## SOIL SCIENCE

## Role of Exchangeable Potassium and Magnesium on Caesium Absorption on Marine Sediments

THE potassium ion fixed into the interlayer spacing of a clay mineral is not easily replaced, and the results of chemical analysis cannot distinguish these interlayer potassium and the structural potassium. Therefore, the total potassium obtained in the chemical analysis includes the gross structural potassium and the edge-site exchangeable potassium. One may assume, therefore, for the comparison of the adsorbability of various clay minerals, that the smaller the ratio of structural potassium, or alternatively the larger the ratio of exchangeable potassium to the total potassium, the greater will be the adsorption of metal ions, especially of rubidium and caesium, which are adsorbed in the dehydrated states having rather small cationic radii and can easily penetrate into the interlayer opening.

This assumption was exemplified in our investigation of the adsorption of caesium on Pacific pelagic and terrigenous sediments, containing illite, chlorite, and montmorillonite, the details of which will be published elsewhere. Samples were fractionated into three portions according to the size of particles. The plot of the distribution coefficients versus the ratio of exchangeable potassium to the total potassium ( $R_{\rm K}$ ) resulted in straight lines intercepting at the origin; the slopes of them differ from one sample to another. Such relation was also found for the ratio of exchangeable magnesium to the total magnesium ( $R_{\rm Mg}$ ), but not for the respective ratios of sodium and calcium.

For the purpose of assigning to which clay mineral is worked either one of the ratios,  $R_{\rm K}$  and  $R_{\rm Mg}$ , cristobalite, kaolinitic montmorillonite, illitic chlorite, and two illitic kaolinites were fractionated into two or three portions according to the particle sizes ranging from 1 to  $44\mu$ . The distribution coefficients of caesium-134 were determined in triplicate in water and in N sodium chloride solution, both at pH 8.0. It was found that linear relation held only for kaolinitic montmorillonite when  $K_d$  versus  $R_{\rm K}$ plots were made (Fig. 1), while  $K_d$  versus  $R_{\rm Mg}$  plots resulted in straight lines, intercepting at the origin, only for illitic chlorite (Fig. 2). From the clay mineralogical data of the samples used, the role of  $R_{\rm K}$  can be attributed to montmorillonite, whereas that of  $R_{\rm Mg}$  can be attributed to



Fig. 1. Linear relation between  $K_d$  and  $R\kappa$  for the adsorption of caesium on kaolinitic montmorillonite



Fig. 2. Linear relation between  $K_d$  and  $R_{Mg}$  for the adsorption of caesium on illitic chlorite

chlorite. These results are consistent with previous reports<sup>1</sup> showing that potassium fixation occurs in montmorillonite and magnesium fixation occurs in degraded chlorite.

In the case of marine sediments, the straight lines obtained in the plot of  $K_d$  versus  $R_K$  and  $K_d$  versus  $R_{Mg}$ exclusively intercept at the origin, while in the present cases  $K_d$  versus  $R_K$  plots do not pass the origin. This situation can be understood because the marine sediments are completely saturated by the metal ions composing sea-water, so that the unbalanced charges in the structural units due to the lattice substitution are completely balanced by these ions. On the other hand, in the present montmorillonite, charges given by the lattice substitutions are available for the adsorption of caesium and the definite magnitude of adsorption even at  $R_{\rm K} = 0$  will result. In the presence of N sodium chloride solution, the plot still does not intercept at the origin, though the distribution coefficients markedly decreased as compared with those in water, presumably due to the incomplete balancing of the charges emerging from the lattice substitution by sodium ions of this concentration and also due to the competition of both cations.

The major cause of cation exchange property of chlorite arises in the broken bonds on non-cleavage surfaces. That the plot of  $K_a$  versus  $R_{Mg}$  passes the origin without observable adsorption on the broken bonds at  $R_{Mg} = 0$ may be the result of complete saturation of these bonds as in the case of marine sediments.

For the other metal ions tested, namely, strontium, cobalt, and europium, no such relations could be found, as was in the case of the marine sediments. Therefore, exchangeable potassium and exchangeable magnesium, respectively, in montmorillonite and in chlorite, play an important part in the adsorption of caesium. Furthermore, two other montmorillonite samples found from different localities, for which particle fractionation was impossible, were missing on the straight lines obtained in Fig. 1. This fact suggests the importance of the clay mineral structure, especially the number of broken bonds, and the chemical composition.

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