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Comparative Analysis of Palygorskite Samples From Different Occurrences in Guadalupe (Piauí, Brazil)

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ABSTRACT: Palygorskite is a clay mineral that has several industrial and environmental applications. Palygorskite main deposits in Brazil are located in the municipality of Guadalupe, Piauí. A comparative study was performed with five samples of palygorskite from different locations through ore dressing and chemical and mineralogical characterization, using the XRD, XRF and methylene blue titration techniques. According to the results, there are significant differences in the samples composition. Among them, the most significant difference was the cation exchange capacity (CEC) value, which ranged from 24.0 to 41.0 meq·100 g^{-1}, followed by the content of some oxides and the crystalline phases present. Despite coming from the same region, the samples contained distinct impurities.

KEYWORDS: Palygorskite; Ore dressing; Characterization.

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INTRODUCTION

In Brazil, palygorskite occurrences are limited to the municipality of Guadalupe, Piauí (Baltar *et al.* 2009) and the Alcântara region in Maranhão (Amorim and Angélica 2011). The Guadalupe region reserves have the highest potential for economic exploitation, especially from Cardoso, Mina Velha, Boa Vista and Angico mines.

Palygorskite is a clay mineral characterized by the unit cell chemical composition of $(Mg,Al)_5Si_8O_{20}(OH)_2(OH_2)_4{\cdot}4H_2O$. Its three-dimensional structure is formed by two sheets of SiO2 tetrahedra with an octahedron formed by Mg^{2+} ions.

Palygorskite fine grain size (< 37 μm) and its fibrous nature associated with ample exchangeable cations give to it a high surface area (125 to 210 $m^2{\cdot}g^{-1}$) and a cation exchange capacity (CEC) of 20 to 50 meq $100{\cdot}g^{-1}$. Due to these properties, palygorskite has several technological applications, such as in bleaching agents, well-drilling fluids, and adsorbents of toxic metals and pesticides (Luz and Almeida 2005; Murray 2000). Recently, clay minerals such as palygorskite, that contain magnesium, aluminum and silicon in their structure, have been used to prepare cordierite ceramics, which have application in the aerospace area (Thomaidis and Kostakis 2015). For example, because of their high thermal stability, cordierite-family ceramics have been used to manufacture lightweight mirrors for cutting-edge space telescopes (Kamiya and Mizutani 2018).

The aim of this study was to analyze five palygorskite samples in pure fractions from different occurrences located in the region of Guadalupe, Piauí.

MATERIALS AND METHODS

Four palygorskite samples of approximately 10 kg were collected from Cardoso, Mina Velha, Boa Vista and Angico mines, as well as a sample called GDP that was provided by a local company. The sample collection area is located in the geotectonic context of the Parnaíba Basin in Guadalupe, where the main deposits of palygorskite occur in Brazil. The samples were sent to the Mineral Technology Center (CETEM-MCTIC) to perform the ore dressing and mineralogical characterization steps. To concentrate the clay minerals, the raw samples were dressed by crushing, grinding, wet screening and magnetic separation. Mineralogical characterization of fractions below 20 μm was performed by X-ray diffraction (XRD) and chemical characterization (oxide content) by X-ray fluorescence spectrometry (XRF). The cation exchange capacity (CEC) was determined according to the standard methylene blue titration method based on the American Society for Testing and Materials (ASTM 2019).

RESULTS AND DISCUSSION

The XRD results (Fig. 1) indicate that the five samples have a mineralogical composition essentially consisting of palygorskite $(Mg,Al)_5Si_8O_{20}(OH)_2(OH_2)_4{\cdot}4H_2O$, kaolinite $Al_2Si_2O_5(OH)_4$ and quartz SiO_2 (Barthelmy 2014). The Angico, Mina Velha and GDP samples showed peaks related to goethite FeO(OH) (Barthelmy 2014). The Cardoso and Boa Vista samples presented low-intensity peaks attributed to montmorillonite $Na_{0,2}Ca_{0,1}Al_2Si_4O_{10}(OH)_2(H_2O)_{10}$ and to diaspore AlO(OH) (Barthelmy 2014), respectively. The Angico sample showed the highest intensity of the clay mineral of interest, with the Cardoso sample presenting the lowest intensity peak. The intensity of the peaks was adjusted according to the second palygorskite peak, at 18.8° (2θ).

The results of the chemical composition to determine oxide content (Table 1) corroborate the results obtained by XRD, since the MgO content in the palygorskite structure was highest for the Angico sample and lowest for the Cardoso sample. Moreover, the higher Al_2O_3 content of the Cardoso sample may be associated with the presence of montmorillonite. The GDP sample had the lowest SiO_2 content, explaining the lower intensity of the quartz peak.

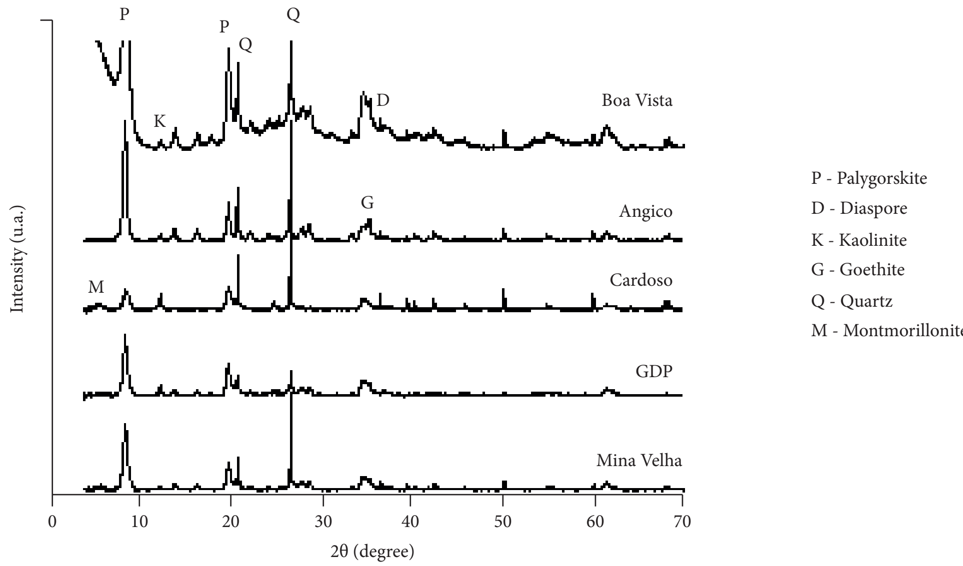

Figure 1. X-ray diffractograms, Co Kα, of palygorskite samples.

Table 1. Chemical composition of palygorskite samples.

Samples (< 20 μm)	Oxides (% w/w)								
	SiO_2	Al_2O_3	Fe_2O_3	MgO	K_2O	CaO	TiO_2	Na_2O	Loss by calcination
Boa Vista	53.8	14.2	6.8	5.7	2.2	0.18	0.52	0.14	16.3
Angico	56.5	12.6	5.5	6.9	1.4	0.21	0.7	< 0.1	15.7
Cardoso	53.6	16.6	9.2	3.4	1.8	0.17	0.64	0.12	14.4
GDP	49.5	16.4	7.2	5.4	2.4	0.33	0.60	0.12	18.1
Mina Velha	53.5	13.5	7.0	5.4	1.9	0.23	0.55	< 0.1	17.8

The CEC values obtained for the Angico, Boa Vista, Cardoso, Mina Velha and GDP samples were 24.0, 24.0, 31.0, 41.0 and 41.0 meq·100g^{-1}, respectively, indicating that all analyzed samples were within the reference values for palygorskite (range of 20 to 50 meq·100 g^{-1}) (Murray 2006). The Angico and Boa Vista samples presented the lowest cation exchange capacity, a fact that may be associated with the low K_2O and CaO contents of those samples, respectively, since these contents are related to exchangeable cations. In addition, the higher contents of these oxides are associated with higher cation exchange capacity values.

CONCLUSIONS

The palygorskite samples, despite being obtained from the same geological context, contained distinct impurities, such as montmorillonite, goethite and diaspore. Chemical composition corroborated these results. In addition, the samples presented different CEC values, but all values were between 24.0 to 41.0 meq·100g^{-1}. Thus, the results highlight the diversity of applications of this clay mineral, such as adsorbents of herbicides and toxic metals in water bodies and of ammonium in swine wastewater. It is also used in the pharmaceutical industry for controlled drug release and delivery. This clay mineral can be used in other applications, such as oil clarification, soil correction and production of high-strength ceramics, among others.

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AUTHORS' CONTRIBUTION

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