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Relationships between major and trace elements during weathering processes in a sedimentary context: Implications for the nature of source rocks in Douala, Littoral Cameroon

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ABSTRACT

In Douala (Littoral Cameroon), the Cretaceous to Quaternary formation composed of marine to continental sediments are covered by ferrallitic soils. These sediments and soils have high contents of SiO_2 (≥70.0 wt%), intermediate contents of Al_2O_3 (11.6–28.4 wt%), Fe_2O_3 (0.00–20.5 wt%) and TiO_2 (0.04–4.08 wt%), while K_2O (≤0.18 wt%), Na_2O (≤0.04 wt%), MgO (≤0.14 wt%) and CaO (≤0.02 wt%) are very low to extremely low. Apart from silica, major oxides and trace elements (REE included) are more concentrated in the fine fraction (<62.5 μm) whose proportions of phyllosilicates and heavy minerals are significant. The close co-associations between Zr, Hf, Th and ∑REE in this fraction suggest that REE distribution is controlled by monazite and zircon. CIA values indicate intense weathering. Weathering products are characterized by the association Al_2O_3 and Ga in kaolinite; the strong correlation between Fe_2O_3 and V in hematite and goethite; the affinity of TiO_2 with HFSE (Hf, Nb, Th, Y and Zr) in heavy minerals. The ICV values suggest mature sediments. The PCI indicates a well-drained environment whereas U/Th and V/Cr ratios imply oxic conditions. La/Sc, La/Co, Th/Cr, Th/Sc and Eu/Eu* elemental ratios suggest a source with felsic components. Discrimination diagrams are consistent with the felsic source. The REE patterns of some High-K granite and granodiorite of the Congo Craton resemble those of the samples, indicating that they derive from similar source rocks.

1. Introduction

Final sediment composition depends primarily on its source rock composition, which is modified by physical processes and associated geochemical alteration during transport from source to deposition area (Nesbitt and Young, 1982; McLennan et al., 1993; Cullers, 1995). Hence, geochemical data of clastic sediments represent an archive for studying their provenance as well as weathering conditions in their source region (e.g., Bhatia, 1983; Cullers, 1988; Fedo et al., 1996; Feng and Kerrich, 1990; Garver and Scott, 1995; Holail and Moghazi, 1998; McCann, 1998; McLennan and Taylor, 1983; Nesbitt and Young, 1996; Singh and Rajamani, 2001; Wronkiewicz and Condie, 1987, 1990). Geochemical analysis and the use of geochemical indices and associated discriminant diagrams give insight into possible source(s), and intensity of weathering as controls on sediments composition (Descourvieres et al., 2011). Ratios of less mobile elements such as those contained within accessory phases are used to determine the provenance (Condie and Wronkiewicz, 1990; McLennan et al., 1993; Cullers, 1995, 2002; Singh, 2009). For example, immobile major and trace elements such as Ti, Fe, Al, Th, Sc, Co and Zr are useful indicators of the source of sediments/sedimentary rocks (Taylor and McLennan, 1985). Some studies showed that the elemental ratios of fine fraction might be more similar to the source rocks (Cullers, 1993, 1995). These elements are also able to reveal the nature of weathering at the source region of sediments, which in turn, is controlled by climatic and tectonic factors. Furthermore, alkalis and alkaline earths have been found useful in this respect (Nesbitt and Young, 1982, 1984, 1996).

In the Douala sedimentary basin, ferrallitic soils (Aubert and Segalen, 1966) were developed over a deep Cretaceous to Quaternary succession of marine to continental sediments (Njike Ngaha, 2004). Numerous studies in the past have focused on the tectonic evolution of the Douala sedimentary basin (Reyre,

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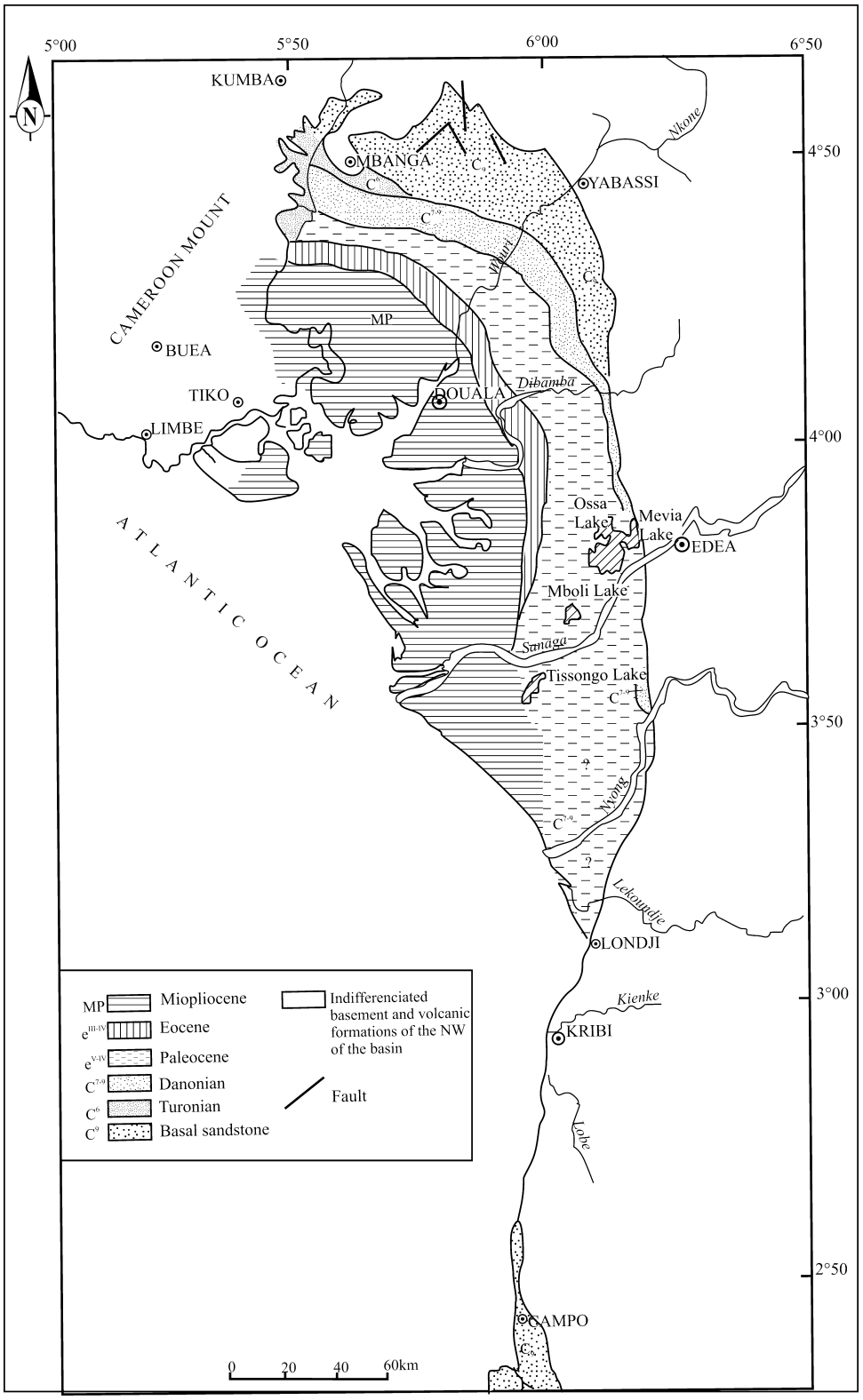

Fig. 1. Generalized geological map of the Douala sedimentary basin (modified after Njike Ngaha, 2004).

1966; Regnoult, 1986; Manga, 2008), while other studies have investigated stratigraphy (Njike Ngaha, 2004; Manga, 2008), reconstruction of paleoenvironment (Njike Ngaha, 2004) and potential resources (Manga, 2008). In addition, observations and physical analyses have been performed for soil classification (Aubert and Segalen, 1966). Until now the behavior of major and trace elements in shallow sediments and in their overlying soils have not been investigated. Hence the nature of their source rock is still controversial.

In this paper, we present the mineralogy and geochemistry of two profiles in the Douala sedimentary basin. Textural and mineralogical data of the strata sediments at the base and their overlying soils, major and trace elements composition for bulk and fractions are combined so as to (i) characterize the weathering process and