PHYSICO-CHEMICAL AND MINERALOGICAL STUDIES ON CLAY OF SOME SOILS OF EGYPT

By

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C O N T E N T S

INTRODUCTION

Physico-chemical and mineralogical properties of soil constituents are generally stable properties which affect all other characters and behaviours of soils. Clay fraction is the most important and effective parameter on soil characteristics, especially from the agricultural point of view such as, cation exchange capacity, texture, retention of moisture, expansion on wetting, shrinkage on drying, surface area, plasticity, cohesion, ion exchange, ... etc.

There is hardly a chemical, physical or morphological soil property which is not influenced by the clay fraction. One may venture to state that there is no problem of soil science which is not, in one way or another, associated with the reaction exhibited by this fraction. Clay fraction normally reflects the chemical changes that have taken place during soil formation. Thus each formation contains a suite, or mixtures of a number of clay mineral species differ than the others resulting in the different processes.

Moreover, clay fraction varies widely in its contents of clay minerals and amorphous gels as well as in the size of its particles. These variations are reflected on the physico-chemical properties of the clay fraction which exists in the soil.

Due to the importance of the clay fraction, the current work has been carried out to identify the type of clay minerals in the major formations of the Egyptian soils and to study its influence on the physico-chemical properties of the soils.

2. REVIEW OF LITERATURE

2.1. MINERALOGY:

2.1.1. Clay mineralogy:

A number of exclusive literature have been published on clay fractions of the soils of Egypt concerning their identification, mode of occurrence and their relation to lithology and depositional sequences.

Concerning the Nile alluvial soils, Hamdi (1952 & 1958), Naga (1953), and Hamdi & Fathi (1961) reported that the clay minerals of the alluvial soils of Egypt is mainly of hydrous mica. Mady (1957), and Hashad & Mady (1961) using x-ray & D.T.A., concluded that the clay minerals present in the alluvial soils taken from different localities in Egypt are hydrous mica with small admixure of montmorillonite which increases with depth. Khadr (1961) stated that the Nile sediments consists mainly of hydrous mica,montmorillonite, and kaolinite. El-Gabaly & Khadr (1962), using x-ray, D.T.A., C.E.C., and electronmicroscope, concluded that the clay minerals recorded in the soils of the middle and northern parts of the Delta, are montmorillonite, followed by kaolinite, with very low content of hydrous mica. Roufail (1963) stated that the soils of Beni-Sweif contain Kaolinite as the dominant clay mineral followed by montmorillonite and hydrous mica. Naga & Mitchell (1964) reported that the clay minerals presented in the surface and subsurface soil of the Nile Delta are mainly montmorillonite with low content of hydrous mica and quartz. Hamdi (1967), concluded that the dominant clay mineral in fine clay fraction of the alluvial soils of Egypt is of the expanding lattice type of montmorillonitic group, with minor quantities of kaolinite and hydrous mica. Van der Marel (1966) showed that the clay fraction ($<$2 u) of the alluvial soils of the Nile Delta contain montomorillonite as the main clay mineral, with a minor amount of kaolinite, illite, quartz and feldspar. Hamdi (1967), Abdalla et al. (1967), Abdel-Aal (1969), Fayed & Hassan (1970)& El-Demerdashe (1970), reported that the predominant clay minerals are montmorillonite, kaolinite, and hydrous mica and the latter increases in the coarse clay fractions. Heakal (1968) concluded that the clay minerals in samples taken from Giza are mainly dioctahedral montmorillonite rich in iron associated with small amounts of kaolinite, quartz, and calcite. Harga (1971) reported from his study on the recent Nile terraces at Beni-Sweif, using x-ray and electronmicroscopy technique, that the constituents of both clay fractions, coarse(2-0.2 u) and fine ($<$0.2 u) are montmorillonite and hydrous mica at high percentage followed by Kaolinite and traces of quartz. Ahmed (1972) stated that x-ray, I.R., D.T.A. and ionic formula proved the presence of Fe-Al-montmorillonite, with few percentage of b-axis disordered kaolinite, illite and chlorite in small amounts. Rabie & Hamdi (1972) reported that the predominant clay minerals in Nile alluvial soils are montmorillonite, kaolinite and mica associated with regular interstratification of montmorillonite-vermiculite or montmorillonite-chlorite. El-Attar & Jackson (1973) showed that the clay mineralogy of the soils of the Nile Valley is dominated by montmorillonite with moderate amounts of mica, vermiculite, chlorite and kaolinite. Regular and irregular mixed layer phyllosilicate are abundant. Ghobrial & Khalil (1975) concluded the presence of dioctahedral abnormal montmorillonite, b-axis disordered kaolinite, dioctahedral illite and chlorite. Quartz, feldspars and calcite were also found. Ibrahim (1975) from qualitative and quantitative mineralogical analyses concluded that montmorillonite is the predominant constituent in the alluvial soil at Zefta, it constitutes about 50% from the clay fraction, followed by kaolinite (about 15%), mica (about 9%) and small amounts of vermiculite, chlorite, quartz, and feldspars. The amorphous materials constitute about 10%. Recently, Khalil & Labib (1976) from quantitative mineralogical analysis of soil sediments, concluded that the clay mineral groups present in the clay fraction (< 2 u) of some scattered soils in the Valley and Delta of Egypt are montmorillonite (48%), kaolinite (17%), mica (10%), chlorite (5%), vermiculite (2.0%) and amorphous materials (6.5%).

With regard to lacustrine soils, Ghaith (1961) from the chemical analyses, x-ray diffraction studies, dehydration curves and D.T.A. of H-clay of some soil profiles adjacent to the Northern Lakes of the Nile Delta, concluded that the clay fraction of this area belongs to the illitic clay group. Labib & Sys (1970) found that montmorillonite and kaolinite are the dominant minerals in the clay fraction of lacustrine soils of El-Fayoum. In the same direction, Khalil (1970) in his study on El-Fayoum area found that the clay fraction consists mainly of abnormal montmorillonite with minor amounts of b-axis disordered kaolinite and quartz, calcite and feldspars are admixtured. Harga (1971) using x-ray and electronmicroscope, concluded that the clay fraction of El-Fayoum area consists mainly of montmorillonite, hydrous mica, kaolinite and quartz. El-Araby (1973), in his study on the lacustrine soils adjacent to lakes Edco and Borullus found that, in both fine and coarse clay fractions, the predominant clay mineral was abnormal dioctahedral montmorillonite, kaolinite was the second predominant mineral and small amounts of mica, vermiculite, chlorite, quartz and feldspars were also present. El-Abaseri (1974) stated that the clay fraction separated from some soil profiles taken from the area adjacent to the Borullus Lake consists mainly of abnormal (Fe^{+3}-Al) dioctahedral montmorillonite followed by kaolinite and hydrous mica with small amounts of b-axis disordered kaolinite, halloysite, quartz, calcite and feldspars (plagioclase), amorphous gels, i.e. gibbsite, silica gel, and hydrated iron oxides. Basta et al. (1974) found almost the same results in El-Fayoum soils. Radi (1975) in his study on the lacustrine deposits in the soils north to Wadi El-Natrun stated that the mineralogical composition of the clay fraction is mainly montmorillonite and kaolinite. Recently El Gindy (1976) reported that the mineralogy of the clay fraction reveals that the dominant clay mineral in most of the samples of El-Fayoum region is montmorillonite, followed by kaolinite, other minerals such as hydrous mica, chlorite, feldspars and quartz also exist, but in small quantities. He added that there is a possible interstratification of illite-chlorite and illite montmorillonite in a regular pattern.

Concerning the fluviomarine soils, Abdel Salam & Allison (1959) in their early studies on El-Amereya and Bourg El-Arab soils, showed that hydrous mica is the dominant clay mineral with minute amounts of kaolinite and traces of montmorillonite. Hammad (1968), El-Kady (1971) and Ghanim et al.(1974) stated that attapulgite is present in the fluviomarine soils of the Western Desert of Egypt. Abdel Aal (1971), Omar et al. (1972) and Fathi et al. (1972), in their studies on some profiles representing the North Eastern Nile Delta using x-ray diffraction analysis, showed that the fine clay fraction (<1 u) is mainly montmorillonite with comparatively minor amounts of kaolinite. Elwan (1975), however, reported that the mineralogical composition of the clay fractions of the fluviomarine soils of Maryut and El-Tahrir contains palygorskite + montmorillonite (31-45%) hydrous mica (14-22%) kaolinite (12-20%), and minute amounts of chlorite, vermiculite, quartz, and feldspars. Amorphous materials are about 5-10% of the clay fraction.

Regarding the calcareous soils, El-Gabaly (1962) reported the presence of attapulgite in the calcareous soil of the Western Desert of Egypt using x-ray, D.T.A., electronmicroscope, K_2O content, and C.E.C. Gewaifel (1967) stated that palygorskite is the dominant clay mineral in the clay fraction of the area along Cairo-Alexandria desert road. He added that kaolinite, hydrous mica and interstratified mica-smectite are present as major admixtures with chlorite and vermiculite as minor admixtures. Hammad (1968) and El-Demerdashe (1970) confirmed the previous finding. Labib & Hamdi (1972) reported that the coarse clay fraotion (1-2 u) of some Nile terraces in north & south El Tahrir as well as in Anshass, is composed of kaolinite, montmorillonite and some mica, whereas in the fine fraction (<0.2 u) attapulgite is almost dominant, some mica, traces of montmorillonite and kaolinite are also detected. Harga (1971) using x-ray and electronmicroscope, found that palygorskite and hydrous mica are the major constituents of the clay fraction in Bourg El-Arab - El-Hammam soils, with small amounts of kaolinite, quartz and feldspars. However, montmorillonite exists only in the lagoons. Youssef (1975) identified the clay mineralogy of Maryut calcareous soils as: montmorillonite, attapulgite, kaolinite, and hydrous mica with minute amounts of chlorite, feldspars, and quartz.

From the previous literature it could be generally concluded that kaolinite, expanding and nonexpanding clay minerals beside palygorskite exist mainly in the soils of Egypt. Moreover interstratification of montmorillonite-mica, mica-chlorite, montmorillonite-chlorite and montmorillonite-vermiculite in regular and irregular patterns exist in these soils.

Concerning the chemical properties of the clay minerals, the cation exchange capacity of the kaolin group , which exist as the second clay mineral in the majority of the soils of Egypt , is low compared with that of the other clay minerals of similar particle size. This group also has a relatively low specific surfaces, Grim (1953). Whereas smectites which are the abundant clay minerals in the majority of the alluvial and lacustrine soils, have high specific surface and high cation exchange capacity. Thus they influence the physical and chemical properties of soils more than the former minerals.

Concerning the hydrous mica, generally, the properties of this clay mineral are intermediate between those of kaolinite and smectite; but they are somewhat closer to kaolinite, Gillot (1968).

Palygorskite clay minerals which were observed as the predominant clay minerals in calcareous soils, their physico-chemical properties are closely linked to the texture and thus more or less directly to the structure and their C.E.C normally ranged between 20-30 meq/100 g. Henin & Cailldére (1975).

With regard to the interstratified minerals it is very difficult to explain the influence of interstratified layers on the physico-chemical properties of clays which contain them.