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The Physico-Chemical and Mineralogical Analysis of Clays in Algeria

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Abstract
The physico-chemical and mineralogical analysis of soils in civil engineering aims to understand the properties and behavior of their components in the field of construction and engineering. Mineralogical characterization makes it possible to identify the minerals present in clays, such as kaolinite, illite, montmorillonite, etc. This is essential for understanding the swelling, retraction and plasticity properties of clay. Knowledge of the chemical composition makes it possible to evaluate their chemical reactivity, their potential for alteration, and their compatibility with construction materials.

Keywords: Clay, Geotechnical, Mineral, Soil, Spectral Characterization.

1. Introduction

Clay is a sedimentary rock, composed of specific minerals, more or less hydrated aluminum silicates, with a laminate structure (phyllo silicates) or fibrous structure (sepiolite and poly gorskite), which explains their absorption qualities, their plasticityand the relationship between the rheological properties and the structural composition of clays [1-9]. The objective of this study is to analyze the mineralogical composition of the different clays from western Algeria using appropriate methods and techniques. This part includes the preparation of samples as well as the analysis of their chemical and physical properties, such as adsorption capacity measured by IR spectroscopy [10] and X-Ray Diffraction [11].

2. Experimental Part

Presentation of clay samples:

The clay samples used in this study come from the national laboratory of habitat and construction of L.N.H.C of Sidi Bel Abbes in Algeria. These are pure clays taken from five regions of western Algeria at a depth of 3 meters below the ground.

E1: Arzew-Oran, E2: Bouhanak-Tlemcen, E3: Douar oueld bouziane - Mostaganem, E4 : Bir el Jir - Oran, E5 : Tessala- Sidi bel Abbes

3. Materials and Methods

-The X-ray diffraction technique makes it possible to identify the nature of the clay minerals composing the clay phases as well as the different impurities. The X-ray Diffraction analyzes were carried out using a RIGAKU MINIFLEX600 type device, equipped with an X-ray tube, a detector and a goniometer which allows the intensity of the rays to be measured. X diffracted as a function of the scattering angle.

The equipment used is the Fourier transform infrared spectrometer (FTIR) of the IR AFFINITY-1S type, controlled by a microcomputer, with Bio Rad software to help analyze the data from the column of this device.

4. Results and Interpretation

The results of the mineralogical analysis by XRD:

The DRX spectral analysis of clay E1 Figure 1 indicates that it is composed of Nacrite $Al_2Si_2O_5(OH)_4$ 35% which is the rarest of the polymorphs of known kaolins, it is a 1:1 aluminous octahedral dilicate phyllo.

In addition, the spectral analysis of our samples indicates the presence of Quartz (SiO_2) 64% and Quartz Löw or Quartz alpha by a major quantity;

It mainly reveals the presence of an intense peak which corresponds to quartz (SiO_2). This implies that E1 clay is heterogeneous.

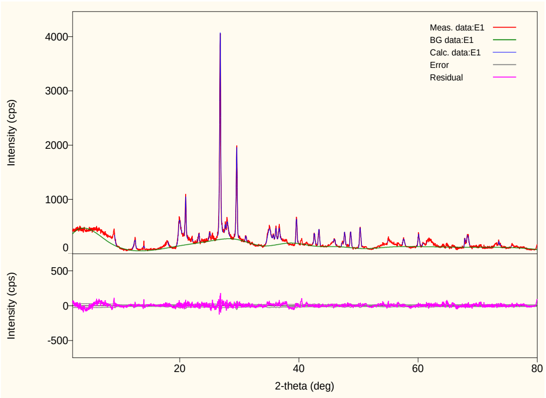

Figure 1: X-Ray Diffractogram of E1 clay

The DRX spectral analysis of the clay E2 Figure 2 indicates that it is composed of Quartz (SiO_2) 86% it reveals mainly by an intense peak, we also note the presence of H_2O molecules 13.2% which indicates that the nature of the soil of the sample E2 is humid. It shows the presence of a minority quantity of Xenolite $Al_{10}O_8Si_{32}$

0.6 % which is an enclave in an magmatic rock (volcanic or plutonic)

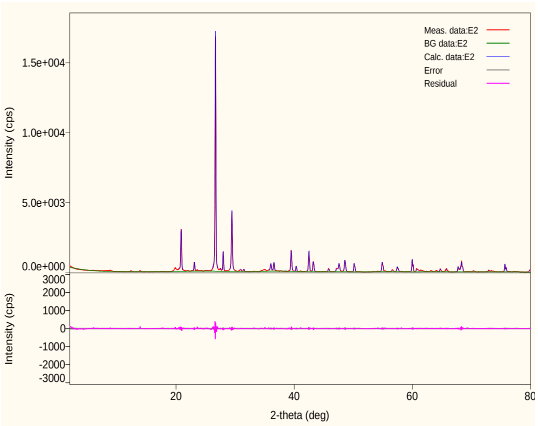

Figure 2: X-Ray Diffractogram of E2 clay

The DRX spectral analysis of sample E3 Figure 3 shows the presence of Quartz (SiO_2) 24.3% and Walstromite $BaCa_2(Si_3O_9)$ 60.5% revealed mainly by two intense peaks. We also note the presence of Nacrite $Al_2Si_2O_5(OH)_4$ 15.2% which is characterized by an intense 3rd peak. We conclude that heterogeneous E3 clay.

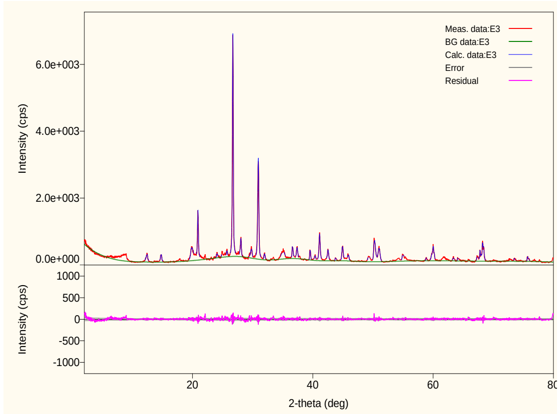

Figure 3: X-Ray Diffractogram of E3 clay

The clay of sample E4 Figure 4 is mainly made up of Margarite $CaAl_2(Al_2Si_2O_{10})$ (OH) 23% and quartz (SiO_2) 77% revealed by the presence of two intense peaks. No impurities are revealed.

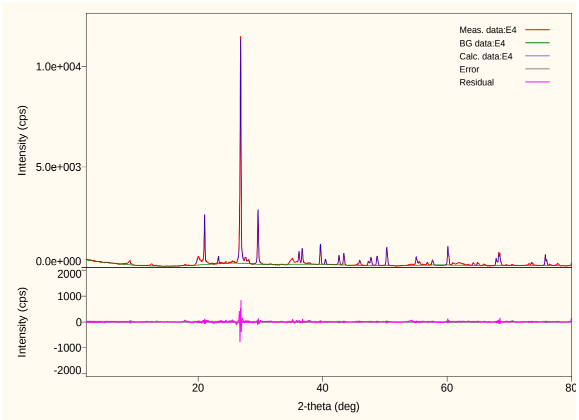

Figure 4: X-Ray Diffractogram of E4 clay

The E5 clay Figure 5 is essentially made up of SiO_2 12.56% and Quartz, 18.26% as well as $Ca_3(SiO_4)O$ 69.2%, which is characterized by very intense peaks. Other small peaks are detected, which shows the heterogeneous composition of this sample.

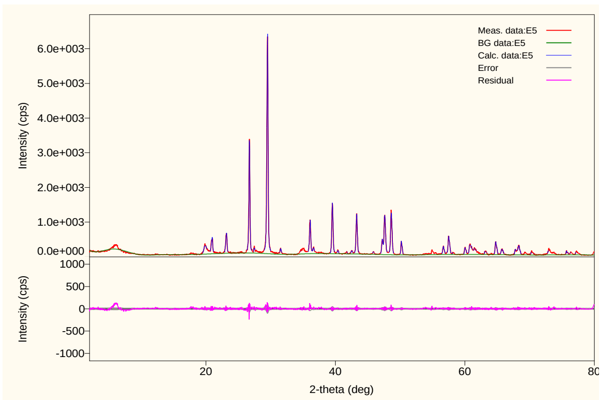

Figure 5: X-Ray Diffractogram of E5 clay

Infrared spectra analyze:

The infrared spectrum of clay E1 is shown in Figure 6, the IR spectrum bands of sample E1 are compared with the IR spectra of Glass2 and Talc.

We note the existence of a characteristic band of absorptions located between [3650-3590] cm⁻¹ and the wavelength 1430 cm⁻¹ which can be attributed to vibrations

- Elongation vibration of the 0-H bond with a thin band and low intensity at 3626.33 cm⁻¹.
- CH3 bond vibration with a narrow and moderately intense band of wavelength 1430.28 in the interval [1400-1500] cm⁻¹.
- However, the existence of a band of [900-1200] cm⁻¹ thin, of strong intensity at 1004.96 cm⁻¹ indicates an elongation vibration of the Si-O bond which characterizes kaolinite.
- A characteristic band of 780.24 cm⁻¹ thin and of slightly average intensity can correspond to Quartz.
- A thin band of strong intensity at 518.87 cm⁻¹ is characteristic of a Si-OH or Si-O (deformation) and/or Al-O (elongation) vibration.

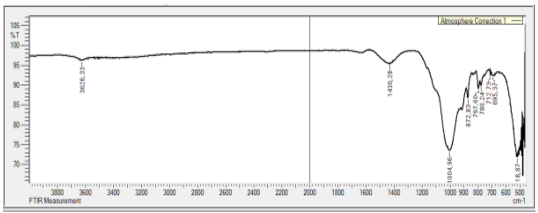

Figure 6: IR Spectrum of E1 clay

The infrared spectrum of clay E2 is shown in Figure 7; the bands of the IR spectrum of sample E2 are compared with the IR spectra of Calcium Carbonate $CaCO_3$ and Kaolin

- A characteristic band of 1428.35 which belongs to the broad, moderately intense [1430-1470] domain is the result of a deformation of the CH_3 bond in the asymmetric plane
- A band which spreads between 900-1200cm⁻¹ located at 1009.78 cm⁻¹ of strong and wide intensity corresponding to the elongation vibrations of Si-O
- A band which extends between 835-910 cm⁻¹ located at 872.83 cm⁻¹ of weak intensity, finer corresponding to the presence of calcium carbonate $CaCO_3$
- The 796.64 cm⁻¹ band corresponds to the Si-O-Al bond.
- A low intensity band located around 711.76 cm⁻¹ indicates the presence of $CaCO_3$.

The 678.97 Cm⁻¹ band is characteristic of hydroxyl deformation vibrations in tri-octahedral clay minerals in general.

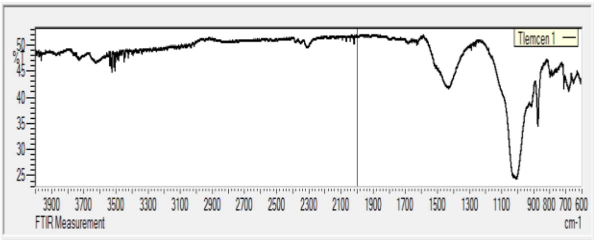

Figure 7: IR Spectrum of E2 clay

The infrared spectrum of clay E3 is shown in Figure 8, the bands of the IR spectrum of sample E1 are compared with the IR spectra of talc and Glass

- A characteristic band which is between 2200-2400 cm⁻¹ fine and of too low intensity is due to the triple bond vibrations of the nitriles
- A band that extends between 1445-1485 cm⁻¹ centered around 1447.64 cm⁻¹ wide and of medium intensity is a CH_3 bond vibration.
- A vibration of high intensity elongation of Si-O also takes place around 1006.89 cm⁻¹
- The characteristic band of average intensity of 780.24 cm⁻¹ indicates the presence of Quartz.

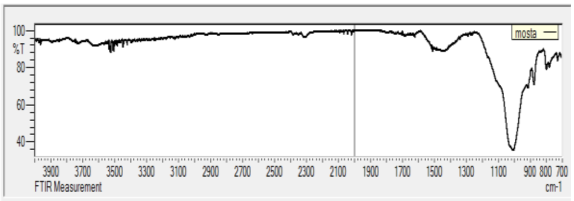

Figure 8: IR Spectrum of E3 clay

The infrared spectrum of clay E9 is shown in Figure 9, the bands of the IR spectrum of sample E4 are compared with the IR spectra of Kaolin and Talc.

- A characteristic band is located between 1400-1500cm⁻¹ centered around 1474.64 cm⁻¹ wide and of low intensity is a CH3 bond vibration.
- A broad band of strong intensity of 1003.99 cm⁻¹ indicates an elongation vibration of Si-O2 (kaolinite)
- We note the presence of a Si-O-Al bond characterized by a weakly intense band at 798.56 cm⁻¹
- Si-O-Al and Si-O-Mg deformation vibration by a highly intense thin band at 529.48 cm⁻¹

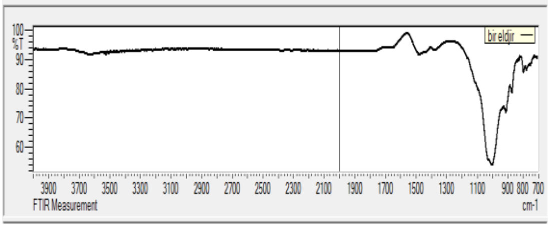

Figure 9: IR Spectrum of E4 clay

The infrared spectrum of clay E5 is shown in Figure 10, the IR spectrum bands of sample E5 are compared with the IR spectra with Calcium Carbonate and Glass2

- A CH_3 bond vibration at 1426.42 cm^{-1} characterized by a broad and highly intense band
- An elongation vibration of Si-O characterized by a broad and highly intense band at 1015.56
- C-O bond vibration ($CaCO_3$) around 872.82 cm^{-1}characterized by a thin and intense band
- 712.72 cm^{-1}correspond to Quartz.

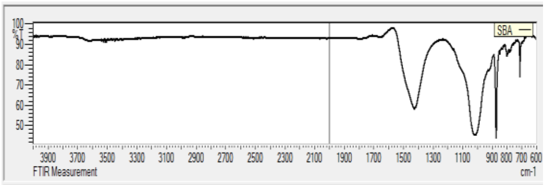

Figure 10: IR Spectrum of E5 clay

5. Discussion

From these interpretations and comparing with our samples we notice a similarity concerning the mineralogical composition of the clays which are silicates which means the presence of Quartz, Si-O bond, Si-O-Al are obligatory [12].

- The C-O bond means the presence of calcium carbonate $CaCO_3$ (calcite)
- The soil spectrum is influenced by its mineral composition
- The spectra differ by the peaks and the intensity of the latter, which explains the variety of clays between kaolin, smectites, illites, etc.

6. Conclusion

The clays characters were also investigated by Fourier Transform Infra-Red spectroscopy (FTIR), and X-Ray Diffraction (XRD). The results carried out led to the following results: The FTIR spectrum showed the existence of intense bands of different molecules or bonds such as Quartz, Si-O bond, C-O bond which reveals the presence of calcium carbonate.

The mineralogical analysis by XRD shows the heterogeneity of the clay samples that we received; it is through the presence of Quartz and other molecules which show the crystalline character in these clays.

According to the results obtained we can say that the mineralogical composition of clays in Algeria is depending on their geographical location and their specific formation following rheological characteristics.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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