REE MOBILITIES DURING INCIPIENT WEATHERING OF VOLCANIC ROCKS OF THE PARANA BASIN, BRAZIL

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INTRODUCTION

The volcanic rocks of the Parana Basin formed from lavas which flood over 1.2 km^2 of southeastern South America = 140-120 Ma ago. These rocks are mainly of basaltic composition (=90 vol%), with minor volumes of intermediate and felsic rock types (= 7 vol% and 3 vol% respectively). The basaltic rocks are further characterized by their Ti contents - high Ti basalts (HTiB, average 3.4 wt% TiO_2) and low Ti basalts (LTiB, average 1.4 wt% TiO^2). The HTiB and LTiB rocks also contain higher and lower concentrations of incompatible elements(e.g., average Ba=684 and 383 ug/g and Zr= 272 and 138 ug/g). Felsic rocks (Palmas rock type- "vitrophyric-granophyric") associated with the LTiB rocks have lower levels of incompatible elements, while strongly porphyritic felsic rocks (Chapeco type) associated with HTiB rocks have higher concentrations of incompatible elements. These rocks contain abundant macrophenocrysts of plagioclase feldspar, pyroxene and magnetite, crystallized in an alkaline feldspar-quartz matrix (=60 vol%).

RARE EARTH ELEMENTS BEHAVIOUR

Studies of REE abundance patterns in the volcanic rocks of the Parana Basin indicate general enrichment with the degree of magma evolution, as well as progressive enrichment of LREE relative to HREE (La/Lu: basalt = 5.2, andesites=7.4; rhyolite, rhyodacites=7.6).

Intense chemical weathering of these rocks has generated deep soils, characterized by secondary mineral assemblages dominated by kaolinite, oxides and hydroxides of Fe and Al, and traces of quartz. Where topography has favoured erosion and rocks have been freshly exposed, it is common to observe spheroidal weathering, during which weathering crust form around fresh rock nuclei, with weathering intensity increasing from the innermost layers to the outermost. In the weathered crusts, the secondary mineral assemblages vary according to lithology which determines the primary mineral precursors. Thus, the basaltic rocks composed mainly of plagioclase feldspars and pyroxenes develop crust composed of smectite, kaolinite and oxy-hydroxides of Al and Fe. Smectite phases (e.g. nontronite) are ephemeral and alter to kaolinite in the more weathered layers. In the "Chapeco type" felsic rocks the plagioclase feldspar phenocrysts alter to gibbsite and those of pyroxene to iron oxy-hydroxides, while the matrix weathers to form a material rich in kaolinite and illite with small proportions of interlayered (chlorite-vermiculite) and smectite clays. Weathering of the "Palma type" felsic rocks, which contains high proportions of

volcanic glass, results in the formation ofsmectite phase, with which is associated significant amounts of amophous marerial forming as the vitrophyric material weathers, and kaolinite and illite as weathering products of the granophyres.

In order to investigate REE behaviour during incipient weathering of the volcanics rocks three weathering zones were identified in the weathered crusts : zone 0 - fresh rock without alteration; zone 1 - initial weathering in which secondary minerals are associated with partially weathered primary minerals. These mineral assemblages are sustained by being in contact with concentrared weathering solutions with relatively high pH levels (pH>7), from which complex clay minerals form; zone 2 - here, the Al-Si secondary phases of the "zone 1" are transformed to kaolinite due to their contact with dilute pores waters, indicative of increasing porosity and thus greater water/mineral interaction. These conditions favour the formation of kaolinite.

CONCLUSION

The results obtained inthis study indicate that :
1) REE are retained in "zone 1", probably by "sorption" processes and/or by formation of slightly soluble hydroxides. In the "zone 2", in which kaolinite is the dominant phase, REE are relatively depleted possible due to the loss of cation exchange capacity accompanied by changes in pore water chemistry.
2) The behaviour of REE during incipient weathering is independent of lithology.
3) The fractionation of REE during weathering does not appear to be significant.

REFERENCES

BONNOT-COURTOIS, C. (1981) - Géochimie de terres rares dans les pricipaux millieux de formation et de sédimentation des argiles. Ph.D. thesis, University of Paris XI, Orsay, France, 271p.

DUDDY, I.R. (1980) - Redistribution and fractionation of rare earth elements in a weathering profile. Chem. Geol., 30, 361-382.

MARQUES, L.S. (1988) - Caracterizaçao geoquimica das rochas vulcanicas da Bacia do Parana : Implicaçoes petrogenéticas. Ph.D. thesis, University of Sao Paulo, Brazil, 178p.

NESBITT, H.W. (1979) - Mobility and fractionation of rare earth elements during weathering of a granodiorite. Nature 279, 206-210.

PICCIRILLO, E.M. and MELFI, A.J. (1988) - The Mesozoic flood volcanism of the Parana Basin. Inst. Astron. Geof. Publishers, 600p.