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Geochemistry of the Paleocene-Eocene and Miocene-Pliocene clayey materials of the eastern part of the Wouri River (Douala sub-basin, Cameroon): Influence of parent rocks

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ABSTRACT

Major and trace element concentrations of clay deposits of the Missole II and Bomkoul respectively from the Paleocene-Eocene N'Kapa Formation and the Miocene-Pliocene-Matanda-Wouri Formation in the eastern part of the Wouri River in the Douala sub-basin of Cameroon have been investigated to identify the parent rocks. To carry out this study, X-ray diffraction, inductively coupled plasma–atomic emission spectrometry (ICP/AES) and inductively coupled plasma–mass spectrometry (ICP/MS) were performed to determine respectively the mineralogical and chemical data of Missole II and Bomkoul clayey materials. Clay sediments are essentially kaolinitic and illitic, and kaolinitic and smectitic respectively in both sites. They are generally siliceous, aluminous with small iron and bases (MgO, CaO, Na_2O, and K_2O) contents. Samples of Missole II profiles are more siliceous than those from the Bomkoul grey and dark grey clayey materials. Clayey materials have high Chemical Index of Alteration (CIA = 80–99.34) which suggests that they are strongly weathered under humid tropical climate before and after their deposition in the coastal plain. The value of Eu/Eu^* (0.48–0.61), La/Sc (2.15–20.50), Th/Sc (0.74–2.25), Th/Co (1.08–8.33), and Cr/Th (5.24–13.55) ratios support essentially a silicic or felsic parent rocks. Total REE concentrations reflect the variations in their grain-size fractions. Chondrite-normalised REE patterns with LREE enrichment, flat HREE, and negative Eu anomaly are attributed essentially to silicic or felsic parent rocks like those from weathered materials developed from the gneisses around the coastal plain in the littoral part of Cameroon (Noa Tang et al., 2012), main characteristic of Paleocene-Eocene and Miocene-Pliocene clay sediments of Missole II and Bomkoul areas.

1. Introduction

Clastic rocks may preserve detritus from long-eroded rocks source and may provide the only available clues to the composition and timing of exposure of such rocks source (Armstrong-Altrin et al., 2004). Indeed, the chemical record of clastic sediments and notably the clay-rich sediments has been widely used for the determination of sedimentary processes, tectonics, weathering and identification of provenance (McLennan and Taylor, 1983; Taylor and McLennan, 1985; Wronkiewicz and Condie, 1987; Cullers, 1988; Nesbitt and Young, 1989; Bertolino et al., 2007; Singh, 2009). In fact, the immobile major and trace elements such as Al, Fe, Ti, Y, Co, Sc, Zr, Nb, Hf, Ta, Th, and the rare earth elements (REEs) have been found to be useful indicators of the rocks source (Taylor and McLennan, 1985). Particularly, their ratios are useful tracers of provenance as they are least affected by processes such as weathering, transport, and sorting (Taylor and McLennan, 1985; Singh, 2009). A common feature of these elements is their relatively high field strength (ionic charge/ionic radius) and hence limited solubility in water. However, Singh (2009) showed that the use of these immobile elements in provenance determination is based on the assumption that they undergo little geochemical fractionation during denudation. Also, these immobile elements are commonly concentrated in the fine-grained sediments because their host minerals including accessory primary and secondary minerals occur in that size range.

In most humid tropical settings these elements are considered to be immobile and resistant to the redistribution caused by mineral alterations, weathering or the processes of sediment transportation and deposition (McLennan and Taylor, 1983; Wronkiewicz and Condie, 1987; Condie et al., 1992; Fedo et al., 1995; Singh

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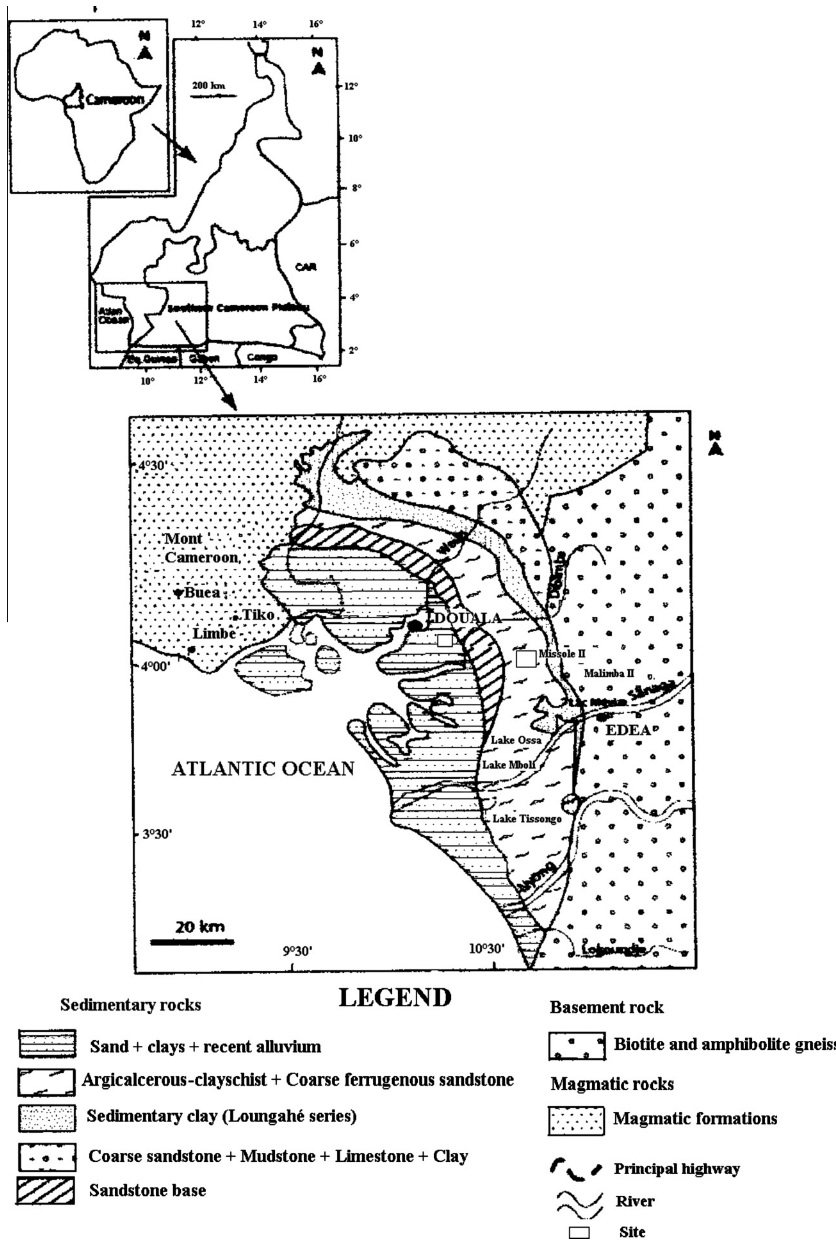

Fig. 1. Location and geological map of coastal sedimentary basin in Cameroon (modified after Njike Ngaha (1984)).

and Rajamani, 2001a,b). Nesbitt et al. (1990) showed that in the case of extreme weathering, the degree of weathering of the source can be recognised in the derivative sediment with the aid of trace elements. The geochemistry of major elements is used partly to determine the degree of weathering of the source material (Nesbitt and Young, 1982; Fedo et al., 1995), however it should be treated with great caution due to the possible mobility and distribution of these elements during chemical weathering and diagenesis (Nesbitt, 2003). The Chemical Index of Alteration (CIA = molar $[Al_2O_3/(Al_2O_3 + CaO^* + Na_2O + K_2O)] \times 100$, where CaO^* is CaO in silicates only; Nesbitt and Young, 1982) is used to determine the degree of weathering of detritus constituting the sedimentary rock. Also, K/Cs ratio should be estimated because it increases with decreasing chemical weathering (Bertolino et al., 2007). K and Cs are mostly adsorbed into clay minerals (particularly illitic minerals) during weathering. Furthermore, the relationship between Th/U ratio and Th concentration can also be applied to estimate the degree of weathering in sedimentary rocks (Bertolino et al., 2007). However, clay-bearing rocks have a much higher concentration of total trace elements than other sediments. Th/Sc, La/Sc, La/Th, Th/Co, La/Co, Eu/Eu^* ratios are very sensitive to the nature of the parent rocks. They are useful in distinguishing mafic and felsic sources. In fact, Sc and Co as compatible elements are good tracers of basic or less fractionated source component particularly when they are compared with Th, which is incompatible and thus enriched in felsic rocks (Taylor and McLennan, 1985; McLennan et al., 1990). REE as Th, and Sc are most useful for inferring crustal compositions, because their distribution is not significantly affected by diagenesis and metamorphism and is also less affected by heavy-mineral fractionation than that for elements such as Zr, Hf, and Sn (Cullers et al., 1979; Bhatia and Crook, 1986; Wronkiewicz and Condie, 1987; Cox et al., 1995; McLennan, 2001; Armstrong-Altrin et al., 2004). REE and Th abundances are high in felsic parent rocks and their weathered products, than in mafic igneous rocks, whereas Co, Sc, and Cr are more concentrated in mafic parent rocks and in their weathered products (Armstrong-Altrin