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# Polygenetic processes in the genesis of clay deposits of Poços de Caldas alkaline massif in southeastern Brazil☆

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ABSTRACT

The purpose of this research is to characterize the clay deposits occurring in the central plateau of the Poços de Caldas alkaline massif, aiming for a better understanding of the involved genetic processes. The results showed that the formation of clay deposits was associated with two processes related to external geodynamic, *in situ* alteration (weathering) and sedimentation. These processes produced two different types of clay layers: residual and sedimentary clay. The mineralogical characterization of the residual clay was conditioned by the parent rock. Thus, in the deposits formed from alkaline rocks, the clay material is mainly kaolinitic, whereas the clay deposits formed from potassic rocks are dominated by halloysite. The sedimentary deposits were formed by the erosion of both weathering products (saprolite) of alkaline rocks and bauxite formations, originating from the upper part of the topography and deposition over the residual clay in a clear unconformity. This is a very interesting situation because these two types of clays with different properties and utilization occur in the same deposit, reflecting a polygenetic origin.



## 1. Introduction

The clay deposits of Poços de Caldas result from tropical weathering of alkaline rocks, including those previously affected by hydrothermal activities. The deposits are known by the presence of clays with particular properties that allow their utilization in the refractory industry (refractory clay), but clays with different characteristics that are used in ceramic manufacturing (plastic clay) exist as well. The formation of these two types of clay is not well known from previous studies, but authors have suggested that they could have different origins, including weathering, hydrothermal processes or gibbsite resilicification (Moniz, 1969; Suenaga et al., 1972; Valeton et al., 1997). Montes-Lauar et al. (1999) noted, for the first time, the importance of sedimentation processes in the formation of aluminum-rich clay materials in Poços de Caldas.

The purpose of this research is to study the morphological and genetic aspects of the clay deposits that contain refractory and plastic clay types in the same profile.

## 2. Geological setting

The alkaline massif of Poços de Caldas is one of the most important among several complexes of alkaline rocks occurring in Brazil, particularly in the southeastern region. Most of the complexes are associated with the end of the South Atlantic Ocean opening process (120 Ma) (Almeida, 1983). The alkaline massif of Poços de Caldas is situated between the states of São Paulo and Minas Gerais (21° 47′ 18″ S, 46° 33′ 45″ W), and presents a circular structure, with a diameter of nearly 30 km and a total area of 800 km$^2$ (Fig. 1). The present topography, resulting from the action of volcanic and erosional processes, is characterized by two distinct components, namely: mountain ridge and a central plateau (Ellert, 1959).

The mountain ridge presents a very high and steep topography and corresponds to the massif circular border, 850 m across, with altitudes that can reach 1600 m. A ring dyke surrounds the alkaline massif.

The central plateau, resulting from the erosion of multiple calderas, is characterized by a smooth and slightly undulated topography, with altitudes about 300 m lower than the mountain ridge. Locally, some areas with higher topography can be found.

The geological, petrological and economic aspects of the massif were the subject of several publications (Ellert, 1959; Moniz, 1969; Suenaga et al., 1972; Ulbrich and Gomes, 1981; Almeida, 1983; Ulbrich, 1984, 1985; Garda, 1990; Waber, 1990; Schorscher and Shea, 1992; Shea, 1992; Waber et al., 1992; Valeton et al., 1997). Other studies, such as

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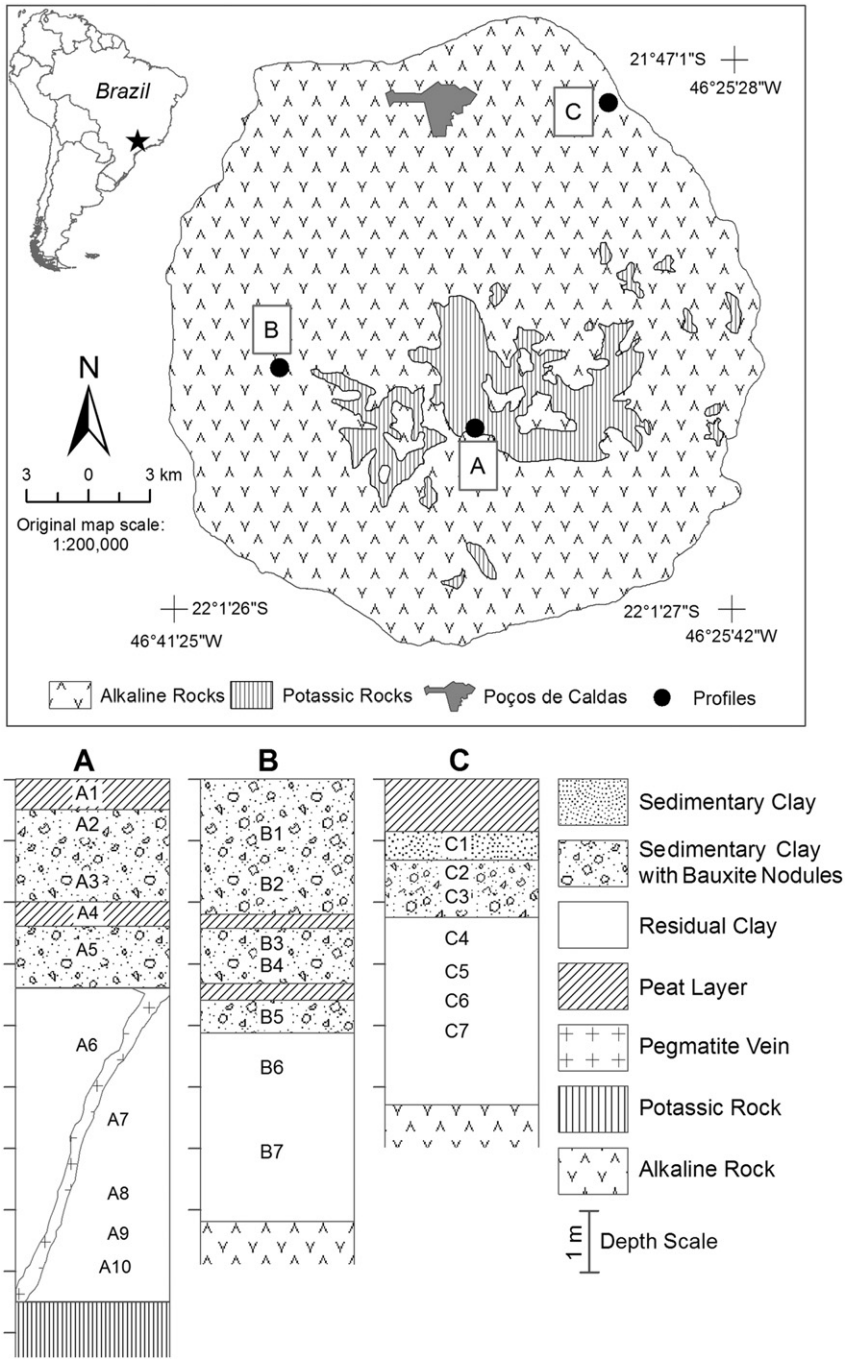


**Fig. 1.** Upper part: geological map of the alkaline massif of Poços de Caldas (adapted from Almeida Filho, 1995) with key sites (A, B and C). Lower part: schematic profiles of the deposits formed by residual clay overlain by sedimentary clay. A1–A10, B1–B7 and C1–C7 distribution of the collected samples within the profiles.

Frahya (1952), Garda (1990), Waber (1990), and Waber et al. (1992), concentrated on the important hydrothermal episodes that affected nearly one-quarter of the alkaline rocks of the massif, particularly in the central southern part. Frahya (1952) named these rocks as "potassic rocks" due to their higher K content. Others (Garda, 1990; Waber, 1990; Waber et al., 1992) noted that the hydrothermal action allowed the conservation of K in this type of rock, due to the substitution of orthoclase by microcline and the neo-formation of illite.

The alkaline massif of Poços de Caldas is composed of two different lithologies: magmatic alkaline rocks and hydrothermal rocks also referred as "potassic rocks".

The magmatic alkaline rocks constitute the major part of the complex and are formed by volcanic and sub-volcanic rocks (phonolites and tinguaytes) and plutonic rocks (nepheline syenites) (Ellert, 1959; Ulbrich, 1984). These rocks present practically the same mineralogical and chemical compositions with different textures corresponding to different cooling conditions of very similar magmas. The rocks are mainly composed of alkaline feldspar (orthoclase) and nepheline as the predominant minerals and other feldspathoids, Na-rich pyroxenes, and, in rare cases, Na-rich amphiboles. Opaque minerals, titanite and more rarely biotite, muscovite and zircon are present as accessory minerals (Ulbrich, 1983, Ulbrich, 1984; Valeton et al., 1997). In several parts of the massif, the alkaline rocks have an unusual mineralogical composition with pyroxenes rich in Zr and Na such as eudialite, lavenite, rosenbuschite and catapleiite as accessory minerals (Soubiès et al., 1991; Duvallet et al., 1999).