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Mineralogy and geochemical behaviour during weathering of greenstone belt under tropical dry conditions in the extreme North Cameroon (Central Africa)

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ABSTRACT

Mineralogy, major, trace and rare earth elements of a weathering profile developed on tertiary greenstone belt in the extreme North Cameroon are reported. The aim of which was to investigate mineralogical evolution and element mobilization and redistribution during weathering under dry tropical climate. The weathering profile consists of four main horizons: (1) a spheroidal weathering zone constituted by a corestone–shell complex, (2) a C horizon, (3) a Bw horizon and an Ah horizon. The results indicate that nontronite, a Fe-rich smectite, is the exclusive clay mineral formed in the exfoliated shells and the C horizon. It is associated with kaolinite in the upper horizons. The coexistence of these two clay minerals induced a decrease of CEC and pH which becomes neutral. The weathering index (WI) values reveal that weathering becomes more and more intensive from the corestone up to Bw horizon, which is the most weathered horizon in the weathering profile. Mass balance calculations, using Th as immobile element, indicate that Ti is quite mobile and that Al and Fe are relatively enriched at the bottom and strongly leached at the top of the profile. Alkalis and alkaline earth elements are strong leached through out the profile, except Ca which displays similar trend as Al and Fe. The same goes for LILE (Cs, Sr), TTE (Cr, Co, Ni) and HSFE (Y, Nb, Hf). In opposite, REE are depleted at the bottom and enriched in the upper horizons, with more enrichment for LREE than for HREE. It appears that weathering of greenstone belt causes a fractionation of HREE and induces a concentration of LREEs. Ce and Eu anomalies display opposite behaviour.

1. Introduction

Weathering of rocks is generally considered as a definitive process for the development of the soil profile, and for various site conditions such as long-term supply of nutrients to the biosphere, precipitation of secondary minerals and counteracting acidity in soil and water. Furthermore, concepts like site capacity, sustainability and vulnerability of soils are clearly linked to the mineralogy of the soil parent material and the nature of the secondary minerals formed within the soil profile (Voicu and Bardoux, 2002; Nahon, 2003). At all weathering of silicate minerals impacts many geological and ecological processes. Therefore weathering of rock is an essential component for understanding soil genesis, properties, and behaviour as well as for formation of guidelines for sustainable land use. During chemical weathering of rocks, the formation of secondary minerals is strongly influenced by the climatic conditions, by the mineralogy and geochemistry of the parent rocks and by the transport of matter by fluids promoting redistribution of mobile major and trace elements within the soils (Aiuppa et al., 2000; Patino et al., 2003; Little and Lee, 2006). For example, in tropical rainforest, weathering of rocks induces the formation of kaolinite, while in tropical dry savannah, smectites are formed. With respect to element mobility, some general trends have been noted (Ma et al., 2007; Voicu and Bardoux, 2002): in general, alkalis and alkaline earth elements are easily removed from primary minerals during chemical weathering. In the opposite, elements that are predominantly hosted in highly resistant minerals, such as Zr, Th, Nb and Hf are believed to be immobile. Some others elements, such as Al, Fe, and Ti tend to combine with secondary minerals and to be retained in soil profile.

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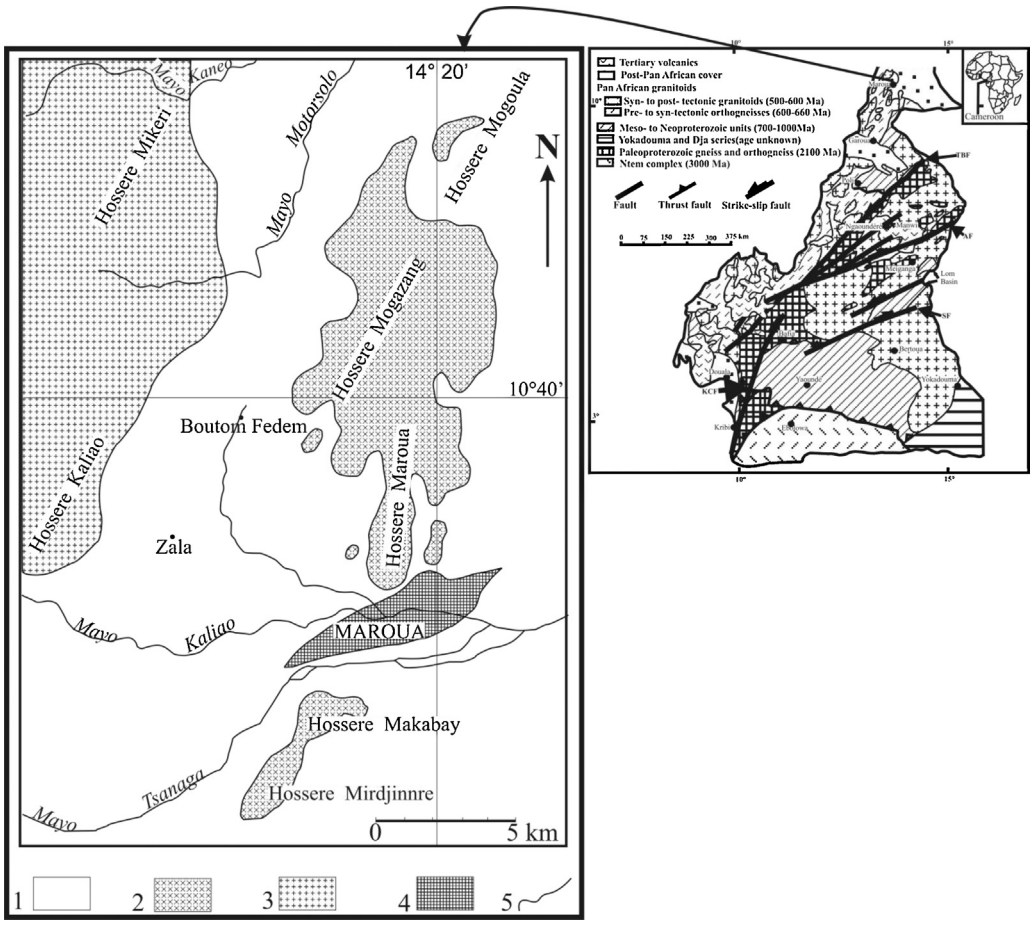

Fig. 1. Location of the studied area. The geological map of Cameroon is from (Toteu et al., 2001). (1): Swelling superficial deposits; (2): greenstone belt; (3): calco alkaline granite; (4): Maroua town; (5): rivers.

In Cameroon, studies dealing with rock weathering have been carried out mainly in the southern region, under a tropical humid climate (e.g. Braun et al., 1993; Bitom et al., 2003; Nguetnkam et al., 2003, 2006; Témation et al., 2004). In contrast, few studies have been carried out in the northern region, affected by the tropical dry climate (Ekodeck, 1976; Nguetnkam et al., 2007). Further no previous studies have been carried out on the weathering of greenstone belt.

In this paper, we report mineralogy, major, trace and rare earth elements of a weathering profile developed on tertiary greenstone belt of Maroua, a region having a tropical dry climate and situated in the extreme North of Cameroon. The comparison of the composition of weathering products with that of fresh parent rock enables us to investigate mineralogical evolution and elements mobilization and redistribution during weathering under dry tropical conditions.

2. Geological setting and weathering profile description

The greenstone belt weathering sequence under study is located in the region of Maroua (Fig. 1), in the extreme North of Cameroon; it consists of tertiary volcanic rocks which cross cut the Precambrian granites. Those volcanic rocks were slightly metamorphosed and acquired the green colour during a hydrothermal metamorphic episode (Nougier, 1979; Montes Lauar, 1997). Further, the greenstone belt is fractured and contains relics of microlitic structure. The climate is the sudano-sahelian type (Suchel, 1987), with a mean annual rainfall of 800 mm. The rainy season extend from June to September, registering maximum rainfall in August. The dry season stretches from October to May. The mean annual temperature is 28 °C. Although the green stone belt with its weathering cover form some hills, this area is characterized by less grade slopes, slow water-flow conditions, and degraded hydrographic network.

The studied weathering sequence is observed from a road cut-exposed profile. Its thickness is about 3.50 m and consists of four

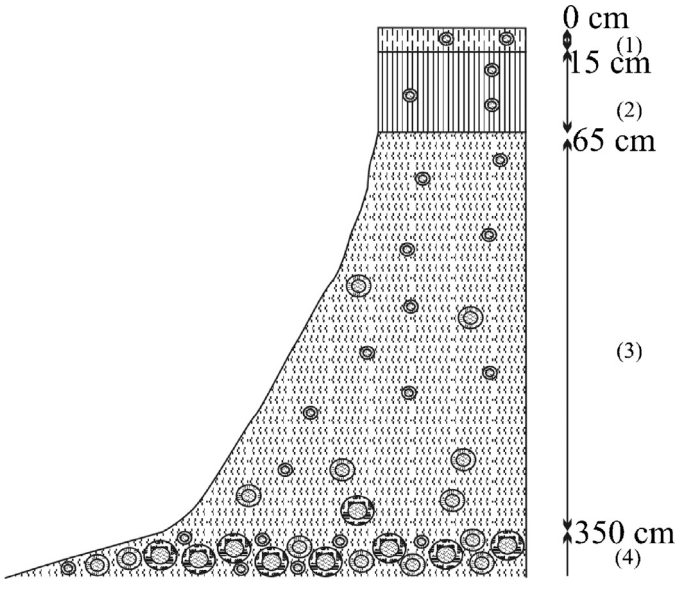

Fig. 2. Greenstone belt weathering sequence.