

CLAY MINERALOGY OF THE ALLUVIAL SOIL OF UPPER EGYPT

S.H.H. AHMED¹ AND BOUTHINA E. EL-TAWEL²

1. General Organization for Rehabilitation Projects and Agric. Development.
2. Soil and Water Research Institute, Agricultural Research Centre, Giza.

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Abstract

X-ray diffractograms cleared the predominance of dioctahedral montmorillonite, with few chlorite, and or /b-axis disordered kaolinite. Illite was found as a binary interstratified mineral with montmorillonite or as a ternary interstratified mineral with montmorillonite and chlorite. The presence of interstratified minerals causes the merging of basal spacings at below 7 Å plateau.

Some substitution of Fe^{3+} for Al in the predominant montmorillonite cleared in (1) the infra-red spectra by the absorption band of (Fe^{3+} , Al, OH-bending) at 880 cm^{-1} after removing of calcite, (2) the D.T.A. by the endothermic peak of dehydroxylation at 515°C .

INTRODUCTION

Egyptian soils of the Nile Valley at Esna (Upper Egypt) are still under basin system of irrigation until 1968. According to Ball (1952) the average rate of deposition the suspended matter is 9 cm per century. The basin soils are the standard for Egyptian soils and the best from the point of view of fertility. The alluvial soils of Upper Egypt were changed to perennial irrigation. Most of the studies on clay mineralogy in Egypt was concerned with alluvial soils of Delta and Middle Egypt (Abd-El-Aal, 1969). Few clay mineralogy studies were conducted on alluvial soils of Upper

Egypt. Fortunately, a soil from the basin soils of Esna is still available now and it may be important to study its clay mineralogy as a reference for the alluvial soils before alteration to perennial irrigation.

MATERIALS AND METHODS

A sample from the top layer (0-30 cm) was collected at 1968 from the basin soils at Hod-El-Musallus, Esna, Egypt before being converted to perennial irrigation. Soil analysis was carried out by the methods followed by Ahmed and Naga (1986). Moreover, the analysis of clay fraction ($<1\mu$) was carried out for X-ray analysis by a philips diffractometer for randomly oriented technique, solved parallel oriented technique, K-saturation and heating of parallel specimen, and infra-red absorption analysis using Unicam SP 100G, double beam. Moreover, D.T.A., total chemical analysis, specific surface area and C.E.C. of clay were carried out as mentioned by Naga and Ahmed (1972).

RESULTS AND DISCUSSION

I. Soil Characteristics:

Chemically, the soil is free from harmful salinity and alkalinity (Table 1). Physically, the texture of the soil is silty clay. Morphologically, the colour of the soil is greyish brown when dry (10 YR 5/2) and very dark greyish brown when it is wet (10 YR 3/2).

II. Clay Mineralogy:

Table 2 shows the total chemical analysis (fusion analysis) for Ca-saturated clay ($<1\mu$) of Egyptian alluvial soils at Esna. Moreover, the same table shows the C.E.C. and the total surface areas for the same sample. The analysis shows the pres-

Table 1. Physical and chemical analysis of Esna basin soil

Mechanical analysis		Exchangeable cations (m.e./100g)	
a) Coarse sand	% 0.15	Cation exchange capacity	45.36
b) Fine sand	% 10.67	Exch. sodium	0.76
c) Silt	% 48.50	Exch. potassium	1.21
d) Clay	% 40.68	Exch. calcium	33.04
		Exch. magnesium	10.35
Total soluble salts	% 0.08	E.S.P.%	1.67
Soluble ions	(m.e./100g)	pH	8.0
CO ₃	- K 0.03	Organic matter %	1.14
HCO ₃	0.82 Na 0.60	Calcium carbonate%	1.33
CL	0.30 Ca 0.44		
SO ₄	0.11 Mg 0.16		

Table 2. Total chemical analysis, C.E.C., and total surface area for Ca-Clay (< 1 μ) of Esna basin soils.

Total Chemical Analysis %		C.E.C m.e./100g clay	Total surface area (m ² /g/clay)
SiO ₂	42.38	69.28	484.44
TiO ₂	1.16		
Al ₂ O ₃	20.75		
Fe ₂ O ₃	8.42		
FeO	1.15		
MgO	3.15		
CaO	6.50		
Na ₂ O	0.15		
K ₂ O	0.80		
H ₂ O (+)	9.91		
CO ₂	2.76		
Organic matter	1.87		
S u m	99.00		

sence of considerable amount of a 2:1 clay mineral, owing to Lawrie (1961) who found that the total surface areas for montmorillonite, illite, hallyosite and kaolinite are 770, 170, 100 and 18 m²/g, respectively.

1. X-ray diffraction analysis:

Fig. 1 illustrates the x-ray diffraction. The presence of strong peak near 4.5A indicates the dominance of layer silicates. The 1st spacing of montmorillonite and their indices are as follows: 14.75A (001), 7.43A (002), 4.48A (110, 020), 2.592A (130,200), 1.719A (310, 150, 240) and 1.503A (330, 060) Brown (1961). Moreover, infra-red spectroscopy and D.T.A. clear the presence of dioctahedral montmorillonite (Fe-Al-montmorillonite). Therefore, the presence of 1.503A of montmorillonite clears that the (OKO) or 060 is dioctahedral layer silicates. Some weak peaks of few percentage for b-axis disordered kaolinite appear at 7.2 A (001), 4.41A (021), 2.562A (201), 2.55A and 2.508A (131) Brown (1961). The presence of 12.3A may be related to interstratified of 10A + 14A minerals such as mica or illite (10A) and montmorillonite or chlorite. The peaks at 5.05A and 4.00A related to mica or illite and their indices are (002) and (032), respectively. Carbonate gives its diffraction as calcite by the presence of peaks at 3.039A (104), 2.495A (200,110), 2.10A (202), 1.919A (108) and 1.512A (136, 207). It is worth to mention that the amorphous materials and calcite removed for running the treatment C (Fig. 1) according to Jackson (1956), and its presence affected the intensities of basal spacings and intensified them. The merging of basal spacings into a diffraction plateau below 7A, supported the inter stratification of layers of illite and other 2:1 & 2:1:1 layer silicates (Jackson, 1956). Ball (1952) cleared that the plateau region of upper Nile resources being chiefly gneisses while the Abyssinian one is chiefly volcanic lavas. Suspended matter which is deposited in Egypt come from Abyssinian plateau during the season of flood and these deposits are recent. Moreover, the removal of the amorphous materials (Fig. 1 C) clears the predominance of montmorillonite by the strong peak at 18.0A X-ray diffraction patterns show a binary interstratification such as mica-chlorite, montmorillonite-illite and a ternary interstratification of montmorillonite-illite (mica)-chlorite. Peak at 24A for K-saturated, heated & glycerol solvated sample, (Fig. 1 C&D) may be due to regular interstratification of mica-chlorite layers. Peak at 12.25A (for the same treatment) may be due to binary interstratification of mica-chlorite layers or ternary interstratification of chlorite-illite-montmorillonite. Montmorillonite samples (Heated at 550°C, Fig. 1D) collapse to about 10A spacing of illite (Jackson, 1956).

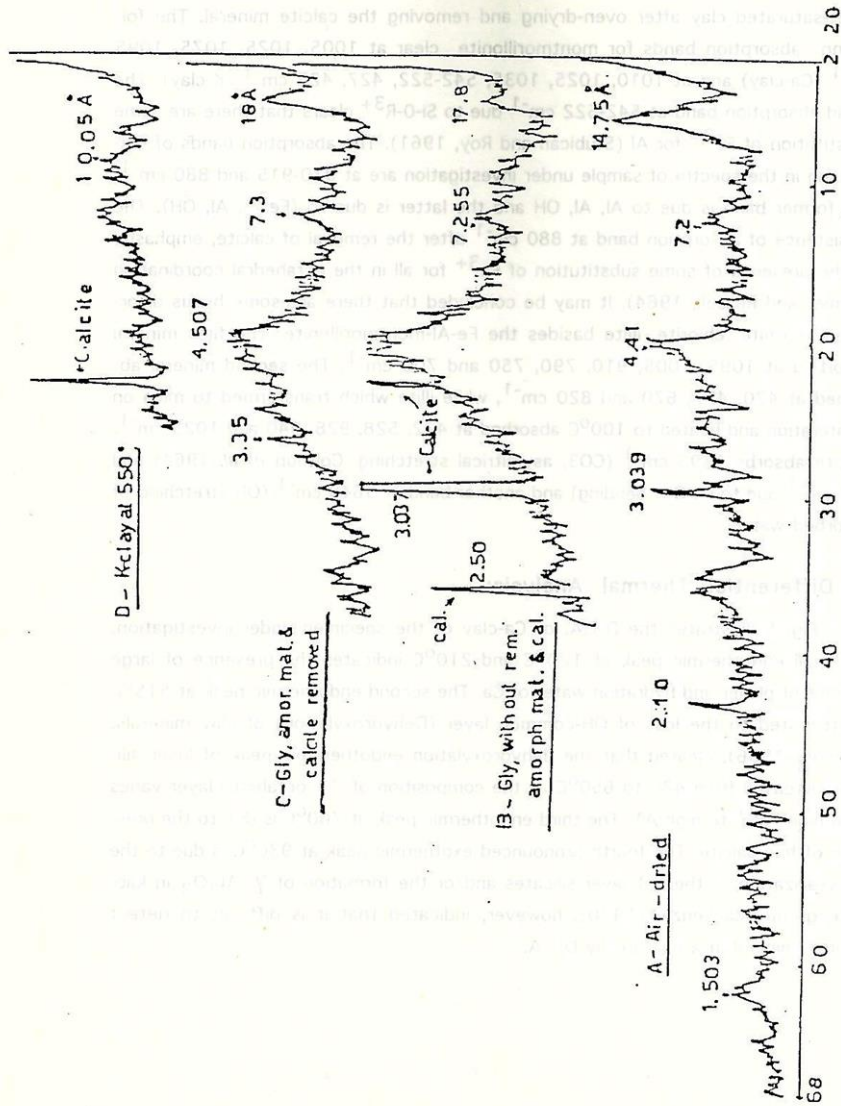


Fig. 1. 1-x-ray diffraction of clay (<math>\theta/\mu</math>) of basin Esna soil

2. Infra-red spectroscopy:

Figs. 2 & 3 illustrate the spectra for Ca-clay. Fig. 4 illustrates the spectrum for K-saturated clay after oven-drying and removing the calcite mineral. The following absorption bands for montmorillonite clear at 1005, 1025, 1075, 1095 cm^{-1} (Ca-clay) and at 1010, 1025, 1035, 542-522, 427, 425 cm^{-1} (K-clay). The broad absorption band at 542-522 cm^{-1} due to Si-O-R³⁺ clears that there are some substitution of Fe³⁺ for Al (Stubican and Roy, 1961). The absorption bands of OH-bending in the spectra of sample under investigation are at 910-915 and 880 cm^{-1} . The former band is due to Al, Al, OH and the latter is due to (Fe³⁺, Al, OH). The persistence of absorption band at 880 cm^{-1} after the removal of calcite, emphasizes the presence of some substitution of Fe³⁺ for Al in the octahedral coordination (Farmer and Russell, 1964). It may be concluded that there are some b-axis disordered koslinite, chlorite, illite besides the Fe-Al-montmorillonite. The first mineral absorbed at 1095, 1005, 910, 790, 750 and 700 cm^{-1} . The second mineral absorbed at 420, 477, 670 and 820 cm^{-1} , while illite which transformed to mica on K-saturation and heated to 100°C absorbed at 472, 528, 928, 940 and 1025 cm^{-1} . Calcite absorbs 1395 cm^{-1} (CO₃, asymmetrical stretching, Colthup *et al.* 1964) and 877 cm^{-1} due to (H-O-H bending) and another band at 3640 cm^{-1} (OH-stretching of absorbed water).

3. Differential Thermal Analysis:

Fig. 5 illustrates the D.T.A. of Ca-clay of the specimen under investigation. The dual endothermic peak at 120°C and 210°C indicates the presence of large amount of planer and hydration water of Ca. The second endothermic peak at 515°C is attributed to the loss of OH-common layer (Dehydroxylation) of clay minerals. Jackson (1956), cleared that the dehydroxylation endothermic peak of layer silicate increased from 420 to 650°C as the composition of 2:1 octahedral layer varies from high Fe³⁺ to high Al. The third endothermic peak at 760°C is due to the presence of fine calcite. The fourth pronounced exothermic peak at 930°C is due to the recrystallization of the 2:1 layer silicates and/or the formation of γ -Al₂O₃ in kaolinite group. Mackenzie (1970), however, indicated that it is difficult to detect chlorite mineral in a mixture by D.T.A.

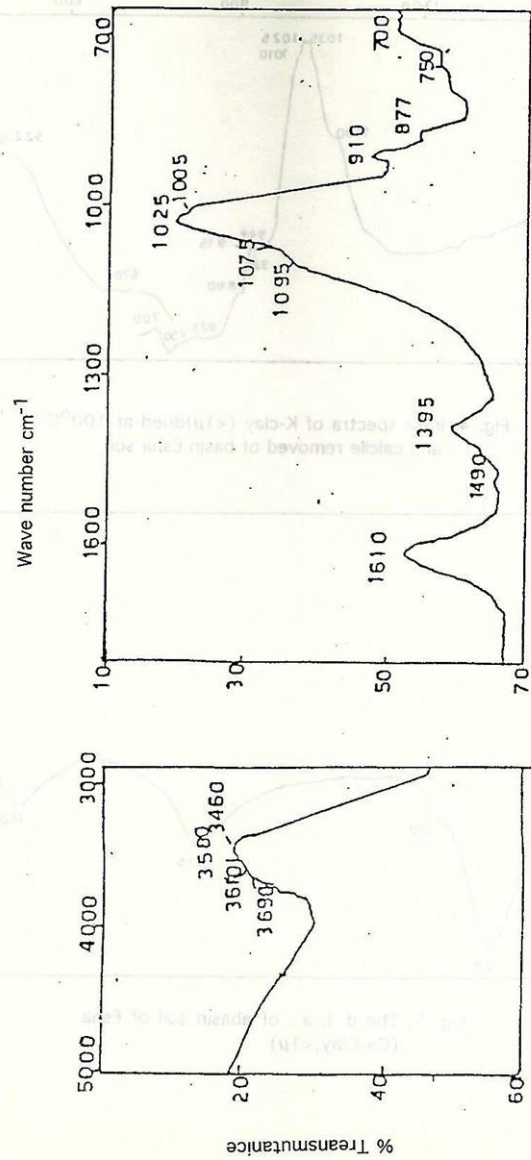


Fig. 2. infra red spectrum (Si_2O Prism) of Ca-caly ($<1\mu$) of Esna basin soil

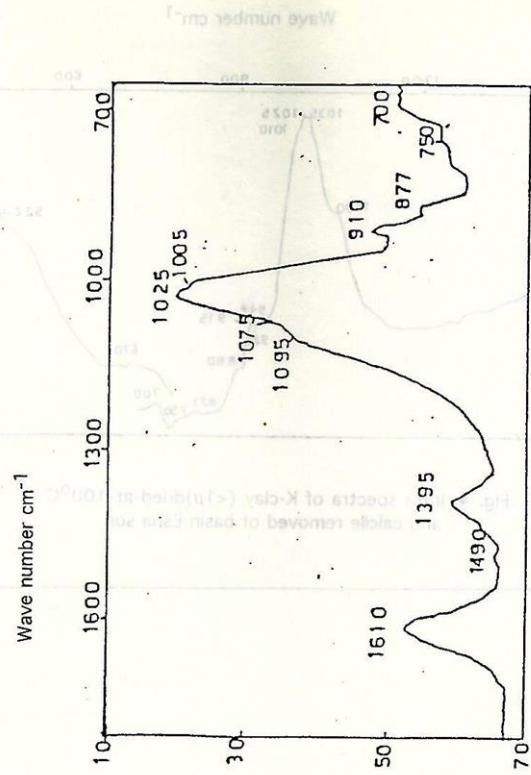


Fig. 3. Infra red spectrum prism of Ca-clay ($<1\mu$) of Esna basin soil

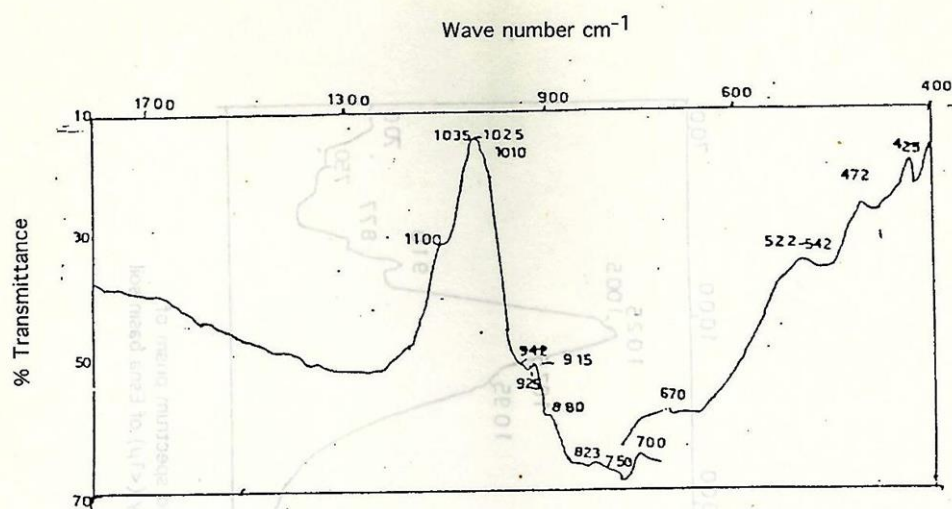


Fig. 4. Infra spectra of K-clay ($<1\mu$) dried at 100°C and calcite removed of basin Esna soil

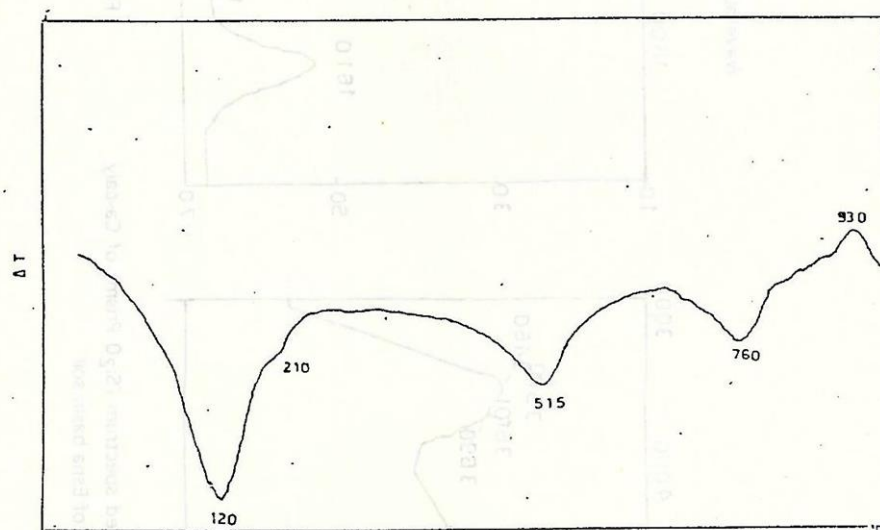


Fig. 5. The d. i. a. of abasin soil of Esna (Ca-Clay, $<1\mu$)

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دراسة معادن الطين فى الرواسب النيلية الحديثة بمصر العليا

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سيد حلمى حسين احمد^١ ، بثينة السعيد الطويل^٢

- ١ - هيئة مشروع التعمير والتنمية الزراعية - وزارة الزراعة
- ٢ - معهد بحوث الاراضى والمياه - مركز البحوث الزراعية - الجيزة

تم دراسة معادن الطين فى الرواسب النيلية الحديثة بمصر العليا فى اسنا وذلك قبل تحويلها من نظام الرى الحوضى الى الرى المستديم. وقد تمت الدراسة باستخدام الاشعة السينية والاشعة تحت الحمراء والتحليل الحرارى التفاضلى والتحليل الكيماوى والسعة التبادلية ومساحة السطوح الكلية للطين (اقل من ١ ميكرون). واوضحت الدراسة مايتى:

- ١ - سيادة معدن المونتمورلنيت الثنائى مع قليل من معدن الكلورايت او مع بعض الكاؤولينيت الغير منتظم فى المحور (ب). ووجود معدن الاليت كمعدن مختلط ثنائى الطبقات مع المونتمورلنيت او فى معدن مختلط ثلاثى الطبقات مع الكلوريت والمونتمورلنيت.
- ٢ - ازالة المواد الامفوتريية تحسن المسافات القاعدية لمعادن الطين.
- ٣ - وجود المعادن المختلفة الطبقات تؤدى الى عدم وضوح الخطوط الرئيسية وارتفاع هضبة الانعكاسات الى ما بعد ٧ انجستروم.
- ٤ - يوجد إحلال للحديد محل الألومنيوم فى الطبقة الثمانية فى معدن الطين السائد (المونتمورلنيت) وذلك بسبب:
- أ- وجود حزام امتصاص للاشعة الحمراء عند ٨٨٠سم^{-١} وذلك بعد ازالة الكالسيت وذلك راجع الى التمدد الانحنائى للأربطة (ح ٣ + لو + أيد).
- ب- اوضح التحليل الحرارى التفاضلى وجود منحنى حرارى داخلى عند ٥١٥°م وذلك راجع الى فقد ايونات الايدروكسل.