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Mineralogical, geochemical and mechanical characterization of the Ayos (East-Cameroon) lateritic and alluvial clayey mixtures: Suitability for building application

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ABSTRACT

The ferrallitic weathering in South-Cameroon produces a thick soil mantle. However, the high iron content of the clayey materials prevents their efficient use in ceramics. To reduce the iron effect, the Ayos lateritic clays have been mixed with alluvial clays taken from the Nyong River. The results obtained show that the main minerals are Quartz, kaolinite, hematite, goethite and muscovite in lateritic clays and kaolinite, chlorite, quartz, muscovite for the alluvial clays. The chemical compositions indicated that SiO_2, Al_2O_3 and Fe_2O_3 are the main elements in lateritic clays while in alluvial clays, SiO_2 and Al_2O_3 are predominant. Fe_2O_3 is less than 2%. The plasticity and ceramic properties are improved with alluvial clays content. The lateritic clays can be used for dense bricks after firing at 1000 °C and 1100 °C. Mixtures with more than 20 wt% of alluvial clays are suitable for dense bricks at all the firing temperatures (900–1100 °C). The limiting factor for these mixtures in roofing tiles is their flexural strength.

1. Introduction

Clays are used in the processing industries, agricultural applications, engineering and construction applications, environmental remediations, geology, and many other miscellaneous applications [1]. They can occur in wide range of environments: as residual product in soil profiles and accumulated materials in some basin or catchment areas. Those found in soils (lateritic clays) are widely spread in tropical countries such as Cameroon where they occupy about 67% of the national territory [2]. In Cameroon, many houses in cities and villages are built using these materials due to the social and economic factors. But the warm and humid climatic conditions cause damage to the masonry blocks which are air-dried and unstabilized. This is due to their high iron content leading to poor mechanical resistance of the final products [3–5], and the lack of fluxing agent as alkali and alkaline earth elements which are necessary for low temperatures firing (900–1000 °C). Most studies carried out on lateritic clays exploited as building materials, focused on their stabilization with addition of lime or cement [6–8]. In the present work, to reduce the iron effect, the Ayos lateritic clays have been mixed with alluvial clays collected from the Nyong River. This study aims to determine the mineralogical and geochemical features of lateritic and alluvial clays found in Ayos, Eastern Region of Cameroon and sort out the effect of alluvial clays addition on the ceramic properties of the characterized lateritic clays.

2. Geographical and geological settings

The study area is located in the Southern Cameroon Plateau, between 3°50′–3°55′N and 12°30′–12°35′E (Fig. 1). The average precipitation is 1510.7 mm (1978–2013) with temperatures varying between 22.4 and 24.4 °C. This region is submitted to a transitional equatorial climate with four seasons (two raining seasons from March to June and from September to November, and two dry seasons from December to February and from July to August). The average altitude is 680 m. The hydrographic network belongs to the Nyong watershed, which is the second most important river in Cameroon with a surface area of 27,800 km^2 [9]. The drainage pattern is dense and dendritic.

Geologically, the basement rocks found are schist with quartz veins belonging to lower metamorphic grade rocks of Mbalmayo-Bengbis and Ayos series that has undergone rejuvenation during the neoproterozoïc [10–12].

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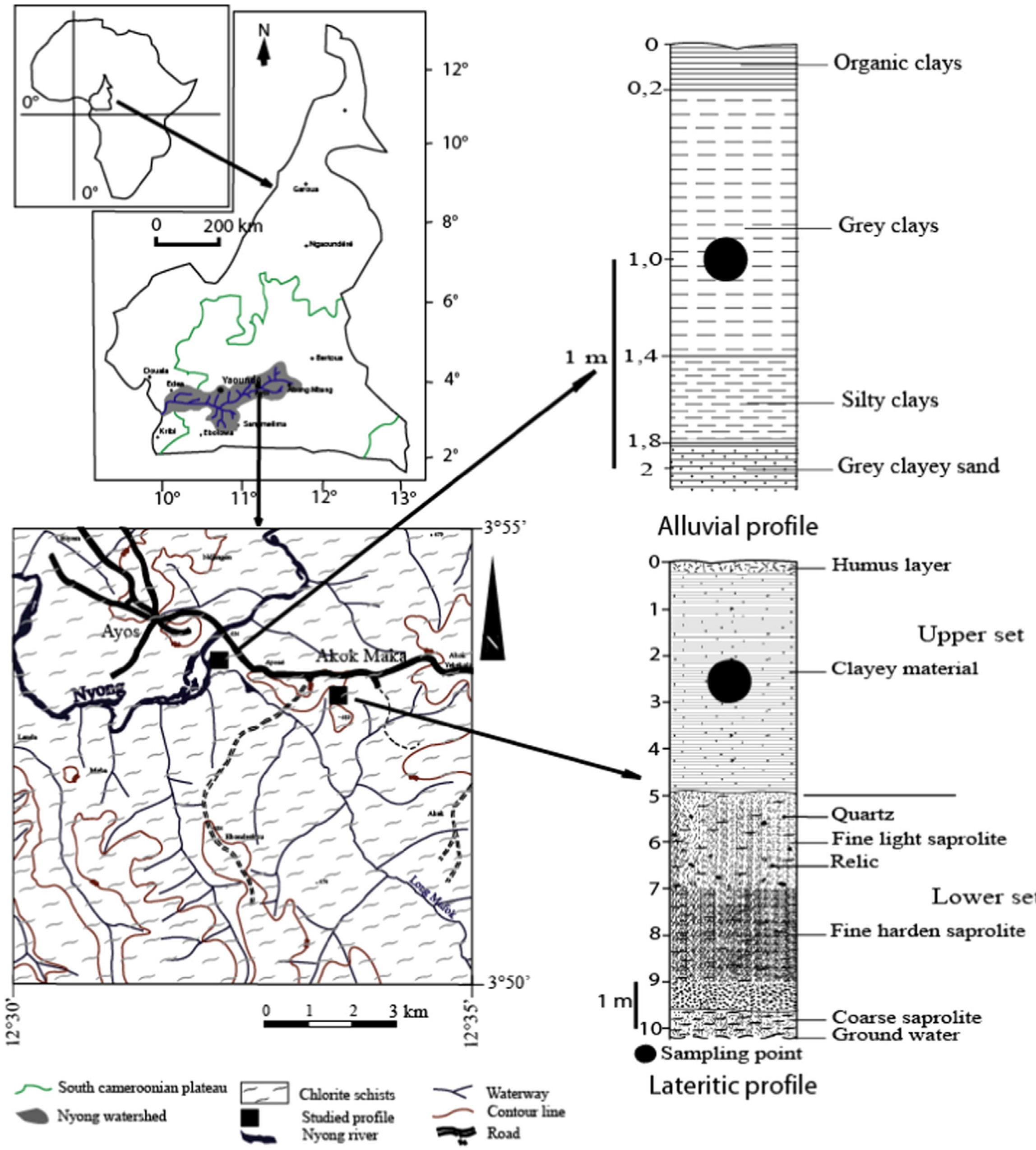

Fig. 1. Location of the study area and sampling profile within the Nyong watershed in South Cameroon.

3. Materials and methods

3.1. Sampling methods

The collection of lateritic clays sample required shaft sinking. The description of the pedologic profile is given in Fig. 1. This profile shows three layers from top to bottom as fine lateritic clays, fine saprolite and coarse saprolite with a mixture of clays, sand, gravels and fragments of parent rock (chlorite schist). The studied sample was collected between 2 and 3 m deepth within the fine lateritic clays layer. The alluvial clay sample (AY-A) was collected at the 1.0 m depth in the swampy valley of the Nyong river at about 2.5 Km from the lateritic clays deposit, using a manual auger. It is a widespread and homogeneous material with 1 to 2.5 m depth, outcropping between Ayos and Akonolinga within the Nyong U-shaped valley.

3.2. Analytical procedures

The color was determined using the Munsell Soil Color chart on dry samples and Fired samples. The hue/value/chroma of the samples was determined by visual comparison with those of standard soils recorded in the Munsell Color chart.

The mineralogical analyses were performed at the Department of Geology, University of Liege (Belgium). The X-ray diffraction patterns were obtained with a diffractometer (Bruker Advance 8) equipped with Ni filtered CuKα radiation, with automatic slit and on-line computer control. The samples were scanned from 2° to 45° 2θ. Measurements were performed on randomly oriented powder preparation from bulk samples and special treatments (oriented samples, samples heated at 500 °C for 4 h, ethylene-glycol saturated samples for 22 h) were carried out to characterize the clayey fraction. Mineral identification on the diffractograms and a semi-quantitative mineralogical composition were