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Research paper

Characterisation and identification of local kaolin clay from Ghana: A potential material for electroporcelain insulator fabrication

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ABSTRACT

The aim of this work was to evaluate two kaolin clays from the southern part of Ghana, Assin-Fosu and Kumasi clays, as source clays for the fabrication of electroporcelain insulators. X-ray diffraction, differential thermal analysis, thermogravimetric analysis, chemical analyses and scanning electron microscopy observations showed the fired clay minerals have broadly similar characteristics, but with significant differences in their chemical composition. The alumina contents were determined to be 35 ± 2 wt% and 22 ± 2 wt% respectively for the two kaolins and the silica contents 49 ± 3 wt% and 58 ± 3 wt% respectively. It is concluded that Assin-Fosu kaolin is a reliable local source material for electroporcelain fabrication, while Kumasi kaolin is more suitable for making wall and floor tiles.

Keywords
Assin-Fosu kaolin
Electroporcelain insulators
Kaolin
Kumasi kaolin
X-ray diffraction

1. Introduction

Clay products have been used worldwide for processing various forms of ceramic materials since antiquity (Velde, 1992; Murray, 2000; Bertolino and Lagaly, 2003). Clay is still used today in the ceramics industry for producing products such as whitewares, high temperature porcelains, sanitary ware and electrical insulators (Carty and Senapati, 1998). The major mineral constituent of the clay used for porcelain is kaolinite; rocks rich in this mineral are typically referred to as either ‘china clay’ or ‘kaolin’. Kaolinite is one of the mineral phases used widely in the clay industry for making many products, including paper (Brindley and Nakahira, 1959; Stathis et al., 2004; Olupot et al., 2010). In addition, kaolin has also found extensive usage in the pharmaceutical, paint and composite materials industries (Murray et al., 1993). The choice of china clay or kaolin for industrial applications is dependent on several factors including specific requirements for developing a particular technology (Nkoumbou et al., 2009). These requirements are dependent on the geological conditions under which the kaolin deposits originate, as well as their mineralogical and chemical composition and degree of kaolinite crystallinity, and physical properties such as colour and firing characteristics (Cases et al., 1986; Cravero et al., 1997; Ekosse, 2000; Pinheiro et al., 2005; Siddiqui et al., 2005; López-Galindo et al., 2007).

The clay industry in Africa, and in Ghana in particular, dates back several centuries because the material is ubiquitous. Natives of the continent find, or have found historically, use for clay for both domestic and industrial applications. The production of pottery and red bricks, geophagy, sculpture, rituals, and plastering are just some of the ways in which kaolin is used in Ghana (Goody, 1972). Most of the recent scientific studies conducted in Ghana on kaolin deposits have focused on understanding the use of kaolin as a reinforcement in composites and as a source material for the production of refractory bricks and porous filters (Efavi et al., 2012; Yaya et al., 2012; Dodoo-Arhin et al., 2013; Agyei-Tuffour et al., 2014). In contrast to this, the potential usefulness of these kaolin deposits for the production of electroporcelain insulators relevant to the continued development of the national electricity transmission network within Ghana has not been considered.

Electroporcelain insulators are materials of choice for both low and high tension insulation (Iqbal and Lee, 1999). These are complex multi-component ceramic materials made from clays, fluxes and fillers. These three ingredients react together under thermal conditions to produce

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the final product (Carty and Senapati, 1998). Despite significant research already conducted in this field, challenges still remain in understanding the properties relating to the selection and investigation of raw materials, their processing, microstructure and phase evolution, all which are critical determinants for their use as electric insulation materials (Cravero et al., 1997; Iqbal and Lee, 1999; Choudhary and Patri, 2009).

One obvious variable in the production of electroporcelain insulators is the source or sources of the clay, because critical aspects of a particular clay, such as its elemental composition, its phase constitution, its microstructure and its plasticity are all a function of geological conditions. These characteristics of a clay are instrumental in determining whether it can be used in the fabrication of electrical insulators.

It is evident that there is significant potential for the use of local clay materials, as well as fluxes and fillers such as feldspar and quartz, to manufacture electroporcelain insulators in Ghana, since all of these materials are readily available in mineral deposits within the country. The objective of the work reported here was to evaluate the properties of two clays taken from two different locations in Ghana in order to establish their suitability for the fabrication of electroporcelain insulators.

2. Materials and methodology

2.1. Sources of the raw materials

The raw kaolin materials for this study were collected from the Assin-Fosu and Kumasi kaolin deposits in Ghana located in the Central region and the Ashanti region respectively (Fig. 1).

2.2. Powder preparation and analysis

In preparing powders used in this study, 400 g quantities of the lumpy kaolin deposits, one from the Kumasi deposits and one from the Assin-Fosu deposits, were first ground using a Thomas grinding machine to break up the agglomerates. The samples were each further milled for 11 h in a cascading ball mill using alumina balls to reduce the particle size and obtain fine powders.

After milling, the particle size distribution of each of the two powders was analysed using a five-stack sieve set arranged in the sequence of International Organization for Standardization (ISO) nominal aperture sizes of 630 μm, 500 μm, 355 μm, 90 μm and 63 μm from top to bottom to determine how well the two sources of clay had milled. Particle sizes below 90 μm were used from the two sets of sieved powders for the characterisation studies.

2.3. Chemical composition testing

Chemical analysis of the kaolin powders was obtained using a Spectro XLab 2000 X-Ray Fluorescence (XRF) spectrometer (AMETEK USA), located at the Ghana Geological Survey. 4 g of each sample sieved through the 90 μm sieve was mixed with 1 g of Licowax powder which served as a binder. The mixture was milled for 5 min in a Retsch milling machine (model MM 301) and pressed in an XRF pellet press. The powder samples were then loaded into the Spectro XLab 2000 sample holders for the XRF analysis.

2.4. Loss on ignition

This measurement was carried out on raw powdered samples of the two kaolins fired in an electric kiln at a temperature of 1000 °C for 2 h.

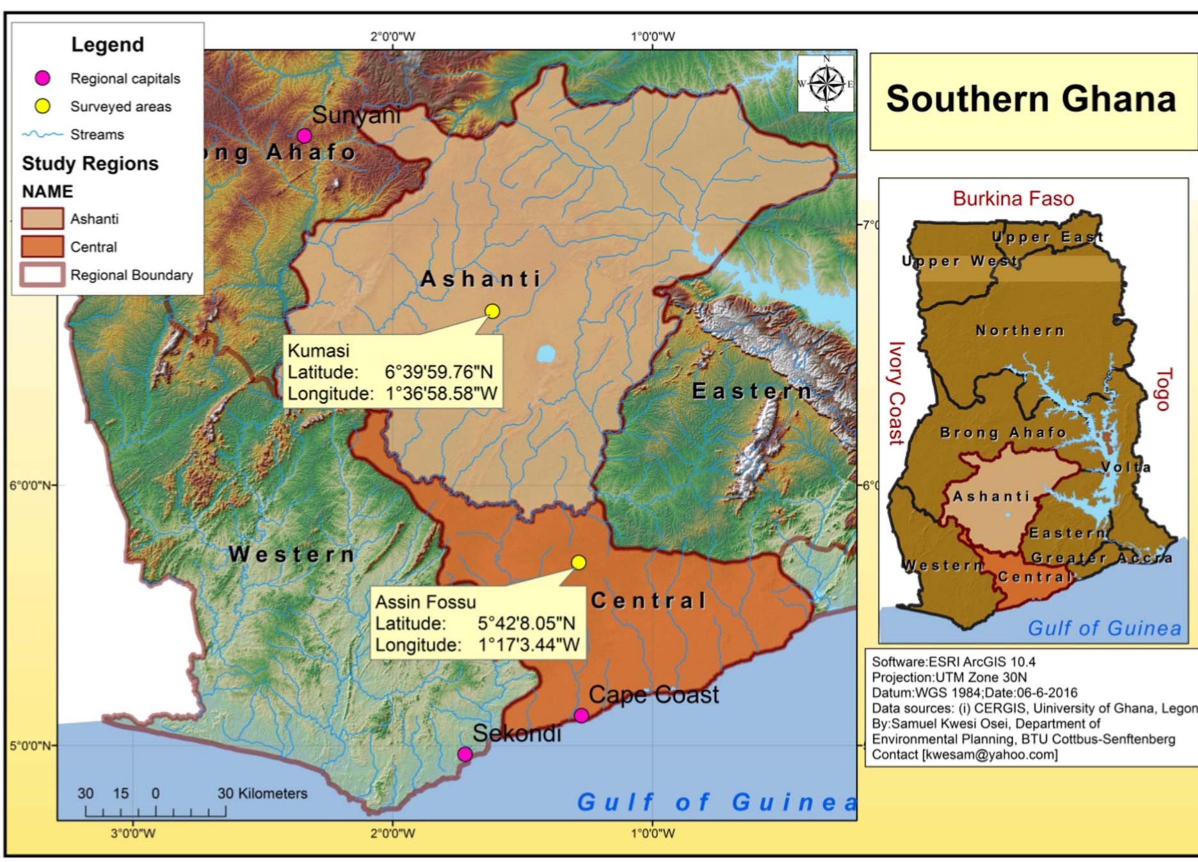

Fig. 1. Regional map of Ghana showing locations of the Assin-Fosu and Kumasi kaolin deposits. Two small yellow dots show the exact locations of these deposits on the left-hand enlargement of the south-west corner of Ghana. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)