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Mineralogical, chemical composition and distribution of rare earth elements in clay-rich sediments from Southeastern Nigeria

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ABSTRACT

Cretaceous claystone sediments from Enugu, Southeastern, Nigeria were analyzed for their mineralogy and chemistry. Major minerals are quartz and kaolinite while montmorillonite is in minor quantity. The sediments are silica-rich, but showed low values of Al, Fe, Sc and Cr. The values of the chemical index of alteration (CIA) ranged from 89.9 to 94.5 and the values of chemical index of weathering (CIW) ranged from 95.1 to 98.9. Low contents of the alkali and alkali earth elements (Na, K, Mg, Al, Ca) of the clay-rich sediments suggest a relatively more intense weathering of source area. Depleted Ba, Rb, Ca, and Mg suggest that they were probably flushed out by water during sedimentation.

The mineralogical composition, REE contents, and elemental ratios in the sediments suggest a provenance from mainly felsic rocks, with only minor contributions from basic sources. Despite intense weathering the REE, Th, and Sc remained in the clays suggesting that they were immobile.

1. Introduction

Clay represents one of the most abundant type of sediment in sedimentary basins worldwide (Pettijohn, 1975) and is considered to represent average crustal provenance composition much better than any other detrital sedimentary rocks (McCulloch and Wasserburg, 1978).

The chemical composition of the various weathering products depends largely upon the rate of weathering and it is expected to demonstrate well established concepts on mobility of various elements during weathering and therefore to assess the state of chemical weathering (Singh et al., 2005). The preferential removal of Ca, Na and K by solution during weathering processes (Nesbitt et al., 1980) due to their high mobility means that the abundance of these elements with respect to less easily removed elements can be used as a measure of the extent of chemical weathering in provenance. The weathering history of ancient sedimentary rocks can be evaluated in part by examining relationships among the alkali and alkaline earth elements such as Ca, Na, Mg and K. This is because alteration of igneous rocks during weathering results in depletion of alkali and alkaline earth elements and preferential enrichment of Al_2O_3 in sediments (Nesbitt and Young, 1982).

McLennan et al. (1993), Taylor and Mclennan (1985), Condie et al. (1992), Cullers (1995), Armstrong-Altrin et al. (2004) have suggested that major element geochemistry of sedimentary rocks is useful in provenance, weathering and chemical mobility studies, and their trace elements (Cr, Th, Hf, Nb, Zr) and rare earth elements (La, Ce, Y, Sc, Sm,) are good indicators of provenance, weathering, depositional condition and chemical mobility because of their relatively low mobility during sedimentary deposition. The relative distribution of immobile elements such as La and Th (felsic rock) and Sc, Cr and Co (basic rocks) has been used to infer sources' relative contribution in claystone from different environments (Wronkiewicz and Condie, 1990). Higher LREE/HREE ratios and negative Eu anomalies are generally found in felsic rocks, whereas mafic rocks have lower LREE/HREE ratios and small Eu anomalies (Cullers, 1995).

Several investigators reported the geology, stratigraphy and economic potentials of the Lower Benue Trough (Simpson, 1954; Reyment, 1965; Agumanu, 1989; Akande and Muche, 1989; Akande et al., 1992; Uma, 1998; Zaborski, 1998). Clays are among the most important minerals used for manufacturing and environmental studies in the present day. In Nigeria, more than 80 clay deposits have been reported from all parts of the country. Examples are, clay deposits in Abak, Akwa Ibom State, Uruove near Ughelli in Delta State, Ifon in Ondo State, Mokola in Oyo State, Sokoto in Sokoto State, Gombe in Gombe State, Dangara in Niger State, Umuahia in Abia State, Onitsha in Anambra State and Kutigi in Niger State etc. (Fig. 1).

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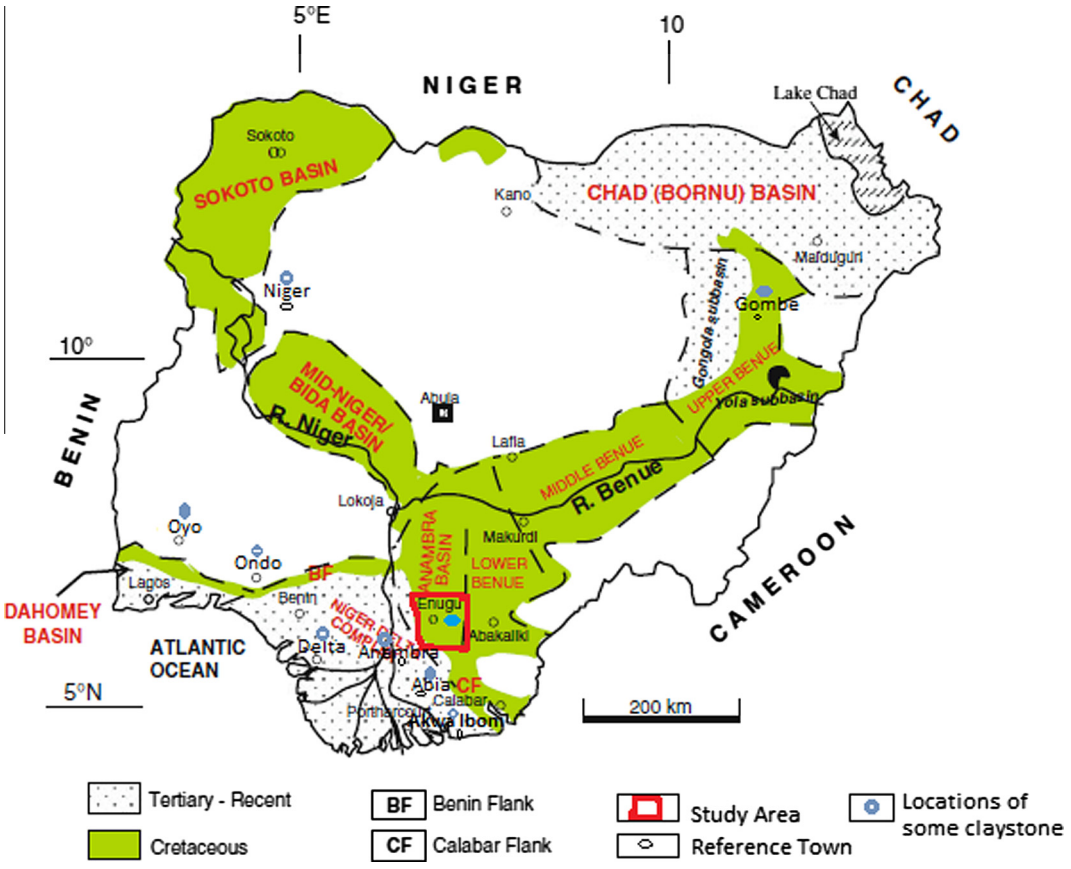

Fig. 1. Map of Nigeria showing the location of the studied Basin/Area and locations of some claystone deposits in Nigeria (Modified after Obaje, 2009).

Clay occurrences vary from the lateritic and residual profiles derived from the weathering of basement rocks (Elueze and Bolarinwa, 1995, 2001; Nton and Elueze, 2005) to those of the sedimentary units and alluvial bodies within the various depositional basins and along the major fluvial channels (Emofurieta et al., 1994; Elueze et al., 1999; Imeokparia and Onyeobi, 2007; Obrike et al., 2007). Despite these studies, the chemical and mineralogical compositions of some of the clay sediments and their sources are still poorly understood. The aim of this study is to determine the mineralogical and geochemical composition of these clay sediments in Enugu area within Anambra Basin. Emphasis is here placed on major geochemistry and the behavior of the REEs. The results are interpreted in terms of source area weathering and provenance.

2. Location and geological description

The study area falls within the geographic coordinates of Latitudes N06°28′09″ and N06°26′05″ north of the Equator and longitudes E007°28′16″ and N007°32′22″ East of the Greenwich

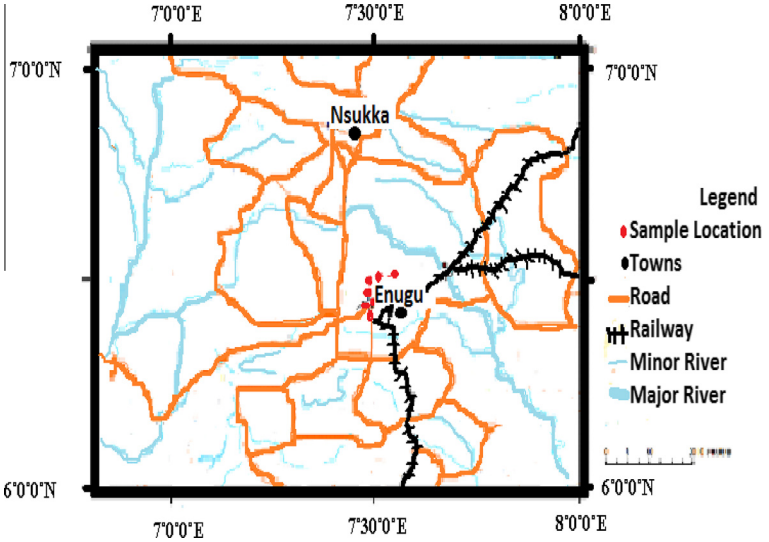

Fig. 2. Map of Southeastern Nigeria showing sampling points/locations.