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Chemistry of clastic sediment-forming smectites and its implications for the smectite-to-illite transformation

Quimismo de un sedimento clástico formador de esmectita y sus implicaciones en la transformación esmectita-ilita

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INTRODUCTION

Prior to the development of "in-situ" analysis techniques, data on the chemical composition of minerals was derived exclusively from whole rocks using monomineral samples or from assemblages in which the separation of minerals was possible. Therefore, knowledge concerning the real composition of smectites in soils and sediments was significantly delayed, and it was assumed that the typical smectite composition was that of materials in which they were the only phase or easily separated. Recently, Analytical Electron Microscopy (AEM) analyses have demonstrated that smectites forming sediments or sedimentary rocks can also be analysed in spite of their small size and their defective nature. Smectites play an important role in the geological cycle. They are the basic material for the smectite-illite transformation during the diagenesis of sedimentary materials giving rise to illite-bearing sedimentary rocks.

Material

Five smectite-bearing soils and sediments were collected from different areas. They were chosen as representative of the different steps of the geological evolution of smectites from clastic materials. Also, the compositions of four K-rich marine smectites reported in the literature have been used to compare their interlayer occupancy with those of the present study.

Results and discussion

Smectite was the principle clay mineral phase present in all the studied samples, with significant amounts of mica, kaolinite and chlorite, in some of the samples. The XRD patterns of the clay fraction after various treatments show a typical behaviour of natural smectite, but no smectite-illite mixed-layers were found.

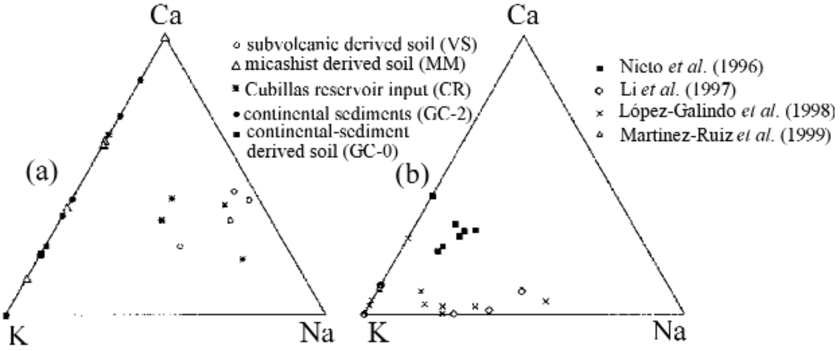

Figure 1. Plot of the interlayer composition of smectites in the Ca-K-Na ternary system. (a) = smectites of the present study, (b) = marine smectites reported in the literature.

Analytical Electron Microscopy of the studied smectites revealed that K was present in significant proportions (Figure 1). It was the major interlayer cation in soils developed on pelitic rocks (MM), and in continental and marine sediments (GC-

0 and GC-2), independently of their diagenetic grade. Na was predominant only in soils from basic rock (VS). Fluvial sediments (CR) contained smectites with both kinds of interlayer compositions. The octahedral composition of each sample ranged widely, covering various fields of dioctahedral-smectite types. These fields defined by Güven (1988) have no significance for clastic-sediment-forming smectites because they are in origin a result of genetic rather than crystal-chemical factors. The most important trend was the substitution of Al by Fe and Mg; the chemistry of each smectite particle was determined by the parent mineral from which it formed.

All the models developed for the smectite-illite transformation assumed that smectites were originally Ca-Na-rich and K-poor. The compositions used in the calculations were based on pure smectite material which is far to be representative of sediment-forming smectites. Therefore, the smectite enrichment in K and a concomitant loss of Ca and Na were considered as the first step in the diagenetic transformation of smectite into illite. The present study shows that the real interlayer composition as determined by AEM method has important implications for the diagenetic smectite-illite transformation. When considering a typical K content such as that found in this study, the smectite-illite reaction, with chlorite and quartz as subproducts, needs only 0.21 K atoms (on the basis of 11 O). For more K-rich compositions, a reaction could be possible even without an external supply of K.

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