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Thermo-physical and chemical characterization of the clay resulting from the mechanical treatment of the clayey ground : case of the clayey ground of the area of Nomayos - Yaoundé - Cameroon.

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Abstract: *The work presented in this article consists in proving that the earth of Nomayos, a district of the city of Yaoundé, central province in Cameroon can produce clays with remarkable results in the manufacture of ceramic materials with remarkable performances. For that, we first made a descent on Nomayos and extracted the ground. Then we made a mechanical treatment of the ground which gave us clay that we characterized physically, thermally then chemically. For the mechanical treatment, we used local materials to obtain clay. For the physical properties, we used the standard tools of the physical characterization of clays by respecting the standards in force. For the thermal properties, we used a LENSEI apparatus to obtain the TGA/DSC of the clay. For the chemical properties, we used an Alpha spectrometer of the Bruker firm analyzed by the ATR technique on a diamond crystal to obtain the FTIR of the clay. Finally we used a USB digital microscope with HD color CMOS sensor, high speed DSP (dricer free available), 24bit DSP, optimal resolution 640x480, 5x digital zoom to observe at a larger scale the physiological composition of the raw and processed soil. We obtained that, the mechanical treatment of the Nomayos soil gives pure clay. The characterization of the obtained clay gives a density between 1.85 and 2.06 g/cm3, a water content of 29.1%, a porosity of 28.60%, a Vbs of 1.43, a granulometric analysis of gravel of 7%, sand of 23.6%, silt of 11% and clay of 58.4%, an atterberg limit provides a liquidity limit of 55%, a plasticity limit of 26.6% and a plasticity index of 28.4% characteristic of clayey soils of group A3. TGA and DSC showed the presence of free water, Kaolinite, illite and Quartz in important proportion affirming that this clay is of kaolinite type. The FTIR showed the presence of -CH2 silane groups, -C-O amorphous silicas affirming that this clay can be used as a binder in buildings and also for coatings. These results of the clay from the nomayos soil reassure us that the muddy and slippery soils contain clay of quality and in considerable quantity.*

Key Word*: Mechanical processing of clay soil, physical properties, Thermogravimetric analysis, Thermo differential analysis, Fourier transform infrared*.

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I. Introduction

Earth, a material available in quantity and ubiquitous, is used in construction in general as mechanical construction (brake linings of elevators, ...), electrical construction (capacitors, fuse shells, some electrical and electronic insulators), building construction (tiles, flowerpots, canaries, mud bricks ...). For thousands of years, earthen construction has been the most widespread in the world, whether in adobe, cob or compressed earth bricks. Earthen architecture allows the construction of simple or monumental buildings in various environments. This construction technique has always been subject to refinement. Attempts to standardize raw and baked earth construction are already present in the texts of Vitruvius, Varro, Cato or Palladius [1]. The clay has largely demonstrated its beneficial contribution within the house as its virtues are numerous (decorations, availability, costs). However, its use as a raw material in construction has a number of drawbacks, such as its weight, which has caused it to be abandoned in favor of other raw materials (sand, laterite). Unfortunately, this technique with its numerous ecological, thermal and economic advantages is being supplanted in many countries in favor of concrete construction, a type of architecture that does not seem to be adapted to all environmental and social contexts. presenting a negative connotation of poor and low quality habitats. Indeed, a certain number of difficulties linked to the use of clay in construction arise. These include the variation in volume (shrinkage and swelling) during the drying of the material causing numerous cracks thus reducing the mechanical performance of the latter. This problem is usually treated by adding stabilizers to the soil. The most commonly used stabilizers are cement, lime and sand [2]. Clay is also used to renovate old houses and half-timberings. A number of observations while traveling through the areas where the penetration of water in the soil takes enough time, added to the fact that the roads are muddy and slippery (case of the roads of the impossible as in Katanga in DRC, in the west and east of Cameroon, in Tanzania and many other roads. We get from previous work on clays that the percentage of clays in the land is high. These regions should benefit from a great number of advantages because these clays would turn into a very specific ore deposit of clays. The difficulties contained in this type of reflection consist, at the time of its extraction, of the dirt that the earth possesses. That is why, in order to obtain a specific quality of ceramic materials of high level from these grounds, it would be desirable to proceed to a mechanical treatment whose result will allow to identify the type of clay which exists in the zone by the characterization of the obtained clay in order to list the whole of the works (roof tiles, tiles, bricks and briquettes, canaries.) which one can produce in the concerned region resulting from their ground. Studies conducted in the world in general show that many muddy soils have clay and can be used in civil, mechanical and electrical engineering constructions, provided that they undergo mechanical treatment. The world in general and Cameroon in particular has these important deposits of clay soil [3] [4].This deposit is therefore sufficient enough to be used as a material. It is in this perspective that for the account of this work; we will extract the earth of nomayos which fulfills the conditions of clayey earths and proceed to a mechanical treatment in order to obtain the clay, then determine the physical, chemical and thermal characteristics.

II. Material And Experimental Methods.

2.1 Materials

material

The material used here is the soil taken from the Nomayos area of the city of Yaoundé in Cameroon.

raw soil

The soil of the study comes from Nomayos.

Table 1 presents the geographical and demographic situation of the area and Figure 1 presents its geolocation on the map of Cameroon according to the data of **fr.climate-data.org.**

Country	Cameroon
Region	Centre
Department	Méfou-and-Akono
Demography	
Population	554 inhabitants.
Geography	
Coordinates	3° 28′ North, 11° 16′ East

Table 1: Geographic and demographic location of the study area

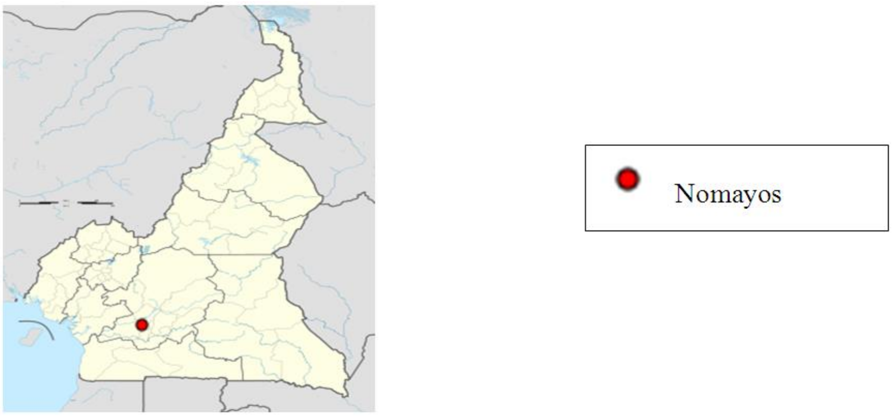

Figure 1: Geolocation of Nomayos on the map of Cameroon

Nomayos is a village in the Centre Region, located in the commune of Mbankomo in the Méfou-et-Akono department, city of Yaoundé in Cameroon. Nomayos is home to a Lafarge cement plant with a capacity of 500,000 tons.

Figure 2 shows the annual rainfall for the city of Yaoundé and Figure 3 shows the annual climatic situations of Nomayos according to the data recorded at the Ministry of Statistics. fr.climate-data.org.

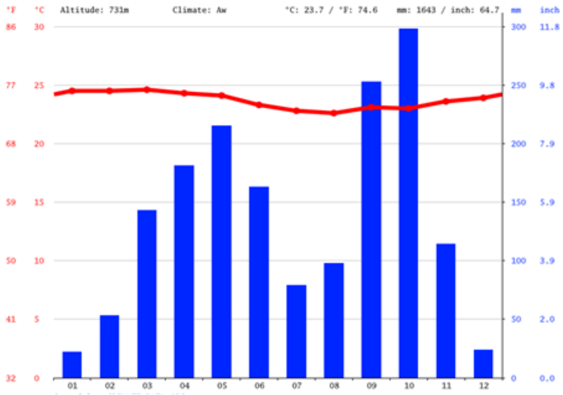

Figure 2: Umbrothermal diagram of Yaounde

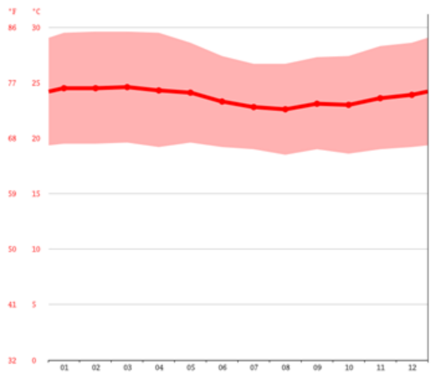

Figure 3: Climatic situation of the city of Yaounde

From figure 2, we obtain that January is the driest month, with an average of 22 mm of rainfall, while October is the month with the highest rate of rainfall with 298 mm, making it the month with the highest rate of rainfall in Yaoundé. **(Fr.climate-data.org).**

From figure 3, we obtain that the month of March is the hottest month of the year, with an average temperature of 24.6°C while the month of August has the lowest temperature with an average of 22.6°C, making it the coldest month in the city of Yaoundé during the year **(fr.climate-data.org).**

Presentation of the land of Nomayos

Figure 4 : land of the city of Nomayos (photo DC001 of **12/01/2021**)

Figure 5: land of the city of Nomayos (photo DC002 of **29/08/2021**)

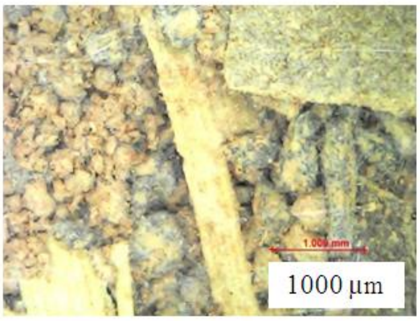

Figure 6a: soil collected in **January** filmed with a USB digital microscope

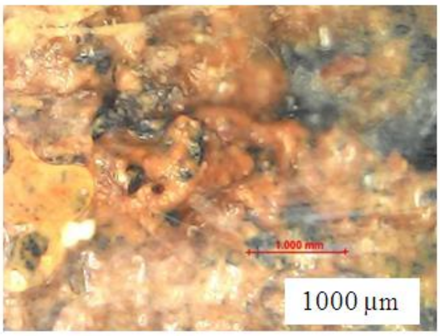

Figure 6b: soil collected in **August** filmed with a USB digital microscope

Figure 6: Land of the city of Nomayos seen under the microscope in the 2 critical seasons of the year.

Figure 4 shows images of the Nomayos land filmed in January 2021. Figure 5 presents the images of the land of Nomayos filmed in August 2021. We obtain from figure 4 that this land has aggregates of all kinds and from figure 5 that it has a remarkable concentration of mud. Microscopic observations show the less important fractions of aggregates figure 6a and the sludge of clays figure 6b. These results show that a mechanical treatment of this soil will allow to obtain good quality clay necessary for the manufacture of ceramic materials in general like stabilized raw and fired earth bricks, tiles, pottery, dishes and many others.

III. Materials

For mechanical processing and physical properties

Crusher: the parameters are those described in the article by Djomi et al., 2018 [5].
Seditech balance at 1/100th
Seditech balance at 1/1000th

***For microscopic observations*:**

USB digital microscope with HD color CMOS sensor, high speed DSP (dricer free available), 24bit DSP, optimal resolution 640x480, 5x digital zoom.

For Thermal Properties

A LENSEIS instrument with an alumina oxide crucible and a capacity of 150 mg. The heating rate is 10°/min. The gas used is oxygen and nitrogen.

For the chemical properties

An Alpha spectrometer of the Bruker firm analyzed by the ATR technique (Attenuated Total Reflection) on a diamond crystal. The resolution during the collection of the spectra is fixed at 4 cm-1, from the laboratory of physical and analytical chemistry of the University of Yaoundé 1.

2.2 Experimental methodology

Mechanical treatment of the soil material.

The purpose of this treatment is to recover the clay contained in the soil by removing the aggregates and waste of any kind contained.

The principle consists in extracting the soil in the study area (figure 6a), stirring with water and an aluminum ladle for about 1 hour so that the soil is well mixed (figure 6b). The resulting slurry is poured into a basin through a 500 micron filter cloth (Figure 6c) to remove impurities (roots, stones, gravel, etc.).

(a) study area *(b) sampled clay* *(c) dehumidified clay* *(d) decanting clay*

Figure 7: Process of mechanical treatment of the Nomayos soil (photo DC003 of 20/01/2021)

The water in this basin is left to settle for 24 hours at room temperature. We carefully release the water and, the leg remaining at the bottom of the basin is clay (Figure 7d). It will be stored directly in a porous bag for dehumidification for 45 days at room temperature.

Characterization of clays.

Physical Characterization

Particle size analysis by dry sieving after washing

The test is carried out in the laboratories of Mipromalo (Mission for the Promotion of Local Materials) according to the standard NF P 94-056 [6].

Particle size analysis by sedimentometry

The test is performed in Mipromalo laboratories according to the NF P 94-057 standard [7].

Atterberg limits

The test is performed in Mipromalo laboratories in two distinct phases according to the NF P 94-051 standard [8].

Water content

The test is carried out in the Mipromalo laboratories, we have weighed the vacuum tare previously cleaned and dried in the oven; put a quantity of material in the tare and weighed the wet mass; put the material in the oven regulated at 105°C during 24h; weighed the dry mass of the material. We applied the relation (b.1) to determine the water content of the treated clay.

$$TE(\%) = \frac{(Mh - Ms)}{Ms} x100 \quad \left\{ \begin{array}{l} \text{WT : Water content} \\ \text{Mh : Wet mass} \\ \text{Ms : Dry mass} \end{array} \right. \qquad (b.1)$$

Methylene blue test.
The methylene blue tests were carried out in the Mipromalo laboratories on the clay samples according to the NF P 94-068 standard [9]

Real density
The test is carried out in the Mipromalo laboratories (Mission for the Promotion of Local Materials), we weighed the pycnometer with vacuum; weighed the pycnometer with distilled water filled to the gauge line; Decreased a good amount of distilled water (more than half) and poured 20g of the material into the pycnometer, then placed it on a hot plate and let it heat up to boiling;Removed and let the mixture cool down in the open air and then in a water bath for a total cooling;Added water up to the gauge line and weighed the mixture.
We applied the relation (b.2) to determine the real density of the treated clay soil.

$$\mathrm{dr} = \frac{(M2-M1)}{(M2-M1)-(M3-M4)} \quad \left\{ \begin{array}{l} \text{M1=Mass of empty Pycnometer,} \\ \text{M2= mass of Pycnometer with sample} \\ \text{M3= mass of Pycnometer, sample and water} \\ \text{M4 = mass of Pycnometer with water} \\ \text{dr= real density} \end{array} \right. \qquad (b.2)$$

Thermal Characterization

The machine is a LENSEIS brand instrument from the organic chemistry laboratory of the University of Yaoundé I. It has an alumina oxide crucible with a capacity of 150 mg. The heating speed is 10°/min. The gas used is oxygen. The initial mass of the measurements is between 100 mg and 120 mg. The starting temperature of the tests is a function of the ambient temperature (20 °C and 35 °C). The data acquisition is done by a software incorporated in the machine which allows the automatic recording on a computer of the thermograms and the data of the recordings. The methodology of the tests is in conformity with the standard and applied in the laboratory. We are provided with the recording data and the ATG and DSC curves at the end of the analyses for interpretation.

Chemical *Characterization*

An Alpha spectrometer from Bruker analyzed by the ATR (Attenuated Total Reflection) technique on a diamond crystal. The resolution during the collection of the spectra is fixed at 4 cm-1, from the laboratory of physical and analytical chemistry of the University of Yaoundé1. The method used is by attenuated total reflectance (ATR) whose methodology is standard. The data acquisition is done with the help of a software incorporated in the apparatus which allows the recording and the plot of the spectra automatically on a computer. We are provided with recording data and FTIR spectra at the end of the analysis for interpretation.

IV. Results and discussion

3.1 Results

Results of the mechanical treatment of the Nomayos soil.

We obtained a muddy clay soil after decantation, and pasty after dehumidification. Then a conservation of 45 days in a bag at room temperature. This conservation allows to make the clay workable.

Figure 8a: Treated and dehumidified clay filmed with a digital camera

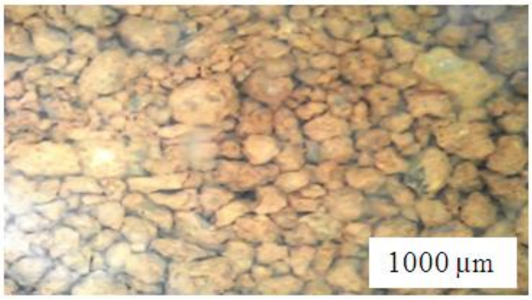

Figure 8b: Treated and dehumidified clay seen with a USB digital microscope

Figure 8: result of the Nomayos clay treatment

Practical observations show that the quantity of aggregates such as aggregates and other wastes occupy a very low volume proportion. This result is justified by the quality of the soil taken in August during the rainy season. We can also add that these results justify the habitats observed in the region built in rammed earth. Also, we can add the quality of the road permanently slippery in the rainy season (in August).

Results of the characteristics of the Nomayos clay

Result of the physical characteristics

Table 2: Result of the physical characterizations of the clay of Nomayos

Particle size analysis					
Ref	Color	% of gravel Φ>2 mm	% sand 2>Φ>0.02 mm	% silt 0.02>Φ>0.002 mm	% clay Φ<0.002 mm
AR	Reddish	7.0	23.6	11.0	58.4
Limit of Atterberg					
AR	Liquidity limit (%)	Plasticity limit (%)	Plasticity index (%)		
AR	55.0	26.6	28.4		
Water content, density, Vbs and porosity					
Water Content (%)	VBS	Apparent density (g/cm^3)	Real density (g/cm^3)	Porosity (ŋ) (%)	
29.1	1.43	1.85	2.06	28.60	

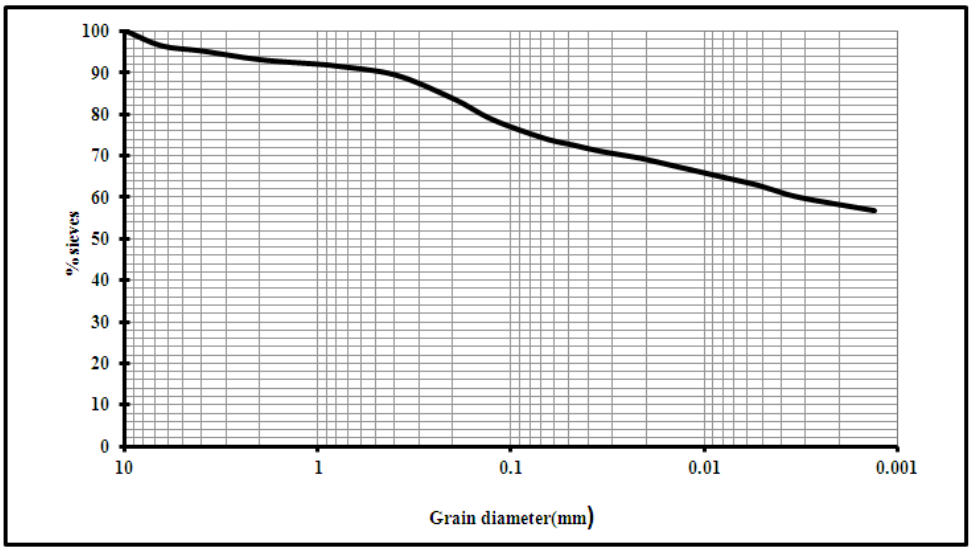

Figure 9: granulometric curve of nomayos clay

Table 2 above tells us that after applying the NF P 94-056 standard to the granulometric analysis by dry sieving and the NF P 94-057 standard to the granulometric analysis by sedimentometry on the clay obtained after mechanical treatment of the Nomayos clay soil, we obtain that the color of the clay is Reddish, with the gravel whose Φ>2 mm is 7. 0%, the sand of which 2>Φ>0.02 mm is 23.6%, the silt 0.02>Φ>0.002 mm is 23.6% and finally the clay of diameter Φ<0.002 mm is 58%. These results were obtained by Nzeukou et al on the alluvial clays of Ebebda [4] and by Ntouala on the alluvial clays of the Ayos region [10].

Applying the standard NF P 94-051 to the Limit of Atterberg, we obtain that Limit of liquidity is 55.0%, the Limit of plasticity is 26.6% and the plasticity index is 28.4%.

Similarly, the standard NF P 94-068, the test with methylene blue gives us a VBS of 1.43 and a Porosity (ŋ) of 28.60.

Finally the density is between 1.85 and 2.06.

2,85>ρ>1,85

Similarly to the table, Figure 9 which presents the granulometric appearance of the Nomayos clay, it shows that the mechanical treatment gives the clay a fairly continuous and decreasing smoothing curve.

Result of the thermal characterization

gravimetric and differential thermal analysis

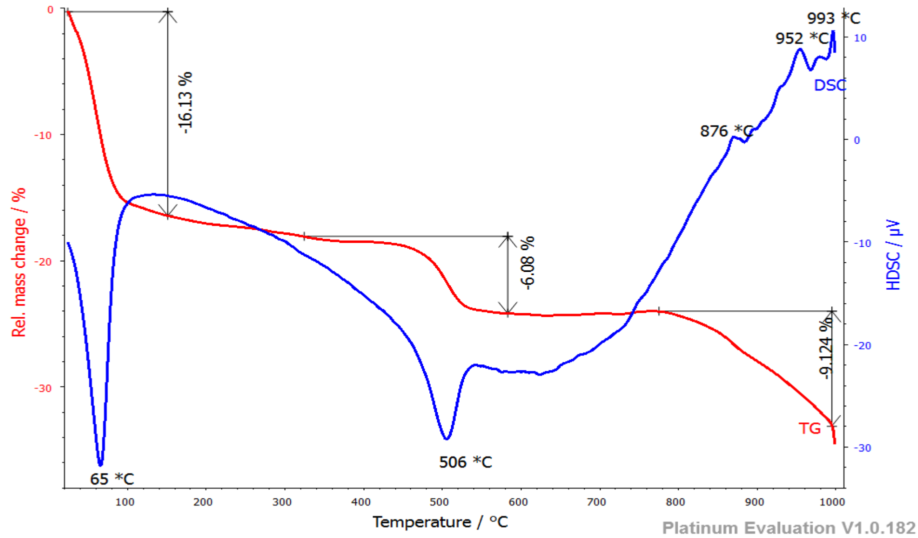

Figure 10 : TG and DSC thermogram of Nomayos clay

Figure 10 is the thermogram of the clay resulting from the earth of Nomayos. It allowed us to bring out the figures 11 namely the thermogravimetric curve (fig11a), the thermo differential curve (fig11b) and the curve of the absorption of the heat of the clay according to the decrease of its mass during its rise in temperature (fig11c). These figures allow us to understand the phenomenon of degradation as well as the fire resistance of Nomayos clay as a function of temperature during firing and during fires.

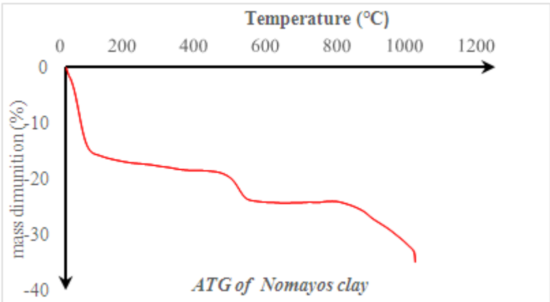

Figure 11a: thermogravimetric analysis of Nomayos clay

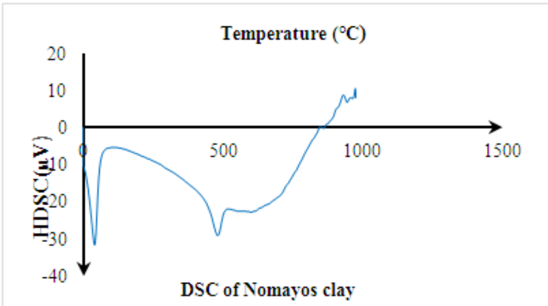

Figure 11b: thermodifferential analysis of Nomayos clay

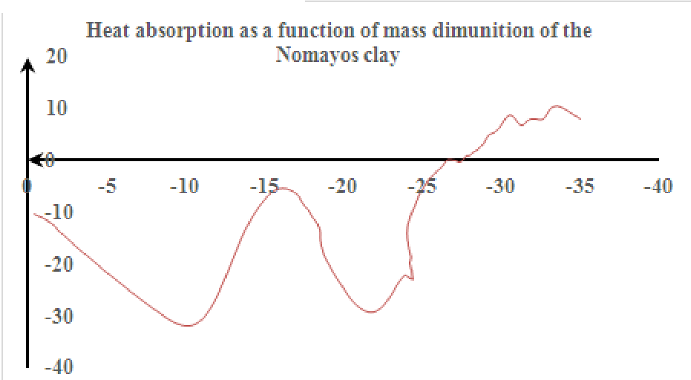

Figure 11c: heat absorption as a function of the mass decrease of the clay
Figure 11: Result of the thermal analysis of Nomayos.clay

It emerges that the DSC figure 11b shows an endothermic heat peak at 65 °C. It is the beginning of the dehydration of the clayey material presented by the TG of figure 11.a. The DSC presents in addition 4 representative and sensitive peaks of the degradation. They are the peaks at 506°C, 522°C, 876°C and 952°C. Then,

- At 65°C, we have an endothermic trough which corresponds to the departure of hygroscopic water and zeolitic water from illite; the percentage of mass loss determined from the ATG curve is about 16.13%;
- At 506 °C a second endothermic trough marks the departure of the water of constitution of Kaolinite and its transformation into metakaolinite; here the loss of mass is estimated at 6.08 %. This result confirms that of some authors who state that the water loss evolves towards a higher temperature[11]. In his work Synthesis and characterization of geopolymeric binders based on local materials from Burkina Faso for stabilization of Compressed Earth Bricks (CEB);
- At 565 °C; we have an endothermic peak which highlights the presence of quartz. This temperature marks the allotropic change of quartz. It goes from quartz α to quartz β. This reaction does not lead to a loss of mass. This observation was by Laibi et al in his work hygro-thermo-mechanical behavior of structural materials for construction associating kenaf fibers with clay soils[12].
- At 952°C, we have an exothermic peak that indicates the formation of mullite from metakaolinite. These results are close to those obtained by Tironi et al in 2017 in his work Pozzolanic activity of calcined halloysite-rich kaolinitic clays [13]. These thermal analysis results show that our clay sample contains kaolinite, illite and quartz. This confirms that the mineralogical analysis will show kaolinite, illite and quartz. In view of these results, it should be noted that the Nomayos clay is of kaolinic type, plastic with a high content of alumina and average contents of coloring oxides and fluxes. The granulometric analysis indicates a fine texture whose essential elements are kaolinite, illite and quartz.
- Similarly Figure 11c shows that in the vicinity of 30µv, an endothermic peak with a mass decrease close to 10% corresponding to the disappearance of free water that is obtained in the vicinity of 65°C at the DSC (Figure 11b). Also, during the thermal degradation of our clay, we obtain in the vicinity of 506°C a decrease in mass estimated at 6.08%. This mass decrease is obtained with a heat discharge up to a neighborhood of 5 µv. Again the further degradation shows a heat absorption of 28 µv losing on average 22% of its mass (Figure 11c). At times, abrupt degradations arise marking the presence of the transition from quartz α to quartz β, this is the case of the peaks in the vicinity of: 22 µv, 0.5 µv as we obtained at 565°C at DSC as Laibi in 2017 in his work also reported [12].

Results of chemical characterization

Fourier Transform Infrared spectral analysis of the raw clay (not heated).

The oven-transform infrared spectra of the clays show an intense peak at 910.29 cm-1 and a band at 523.75cm-1 relating to the elongation and torsional vibrations of the Si-O bonds respectively. These results are similar to those of shanmugharaj in 2016 in his work (Shanmugharaj et al., 2007) in the same way as Benbayer in his work in 2015 (Benbayer, 2014), the broad bands at 3651.16 cm-1 and 1635cm-1 are attributable to the elongation and deformation vibrations of -OH and water molecule absorbed in the interfoliar space of the clay sheets [14] . The results obtained highlighting the presence of two new adsorption bands at 2931 cm-1 and 2865 cm-1 corresponding to asymmetric and symmetric elongation vibrations of -CH2 groups, which shows the presence of silane in clays. These results obtained on elongation and deformation vibrations and then on asymmetric and symmetric elongations of the groups are close to the results of Risite, shanmugharaj and Hongping, in their work on clays in 2015, 2007 and 2004 respectively [15] [16] [17].

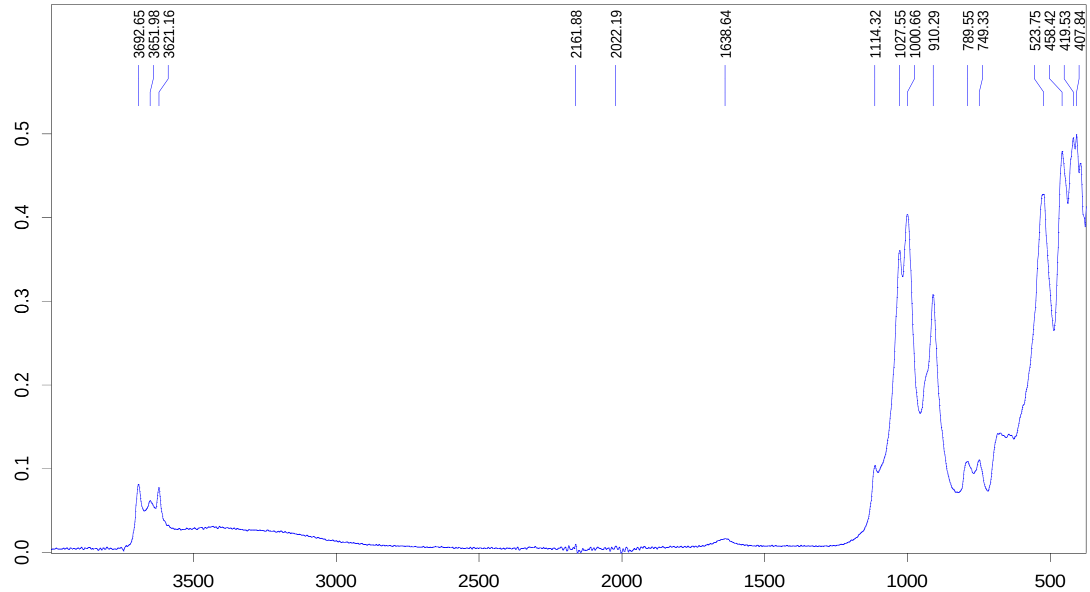

Figure 12: infrared spectral analysis of clay (not heated***).***

The presence of new absorption peaks at 1554cm-1, 1494cm-1, and 693cm-1 corresponding successively to deformation vibrations of -NH2 and -CH2 and out of plane deformation of -CH. The peak at 1307 cm-1 is attributed to an elongation vibration of C-N [16]. These results obtained in our work are very similar to those obtained by Laibi in his research work[12] and Tironi [13].

Fourier Transform Infrared Spectral Analysis of clay heated to 800°C.

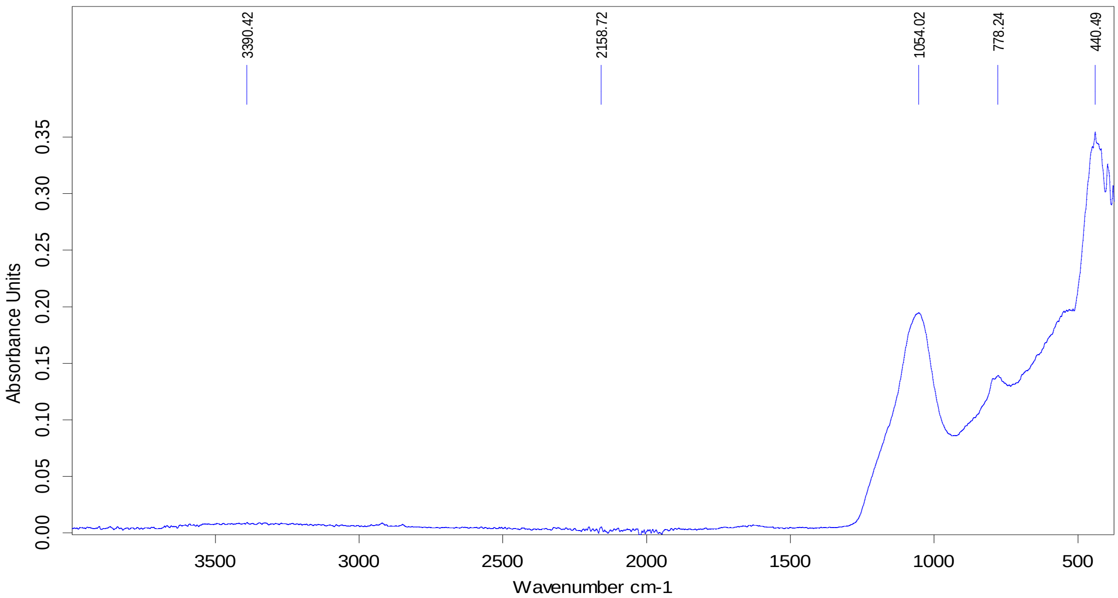

Figure 13: infrared spectral analysis of clay heated to 800°C.

The oven-transform infrared spectra of the clays fired at 800°C show an intense peak at 440.49 cm-1 is attributed to microcline feldspar [18] relating to elongation and torsional vibrations of Si-O bonds. The bands at 778.24 cm-1 and 1054.02 cm-1 correspond to the elongation vibrations of Si-O-Si and Si-O-Al bonds, respectively. These results are similar to those of shanmugharaj in his work [16] and Benbayer in his work in 2014 [19], The fine bands at 2158.72 cm-1 and 2865 cm-1 corresponding to asymmetric and symmetric elongation vibrations of the -CH2 groups, showing the presence of silane in the clays. These results obtained on elongation and deformation vibrations and then on asymmetric and symmetric elongations of the groups are close to the results of Risite, shanmugharaj and Hongping, in their work on clays in 2015, 2007 and 2004 respectively[15] [16] [17].

3.2 Discussion

Mechanical processing of the Nomayos soil yielded clay after dewatering and dehumidification. The particle size analysis revealed in Table 3 that the soil has a high clay content with a continuous particle size curve shown in Figure 9 with a better spread out particle size distribution. According to the results, observations and discussions of the work of Nzeukou et al in 2013 on the alluvial clays of Ebebda, Ntouala in 2014 on the alluvial clays of the Ayos region, Ngalamo in 2007 to name a few, these clays are suitable for the manufacture of ceramic products. This is why in these regions, we find houses, cooking stoves made with clay, roofs covered with clay. Moreover the limit of atterberg shows that these clays are of good quality provided that it undergoes a good mechanical treatment. This is justified by the results of the plasticity, liquidity limit and plasticity limit indices. Going through the results of research on clays and clay soils [4] [10] [20], then by making a descent in the regions with clay soils the particularity is remarkable from the point of view of vegetation, roads, construction of local technical activities, the index of plasticity show that these soils by undergoing a mechanical treatment of good precision, these regions with clay soils are predisposed for the production of roof tiles, mud bricks, canaries, dishes, charcoal fireplaces and many ceramic materials although the results are not competitive enough. Thus, the apparent density of the sample is 1.85 g/cm3, a value slightly lower than that required for traditional ceramics shows that there is a significant amount of water in our clay which brings an advantage to subject the clay to heat treatments because the mobility of its seeds will increase with temperature by the appearance of the glassy phase (Lambercy & Lambercy, 1993). By promoting the interaction between the minerals creating the crystalline structure. Which promotes melting at low temperature [21] [22], on the clays of Ipoh, Kuala Rompin and Mersing (Malaysia).

Then, the degradation of the clay from the Nomayos soil as a function of temperature shows from their TG and their DSC figure 11, that the clay dehydrates at very low temperature (65°C) it is hygroscopic water and zeolitic water of illite that disappear making the clay light by nearly 16.13%. Thus, going through the works on slippery earths as those in Burkina Faso of Sore omar seick in 2019 [23] and then [12] in his research work (Laibi, 2017), we get the manifestations of quartz (passage of quartz α to quartz β) and then the departure of the water of constitution of Kaolinite and its transformation into metakaolinite which presents a good attitude in traditional ceramic materials. That this result gives a significant advantage for the production of materials that must undergo heating because the loss of water evolves towards a higher temperature of the clay. Furthermore, the formation of mullite from metakaolinite at low temperature shows that our clay sample contains kaolinite, illite and quartz. This confirms that the mineralogical analysis will show kaolinite, illite and quartz. In view of these results, we confirm that the Nomayos clay is of the kaolinic type, plastic with a high content of alumina and medium contents of coloring oxides and fluxes. The granulometric analysis indicates a fine texture whose essential elements are kaolinite, illite and quartz. Thermal studies also show that this clay can be used for the manufacture of stabilized earth bricks and fired roof tiles. All these thermal results confirm the studies carried out on the physical characterization of the clay. It can be used as we said on the results of the limits of liquidity and plasticity and then of the index of plasticity, that these clays from clay soils are suitable for the production of bricks and other cold stabilized products. Finally, clays behave as if they release heat when the temperature increases without however decreasing mass considerably. This phenomenon of heat absorption according to the decrease of its mass highlights the phenomenon of the degradation of the clay, this by interpreting the clay obtained from the mechanical treatment of the clayey earth of Nomayos, and by observing the results of the studies on the physical characterizations of the clay, we obtain that the pieces obtained from these clays coming from the clayey earths will be rather light and will rise in temperatures quickly and will stabilize. These results are confirmed by the nature of the soil (muddy, slippery, water infiltration after a slow rain).

Finally, the chemical analysis indicates that our clay has mainly three (3) oxides namely silica (SiO_2), alumina (Al_2O_3) and iron oxides (Fe_2O_3) affirming that this clay can be used as a binder in buildings and also for coatings.

V. Conclusion

We regularly come across lands that hardly let water infiltrate after a rain. We find that the roads in these areas are muddy and slippery. Research results show that these soils contain clay. They are commonly known as clay soils. The use of clays requires the control of its physical, chemical and thermal properties. For this reason, the Nomayos clay samples from the city of Yaoundé - Cameroon were subjected to a series of characterization. The physical characterizations revealed that the apparent density of the clay is 1.85 g/cm3, a water content of 29.1% and a porosity of 28.60%. The chemical analysis indicates that our clay has mainly three (3) oxides namely silica (SiO_2), alumina (Al_2O_3) and iron oxides (Fe_2O_3). The thermal analyses allowed to identify and confirm the minerals contained in the clay. Thus, it appears from this that the clay contains kaolinite, illite, and quartz. The results of the thermogravimetric and differential analysis show that the clays decrease in density when they are elevated in temperature, favoring the use of fired bricks for multi-level building construction. Following the results of the clays from the Nomayos earth, the clayey earth reassures us of the potential of the clays contained in these earths.

References

[1]. C.-A. de Chazelles, « Témoignages croisés sur les constructions antiques en terre crue: textes latins et données archéologiques », *Tech. Cult. Rev. Semest. D'anthropologie Tech.*, nº 41, p. 1-27, 2003.

[2]. S. Ouattara, M. O. Boffoue, A. A. Assande, C. H. Kouakou, K. C. Kouadio, et E. Emeruwa, « Influence du ciment Portland sur les caractéristiques mécaniques et physiques d'un composite argile-sciure de bois utilisé comme Bloc de Terre Comprimée (BTC) », *Matér. Tech.*, vol. 105, nº 2, p. 203, 2017.

[3]. C. Nkoumbou *et al.*, « Kaolin from Mayouom (Western Cameroon): industrial suitability evaluation », *Appl. Clay Sci.*, vol. 43, nº 1, p. 118-124, 2009.

[4]. A. N. Nzeukou, N. Fagel, A. Njoya, V. B. Kamgang, R. E. Medjo, et U. C. Melo, « Mineralogy and physico-chemical properties of alluvial clays from Sanaga valley (Center, Cameroon): Suitability for ceramic application », *Appl. Clay Sci.*, vol. 83, p. 238-243, 2013.

[5]. R. Djomi *et al.*, « Physicochemical and Thermal Characterization of Dura Palm Kernel Powder as a Load for Polymers: Case of Polyvinyl Chloride », *J. Mater. Sci. Chem. Eng.*, vol. 6, nº 6, p. 1-18, 2018.

[6]. B. Abdelmalek, B. Rekia, B. Youcef, B. Lakhdar, et F. Nathalie, « Mineralogical characterization of Neogene clay areas from the Jijel basin for ceramic purposes (NE Algeria-Africa) », *Appl. Clay Sci.*, vol. 136, p. 176-183, 2017.

[7]. J. M. Moutou *et al.*, « Characterization and Evaluation of the Potential Uses of Mouyondzi Clay », *J. Miner. Mater. Charact. Eng.*, vol. 6, nº 01, p. 119, 2018.

[8]. R. M. Voula, F. Z. M. Diamouangana, J.-M. Moutou, V. I. B. Samba, M. P. Foutou, et J. P. Ngoma, « Characterization and Valuation of a Clay Soil Sampled in Londéla-Kayes in the Republic of Congo », *J. Miner. Mater. Charact. Eng.*, vol. 9, nº 2, p. 117-133, 2021.

[9]. I. Sanou, M. Seynou, L. Zerbo, et R. Ouedraogo, « Mineralogy, Physical and Mechanical Properties of Adobes Stabilized with Cement and Rice Husk Ash », *Sci. J. Chem.*, vol. 7, nº 1, p. 1, 2019.

[10]. R. F. D. Ntouala, V. L. Onana, V. Kamgang, et G. E. Ekodeck, « Mineralogical, geochemical and mechanical characterization of the Ayos (East-Cameroon) lateritic and alluvial clayey mixtures: Suitability for building application », *J. Build. Eng.*, vol. 5, p. 50-56, 2016.

[11]. B. de l'Environnement, « Stabilisation des blocs d'argile avec une base naturelle, la potasse », *Afr. Sci.*, vol. 15, nº 5, p. 1-11, 2019.

[12]. B. Laibi, « Comportement hygro-thermo-mécanique de matériaux structuraux pour la construction associant des fibres de kénaf à des terres argileuses », PhD Thesis, Normandie, 2017.

[13]. A. Tironi, F. Cravero, A. N. Scian, et E. F. Irassar, « Pozzolanic activity of calcined halloysite-rich kaolinitic clays », *Appl. Clay Sci.*, vol. 147, p. 11-18, 2017.

[14]. M. A. Qtaitat et I. N. Al-Trawneh, « Characterization of kaolinite of the Baten El-Ghoul region/south Jordan by infrared spectroscopy », *Spectrochim. Acta. A. Mol. Biomol. Spectrosc.*, vol. 61, nº 7, p. 1519-1523, 2005.

[15]. H. Risite, « Nanocomposites polymères/montmorillonites: Rôle des interactions générées par la modification des argiles/polymères sur la morphologie et les propriétés structurales, thermiques, rhéologiques et mécaniques », 2015.

[16]. A. Shanmugharaj, J. Bae, K. Y. Lee, W. H. Noh, S. H. Lee, et S. H. Ryu, « Physical and chemical characteristics of multiwalled carbon nanotubes functionalized with aminosilane and its influence on the properties of natural rubber composites », *Compos. Sci. Technol.*, vol. 67, nº 9, p. 1813-1822, 2007.

[17]. H. Hongping, F. L. Ray, et Z. Jianxi, « Infrared study of HDTMA+ intercalated montmorillonite », *Spectrochim. Acta. A. Mol. Biomol. Spectrosc.*, vol. 60, nº 12, p. 2853-2859, 2004.

[18]. R. Palanivel et U. R. Kumar, « Thermal and spectroscopic analysis of ancient potteries », *Romanian J. Phys.*, vol. 56, nº 1-2, p. 195-208, 2011.

[19]. C. Benbayer, « Nanocomposites à base d'argile et de surfactants polymérisables (surfmers): synthèse et propriétés », PhD Thesis, Université Nice Sophia Antipolis, 2014.

[20]. A. S. L. Wouatong, W. H. Tchungouelieu, F. Ngapgue, V. Katte, et V. K. K. Beyala, « Mineralogical and geotechnical characteristics of the loose weathered trachytes of Fongo-Tongo (West-Cameroon) », *Int. J. Appl.*, vol. 4, nº 7, 2014.

[21]. M. Karfa, M. Kumar, V. Kumar, A. Sanjid, et S. Karfa, « Simple device, technique-cum-software for measurement of refractive index of liquid medium using" 00" grade slip-gauge concept », 2003.

[22]. C. L. Chin, Z. A. Ahmad, et S. S. Sow, « Relationship between the thermal behaviour of the clays and their mineralogical and chemical composition: Example of Ipoh, Kuala Rompin and Mersing (Malaysia) », *Appl. Clay Sci.*, vol. 143, p. 327-335, 2017.

[23]. B. de l'Environnement, « Stabilisation des blocs d'argile avec une base naturelle, la potasse », *Afr. Sci.*, vol. 15, nº 5, p. 1-11, 2019.

R Djomi, et. al. "Thermo-physical and chemical characterization of the clay resulting from the mechanical treatment of the clayey ground : case of the clayey ground of the area of Nomayos - Yaoundé - Cameroon." *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 18(4), 2021, pp. 43-53.