Sediments of the middle Sebou Downstream Fez stream, between Fez River and Inaouene river, Pre-Rif, Morocco

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Abstract: *Sedimentary characteristics are of great importance in monitoring and understanding the state of the watercourse. The Sebou valley downstream of Fez, between Oued Fez and Oued Inaouene, is characterized by sedimentary components that differ between the top and the bottom, where the latter prints coarse and fine sediment banks, revealing the succession of different sedimentation periods for Oued Sebou.*

Its sedimentary components vary between the two banks of the watercourse in terms of components, texture and structure. This part is subject to violent fluvial dynamics, which leads to the development and change of its sediments from one place to another within the watercourse. Based on fieldwork (observation, shots, sediment sections and samples) and laboratory work (measurements, granular and microscopic analyses), we have found that this watercourse is differentiated by its sedimentary formations, and we have taken an example that represents it well, we aim through these characteristics to know and understand the sedimentary formations of the latter.

Keywords: *Sedimentation; Watercourse; Middle Sebou; Downstream from Fez; Pre-Rif; Morocco*

1. Introduction

This article focuses on studying and tracing the sedimentary state of Oued Sebou, which extends between the two wadis, Oued Fès and Oued Inaouene. It is an area that extends for about 37 km (Fig. 1), and this part draws meanders whose sediments differ from one place to another.

In this article, we will study the sedimentary characteristics of the stream. And we are thereby seeking to know the characteristics of sedimentation within it and the environment in which the deposit took place. (V. Bacchi., 2011 ; M.G. Wolman., 1954 ; A. Taous., 1994 ; C. Castanet et al 2007 ; R. Tony., 2006 ; L. Champagnac., 2005 ;) (J. Corbonnois et al 2011 ; J. Deferne et N. Engel., 2010 ; X. Devleeschouwer., 2009 ; N. Galliot., 2007), and this through field work in the laboratory and the analysis of topographic maps.

2. Method and Tools

In this paper, we have relied on fieldwork, including observation of the sedimentary landscape of Sebou streams, to determine the locations of cross-sections of sedimentary components in the stream and plot them. in the field, as well as the collection of samples of the sedimentary components of the watercourse.

We also relied on a Wolman grain size measurement protocol (Image 1), to measure the coarse element sizes of sedimentary materials in the valley floor, and took photographs to present this as evidence.

We relied on laboratory work, so we worked on sieving and analyzing the fine sedimentary components (Image 2) of the stream, using AFNOR sieves, while we worked on the morphoscopic analysis of quartz grains (Image 3).

Image 1: Example of Wolman pebble morphometric measurement protocol

Image 2: AFNOR sieve method for sediment sieving

Image 3: Adoption of morphoscopy for quartz analysis

The study area is located northeast of the city of Fez, from the confluence of wadi Sebou with wadi Fez to wadi Inaouene, and is bordered to the south by the Zouagha region of the Moulay Yacoub region, to the south. east by the commune of Tbouda, the region of Sefrou, and to the west by the Ouled Mimoune community, region of Moulay Yacoub, and to the north it is bounded by the region of Taounate (Monographie des communes d'El Ouadaine 2000- 2012, Ain Kansra 2012, Ain Bouali 1997).

The maps of Fez East and Fez West show at 1/50000 that the location of the study area is between latitudes 34 degrees and 05 minutes, 34 degrees and 15 minutes north of the equator, and between longitudes 4 degrees and 50 minutes and 5 degrees 05 minutes west of the Greenwich line.

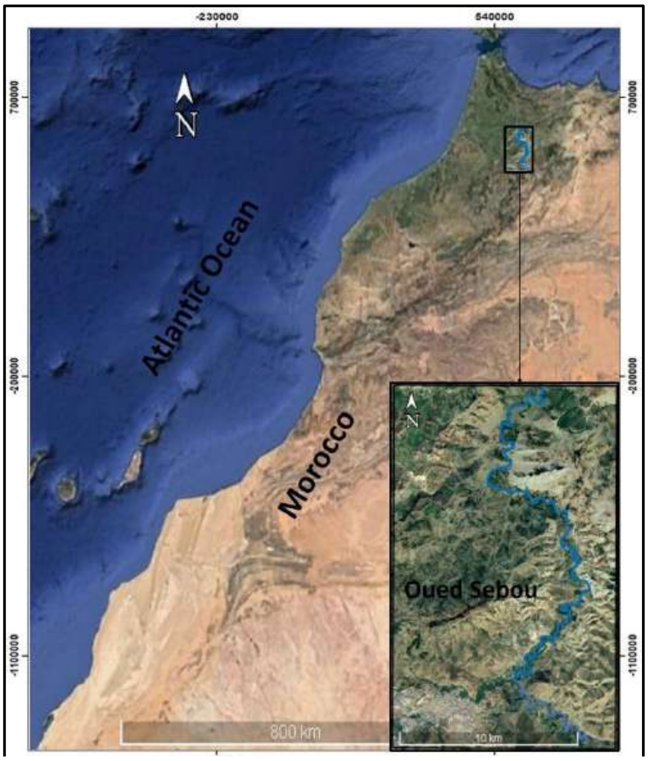

Fig -1: Location of the studied field

The general topography of the land surrounding the valley is characterized by the predominance of clayey hills, whose slopes overlook Oued Sebou or directly towards the watercourse, sometimes directly, and often from the eastern bank, such as JbelBourdim, in south of Ben Dadouche and Jbel Chwachi in the douar of Chaaba Boukraa. As for the west bank, only Jbel Fechtala is directly overlooked, on the north side of the Srarja region, and often monitoring is progressive in the study area.

3. Results and Discussion

3-1- Characteristics of river sediments

We show in Figure 6 the shape of the stream and its sediments, and the floodplain is about two meters deep. The sediments of the stream vary between coarse gravel and gravel and fine sand, but they differ in their distribution within the stream according to the hydro-morphological units of rotating barriers, sills and pits.

Fluvial sediments are generally made up of coarse elements containing pebbles, gravel and sandy silt, especially at the level of the convex banks where the bend barriers appear where coarse sediments accumulate dominated by pebbles and gravel and some silt sandy. Coarse sediments containing large boulders may also appear, especially where tributaries meet (Fig 2).

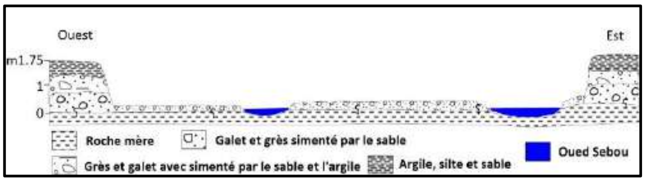

Fig 2 :A simplified section showing the shape and sediments of the Sebou valley, south-west of the douar of El-Khnachfa

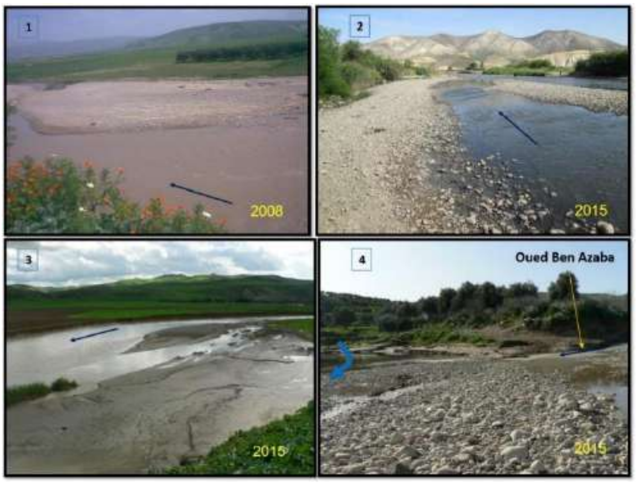

Photo Panel 4: Samples of common sediment types in the Sebou downstream of Fez

1- Example of the convex sediments of the right bank (at Fergouga place) north of the center of Hamria, where the pebble and gravel sediments were dominated by sand cements;

2- Example of coarse sediments consisting of pebbles and gravel and some mixed limestone between sand, clay and silt, at the threshold of the watercourse, south-west of Douar Al-Khnachfa;

3- Example of fine sediments made up of sand and silt on the convex left bank, north of Hamria;

4- Example of coarse sediments with blocks exceeding 20 cm, deposited at a sill, at the mouth of the Ben Azaba tributary, south of Hamria village.

3-2-River sediment analysis

The study and analysis of the coarse elements relied on field work, and we relied on laboratory work for the analysis of fine sandy materials (granulometry) and morphoscopic analysis, as well as the extraction of blunting, homogeneity and rounding indicators (A. Taous et M. Amayay, 2001 ; M. YazamiZtait, 2022), in order to know the conditions of flow and transport and the sediments.

3-3-Coarse element size

To study the size of the coarse elements, we relied on the measurement of the length of the coarse elements

(Fig. 3), and we worked on their measurement on the ground in the stream in the convex sediments of the bank. left to the southwest of the Al-Khnachfa dours (Image 2 in Photo Panel 4), according to the method of Wolman (M.G. Wolman., 1954) described previously.

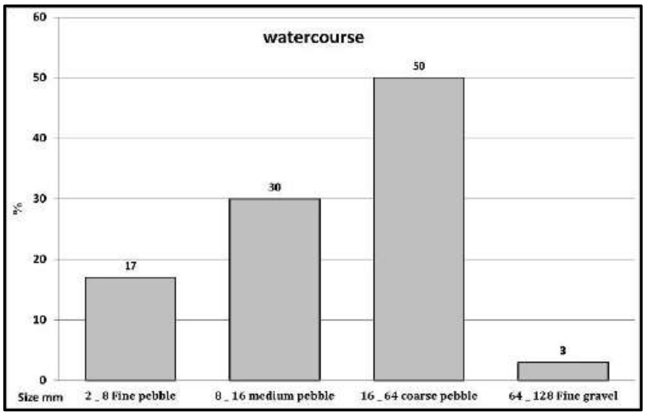

Fig 3 : Coarse elements in stream sediments, Al-Khnachfa area

Through the results, the stream sediments in this part are dominated by the gravel formations, constituting 95% of it, most of which consists of 50% coarse gravel, and the cobble constitutes only 3 % fine formations, while coarse gravel formations and boulders are rarely found, as shown in Fig 3, indicating that the force of the flow during the deposition of these sediments was moderate to medium strong.

a- Pebble morphometry

Selon la méthodologie de Wolman (O. Navratil, 2014 ; L.B. Léopold et G.M. Wolman, 1957), nous avons mené une etude morphométrique des elements graveleux, en mesurant la longueur, la largeur et l'épaisseur de chaque élément (le nombre étudié est de 100), et en utilisant la planche de visée pour déterminer le plus petit rayon (A. Mezghab, et al. 2000; Taous et M. Amayay, 2001), Puis nous avons calculé les indices de tassement et d'aplatissement des elements graveleux (Figs. 4, 5 et 6).

a- The flattening index (Ia)

The indicator is calculated using the following equation: Ia = (L+l) /2E

So that: (L = Length, l = Width, E = Thickness), in the case where the gravel is round, then: Ia = 1, and the higher this indicator, the more the shape of the gravel deviates from l rounded, depending on its rocky nature, and in general the flattening index is between 1 and 4.

Figure 8 shows that the category whose index is between 2 and 3.5 and which registers more than 80% is oval to semi-flat, while about 16% of them are semi-round, because the index is between 1 and 2 and about 4% is nearly flat because the index is 4.00.

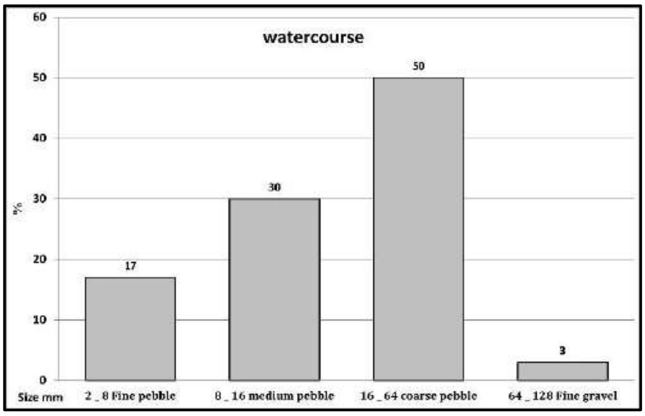

Fig 4 : Percentage of flattening index categories

The flattening index (Fig. 4) oscillates between 1 and 4, with an average of 4 and an average of 2.88, which highlights that the proportion of round pebble is very low, with a predominance of pebble flat oval, which indicates that these sediments were transported from a somewhat distant place by a flow of medium to somewhat strong intensity as well, since its index is dominated by the ratio oscillating between 1.5 elliptical and 3, 5 semi-flat.

b- The blunting index (IE)

This indicator is applied to the rollers which appear on their face as prone to jamming (Fig. 3-15), and to avoid fractional numbers, one calculates by the following equation: IE = 2r/L or IE= (2r x1000) /I

r = radius of the smallest circle on the gravel.

L = length of gravel.

In the case, if the pebbles are round and blunt, then IE = 1, (or 1 x 1000), and the lower this indicator, the less blunt the pebbles.

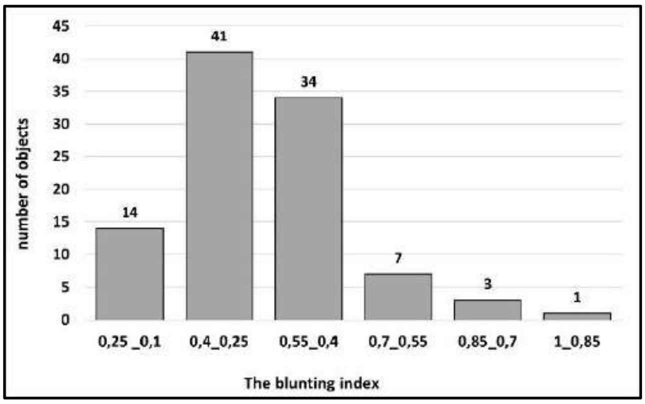

Fig 5 : The pebble roundness index

The bluntness index did not exceed this specified limit of 1 in all samples, so its mode belongs to the category

0.25 and 0.4, and its average is estimated to be around 0.37, which which indicates that all the pebbles are not blunt except one, but rather fluctuates between blunting and flattening, and also because its index oscillates in these samples between 1<IE<0.17, which confirms what we were talking through the previous clue.

c- The dissymmetry index (Id)

This indicator is calculated by applying the following equation: Id= Ac/L or Id= (Ac*1000) /L

So that Ac: the distance between the highest and furthest point in the rock or pebble (Fig. 6), and the higher this indicator is in Ac>L/2, the more heterogeneous the pebble becomes, and for the pebble is perfectly round, Id = 0.5 or 500 if we multiply 0.5 by 1000.

There is no great divergence between the coarse sedimentary components (pebble) since it is between 0.54<Id<0.90, with a mode belonging to the class of 0.65 and 0.8 and the average is estimated at 0.67, and therefore it is completely heterogeneous because it exceeds All have an asymmetry rate fixed at Id=0.5, which confirms that they were transported from a fairly distant space by strong flow to medium strength as they are nearly all semi-elliptical to flat (Fig. 6).

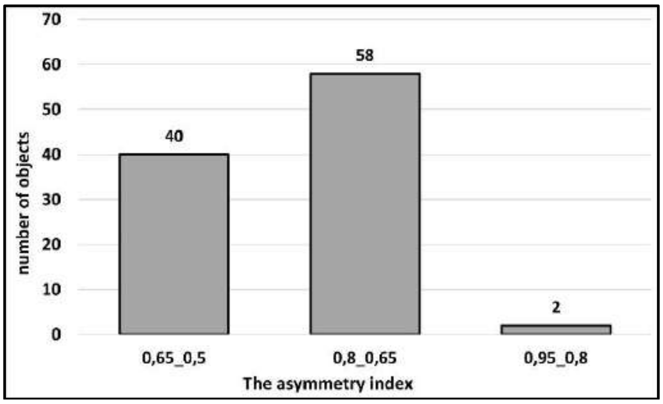

Fig 6 : Sediment homogeneity index

d- Granular analysis of fine sediments in the watercourse

We took a sample from the sediments of the Sebou valley, southwest of El-Khnachfa dour, in order to precisely analyze its sediments and know the state of its current sediments based on laboratory work.

After washing 300 g of the studied sample, of which 200 g of sand remains, which we sieved in the laboratory, we obtained the results represented in the cumulative frequency curve Fig 7.

The median of this sample is 0.51 mm, so the difference between the indicators still prevails, but there is convergence in the data, so the ranking index equal to So=1.94 shows that the arrangement of these sediments is very good according to TRASK, while the isolation and arrangement of materials is considered good according to INMAN because it is equal to 0.48σ◦ and according to FOLK and WARK because it reaches σ1 = 0.45. And the uniformity coefficient according to TRASK, which is SK = -1.29, shows that the distribution of materials is not uniform, but their arrangement is good for coarse sand.

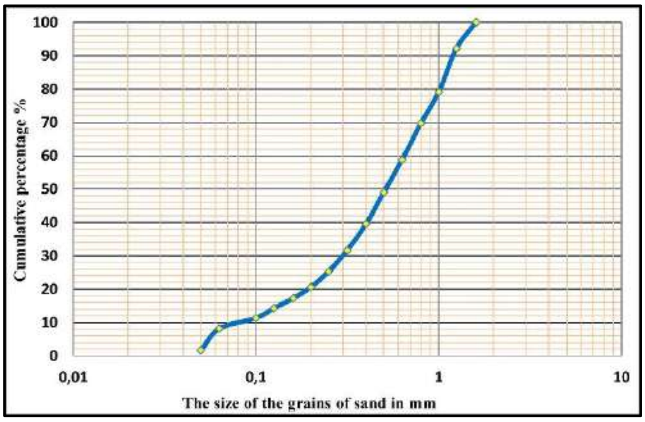

Fig 7: Cumulative curve of particle size values for the sample studied

e- Morphoscopic analysis of quartz grains

Thanks to the morphoscopic analysis of the quartz grains at the bottom of the stream, we obtained the following results (tab 1):

Type of beans	Percentage
Not worn	%17
Shiny Dulls	%33
Rounded grains	%50
Sum	%100

Tab 1: Results of morphoscopic analysis of quartz

The morphoscopic state of the grains shows that the river sediments differ among themselves, where the percentage of non-abrasive grains with sharp parts is 17%, which is the lowest percentage among the grains, indicating that the source of these materials is close, so they have not undergone friction, while the percentage of compacted and shiny grains reaches the rank The second is 33%, which indicates its prolonged friction due to river transport, and which predominates at the surface of abrasive granules, which are characterized by flatness and gloss, but the largest percentage of round granules remains at 50%, since the cause of their friction is the distance transport factor, which led to the disappearance of sharp places of these, that these granules are inherited from the sediment.

Morphoscopic analysis of the quartz grains shows that there is a great similarity between the floodplain sediments and the stream bottom sediments, which shows that these materials are from the same source, and have been subjected to the same mode of transport and sedimentation.

4. Conclusions

By analyzing the results of this article, it appears that the course of the Sebou in the fluvial zone which extends north of Fez to the borders of the meeting of the Sebou with Inaouene at a distance of 37 km, with a slope estimated at 0.3%, and the nature of its permanent flow, is currently controlled by the Allal El Fassi dam.

Its watercourse is characterized by loose bends in a vast floodplain in a geomorphological domain, in which generally a shaky schist basement predominates, facilitating various forms of fluvial erosion.

The deposited materials vary along the stream in terms of structure and sedimentary components, and they are coarse fluvial materials which appear at the bottom of the sections (cobble and gravel with cementation of sands) and fine silty materials appear at the top of the sections. The nature of the pebbles and gravels is characterized by the predominance of carbonated elements (limestone and dolomitic) from the Middle Atlas.

The sizes of coarse and fine sedimentary materials vary in different layers, depending on the conditions of the sedimentary environment of the river. The silt that appears at the top is material that was deposited during the flood phases of the river, which clearly shows that the water flow in the studied course differed from time to time in terms of strength and weakness of the flow.

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