Types of Clay Minerals in Alabama Soils

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During the course of field and greenhouse experiments in Alabama, differences in the behavior of some soils have been observed that could not be explained on the basis of chemical composition. The purpose of the present study was to characterize, mineralogically, the clay separates of typical members of the various soil regions of the state with a view toward providing additional information for interpretation of field results.

In several instances (1, 6, 8), Red-Yellow Podsol soils of the Southeastern United States have been included in mineralogical studies. In general, these reports indicate that the kaolinitic minerals predominate in the soils of the Coastal Plains, Piedmont, and Limestone Valley areas and that montmorillonite occurs in significant amounts, with one exception, only in the soils of the Black Belt. This general conclusion is not supported, however, by the more recent work of Coleman and Jackson (3) who reported considerable quantities of montmorillonite in both the Norfolk and Orangeburg soils. This apparent lack of a pattern in the occurrence of certain of the clay minerals in the soils of the region, and the need for a more complete representation among the soils of the state dictated the present study.

EXPERIMENTAL PROCEDURE

The soil types included in this investigation are listed in Table 1 together with brief descriptions of the horizons sampled. The sites were selected and the soil series identified by L. G. Brackeen, State Soil Surveyor.

Samples from the A horizon were treated with H2O2 and those from horizons containing calcium carbonate with dilute HCl in the amount required to neutralize the free carbonates. The clay fraction (< 2 μ) was separated by use of the centrifuge (10).

Free Fe₂O₃ was removed from the clay by Jeffries' method (7) and the amount removed was determined by difference in the weight of the sample before and after treatment. Comparison of this procedure with the direct determination of iron in the extract indicated that in most cases 95% or more of the loss in weight of the sample upon treatment was due to Fe₂O₃ dissolved.

Both X-ray diffraction (2) and differential thermal (9) methods were used for the identification and estimation of the clay minerals present. Montmorillonite and quartz were estimated from X-ray data, and hydrated Al₂O₃ from the thermal curves. Since both methods are satisfactory for determination of kaolinite, and good agreement between them was found, an average for the two methods was reported for this mineral. In instances where positive identification was not possible, relative intensities of the diffraction lines were recorded together with the spacing.

Differential thermal curves were run for both untreated and iron-free clays to determine whether hydrated oxides of iron and aluminum were present. This was necessary because of the coincidence of the thermal decomposition peaks of hydrated oxides of iron and aluminum.

The base exchange capacity of the clay separates was determined at pH 6.8 with 1 N calcium acetate as the solution.

DISCUSSION OF RESULTS

The base exchange capacities and percent mineral composition of the twelve soils studied are presented in Table 2. It is immediately evident that the soils fall into two distinct groups on the basis of mineral type: (1) those containing no appreciable quantities of montmorillonite, and (2) those containing appreciable quantities of montmorillonite. The first group contains the soils from the Coastal Plains, Susquehanna, and those from the Piedmont, Valley, and Appalachian Mountain areas. The second group includes the Susquehanna and the soils of the Black Belt. The base exchange capacities reflect this difference in clay mineral type. Values ranged from 1 to 70 milli-equivalents per 100 grams in the kaolinitic clays as compared to a range of 17 to 70 milli-equivalents per 100 grams in the montmorillonitic clays.

An unidentified mineral which produced a diffraction line at 14.3 A° was found to be present in all of the kaolinitic clays. This line could not be identified in the diffraction patterns of the montmorillonitic group, possibly due to its proximity to the 14.1 A° line of montmorillonite. The clay samples containing this material were treated with glycerol and different patterns made. Comparison of the patterns of treated and untreated clay revealed no change in position of the line in question. Thus, it is believed that the unidentified mineral present in the Black Belt soils is responsible for this line and is not montmorillonite. This is in agreement with the data of Grim (4), who reported that montmorillonite was not present in these soils.

The occurrence of a mineral with a non-expanding lattice, which gave a characteristic montmorillonite peak, and suggested that it was actually a mixture containing large amounts of illite. In none of the soils included in the present study, however, was a characteristic hydrous mica line observed.

Very little change in clay mineral type was found with depth in the Black Belt soils.