THERMODYNAMIC STUDIES OF SOME CLAY MINERALS

By

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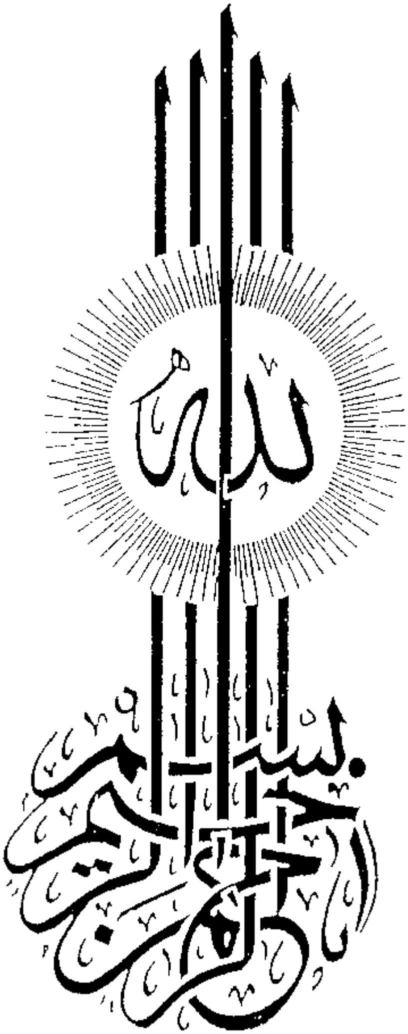
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ABSTRACT

Two different soils were selected to study the solubility and stability of clay minerals using thermodynamic data of the dominant clay minerals. In order to reach that ten soil profiles and water table samples were collected from different regions in Egypt, then were subjected to chemical, physical and mineralogical analysis. Results reveal that soil texture is dominated by fine texture in most soils and clay loamy in the others. Total carbonate content varies widely between the studied soils. Soil salinity is quite low in most cases and high in calcareous soil samples. Soil reaction is generally slightly alkaline to extremely alkaline in all soils. Generally amorphus inorganic material is high in alluvial soils than the calcareous ones.

C.E.C. values are high in fine texture soils than the coarse texture and calcareous soils.

Exchangeable cations in the studied soil profiles are dominated by Na^+ followed by Ca^{+2} or Mg^{+2} while exchangeable K^+ is the least exchangeable cation.

Total elemental analysis reveals that SiO_2 is the dominant oxide, Al_2O_3 and Fe_2O_3 come next followed by CaO, MgO, MnO, Na_2O, and K_2O.

Amorphous inorganic materials of the clay fraction, predominated by silica followed by iron oxides and alumina.

C.E.C. values of the clay fraction are quite high in all of the studied clays.

Concerning the mineralogical composition of Ismailia and El Sharkia soils, the obtained data reveal the dominancy of smectite followed by kaolinite, interstratified minerals, vermiculite, mica and chlorite. In case of Burg El-Arab soils, kaolinite and hydrous mica are the dominante minerals followed by palygorskite, smectite, vermiculite and chlorite. The identified accessory minerals are dominantly quartz and feldspars is all soils.

The elemental analysis of the clay fraction shows that the predominant constituents are silica followed by Al_2O_3, Fe_2O_3, CaO, MgO, K_2O, Na_2O and low content of MnO.

Water soluble silica and alumina are quite different and range between 6.86-61.74 ppm and 0.03 to 0.47 ppm for either Si and Al respectively. Water table samples indicate that these values range between 27.44 to 73.75 ppm and 0.1 to 0.3, respectively.

Mineral stability and concentrations of H^+, Mg^{+2}, Si^{4+}, and Al^{+3} in the soil saturation extract were used to calculate the pH-1/2 P Mg^{+2}, pH-1/3 P Al^{+3} and P $Si(OH)_4$ parameters. Then, data were plotted in solubility diagrams of Weaver's and kittrick. Results showed that the soil of Ismailia, Sharkiyia and Burg El-Arab lie in the stability fields of montmorillonite with some differences in the position from the solubility line of montmorillonite-kaolinite. Also water table samples lie in most cases very close to its corresponding profile.

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1. INTRODUCTION

Past ideas concerning the weathering of soil minerals have emphasized the chemical composition of the minerals involved. The composition of the soil solution was usually considered in qualitative or semiquantitative terms, if at all. The very low solubilities and slow rates of dissolution and precipitation of common soil minerals under most conditions have tended to obscure what is now becoming obvious, that is that equilibrium reactions of soil minerals with the soil solution can be described by elementary chemical thermodynamics.

Understanding mineral weathering requires a knowledge of mineral stability in the weathering environment. In this environment, temperature and total pressures are essentially fixed, so that the variable of major concern is the activity of ions and molecules in the aqueous phase. Because soils are usually short term entities relative to the time required for dissolution and formation of most minerals, it might seen hopeless to observe mineral changes that may have taken place on the time scale of soil formation. This is true for the bulk mineralogy of most soils, but not necessarily true for the mineralogy of the clay size fraction.

The application of thermodynamic data of mineral equilibria at earth surface temperatures has been increasing rapidly in recent years. A major problem is the lack of reliable G values for the mineral involved, particularly layer silicate minerals. Recently stability diagrams for individual minerals or between two or mor minerals were recorded by many investigator. The current work is a trial to investigate the reliability of using stability diagrams to predicte the stability and solubility of silicate minerals in the soils of Egypt. Therefore, some soil profiles were selected to represent different soil conditions regarding soil pH, total soluble salts and $CaCO_3$ contents. The mineralogical composition of those profiles was identified using chemical and X-ray analyses, then thermodynamic data were applied to find out the relation between the different results obtained.

2. *REVIEW OF LITERATURE*

2.1. Clay Mineralogy of Egyptian Soils :

Clay minerals of the Nile alluvial soils have been subjected to several studies. Ball (1939) stated that, the composition of the Nile mud throughout its entire thickness agrees substantially with that of the suspended matter of the river. He was the first to report that Kaolinite dominates all other minerals. His results agree with those obtained by Roufail (1963) in Beni Swef soils.

Contrary to these results, Hamdi and Naga (1950) showed evidence of the dominance of illite in the clay fraction of the alluvial soils at Giza. These data were later confirmed by Hamdi (1952, 1956), Naga (1953) and Hamdi and Iberg (1954). They added that there were evidences of amorphous admixtures and clay minerals being of transitional nature between illite and montmorillonite. Work by the later authors and also by Hamdi and Fathi (1959) showed a close relationship in clay mineralogy between alluvial soils and suspended matter of the Nile. The presence of illite together with montmorillonite in amounts not exceeding 10% was reported by Mady (1957) and Khadr (1961) who stated that montmorillonite and kaolinite are complementary constituents. The dominance of illite was also reported by Ghaith (1961), Hashad and Hady (1961), Ghaith and Tanious (1964), and El-Demerdashe (1966).

The dominance of montmorillonite in the soils of the Nile Delta on the other hand was also reported by other investigators. El-Gabaly and Khadr (1962) found that clay fraction below 1 u in soils of the middle and northern parts of the Delta was dominated by montmorillonite and contained low contents of kaolinite and lower contents of illite. Similar findings were reported by Naga and Mitchell (1964), Heakal (1968), Abdel Aal (1969), El-Demerdashe (1970), and Labib (1970). These studies were concerned with alluvial soils of the Delta region or in the Nile Valley.

Also, Khalil and Labib (1976) carried out quantitative determination of clay minerals of six profiles from the Nile Valley and Delta and concluded that soils of the Delta differed slightly from those of the valley as the former contained relatively high contents of montmorillonite and mica, and lower contents of kaolinite. Vertical variations were also detected as montmorillonite, vermiculite and kaolinite slightly increased with depth, while the contrary was recorded for mica and chlorite.