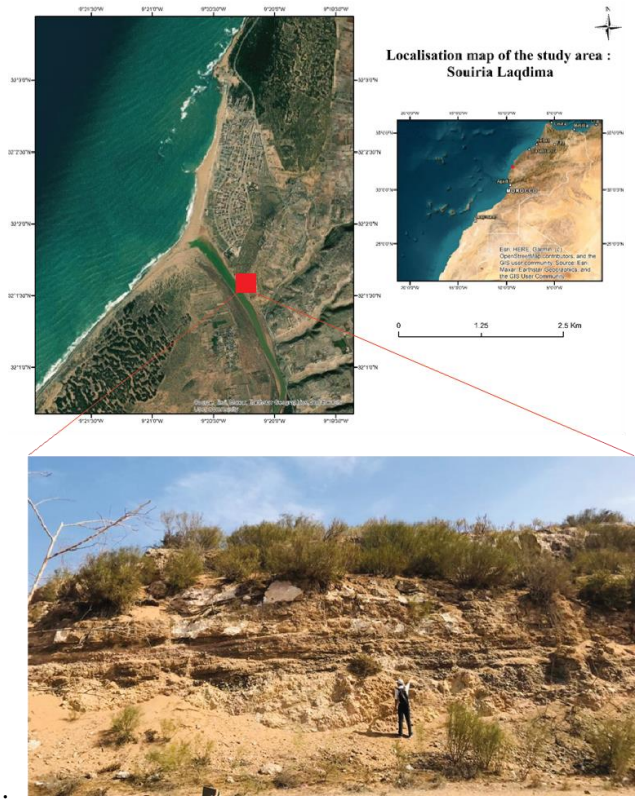

Fig. 1 location map of the fluvio-estuarian deposit studied in the study area

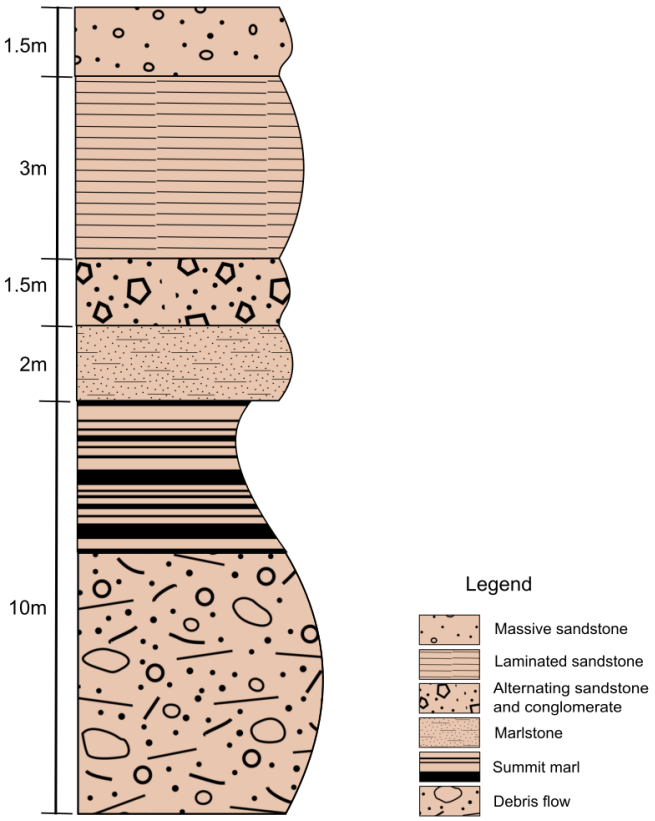

Fig. 2 the studied stratigraphic log

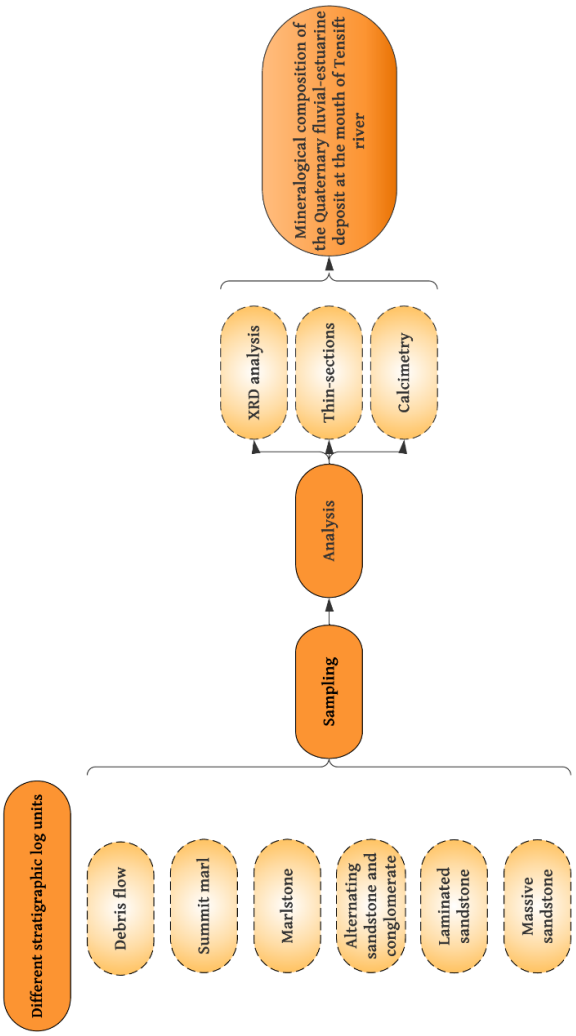

Fig. 3 Charter of methodology used

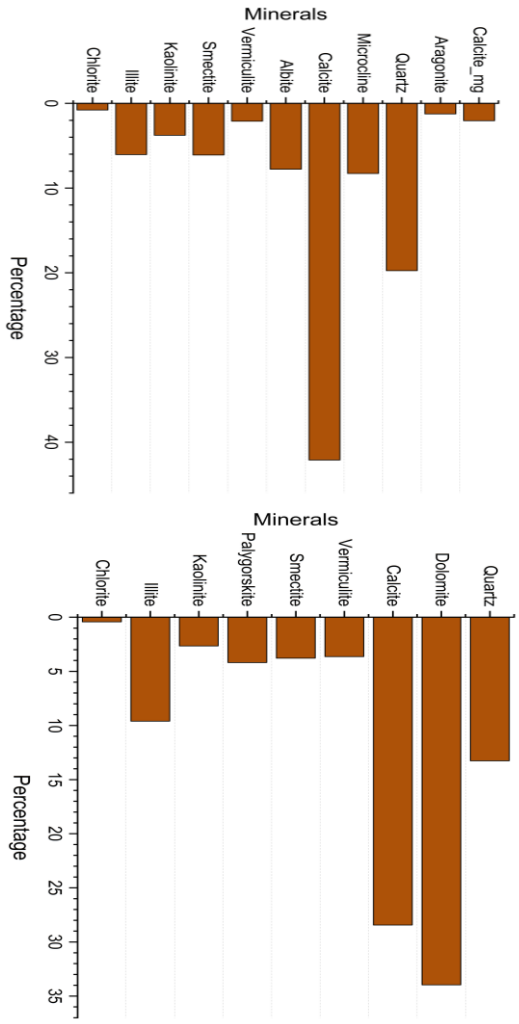

Fig. 4 percentage of different minerals in the samples ‘’debris flow’’ ‘’and Summit marl’’

III. Results And Discussion

The observed results are depicted in diagrams for X-ray diffraction (XRD) and carbonate content, in addition to thin sections.

- XRD analysis

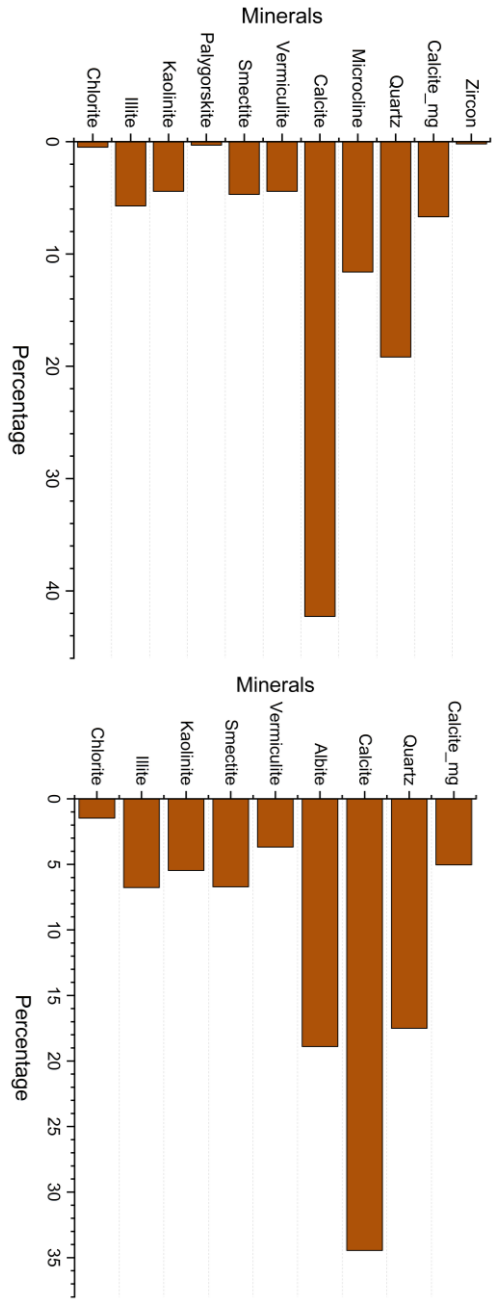

Fig. 5 percentage of different minerals in the samples ''Marlstone'' and ''Alternating sandstone and conglomerate''

The debris flow sample exhibits a significant predominance of calcite CaCO3, together with a moderate proportion of quartz SiO2. However, it shows low concentrations of Microcline, Albite, calcite_mg, and Aragonite.

From a mineralogical perspective, the upper marl sample is a sedimentary rock with a significant concentration of dolomite and calcium carbonate CaCO3 (the primary constituent of limestone). The proportion of clays and quartz is approximately equal.

The Marly sandstones, which were produced by seawater, exhibit a prevalence of calcite, with almost equal proportions of quartz and clay. This sample also contain an average amount of microcline and negligible amounts of zircon.

The alternating layers of sandstone and conglomerate indicate a significant abundance of calcite, as observed in the previous samples as well. Additionally, albite and microcline resurface, although the occurrence of zircon remains insignificant. At the top of the same sample, we observe the presence of diopside, which is a type of mineral belonging to the inosilicate subgroup of the clinopyroxene family. Diopside has the chemical formula CaMgSi2O6. Additionally, we also find anorthite, which is a silicate mineral composed of aluminum and calcium. Anorthite is commonly found in volcanic rocks and belongs to the feldspar family.

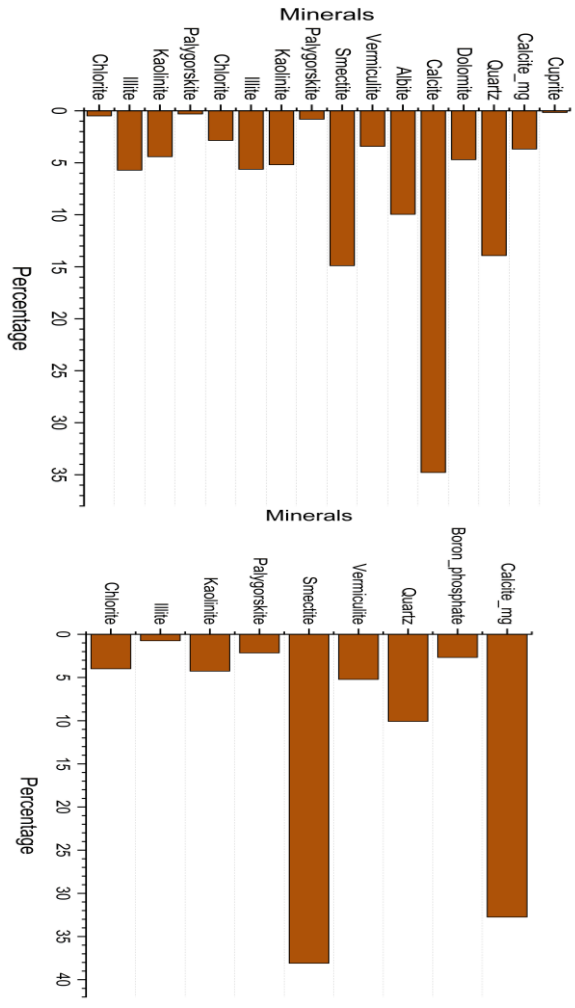

Fig. 6 percentage of different minerals in the samples ''Laminated Sandstone'' and ''Massive sandstone''

The laminated sandstone sample contains calcite, calcite_mg, dolomite, quartz, albite, clays, and a little amount (0.161%) of cuprite. Cuprite is a mineral species made of cuprous oxide with the chemical formula Cu2O (Fig.6)

The last sample contains several elements. Boron phosphate is an inorganic compound represented by the chemical formula BPO_4. The most straightforward method to generate it involves the chemical reaction between phosphoric acid and boric acid. This substance is a white solid that cannot be melted and vaporizes at temperatures exceeding 1450°C.

These results of XRD analysis indicate that illite originates from detrital sources, while kaolinite and vermiculite are both detrital and diagenetic in nature. Furthermore, these minerals are found in all the facies that were examined.

Palygorskite is found in the majority of samples, excluding the laminated marls. This indicates that the specimen has undergone diagenesis and is indicative of a tranquil seaside setting characterized by a reasonably mild climate.

Smectite exhibits elevated values across all its facies, indicating its formation in a warm and semi-arid environment conducive to sedimentary deposition.

There is a downward trend in the proportion of illite, which is derived by the weathering of rocks, and an upward trend in smectite, indicating a restricted environment.

- **Calcimetry analysis**

It is observed that the proportion of calcium carbonate progressively rises from the base to the transitional phase between sandstone and conglomerate, and then experiences a minor decline.

The phenomenon can be elucidated as follows: carbonate sediments can originate from the process of wave reworking of pre-existing limestone formations. The current conditions on the moroccans Atlantic beaches are conducive to the deposition of silico-clastic sediments. However, the waves also disturb the carbonate deposits from the Quaternary period and mix them with siliceous detrital components, resulting in sediments of mixed composition (Fig.7).

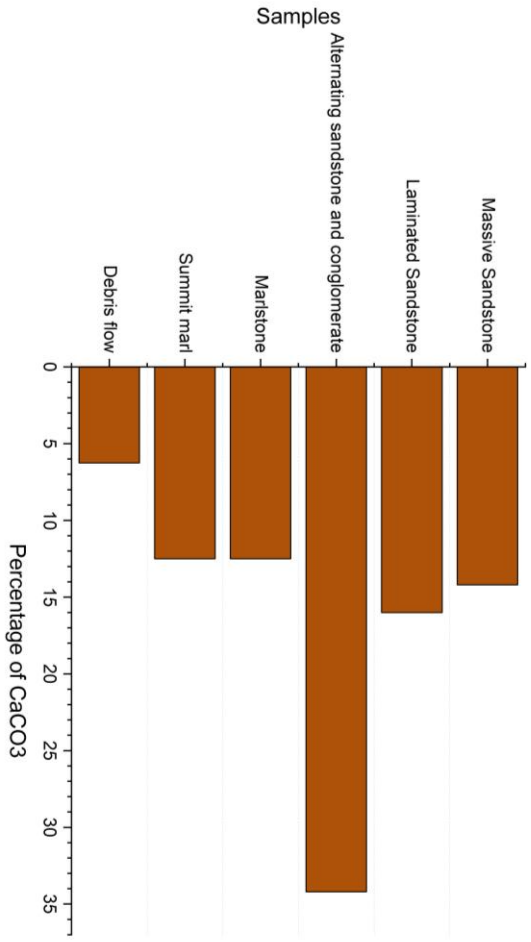

Fig. 7 percentage of CaCO3 of the six layers of the stratigraphic log

- **Thin sections**

This slide labeled "A" exhibits a micrite-type bonding phase characterized by a scarcity of elements and the presence of just a few numbers of bioclasts, specifically fine shells known as Ostracods (Fig.8)

When observed under the microscope, this thin section ‘’B’’ shows a carbonate binder with a moderate grain size. It contains minerals, primarily consisting of numerous small quartz grains that display a first-order birefringence hue. Additionally, there is a fragment of biotite, which appears brown in natural light and has low relief. Hence, this rock can be classified as a quartz sandstone.

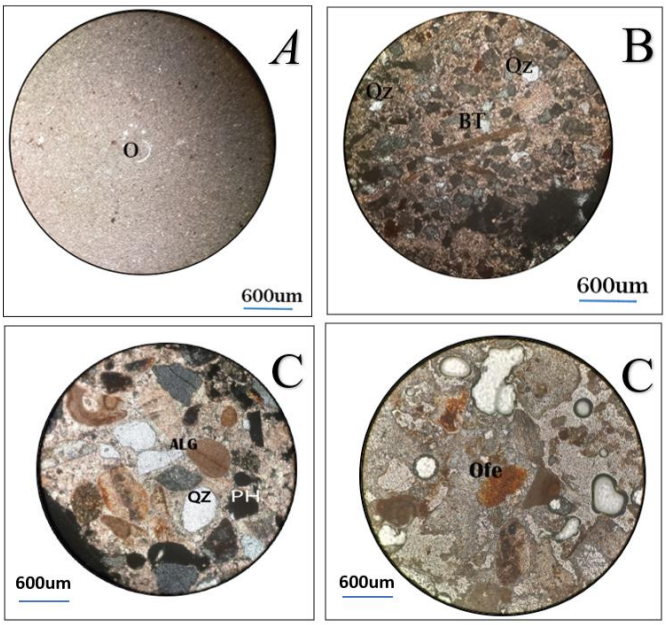

Fig. 8 Polarized light thin section of the samples: A: ''Alternating sandstone and conglomerate'' with Ostracod, B: 'Laminated Sandstone'' with Quartz and biotite, C: ''Massive sandstone'' with iron oxides, algae, phosphate and quartz.

The "C'' thin section contains bioclasts such as algae and gastropods, as well as minerals including quartz, altered volcanic debris, isotropic phosphate grains, and iron oxide, all held together by a calcareous binder (Fig.8).

IV. CONCLUSION

Ultimately, examining the outcomes of the diverse physical and mineralogical attributes yields insights on the paleoenvironment of our stratigraphic log.

The paleoenvironment undergoes a transformation from the bottom to the top, which is corroborated by the three extensively mentioned methodologies. Calcimetry provides insight into the changes in the proportion of calcite over time. The results of DRX analysis indicate the presence of quartz, Illite, Albite, Dolomite (CaO MgO 2CO2), calcite (CaCO3), Kaolinite, Biotite, Microcline, and Palygorskite in most samples, except for the laminated marls. This suggests that the samples have undergone diagenesis and indicates a calm and non-agitated coastal environment with a relatively warm climate. Smectite exhibits elevated values across all facies, indicating a depositional paleoenvironment that is conducive to its development. The paleoclimate exhibited warm and semi-arid conditions. Our thin section investigation has yielded fossils that unequivocally validate this climatic fluctuation.

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