CHARACTERIZATION OF CLAY MINERALS FROM THE REJECT OF THE SAND EXTRACTION IN CAPELA DE SANTANA-RS, BRAZIL

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Abstract: Clay minerals are largely used in various industries and engineering works, as an essential raw material. In the municipality of Capela de Santana/RS, Brazil, several sand deposits are explored, and in a specific manner the beneficiation process of this material generates large amounts of sediment of very fine grain size in its tailing basin. The characterization of this material can add economic value to the slag mineral, previously discarded, and supply market demands. This study aims to characterize that sand mining reject, by classing its granulometry, mineralogical composition and physico-chemical behavior, with the purpose of evaluating their future application in geotechnical works.

Keywords: clay minerals, raw material, environment, Brazil, natural resources, valuation, geotechnical works.

1. INTRODUCTION

Clay minerals are in general, secondary minerals and are mainly composed of the kaolinite groups ($Al_4(OH)_8Si_4O_{10}$), illites (complex hydrated silicates of Al, Mg, Fe and Na), montmorillonites (complexes hydrated silicates of Al, Mg and Na), among others.

Due to their specific physical and chemical properties these mineral groups are used in a wide range of industrial and engineering works. Its applications are related to its structure, composition, physical and chemical behavior. Thus, knowledge of these characteristics can define their use, improve their utilization or even open new areas of application (Savicet et al., 2014).

With interest in the possibilities of application of clay minerals in geotechnics, such as the construction of dams, use as a waterproofing layer in engineering works, road paving, liners in sanitary landfills, constituents of geomembranes, or stabilization of soils and slopes, this work will seek to characterize its mineralogy and define the physical-chemical parameters of clays to define their applicability.

Clay minerals can be widely used in engineering works, from the geological drilling process where clays are used as drilling fluid to slope stabilization works, foundations for structures, chemical or water containment barriers, etc.

Due to this, the current market demands a large range of clays with specific characteristics; with the study being developed it will be possible to define the applicability of an existing clay deposit, adding value to the sand mining activity and possibly supply a niche market.

The main objective of this work is to characterize the waste material from a sand deposit in the municipality of Capela de Santana/RS, in Brazil, and to evaluate its applicability as a sealing layer in sanitary landfills (mineral liner).

2. LOCATION AND GEOLOGY OF THE STUDIED AREA

This work was carried out at Sanga Funda, in the Capela do Santana county (Fig. 1), in the state of Rio Grande do Sul, Brazil, located on the southern flank of the huge Paraná Sedimentary Basin comprising near shore environments stratigraphic units of Neopaleozoic to Mesozoic ages. The Mesozoic units are represented by the Sanga do Cabral Formation (Rosário do Sul Group) and Pirambóia, Botucatu and Serra Geral Formations (São Bento Group) (Milani et al, 2007). The Pirambóia Formation is one of the units with the largest outcrops areas in Capela de Santana (Fig. 2) and encompasses a large portion of the municipality, from its center-west to the east, and covers the region of the area under study (Zalán et al., 1990; Montardo, 1982; Lavina et al., 1993; Grehs, 1976; Bilal et al., 1998; Bilal et al., 2000).

3. MATERIALS AND METHODS

The object of this study is a geotechnical characterization of the existing material in the reject pond from the mineral extraction of sand. Sand mining at the site is accomplished by the hydraulic removal of soil horizons and saprolitic material from the alteration of the sedimentary rocks of the Piramboia Formation.

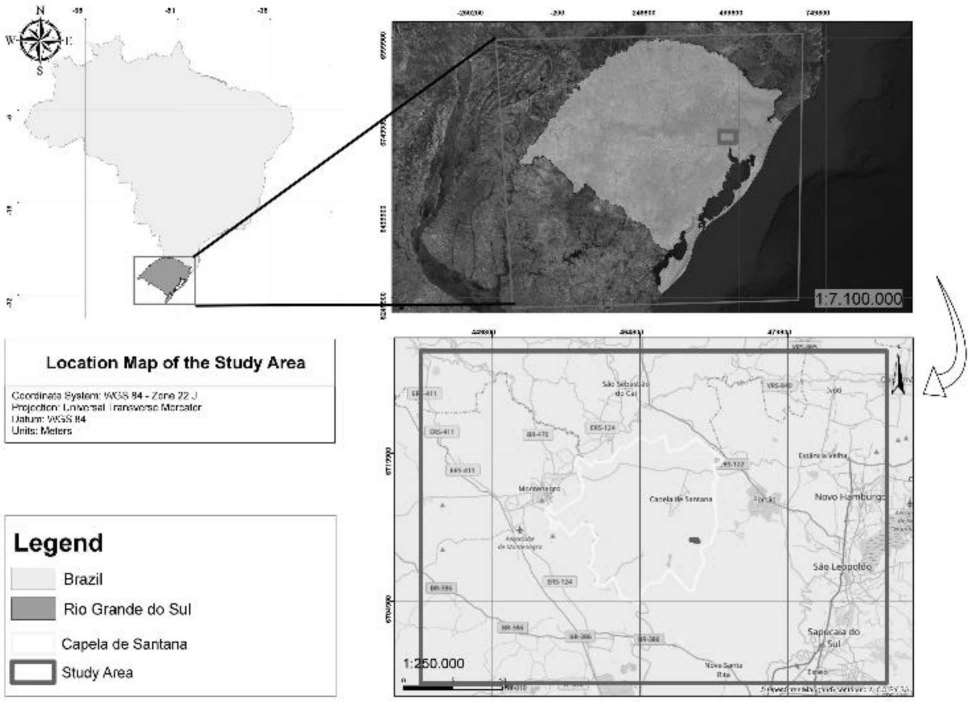

Fig. 1. Location map of the study area in relation to the state of Rio Grande do Sul, Brazil.

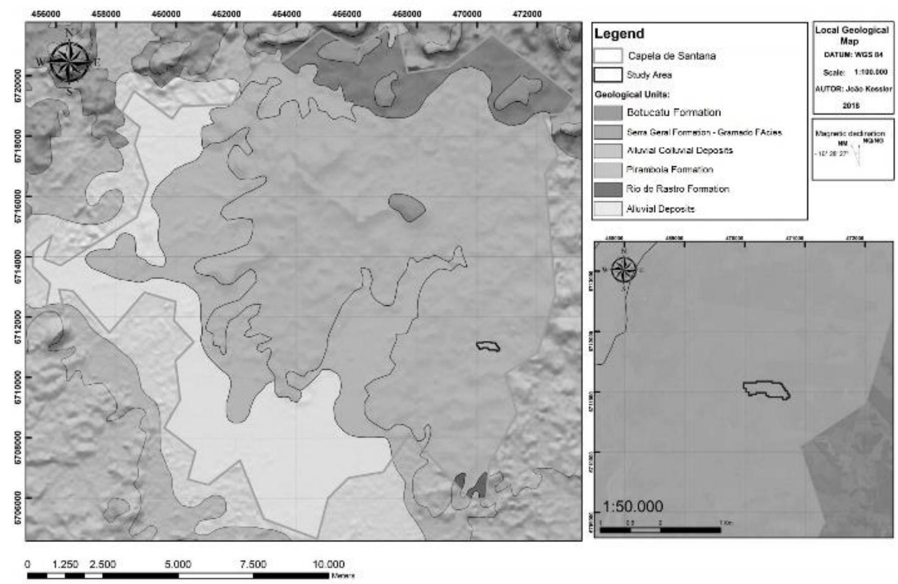

Fig. 2. Geological map of the study area.

The plowed material is selected by density in decantation basins and the sands are currently commercialized from fine-grained to medium-grained, the remaining material is sent to reject basins. With the plowing process used, as shown in Fig. 3, the discarded material is composed of fine granulometry sediments, and it may become viable the economic exploitation of this mineral good, now discarded as waste from the process.

In order to carry out the characterization of the reject, samples were collected from two reject ponds that were already in their maximum capacity in the period in which the samples were collected. Material from each sampled basin has clearly compositional variations, highlighted by the etching of the material.

As a preliminary analysis, sedimentation, liquid limit (LL) and plasticity limit tests were performed according to Brazilian standards NBR 6457/86, 6508/84, 7181/16, 7180/84 and 6459/84, in order to obtain a prior knowledge of the grain size distribution and some behavior of the samples. These characteristics are essential for the application of materials such as sealing layer in landfills. In addition, the determining factor for the use of this material as mineral liner is percolation velocity and water through the material.

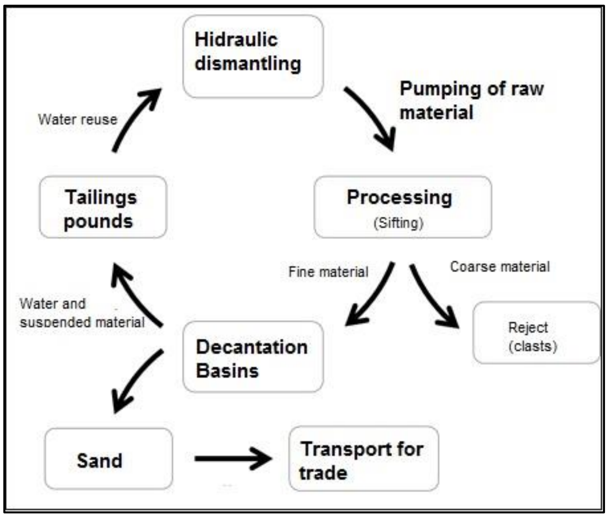

Fig. 3. Flowchart of the extraction method of the material.

It is very important to define the mineral specimens in the reject, because different clay minerals will present different behaviors. For this, X-Ray Diffraction and X-Ray Fluorescence analyzes were performed on samples from the two reject basins, since these methods are well suited for the identification of different types of clays, as they have very characteristic diffraction profiles and easy distinction (Albers et al., 2002; Arab et al., 2015; Benson et al., 1994).

From the data obtained so far it is possible to say that the material has potential to be used in the purpose proposed by the study. Still remaining to assess the permeability coefficient to ensure that all the requirements implied by the standards for the construction of landfills are met.

The sedimentation tests and the Attenberg Limits performed initially were redone. After the sedimentation test was carried out pH was measured from the deflocculant solution ($(NaPO_3)_6$) and it was found to be pH below the ideal provided by the standard, which may lead to a reduction in the efficiency of particle disintegration, resulting in a larger particle size than the real sample. Therefore, it was necessary to retake the deflocculant solution, with greater control in the preparation.

In addition, sedimentation tests were performed with two sample preparation methods. In the first one the material was disaggregated using a ball mill and then subjected to the action of the deflocculant and the second, the material was only subjected to manual disaggregation and then applied the deflocculant solution for the sedimentation test. These two preparation methodologies were applied due to the behavior resulting from the granulometry of very fine nature of the material since both the methods are questionable. Due to the disintegration in the mill, grain breakage and granulometry reduction can occur, and disintegration can only be achieved by the action of the deflocculant solution, the possibility that grains remain aggregated and decant more rapidly, resulting in an increase in granulometry.

4. RESULTS AND DISCUSSION

So far, the tests for two samples, one of each reject basin, denominated AM1-B1 and AM1-B2 (Reject basin 1 and 2, respectively), have been carried out. The sample AM1-B2 has a LL of 81% (Fig. 4) and a plasticity limit of 29.94%. The sample has a high plasticity, having a plasticity index of 51,06.

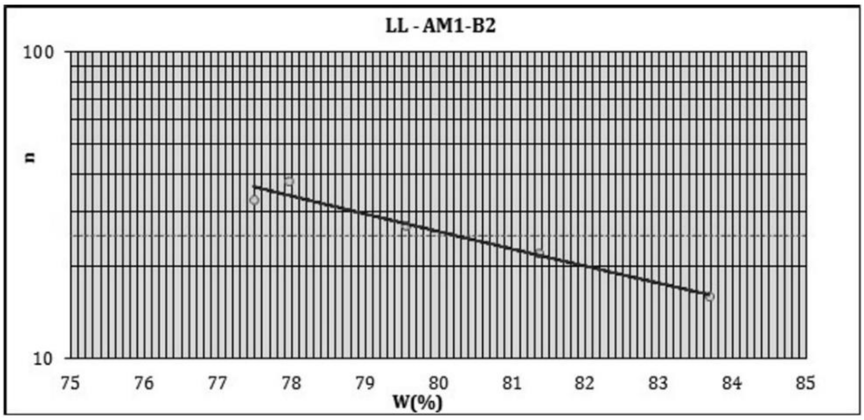

Fig. 4. Graph of sample liquidity limits AM1-B2

The sample AM1-B2 presents high clay contents, as shown in the grain size distribution curves presented in Fig. 5.

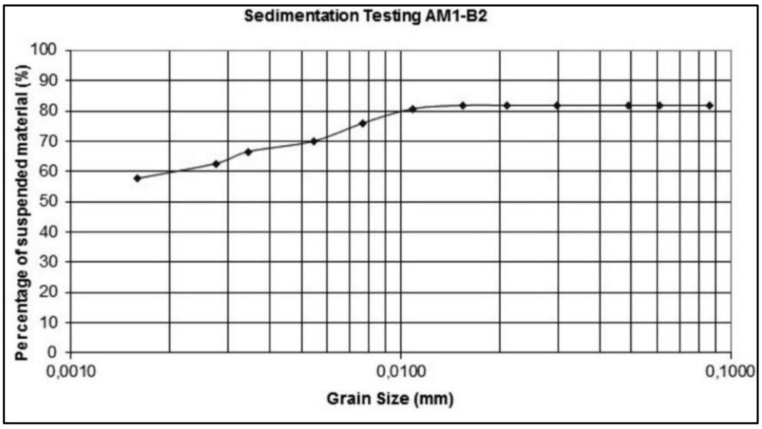

Fig. 5. Sample size curve AM1-B2.

The sample AM1-B1 has a liquidity limit of 71.9% (Fig. 6) and a plasticity limit of 31.7%. The sample has a high plasticity, with a plasticity index of 40.2.

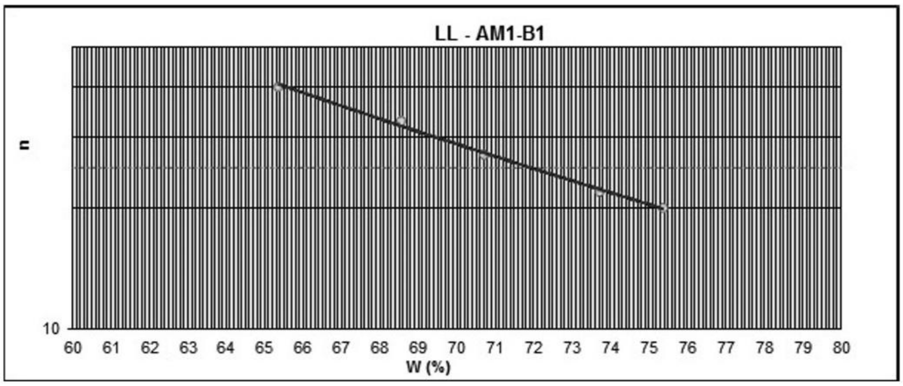

Fig. 6. Graph of sample liquidity limits AM1-B1.

The AM1-B1 sample also appears to have a high clay content, since after the time of 24 hours of sedimentation 69.5% of the particles remained in suspension, however due to the low specific weight of the particles, it was not possible to reach the expected particle size, only the silt fraction (0.002 mm), as shown in the grain size curve shown in Fig. 7.

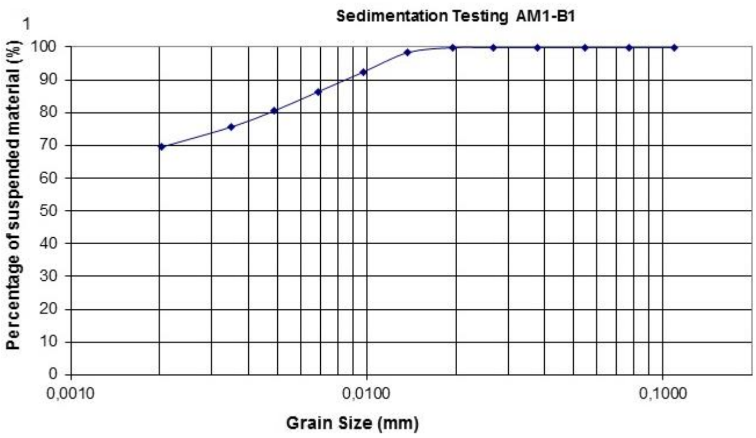

Fig. 7. Grain size distribution curves of sample AM1-B1.

X-ray (XRF) analyzes were performed on the samples from the two reject basins, through which quantitative data were obtained of the chemical composition of the samples, mainly composed of SiO_2, Al_2O_3, organic matter and Fe_2O_3, which corresponds to the basic composition of most of the clay mineral groups (Gomes, 1988), as shown the Fig. 8. The main mineral phases in the samples were identified by X-Ray diffraction, being montmorillonite, kaolinite, quartz, muscovite and microcline (Figs. 9 and 10).

Quantitative Result

Analyte	Result
====[No. 1 Layer]====< Layer1	
Layer1	6.000 um
C3H6	100.000 %
====[Base]==========< Base	
Na2O	0.522 %
MgO	0.408 %
Al2O3	17.269 %
SiO2	51.002 %
P2O5	0.191 %
SO3	0.034 %
K2O	0.610 %
CaO	0.032 %
TiO2	0.987 %
MnO	0.019 %
Fe2O3	3.513 %
L.O.I	10.605 %

Quantitative Result

Analyte	Result
====[No. 1 Layer]====< Layer1	
Layer1	6.000 um
C3H6	100.000 %
====[Base]==========< Base	
Na2O	0.455 %
MgO	0.611 %
Al2O3	20.715 %
SiO2	48.139 %
P2O5	0.035 %
K2O	0.600 %
CaO	ND %
TiO2	1.582 %
MnO	0.010 %
Fe2O3	3.218 %
L.O.I	12.097 %

Fig. 8. Results of XRF sample from the reject basin 1 (AM-01/B1) in left, and basin 2 (AM-01/B2) at right.

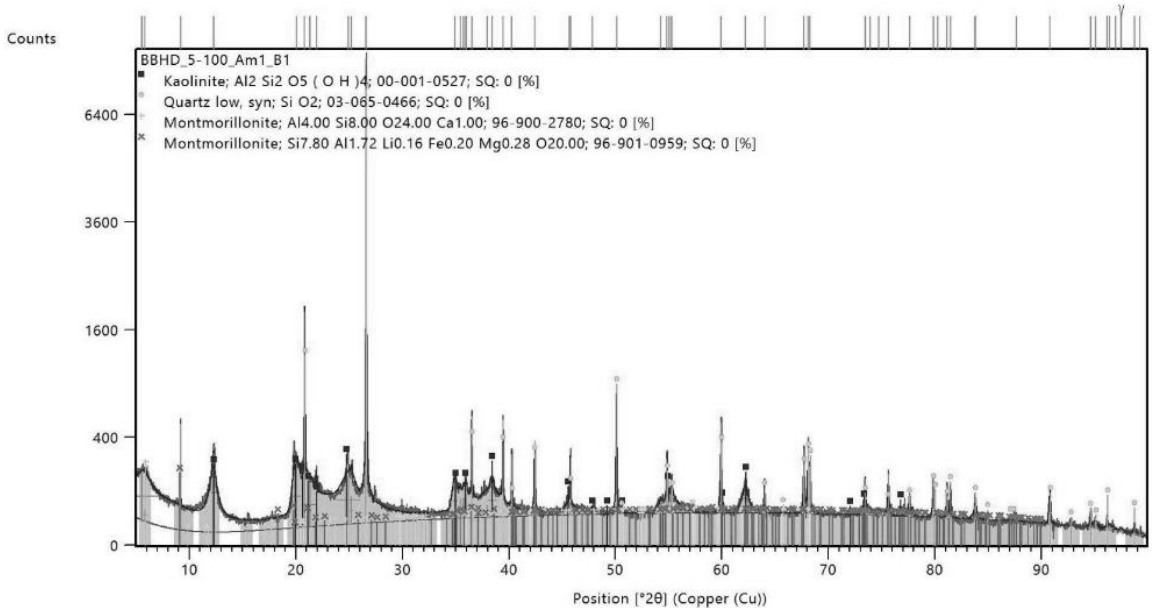

Fig. 9. XRD result of reject sample 2 (AM-01/B1).

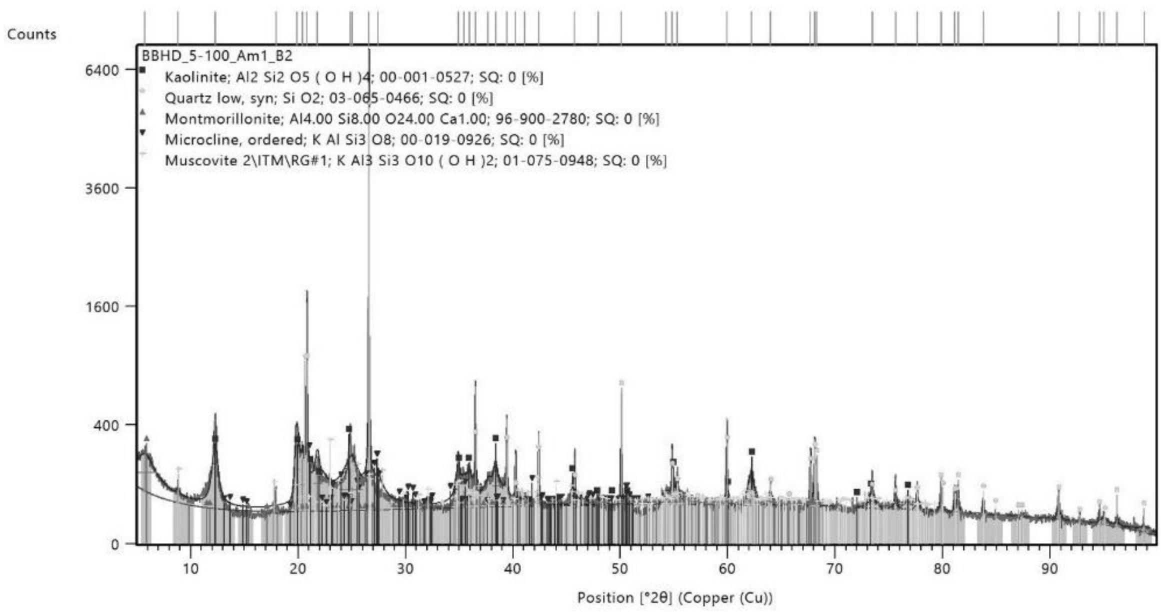

Fig. 10. XRD result of reject sample 2 (AM-01/B2).

5. CONCLUSIONS

Through the analyses carried out so far, it was possible to assess some behavior of the studied material and to verify by the grain size distribution, that showed its very fine nature, with a high percentage of clays. The possible application of the material is, in a first approach, as a waterproofing layer. Another necessary aspect to be investigated will be the causes of the compositional variation in the different reject basins.

In order to do this, future research is pointing to carry out other field visits and sampling at the study area to evaluate the method of beneficiation of the deposit and possible variables in the process. Moreover, an analysis of possible lithological variations of the prospected rock. If the possibility of changes in the beneficiation method is eliminated and compositional variations in the lithology are identified, the aim is to collect samples from the lithology and perform petrographic analyzes in order to understand the origin of the clay material.

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