The effect of organic matter on chemical weathering: study of a small tropical watershed: Nsimi-Zoétélé site, Cameroon

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The effect of organic matter during soil/water interaction is still a debated issue on the control of chemical weathering in a tropical environment (Schwartzman and volk, 1989; Chin and Mills, 1991; Heyes and Moore, 1992; Drever, 1994). In order to study this effect in detail, we focused on the weathering processes occurring in a small tropical watershed (Nsimi/Zoétélé, South Cameroon).The Nsimi basin is a pilot site of the PEGI program (programme d'Environnement de la Géosphère Intertropicale, ORSTOM-CNRS) and it offers a unique opportunity to study weathering mechanisms in a lateritic system within a small basin by coupling soil and water chemistry.

The lateritic cover in this site can reach up to 40 m in depth and show two pedological distinct zones: 1) slope soils on the hills or elevated areas had 2) hydromorphic soils in the swamp zone which represent 20% of the basin surface. The first results obtained from this program (Viers *et al.*, 1997) show strong chemical differences between waters located in slope zones (depleted in organic matter) and those ponded in swamp zones (enriched in organic matter).

The study was performed on waters samples taken from piezometric wells and springs in slope areas, and from piezometric wells and marsh waters in the swamp zones, between 1994-1997. Soil samples analysed in this study were collected during a well drilling in December 1996.

Water samples were analysed by high pressure liquid chromatography (HPLC ; major cations and anions) and inductively-coupled plasma mass spectrometry (ICP-MS ; trace elements). Dissolved organic carbon was measured by low temperature

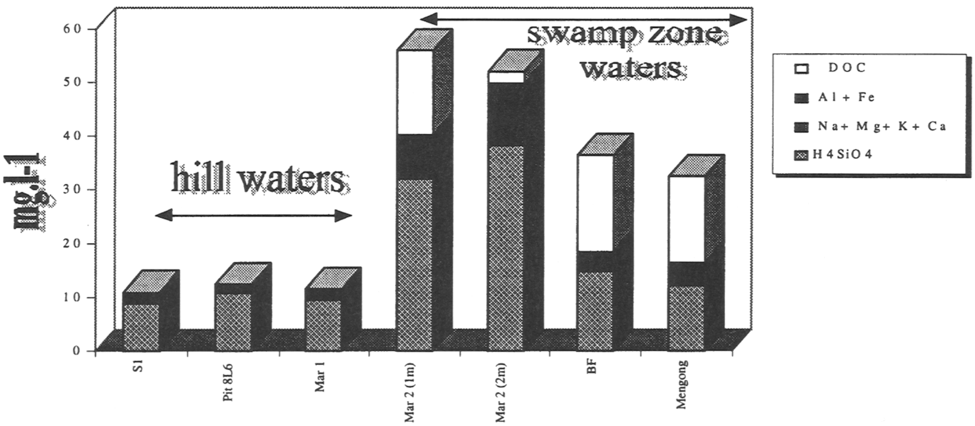

FIG. 1. Stacked diagrams showing the relative importance of major elements in the <0.2μm phases.

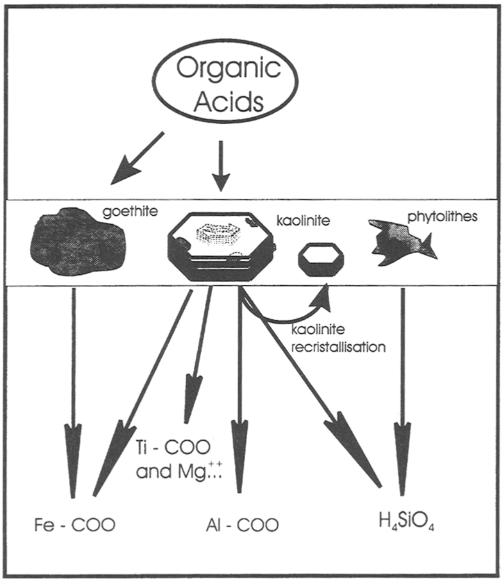

FIG. 2. Model of mineral chemical weathering.

chemical oxidation (LTCO). Soil mineralogy was characterized by x-ray diffraction (XRD), infrared spectroscopy (IR), scanning electron microscopy (SEM), electron microprobe analysis (EMPA), and ICP-MS.

The results on water samples suggests the existence of chemical and spatial heterogeneities of waters in the basin: coloured waters flooding the swamp zone have much higher concentrations of both organic (e.g. DOC) and inorganic ions (e.g. Ca, Mg, Na, K, Al, Fe, Th, Zr) than those from springs and grounwaters from the hills (Fig. 1). Nevertheless, these organic rich waters present cations concentrations (i.e. Na, Ca, Mg, K) which are among the lowest compared to that of most world rivers.

In general, the soil profile in the swamp zone can be divided in three major horizons: 1) a top horizon rich in organic matter, 2) an intermediate sandy horizon, and 3) a bottom clay-rich horizon. The most abundant minerals found in the whole soil profile are quartz, kaolinite, and goethite. Heavy minerals such as zircon and rutile are also found along the profile. All these minerals, including the oxide phases which are highly resistant to low temperature alteration, are affected by the weathering process. SEM observations show evidence for secondary recrystallyzation of kaolinite microcrystals in the upper part of the bottom clay-rich horizon.

Water chemistry and mineralogical observations suggest that hydromorphic soils of the swamp zone are responsible for almost all chemical weathering in the basin. A qualitative model describing both geochemical and mineralogical changes in the basin has been elaborated (Fig. 2). This model is based on the important role of organic acids during mineral dissolution (e.g. kaolinite, goethite, zircon) and subsequent release of complexed insoluble elements (e.g. Fe, Al, Ti, *REE* and Zr). The marked presence of Fe can also be explained by the dissolution of iron-rich phases under reducing conditions in an organic-rich anoxic environment. Al/Mg ratios obtained for the soil and the Mengong river water show that a significant amount of Al does not leave the system due to kaolinite recrystallisation in the swamp zone soils. SiO2(aq) concentrations in these waters are above saturation with respect to quartz. Dissolution of phytholithes (amorphous silica) may be responsible for this relatively high SiO2(aq) concentration.

In summary, on the basin, the interaction between soils and waters occurs mostly in soils that are very depleted in soluble elements. Thus, although the presence of large amount of organic matter could greatly enhance chemical weathering, this effect is limited by the the depleted nature of the soils that explain the low concentration of major elements in these waters.

References

Chin, P.-K.F. and Mills, G.H. (1991) *Chem. Geol.*, **90**, 307–17.

Drever, J.L. (1994) *Geochim. Cosmochim. Acta*, **58**, 2325–32.

Heyes, A. and Moore, T.R. (1992) *Soil Sci.*, **154**, 226–36.

Schwartzman, D.W. and Volk, T. (1989) *Nature*, **340**, 457–9.

Viers, J., Dupre, B., Polve, M., Schott, J., Dandurand, J.-L. and Braun, J.-J. (1997) *Chem. Geol.*, **140**, 181–206.