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Spatial Distribution of Beach Sediments between Grand-Lahou and Jacqueville (Côte d'Ivoire): Granulometric and Mineralogical Approach

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Abstract: ***This work is a contribution under investigation heavy and light minerals of the sandy sediments of the littoral perimeter of Grand-Lahou and that of Jacqueville. It also relates to the granulometric distribution of sandy sediments taken on these beaches. The heavy minerals are composed in majority by ilmenite and the rutile in all the samples taken on the beach of Grand -Lahou. The other mineralogical species met play a secondary part in the composition of the heavy mineral processions. They are in particular, the chlorite, epidote, garnet, pyroxene, the rutile, sillimanite and the sphene. The light minerals are primarily made up of grains of quartz with hyaline aspect or translucent and of the grains with milky aspect. Among light minerals, one also recognizes the feldspars which are slightly represented in these samples. On the beach of Jacqueville one notes the presence of quartz, feldspaths, sillimanite, biotite, pyroxene, ilmenite and amphibole. Whatever their source, sands contain minerals at various stages of deterioration. The mineralogical procession is influenced by the geological nature of the area***

Keywords: Granulometry, mineralogy, beach Grand-Lahou, Jacqueville

1. Introduction

The heavy minerals are excellent tracers of the origin of the deposits. They bring information on the origin and the dynamics of deposit of detrital equipment (Pomerol, 1968; Lapierre, 1970; Jones and Davies, 1979) : [1,2,3]. The study of heavy minerals on the beach of Grand -Lahou and that of Jacqueville is fragmentary. Old work of which we lay out (Wognin 2004, Kouakou 2004, N'Doufou, 2005, Fea 2006, N'Doufou, 2012) : [4,5,6,7,8]. show that the mineralogical species most abundant are… the ilmenite, the qartz…. However, the origin of the sediments misses precision. This study was initiated in order to bring precise details on the origin of certain deposits. It relates to heavy and light minerals of samples taken on the beach of Grand-Lahou and that of Jacqueville (figure 1). We will give the mineralogical processions particular to these two zones as well as the granulometric distribution of the sandy sediments.

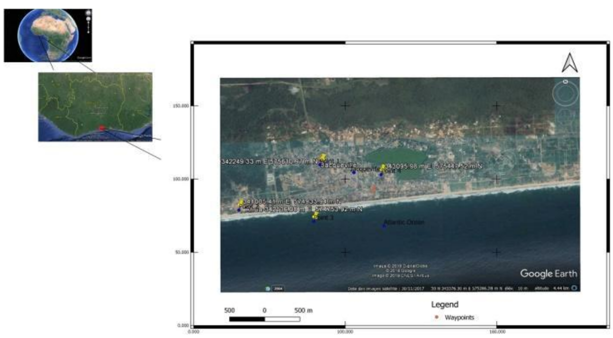

Figure 1: Localization of the study area (A) Jacqueville and (B) Grand-Lahou

2. Materials and Methods

The characterization of the sandy sediments was made in laboratory by grain size and mineralogical analysiss after a data collection campaign on the beaches of Grand-Lahou and Jaqueville.

2.1. Mineralogy

The sediments intended for this study were taken in a synchronous way on the various beaches. After treatment and sifting on a series of sieves meeting standards AFNOR, the samples whose diameters lie between 63µm and 125 µm were retained for the study. This fraction contains the maximum of minerals. Indeed, various work (Pomerol, 1968; Pupin, 1976; Tourenq, 1986; Censier, 1991) : [1,9,10,11]. showed that the heavy residue of this fraction is representative of a clastic rock. It is then possible to establish mineralogical filiations likely to exist between the various formations, then to locate the petrographic provinces from where they result. The mineralogical composition of sands was given, under the optical microscope and the electron microscope (MEB-EDS) after clothes industry of thin blades. The thin blades were observed under the optical microscope in natural light (LN), and in polarized light (LP) in and the research Analyses Center of the PETROCI. The device used is a polarizing microscope Eclipses 5Oi POL. coupled to a numeric camera. The digitized images were treated using the operating software of the digitized images. The estimate of the content of minerals was done starting from the diagram established by Cailleux and Tricart (1959) [12]. The made thin blades also were the object of chemical analyses with the MEB-EDS with an analyzed minimal surface of 4 mm2. The MEB of the type FEG SUPRA 40 VP Zeiss made it possible to characterize the morphology and the chemistry of the various mineral phases of the samples. Spectra characteristic in dispersion of energy of some mineral phases were carried out in order to specify the content the elements present. The images in mode retrodiffused and the microanalyses were carried out under a tension of acceleration of 12 Kv.

2.2 Granulometric parameters

The principal granulometric parameters that are the average, the standard deviation, the skewness, the kurtosis and the median were calculated according to the method of Folk and Ward (1957) [13].

2.3. Mode of transport of the sediment

The mode of transport of the sediments was given starting from the test of Visher (1969) [14]. Indeed, the granulometric distribution of the sediments starting from the cumulative curves generally presents formed curves of several segments of right-hand sides. What seems to indicate that the sediment consists of a mixture of several granulometric families. The types of curves obtained are directly connected to the modes of transport of the particles. This method makes it possible to define three modes of transport ([15]Larras, 1972): the suspension (90 to 100%): the particles progress in the direction of the current within the liquid without never falling down, except very episodically, on the bottom; the saltation (10 to 90%): the particles move by jumps and fall down successively at relatively appreciable distances; haulage or bearing (0 to 10%): the particles slip and roll (or jump slightly) in the direction of the current on the bottom".

2.4. granulometric Facies

The cumulative curves also made it possible to determine the various granulometric facies. The determination was done starting from the terminology of Tricart (1965) [16]. The granulometric facies reflect either a mode of deposit, or a kind of evolution after the deposit (Pinot, 1994) [17].. One associates with each figure, an environment of deposit and one gives an interpretation according to the curve of the curve (Serra 1985[18]): The parabolic facies is a fragment of parabola which share either of the origin, or of an unspecified point of the x-axis. This facies indicates a brutal stop during the transport of these sediments. This facies is generally associated with sediments where the transport of the particles could be carried out in suspension graduated for the coarse particles and in uniform suspension for the fine particles; The hyperbolic facies or sigmoid facies represented by a sigmoid curve results from a limited only one selection slices of equipment. Sedimentation was done by free accumulation; The facies logarithmic curve is represented by a curve more or less comparable to a line. The slope of this line varies mainly according to the proportion in fine elements. The slope of the central part is all the more stiff as the deceleration of the current is brutal. This facies indicates a deposit by excess of load following a reduction in the competence of the freight agent.

2.5 Environment of deposit

The determination of the environment of deposit was possible starting from the digraphs of dispersion of Moiola and Weiser (1968) [19]. The scatter chart Sk-Md makes it possible to differentiate the environment from deposit continental dune of the environment of deposit coastal dune starting from the line of equation Y= -0,53x+1,24. The scatter chart Md-S0 makes it possible to differentiate the stream sands from sands of beach starting from the line of equation Y= -4,9x+3,76.

3. Result

3.1 Granulometry and mineralogy of the sediments of the beach from Grand -Lahou

3.1.1 Granulometry of the sediments of beach

The sandy sediments are average with coarse 409 < Mz < 560 good with moderately classified 0.41 < σ < 0.64 and symmetrical (- 0.06 < Sk < 0). The sediments of BE are platykurtic 0.31 < K < 0.37 when those of HE are mesokurtic 0.7 < K < 0.75. The mode of transport dominating remains the saltation (86,75%). The proportions of sediments transported by suspension and haulage are respectively of 6,75% and 6,5% (Figure 2). Transport by haulage and transport by suspension are the least important modes of transport. The cumulative curves take a sigmoid form with the Headlight as with the Catholic Mission (Figure 3). Sedimentation was done by free accumulation. The facies does not vary according to the sectors of study

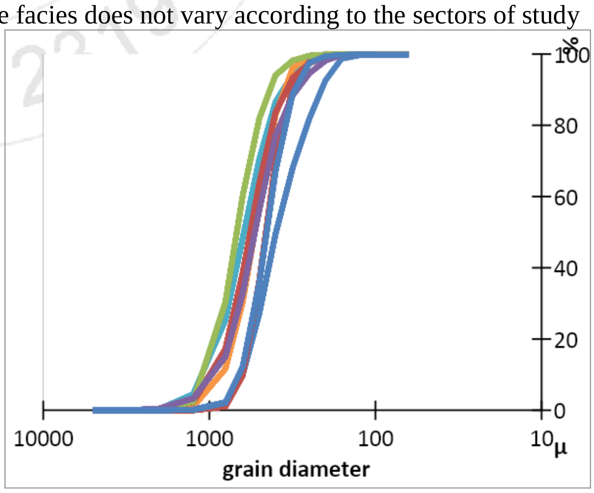

Figure 2: Granulometric facies with the Catholic Mission and the Headlight of Grand-Lahou

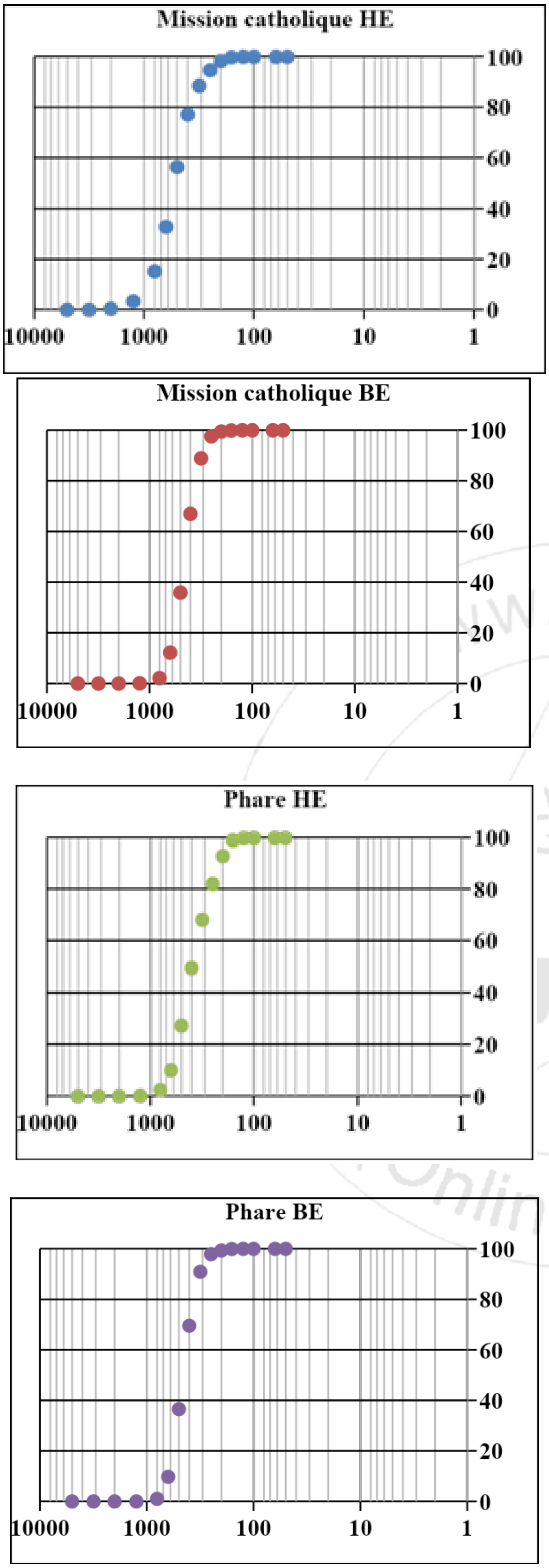

Figure 3: Mode of transport of the sediments to the Catholic Mission and the Headlight of Grand-Lahou

3.1.2 Mineralogy of the sediment of beach

The chemical analysis shows high percentages of dioxide TiO_2 titanium, iron oxide (FeO) and of silica (SiO_2) (Figure 4). These high contents testify to the titaniferous mineral and quartz abundance. The observation under the polarizing microscope confirms these results (quartz (35 to 50%), (ilmenite (25 to 35%)) and also a considerable presence of rutile (10 to 15%) reveals (Figure 5). The presence of rutile would be explained by the fact why it is formed starting from ilmenite by a hydrothermal process (Wilhelm, 1988) [20]. The rutile is generally presented under the aspect of particles rounded brown red. The ilmenite grains tabular in strips are more or less blunted because the ilmenite wears even with difficulty after a long transport (Parfenoff and al. 1970) [21]. The chemical analysis of the samples of HE shows contents of TiO_2 which oscillate between 12 and 18%. That of the samples of BE shows that the contents lower than 1%. The observation under the polarizing microscope reveals that the heavy minerals are more abundant on HE compared to BE. This remark confirms the observations made by the chemical analysis, which showed higher contents of TiO_2 on haut estran. Biotite with inclusion of zircon, amphibole, pyroxene, epidote, hematite, magnetite and feldspars are scarce on the beach (2 to 4%).

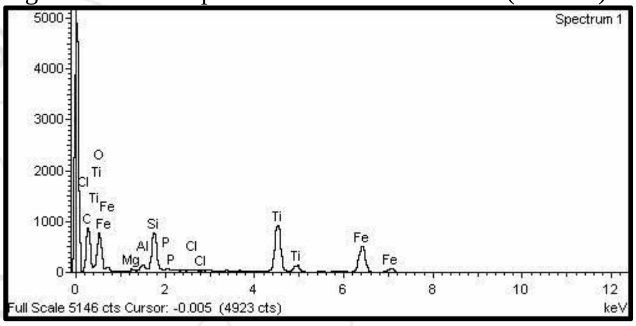

Figure 4: Spectrum of sediment analyzed to the MEB

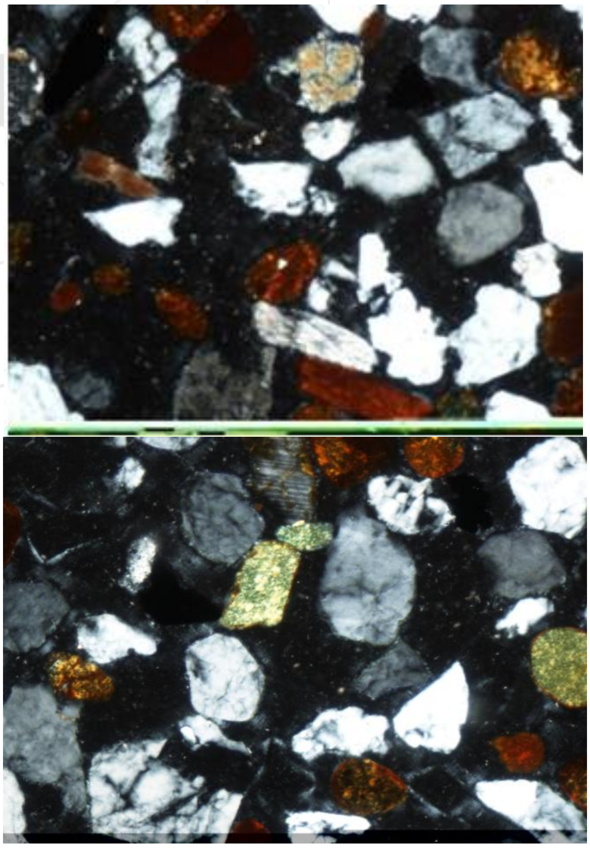

Figure 5 (a and b): Thin blade of sediments of beach in polarized light: 1: rutile; 2; biotite; 3: ilmenite 4: epidote; 5: pyroxene 6: quartz

3.2 Granulometry and mineralogy of the sediments of the beach of Jacqueville

3.2.1 Granulometry of the sediments of beach

Sands are average with coarse 457 < Mz < 609, moderately classified 0.5 < σ < 0.55, symmetrical -0.03 < Sk < 0.00 and platykurtiques 0.48 < K < 0.55. The sediments are generally transported by saltation (81%) (Figure 6). Transport by suspension is estimated at 6.5%. 12,5% of sands are transported by haulage. The grading curves take a sigmoid form (Figure 7) and are similar to those observed with Grand-Lahou. The deposit was carried out because of a variation banal and moderated in the competence of the current of transport.

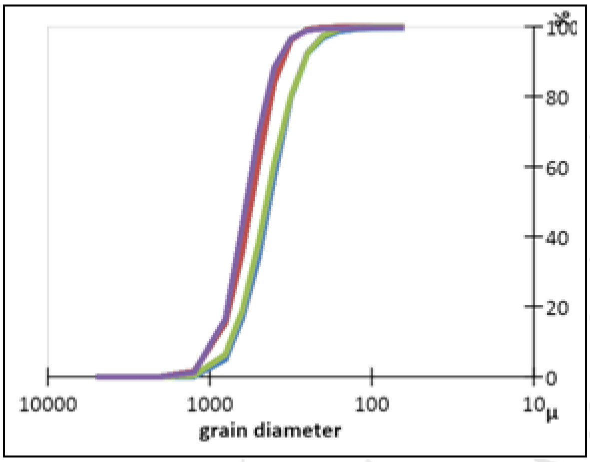

Figure 6: Granulometric facies with Jacqueville

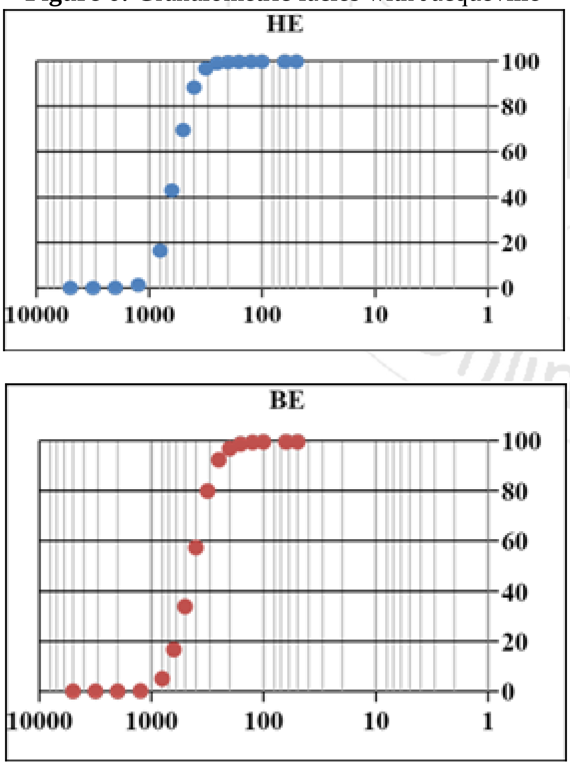

Figure 7: Mode of transport of the sediments of beach in Jacqueville

3.2.2 Mineralogy of the sediments of beach

Chemical analysis carried out watch of the high percentages of silica (SiO2) (Figure 8). The contents of TiO2, FeO, K2O, P2O5 and Al2O3 are very weak, generally lower than 1%. The observation under the polarizing microscope reveals the abundance of quartz (65%) (Figure 9). One observes also feldspars (5%), sillimanite (7%), biotite (4%), pyroxene (2%), ilmenite (10%) and the amphibole (2%).

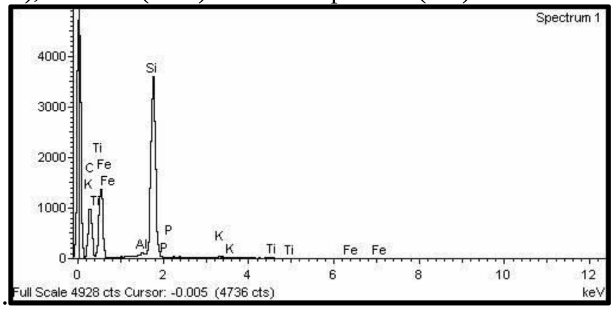

Figure 8: Spectrum of sediment analyzed to the MEB

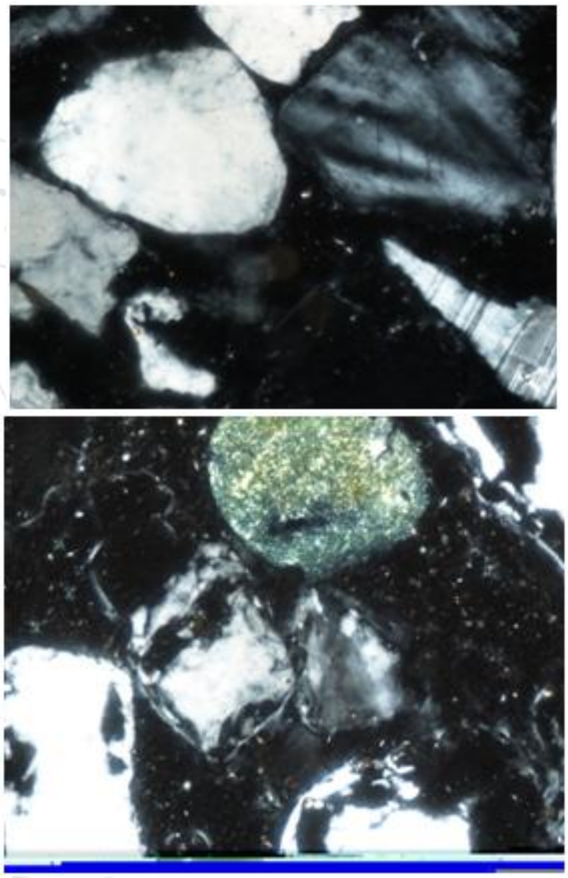

Figure 9 (a and b): Thin sand blade in polarized light 1 plagioclase; 2: quartz with undulating extinction; 3: Green hornblende

3.3 Environment of deposit of the sediments of beach

The distribution of sand in the diagram reveals two origins: fluviatile and marine (Figure 10). The beaches of Grand-Lahou and Jacqueville are consequently fed by the sediments coming from the rivers and the erosion of the continental shelf. Diagrams Sk-Md present a group of dots distributed in the field of coastal dune in the two stations (Figure 11 and 12).

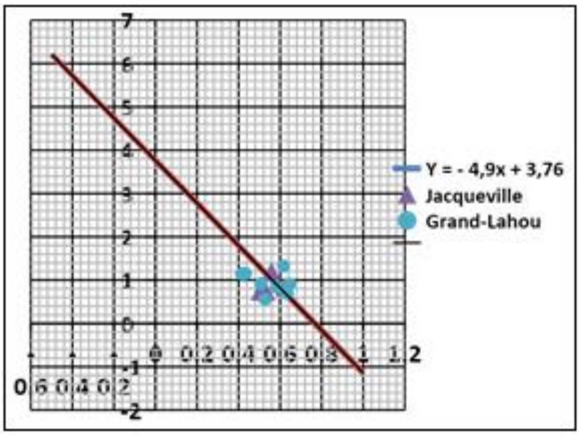

Figure 10: Scatter chart (Md-So) of sands of beach to Grand-Lahou and Jacqueville.

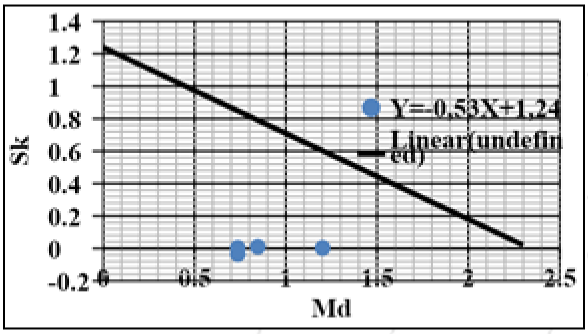

Figure 11: Scatter chart (Sk-Md) of sands of Jacqueville

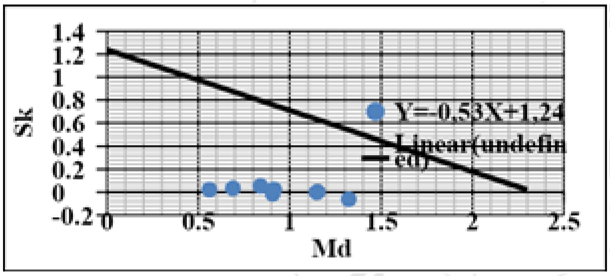

Figure 12: Scatter chart (Sk-Md of sands of Grand-Lahou

4. Discussion

The sediments of the high estran are generally coarser than those of the low estran. The sediments of the bottom of beach subjected to energy conditions should be coarser than those of the high estran (Miller and Zeigler, 1958; Fox terrier and al., 1966; Dubois, 1982) [22, 23, 24]. The coarse sediments would have been deposited on the high beach during the bank jet. During the withdrawal, speeds of current being weak, the fraction of the coarse sediments could not be trained towards the broad one. The action of the waves results thus in a sedimentary sorting, the fine sediment is winnowed towards the broad one whereas the coarse sediment accumulates on the coast (Zenkovich, 1946; Murray, 1967[25, 26]). The sediments of the low estran are classified generally better than those of BE. These observations made on the sediments of the BE and those of HE starting from the average and the standard deviation are of the same type as those described by McLaren (1981) [27]between a sediment source which would be sands of the HE and a sediment deposited from which it is resulting after transport, sands of BE. On the level of BE, one finds the strongest variations granulometric, which is justified by the fact that it is the zone where the energy of the swells is strongest (Zeigler and Tuttle, 1961; Oyegun, 1991) [28, 29]. The heavy minerals are irregularly distributed on the beaches. They are more abundant on the high beach. Their distribution controlled by the local hydrodynamics (coastal waves and currents) depends on the density, the form and the size of the various mineral species (Parfenoff and al., 1970) [30]. Ilmenite grains contained in the sediments black, tabular in strips are more or less blunted comparable with the described grains by Parfenoff and *al*., (1970[30]). High titaniferous mineral concentrations were announced on several beaches located near the estuaries on the Atlantic (Mhammdi, 1990 ***in*** Mhammdi and ***al***., 2005). [31] The concentration of heavy minerals in the sediments of beach can be due to several factors such as, the source of contribution, the sedimentary processes of deterioration and transport following the example of the terrigenous surface sediments of continental platform described by (Mange and Maurer, 1992; Morton and Hallsworth, 1999) [32, 33].

5. Conclusion

The granulometric analysis showed a prevalence of average sands to coarse on the two sites which are transported mainly by saltation. The semi-logarithmic cumulative curves of the sediments take as a whole a sigmoid form indicating that the deposit of the sediments on the beaches was carried out because of a variation banal and moderated in the competence of the current of transport.

Black sands of the beach of Grand-Lahou are almost exclusively made up of ilmenite, derutile as well as zircons and epidotes of continental origin. The Ilmenite is the mineral most characteristic of the heavy mineralogical procession. It only accounts for with him 35 to 55% of heavy minerals identified on the beach of Grand-Lahou. These important contents in fact are located exclusively in the immediate neighbourhoods of the mouth of Bandama thus translating a continental origin of the contributions and a coastal transit resulting since the source until the medium from deposit. The light minerals are represented by a varied mineral procession where quartz occupies nearly 55% of the detrital fraction. The feldspars are represented by orthoclase and the microcline.

The distribution of minerals on the beaches is controlled by the local hydrodynamics (coastal waves and currents) and depends on the size of the various mineral species. In the studied samples, certain minerals are at various stages of deterioration. They are associated with other minerals presenting a fresh aspect. It is the case of ilmenite and the rutile. This characteristic let's suppose that the analyzed sediments were inherited more or less old formations presenting variable degrees of deterioration, which indicates a multiple origin of these sandy sediments. These sandy minerals can be inherited as well metamorphic rocks as of rocks eruptive and conveyed by the rivers.

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