

<sup>10</sup>Be AND NATURAL ISOTOPES OF U AND Th  
IN A LATERITE COVER FROM CAMEROON

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## INTRODUCTION

Laterites are widespread pedogenetic formations covering about a third of the emerged lands of the world, they result from the chemical weathering of a variety of rocks under humid tropical conditions. The laterite material is essentially made of an assemblage of kaolinite crystals with crystallized iron and aluminium oxihydroxides, and sometimes relics of parent minerals such as quartz and muscovite grains. Laterite profiles develop in a succession of layers of different facies and composition. These profiles often show indurated ferruginous facies, in the form of hard crusts (Tardy and Nahon, 1985) or nodules (Muller and Bocquier, 1986), where Fe-oxihydroxides are the predominant minerals.

The behavior of U and Th isotopes in weathered profiles from tropical areas, like laterites, is poorly documented (Pflüger and Adams, 1962; Hansen and Stout, 1968; Moreira-Nordeman, 1977; Boulad *et al.*; Langmuir and Herman, 1980; Lowson *et al.* 1986; Short and Lowson, 1988). Neoformed minerals, and among them iron oxihydroxides, seem to play an important role in controlling the released elements (Sharkov and Yakoleva, 1971; Zhmodik *et al.*, 1980; Gueniet *et al.*, 1982; Michel, 1983).

A few results have been published on <sup>10</sup>Be in soils, terrasses and very few on alterites facies (Brown *et al.*, 1981; Pavich *et al.*, 1984, 1985; Bouchard et Pavich, 1989).

The goal of this paper is to assess the distribution and behavior of <sup>10</sup>Be, a cosmogenetic radioisotope introduced at the interface atmosphere-soil, and compare with the U and Th

family short-lived radioactive descendants already present in the altered milieu. We present results obtained on material sampled all along a 12 m deep lateritic profile. This profile, which represent a general case under humid tropical climate and forest cover, comes from the Goyoum area (E. Cameroon), it is located along the upper part of a soil toposequence, which developed at the expense of a gneissic basement (Sarazin *et al.*, 1982; Muller and Bocquier, 1986; Muller, 1987).

## MATERIALS AND METHODS

### Macroscopic and Mineralogical Features of the Profiles and Materials

The parent gneiss is a fine-grained orthogneiss with an oblique foliation. Veins of darker rock, rich in biotite, are enclosed in the leucocratic main body. The major minerals are quartz, biotite, muscovite, oligoclase and microcline. Garnet is a minor element. The accessory minerals are apatite, rutile, zircon, xenotime and monazite.

The profile exhibits three main horizons, secant to the oblique foliation of the parent rock.

(1) - A thick friable and porous saprolite where the texture and structure of the parent rock is preserved. The weathered products are mainly large booklets of kaolinite following the original foliation, and iron oxides (goethite and hematite; 10% Fe<sub>2</sub>O<sub>3</sub>). The remaining parent minerals are quartz, muscovite, zircon and monazite. In the upper part, saprolite is embedded in red and yellow clay materials characterized by the disappearance of the original

rock texture and structure. The clay material is made of thin platelets of kaolinite associated with iron oxides (10% Fe<sub>2</sub>O<sub>3</sub>).

(2) - A nodular ferruginous horizon in which two types of indurated and mainly hematitic nodules are recognized: large and irregular nodules (20-80 mm diameter) with the original rock texture still present, and small (less than 20 mm diameter) rounded nodules, with a soil texture. These nodules are embedded in dense clay-iron oxide materials, redder (hematite more abundant than goethite) and more compact than that found at the top of the saprolite. The boundary of the upper limit of this horizon is sharp.

(3) - A loose top-soil horizon, mainly kaolinitic, composed of a red material which progressively disappears at about one meter depth, meanwhile, the yellow material becomes predominant and denser. Near the surface organic matter is present down to 20 cm.

### Methods

Uranium, thorium were extracted from the same samples. U and Th isotopes were analysed by alpha spectrometry. After addition of a known quantity of <sup>9</sup>Be carrier, <sup>10</sup>Be was measured by accelerator mass spectrometry (AMS), using the Tandem AMS facility at Gif sur Yvette (Raisbeck *et al.* 1987).

## RESULTS

### U and Th concentrations.

In the bed-rock U and Th concentrations are lower than in the saprolite. The saprolites show a slight U and Th enrichment (fig. 1) from the bottom to top. The concentrations reach a maximum in the nodules, and especially in the small iron nodules, while in the embedding material they are comparable to the saprolite concentrations. Above and upward the concentrations decrease. The Th/U ratios decrease with depth.

Compared to the bedrock, there is a general enrichment of U and Th. Assuming a low thorium mobility this enrichment must be relative, resulting from a balance effect, as a consequence of a mass loss. On the basis of the Th concentrations, one may compute that, compared to the bedrock, in the upper part of the saprolite almost half of the original material of the rock has been removed. The embedding nodule material and the deep part of the topsoil shows only slight additional loss.

The <sup>234</sup>U/<sup>238</sup>U and <sup>230</sup>Th/<sup>234</sup>U ratios are less than unity (fig. 2). The points are closer to the equiline and only the base of the saprolite, the

nodules and the embedding material are distinct zones.

### <sup>10</sup>Be

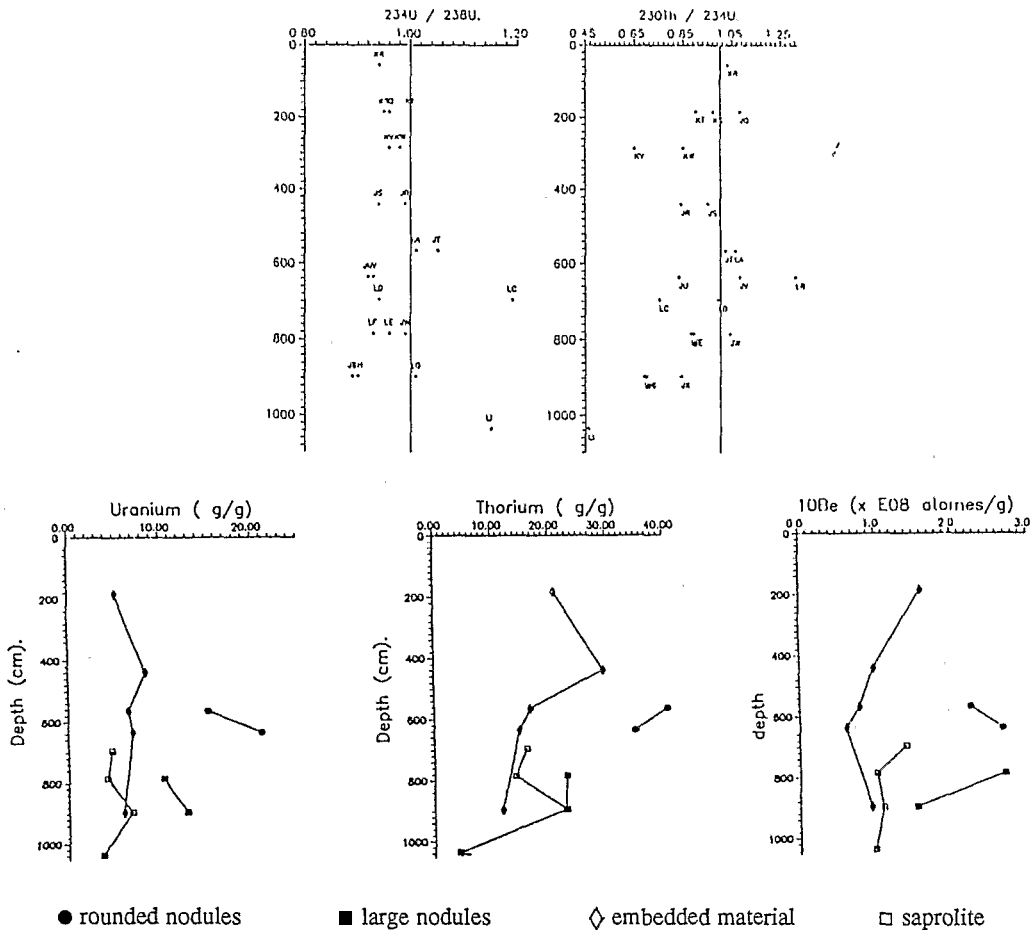
<sup>10</sup>Be distribution are shown in fig. 3. Like U and Th, <sup>10</sup>Be is concentrated in the nodules, we note also that it goes down as deep as the lower saprolite level (10 meters).

## DISCUSSION AND CONCLUSION

According to Muller (1987) the present occurrence of three main zones along the vertical profiles reflects changing conditions of weathering of the rock during the deepening of the altering front. The principal characteristics of the material are inherited from the initial weathering of the rock. Further modifications would be limited to the material close to the topographic surface, where organic matter accumulates. If so, the three main zones are quite closed systems. But, if U and overall Th distribution can be explained by a relative enrichment, the <sup>230</sup>Th/<sup>234</sup>U and <sup>234</sup>U/<sup>238</sup>U ratios are out of equilibrium, which indicates that the three zones are not closed systems, at least for U.

The intensity of the original <sup>230</sup>Th or <sup>234</sup>U disequilibrium is not known and must have been changed with the weathering conditions. We may only put forward (Bernat *et al.*, 1990) that, the material is younger than the limits of both dating methods (300,000 years).

<sup>10</sup>Be is present in all the different samples we analysed. Concentrations range from 2.7 to 0.62 x 10<sup>8</sup> atoms/g, slightly lower to what is reported by Brown *et al.* (1981) from surface soils, lower to the values of Pavich *et al.* (1985) from altered rocks, but comparable to the Bouchard (1989) results. In the saprolite the concentrations are higher than in the base of the embedding material, whose distribution resemble a diffusive pattern. We observe moreover that Be accumulate in the nodules, up to now we have few arguments to decide if nodules trap Be during their formation and/or after. Assuming a nominal rate of 10<sup>6</sup> atoms/cm<sup>2</sup> yr (which should be checked by measuring <sup>10</sup>Be in precipitation at this location), and no horizontal transport, the estimated <sup>10</sup>Be inventory in the profile (2 x 10<sup>11</sup> atoms) suggests a formation time of 200 000 years. If there as been loss of <sup>10</sup>Be, either in solution or by erosion, then the actual formation would be longer. On the other hand if this profile (situated at the lower part of a hill) acted as a trap for <sup>10</sup>Be downstream solutions the formation age could be shorter than 200.000 years.



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