



# Management of An Aquatic System Using a Morphoscopic and Exoscopic Approach: The Case of the Ebrie Lagoon System (Coast of Côte d'Ivoire)

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## Abstract

The morphoscopic and exoscopic analysis of quartz grains from the eastern sector of the Ebrié lagoon made it possible to determine the environment and reconstruct the sediment deposition environments. To achieve this objective, sediment samples were taken using a Van Veen grab and positioned by a GPS. They are washed with hydrochloric acid. Dry sieving produces medium quartz grains (0.5 - 0.25 mm). The selected quartz grains are observed under a scanning electron microscope (SEM). The morphoscopic study showed angular, sub-rounded to rounded quartz grains with blunt and shiny contours. Coming from the Mé, Comoé rivers, the Adjin and Potou lagoons, these sediments were transported at low energy over a very long distance before being deposited in the study area. Exoscopic examination of quartz grains from the sediments revealed large breaks on the surface of the quartz grains. Several shock trails are also visible and spread over the entire surface of the quartz grains. The presence of observed breakage and impact marks is the origin of the numerous movements of the quartz grain over a very long distance in a very agitated environment. The traces of chemical action identified are dissolution cavities and silica deposits. The strong presence of dissolution figures would facilitate the diffusion of silica and reveal the sedimentary history of the area. The quartz grains underwent torrential and marine fluvial transport.

## Subject Areas

Geology

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## Keywords

Morphoscopy, Exoscopy, Quartz, Environment, Ebrié Lagoon

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## 1. Introduction

Lagoons are coastal depressions located above mean sea level, in permanent or temporary communication with the sea, but are isolated from it by a barrier beach or other type of littoral barrier [1]. Côte d'Ivoire has one of the largest lagoon systems in Africa. This lagoon system is the receptacle for numerous urban and industrial activities, as well as household wastewater from the city of Abidjan [2] [3]. The Ebrié lagoon system in south-eastern Côte d'Ivoire comprises the Adjin, Potou and Ebrié lagoons. The eastern branch of the Ebrié lagoon will be the focus of our study. Motivated by the monitoring, protection and management of aquatic ecosystems, this study will provide management indicators based on the morphoscopy and exoscopy of quartz grains. This system is not immune to all forms of pollution linked to trace metals (TMEs). Sediments can be associated with trace metals, which are a threat to water, living species and human health [4] [5]. Their deposition over time could modify the morphology and lead to the lagoons filling in or silting up. This could lead to a reduction in water volume and the disappearance of certain aquatic species. These sediment deposits are made up of grains of quartz with several microstructures on their surfaces. These will enable us to characterise the sediments in the eastern sector of the Ebrié Lagoon. Then, to determine the environment in which these sediments were deposited. Finally, to identify the traces of mechanical and chemical action of the sand grains. This could be possible with the sole aim of determining the environment and reconstructing the sediment deposition environments in the eastern sector of the Ebrié lagoon in order to better manage and preserve the lagoon.

## 2. Study Area, Materials and Method

### 2.1. Study Area

This part of the lagoon is located in the eastern branch of the Ebrié lagoon system, precisely in the south-east of Côte d'Ivoire. It extends from the bay of Bingerville to the Île vitrée by far of the Comoé River at Grand-Bassam (Figure 1).

### 2.2. Materials and Methods

The equipment used consisted of four (4) sediment sampling stations spread over our study area. At each sampling point, the sediments were taken with a Been van veen. The positions of the samples (x and y coordinates) were given by a Garmin GPS. The sediments were packed in zipper bags and labelled (sample number and x and y coordinates). The sediments were kept in a cooler for processing in the laboratory. In the laboratory, the sediments were sieved on a column of 16

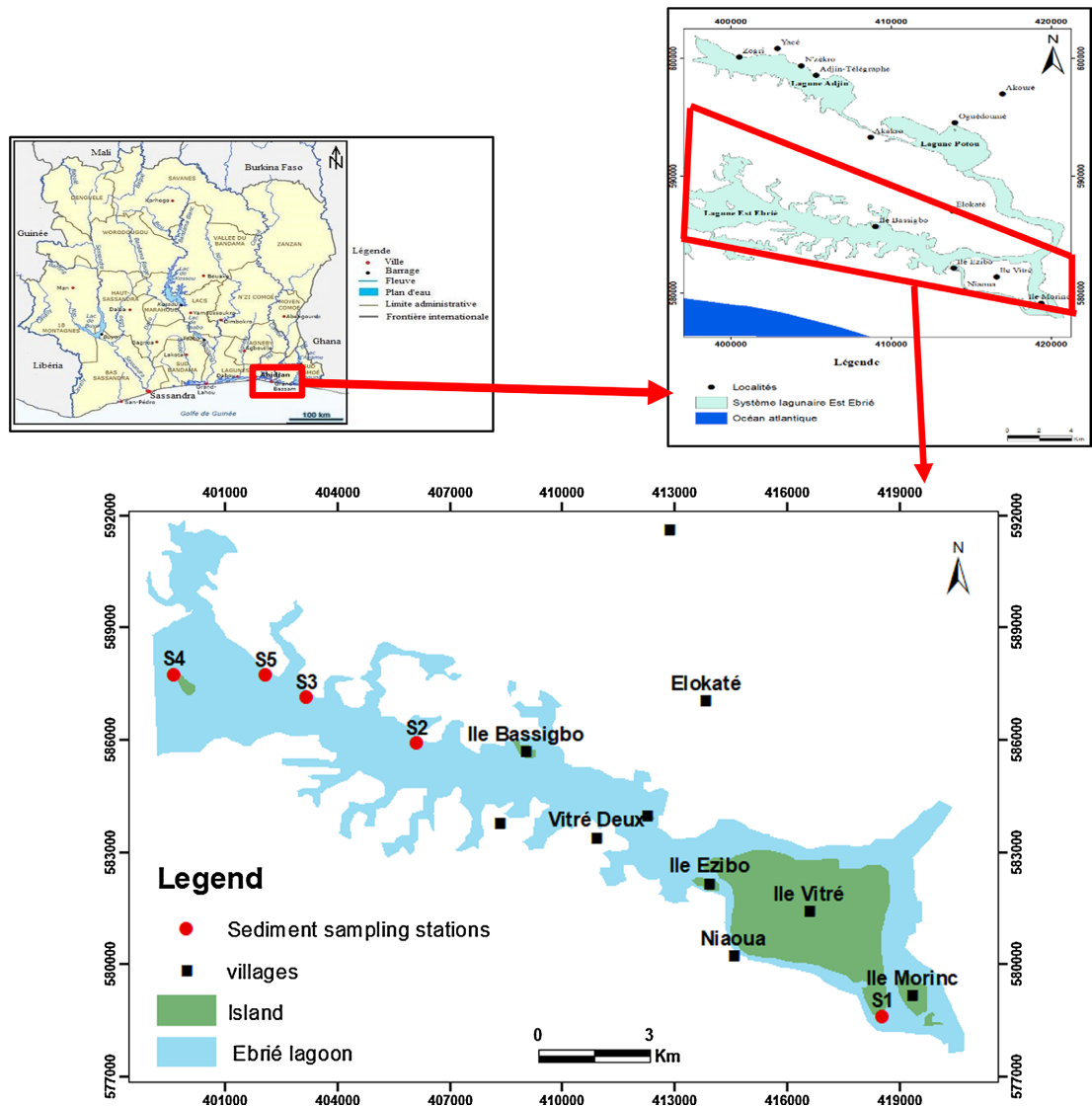


Figure 1. Location of the study area.

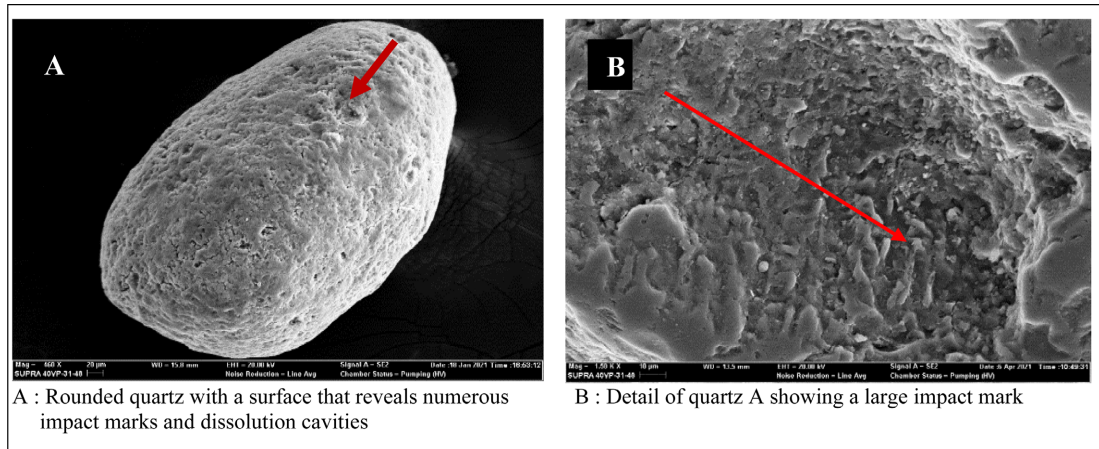
AFNOR-type sieves with mesh sizes ranging from 0.063 mm to 2 mm. Sieve rejects by particle size class (which provide information on the sediment’s degree of classification: mean, standard deviation, skewness) are calculated [6] [7]. Morphoscopic analysis [8] [9], using an SEM microscope, consists of examining the general shape of the grains and their degree of wear. The exoscopic study with average grains of 250 to 400 µm will consist of simultaneously analysing the traces resulting from mechanical and chemical actions with a scanning electron microscope [10]. These different analyses will provide information on the transport and deposition environment of the quartz grains.

### 3. Results

#### 3.1. Analysis of the Quartz Grains in Plate 1

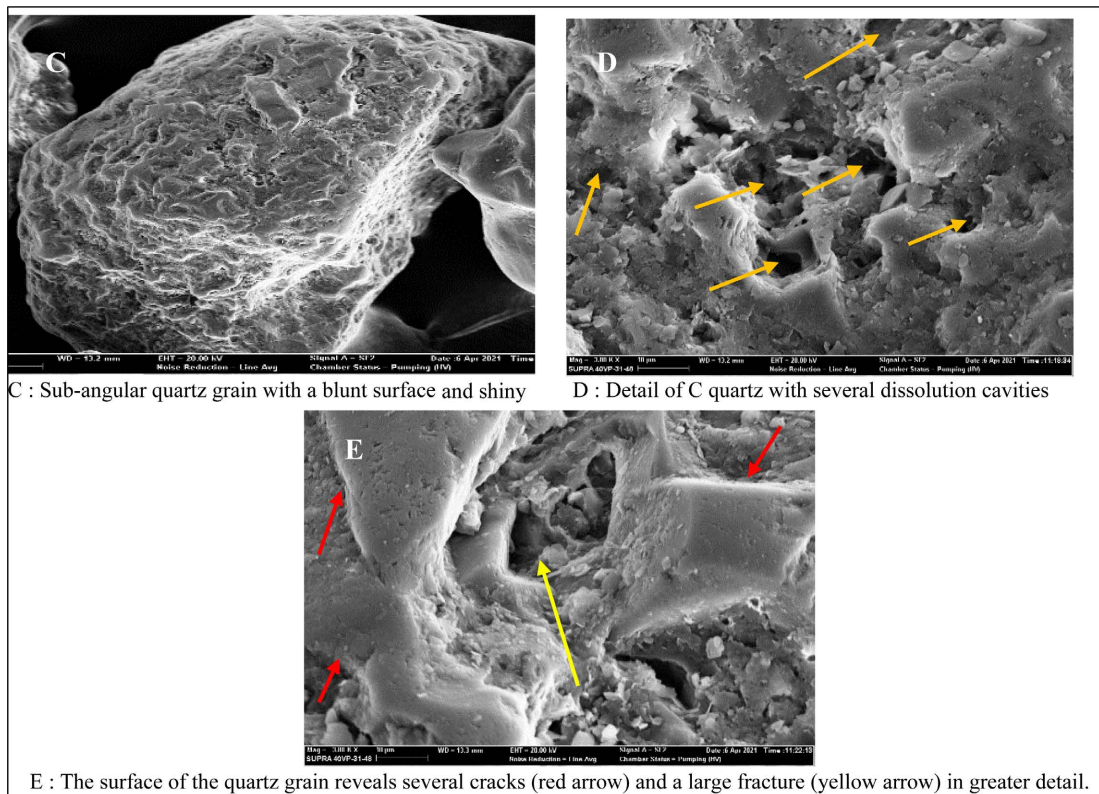
Traces of mechanical action can be seen on the surface of the quartz grain (Plate 1).

These traces of mechanical action are represented on the rounded quartz grain by several marks and impact marks (photo A). From these impact marks, which are present all over the surface of the grain, we can also distinguish large marks depending on the thickness (photo B). Photo A of the grain surface also reveals dissolution cavities, symbolising traces of chemical action. These dissolution cavities differ according to their thickness over the entire surface of the quartz grain.



**Plate 1.** Rounded quartz grain affected by traces of mechanical action.

### 3.2. Analysis of the Quartz Grains in Plate 2

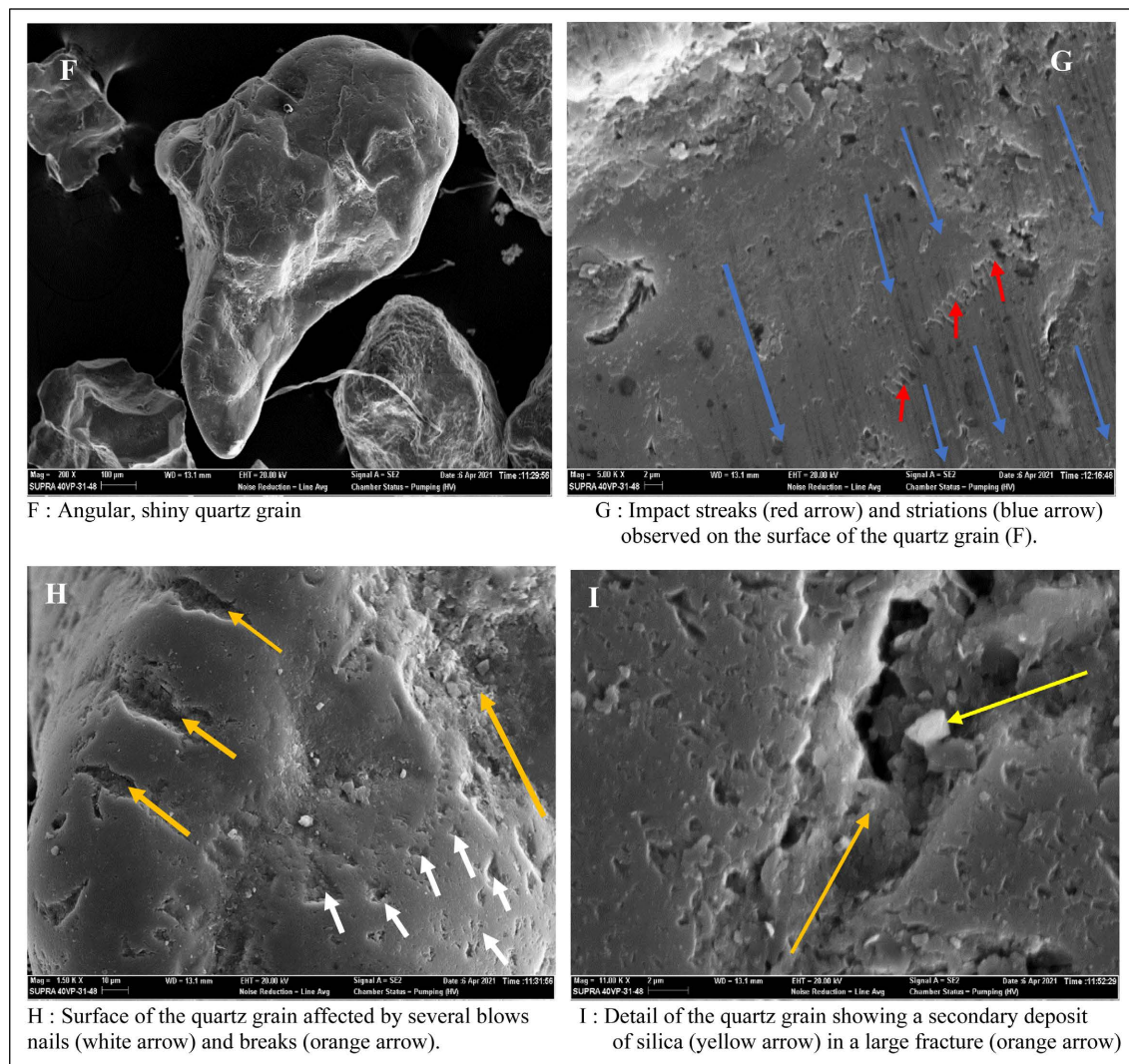


**Plate 2.** Sub-angular quartz grain, traces of mechanical and chemical action observed on the quartz grain.

The sub-angular, blunt and shiny quartz grains (photo C) reveal several cracks (red arrows) as well as a large break (yellow arrow) on the surface of the quartz grain reflecting traces of mechanical action (photo E). The thickness of the fracture shows the extent of the impact on the quartz grain. The surface of this quartz grain also reveals several dissolution cavities (orange arrows), which are traces of chemical action (photo D). These dissolution cavities are arranged one after the other, forming a particular pattern on the surface of the grain.

### 3.3. Analysis of Quartz Grains from Plate 3

Morphoscopic analysis of the quartz grains in **Plate 3** reveals that the quartz grains are angular with a shiny surface. Photo G shows several impact streaks (red arrow) and striations (blue arrow) on the surface of the quartz grain (F). The striations are distributed over almost the entire surface of the grain, in which we can see the shock trails. The surface of the quartz grain is also affected by several nail cuts (white arrow) and breaks (orange arrow) (photo H). This arrangement of



**Plate 3.** Angular, shiny quartz grains with traces of mechanical and chemical action.

structures is characteristic of traces of mechanical action. Photo I shows us a detail of the quartz grain (F) showing a secondary silica deposit (yellow arrow) lodged in a large fracture (orange arrow). The whitish colour of the silica confirms the presence of a trace of chemical action.

#### 4. Discussion

The results of the morphoscopic analysis in this study revealed that quartz grains have rounded, angular and sub-rounded shapes. These results are in agreement with the work of [11]. The surface of these quartz grains is blunt and shiny. The rounded quartz grains found in this sector of the Ebrié lagoon could indicate transport over a relatively long distance in a fluvial environment [12]. Given the geographical location of our study area, these quartz grains could have originated from the Adjin and Potou lagoons before being found in the eastern sector of the Ebrié Lagoon. The transport and deposition of these sediments took place in a relatively calm environment. In addition, the angular to sub-angular quartz grains could be explained by the various water currents (rivers) and streams (Mé and Comoé) that flow into the Ebrié lagoon. These tributaries favour high-energy transport over a short distance [13]. We have also noted the presence of sediments from run-off and agricultural activities near the lagoon. This can be explained by the fact that the sediments originating from the bedrock in contact with the coastal basin were not worn away by the mechanical action of transport prior to deposition [14]. However, exoscopic examination of the quartz grains revealed numerous traces of mechanical and chemical action. The appearance of traces of mechanical action represented by (impact trails, breaks, cracks, striations and finger-nail marks) on the surface of the quartz grain is at the origin of transport over a long distance with torrential energy. This is the active phase [15]. The distant origin of these sand grains confirms their dynamic movement in the Ebrié lagoon system. We also observed dissolution cavities and secondary silica deposits (traces of chemical action) on the surface of the quartz grains. The dissolution cavities observed in the eastern sector of the Ebrié lagoon involve the removal of surface zones, small (photo A) and large (photo D) openings on the surface of the quartz grain. This is due to shocks that facilitate silica diffusion [16]. The siliceous deposits disseminated in the breaks on the surface of the quartz grain indicate immobilisation of the grains in an aquatic environment. These siliceous deposits only appear on grains immobilised in a marine environment, which characterises the intertidal and high beach domain [10]. The siliceous film observed in our study area is rectangular, characteristic of a geometric shape with very distinct angles. When the siliceous film is better developed and thicker, as encountered in our work, this indicates a low-energy environment [17]. In this case, the transition from the lower to the upper middle of the quartz grain in the eastern branch of the Ebrié lagoon will be long and perfectly immobilised. The dissolution patterns and variations in shock marks indicate the important role played by the Ebrié lagoon in the emplacement of the sediments.

## 5. Conclusion

This study, carried out in the eastern sector of the Ebrié Lagoon, focused on the morphoscopic and exoscopic analysis of quartz grains with the aim of reconstructing the sediment deposition environment in order to better manage this aquatic resource. The morphoscopic study of the quartz grains revealed the presence of rounded, angular and sub-rounded grains. These grains are blunt and shiny. Exoscopic examination of the quartz grains revealed an abundance of microstructures. Shock streaks, fractures, cracks, striations and fingernail marks are all mechanical microstructures. The chemical microstructures observed on the surface of the quartz grain are represented by dissolution cavities and silica deposits. Interpretation of these traces of mechanical and chemical action shows that the Adjin Lagoon, the Potou Lagoon, the Me and Comoe Rivers were an effective middle for the various displacements and sedimentary movements of quartz grains in the eastern part of the Ebrié Lagoon. Our quartz grains would have evolved according to their sedimentary history in a torrential fluvial and marine environment. The variation in the shape and appearance of quartz grains reflects the amplification of human activities. This amplification is at the origin of the variety of anthropic activities that have a considerable impact on the Ebrié Lagoon system. The introduction of a number of management methods will enable the Ivorian government to take a closer look at the protection and monitoring of aquatic ecosystems.

## Conflicts of Interest

The authors declare no conflicts of interest.

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