STUDIES ON GENESIS, CLASSIFICATION AND EVALUATION OF SOME SOILS FORMED ON FERRUGINOUS SANDSTONE, EL-WAHAT EL-BAHERYA, EGYPT

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ABSTRACT Egypt soils are generally characterized by slightly alkaline to alkaline pH values which are mainly due to its dry environment. Under such aridic conditions, the occurrence of acid soils is considered an anomalous, and interesting to be studied. Three acid soil profiles, located at El-Wahat El-Bahrya, Giza Governorate, Egypt were investigated for this study. The field description indicated the occurrence of common iron oxides, jarosite and clay-iron cutans. Except the Ap horizon of profile 3, all the pH values of the studied soils were acidic and ranged between 3.63 to 5.15, which is mainly considered due to the oxidation of pyrite that was formed during an old more humid period. The chemical analysis assured the presence of exchangeable acidity and low cation exchange capacity due to the dominance of kaolinite clay mineral. The results were confirmed by the x-ray diffraction and transmission electron microscope examinations, which indicated the dominance of kaolinite clay minerals and the presence of ferric oxides and jarosite. Both skell-ferriargillans and the undulic plasmic fabric were identified by the micromorphological inspection confirming the formation of kandic horizon in the studied soils. The soils are classified mainly as “Typic Haplosalids and "Plinthic Kandiudalfs”. All the soils have kandic horizons that were pedologically developed on ferruginous sandstone materials during different paleo-environments and were preserved under the recent arid conditions within which some salic horizons are formed. The suitability of the studied soils for irrigated agriculture was evaluated as S2 and S3 classes. Integrated environmental management is recommended for the area to conserve soils from the irruptive degradation that occur mainly due to the mismanagement activities.

Key words: *Acid soils, soil genesis**,** land evaluation, soil classification, kandic horizon, jarosite.*

INTRODUCTION

Acidity is considered an important key agent in identification of soil mineral types and environmental conditions in any area. Soil acidity is generally related to the oxidation of pyrite through the weathering process, (van Breemen, 1973). This oxidation process may result in alteration of pyrite to jarosite, (Carson and Dixon,1983). Jarosite and ferric oxides are usually accumulated on ped surfaces. Micromorphologically, argillans and ferri-argillans are considered the main features characterizing acid soils (Rabenhorst and Wilding, 1986). Also, small masses of the s-matrix are imbedded by jarosite and ferric oxides in some arid soils (Clark et al., 1961). The major clay minerals in acid soils are of 1:1 type clay minerals (kaolin - serpentine group) due to its inheritance from the parent materials or as a result of mineral alterations through weathering and leaching processes (Dixon, 1989). The objectives of this study are: (i) to determine the effect of acidity on some morphological, chemical, mineralogical and micromorphological properties in some acid soils in El-Wahat El-Bahrya soils. (ii) evaluate the associated processes such as weathering and translocation of soil constituents (illuviation). (iii) identify and discuss the genesis and formation of these acid soils and (iv) evaluate their suitability for irrigated agriculture.

MATERIALS AND METHODS

The soils used in this study occur in ancient natural deposits at El-Wahat El-Bahrya, Giza Governorate, Egypt (Map 1). Three soil profiles were investigated in August, 2002 and described in the field according to Soil Survey Staff (1993). Field lens 20X was used to investigate cutans in the field. Soil samples were taken according to the morphological features of the different horizons and prepared for different soil analyses. Particle size distribution was determined using the pipette method (Klute, 1986). Soil pH was measured in soil suspension of 1: 2.5 soil to water. Electrical conductivity of the soil paste extract (ECe) and exchangeable bases were determined according to Jackson (1967). Exchangeable $A1^{3+}$ and H^+ were determined by the method proposed by Yuan (1959). Cation exchange capacity (CEC) was determined by the method described by Gillman (1979).

Both fine and coarse clay fractions were identified by X-rays powder diffraction (XRD) using Philips x-ray diffractometer with monochromatic Cu kα-radiation. Three treatments for each clay fraction , i.e., Mg-air dried, glycerol solvated and K-heated at 550 ºC, were examined by x-ray diffractometer. The morphological characteristics of the clay minerals were examined with a Philips transmitted electron microscope (TEM). The micromorphological investigations of the soil thin sections were carried out after the pretreatments of the undisturbed soil samples were done according to Ashley (1973). The description of the micromorphological features were achieved according to Brewer (1976).

RESULTS AND DISCUSSION

Soil Morphology

As shown in Map (1), the studied soils are located in an undulating hilly area around El Giza-El-Bahrya main road and nearby Mandisha city in the bottom of El-Bahrya depression. The area belongs to the old Bahrya Cenomanian Cretaceous formation, (Conoco,1985). Field studies and profile descriptions, (Table 1) show the presence of clay films in some subsurface layers, i.e. at 40-110 cm and 10-60 cm throughout profiles 1 and 2 (Bzt1&Bt2) and (2 Bt) in soil profile 3. The illuviation of clays was confirmed by the relative high clay contents at these depths (Table 2), indicating the translocation of clay from the uppermost horizons and its accumulation as a neoformed material in mid-profile layers. This is confirmed by field morphology and the micromorphology of the tested thin sections, Figures 4,5&6. Clay contents of these layers, their thickness, the occurrence of clay films and the low CEC values fulfill the requirements for Kandic horizons. Accumulation of soluble salts was observed in profile 1, forming salic horizon in A2z and Bzt1 horizons. Since the salic horizon was given a higher priority than the kandic horizon in the Keys of Soil Taxonomy, (Soil Survey Staff, 2003), therefore the soils of profile 1 were classified as "Typic Haplosalids" although the soils exhibit kandic horizon in their profiles. Such salic horizons may be formed in more recent arid conditions that were different from those under which the kandic horizons were formed. Soils represented by profiles 2 and 3 were classified mainly as "Plinthic Kandiudalfs" due to the common dark brown iron-rich (7.5 YR 2/2) mottles. The occurrence of yellowish coated particle (5Y 7/6) and the dark brown (7.5 YR 2/2) mottles, are more related to jarosite and iron oxides respectively. These findings are in agreement with Carson and Dixon, (1983).

Lithologic discontinuity, was observed on the top soil of profile 3. But this was not counted in soil classification due to the thin thickness of that layer, i.e. 20 cm.

The relative coarse texture of the studied soils, (Table 2) is reflecting mainly the lithology of the parent material which is Cenomanian sandstone. It could be concluded that the relative enrichment of translocated clay in the mid profile layers, the thickness of Bt1 and Bt2, and the neoformed clay films features, (Tables 1&2 and Figures 4,5&6) could be considered as an evidence of the formation of kandic horizons through illuvation process during an old and relatively humid period.

Mismanagement of agricultural activities was recorded in the surrounding area. Salinity, marshes and degradation problems are spreading due to the over-use of irrigation water. Integrated GIS environmental management plan is needed for this area.

Soil Chemical Properties

The ECe values Table (3), indicate that the soils are generally saline and the dominant cations are Na followed by Ca and Mg, whereas chloride followed by sulfate are the dominant anions. The relative low pH values of the various soil horizons of soils under study reflect soil acidity that tends to increase with depth, (Table 4). The decrease in soil pH by a few tenths of a unit after 24 hours of sampling appears to be similar to what happens in the acid sulfate soils where acidity is caused by the slight dissolution and hydrolysis of jarosite, (Dixon1989). This soil acidity is believed to be the result of pyrite oxidation, mineral weathering and leaching processes during earlier environment. This was confirmed by the common presence of jarosite in Bt and the iron rich mottles in C horizons of profiles 1 and 2 respectively, (Table 1).The relative low cation exchange capacity CEC values of the studied soils (Table 4), are not only related to the low clay contents but also to the dominance of 1:1 clay minerals as discussed later. Data in Table 4 reveal that the base saturation values are *51 to 95* %, with relatively high Ca/Mg ratios in the studied soils which indicate the dominance of kaolinite, Wilding (1983). Why the base saturation values indicate more than 50% inspite of the prevailing acid conditions? To get an answer for this question, both analysis were checked and repeated and no change was obtained . The sensitivity of the ammonium acetate method for exchangeable cations is not satisfactory under the relatively high free Ca^{2+} from gypsum as it is found in the studied area especially in top soil. Page et al. (1982) indicated the same observation and added that “no other method is satisfactory”. The occurrence of gypsum in the area may indicate that the studied soils were submerged with fresh water during its historical times. As shown in Table (4), soil pH values of Az horizon in profile 3 is 9 (strongly alkaline) whereas its values in the subsurface ones are acid in nature. This reflects the occurrence of lithologic discontinuity in this profile as confirmed by the field description. Also, cation exchange capacity, clay contents and CEC/clay values confirm the lithologic discontinuity as their values are relatively high in the Az horizon in comparison with the subsurface ones of all horizons (Tables 1,2 and 4). Since the surface new mantle materials is less than 30 cm, it could not be taken in account as a differentia in soil taxonomy. However associations of buried paleosols are expected to occur in areas with more thick surface mantle materials.

Soil Mineralogy

The x-ray diffraction patterns of the studied soil profiles (Figures 1&2) indicate that kaolinite is the major dominant clay mineral in both fine and coarse clay fractions. Montmorillonite, mica, quartz, gypsum and dolomite constitute the minority ones in these soils. Also, the data reveal the presence of some iron oxides and jarosite, as confirmed by the presence of low intensity broad jorasite peaks at 5.03 -5.09 A^{o} , goethite peaks at 4.15 - 4.16 A^{o} and hematite peaks at 2.7 -2.69 A^{o}. The occurrence of jarosite mineral is mainly related to the weathering and hydrolysis of iron oxides and pyrite minerals, which are the major source of acidity in the studied soils. The sharp intense 001- kaolinite peak at 7.3 A^{o} indicates the presence of well-formed iron rich kaolinite crystals. Increasing the intensity of the peak in the subsurface layers indicate that the kaolinite content tends to increase with soil depth due to both weathering and ageing. Examination of soil clays by the transmitted electron microscope showed that the common clay mineral in these soils is kaolinite (Figure 3)**,** which confirms the results of the x-rays analysis.

Thus the previous obtained results of chemical analysis (the relatively low CEC and the presence of acidity conditions), the x-ray analysis of both coarse and fine clay fractions (sharp intense 001 kaolinite peak at 7.3 A^{o}) and the electron microscope examination confirm the abundant of kaolinite minerals in the studied acid soils

Soil Micromorphology

The observed pedological features of vughy manganiferrans, vughy-hypoferrans. and skel-ferriargillans (Table 5 and Figures 4,5 & 6) are mainly due to the movement of some concentrated plasma mangans and iron oxides towards the accumulation zone. This could be achieved by the diffusion from soil solution towards these natural surfaces (voids or skeleton grains), or by illuviation process of the clay colloids and dissolved iron along the voids and/or penetration into the s-matrix forming the cutanic films on walls of pores and around grains. This interpretation is in agreement with Al-Sharif et al. (1998). The presence of undulic plasmic fabric (Figure7), and the nodules of quartz grains cemented by iron oxides indicate a pronounced content of iron oxides in these studied soils, as confirmed by the above mentioned data.

Soil Genesis

The profile descriptions show the occurrence of pale yellow jarosite coatings and mottles in Bt and C horizons, with more frequency in C layers, (Table 1). The reddish brown mottles in Bt horizon also, indicate the accumulation of ferric oxides. The occurrence of both jarosite and soil acidity suggests their formation from the weathering of pyrite-containing parent materials during old historical periods, as they are more pronounced increase with depth. The acidity of the studied soils may not be only a result of pyrite oxidation to jarosite but also may be due to the dissolution and hydrolysis of the latter one (van Breemen, 1973). The abundance of the kaolinite in the clay fraction of the studied soil profiles and increasing its content with depth is more related to the fact that geochemical weathering and ageing of the primary minerals (feldspars and micas) which are found in the sandstone parent materials of these soils. This result is in agreement with those obtained by Fiskell & Perkins, (1970), Shendi (1990) and Al-Sharif (1994).

The presence of argillans and ferrans clay films (Table. 1), are mainly attributed to the genetic process of illuviation, i.e, translocation of fine clay particles or iron solutions, and their deposition, crystalization and orientation around the stable surfaces of peds, skeleton grains and void walls. Thus, illuviation process is the main factor causing the occurrence of the argillic horizon (Verheye and Stoops, 1973). Concerning soil profile no 3, data in Tables 1, 2&3 indicate the occurrence of lithologic discontinuity or the stratigraphic change between Az horizon and the underlying ones, that clearly shows a break up of the depositional episode. Therefore, the acidic nature of the subsurface horizons 2A, 2B and 2C could be originated from a former development during a more humid environment, and could be considered as paleosols (Rtiellan, 1971). Thus, these acid soils are mainly considered as residual ones developed on ferruginous sandstone under a former humid environment and the diagnostic features were preserved under the recent arid episode. The presence of salic horizons in these soils represented by profile 1 may be formed during the more recent arid conditions.

Land evaluation

According to FAO (1976 & 1985) framework and Sys and Verheye (1978), the soils were evaluated for irrigated agriculture as S2s and S3st subclasses for profiles 3 and (1&2), respectively. The main limiting characteristics were the salinity (s), the coarse texture (t), the low CEC, and soil depth in profile 2.

Table (1) Field description of the studied soils and soil classification.

Profile No.	Horizon	Depth (cm)	Colour	Structure	Consistence	Special feature	Boundary	Classification
1	A	0-20	7.5YR 5/6	massive	slightly hard	very few yellow 5Y 7/7 jarosite mottles	clear smooth	Typic Haplosalids
	A2z	20-40	7.5YR 5/6	1 f sbk	hard	common yellow 5Y 7/8 jarosite mottles	clear smooth	
	Bzt1	40-80	7.5YR 5/4	2 m sbk	very hard	many clay films, many common dark brown 7.5YR 2/2 ferric iron rich mottles, 5Y7/8 jarosite mottles	gradual wavy	
	Bt2	80-110	2.5YR 3/6	2 m sbk	very hard	many clay films, many 5Y7/8 jarosite mottles, common dark brown 7.5YR 2/2 ferric iron rich mottles.	clear smooth	
	C	110-150	5YR 7/2	massive	hard	common 5Y7/8 jarosite mottles and many 7.5 YR 2/2 ferric iron mottles		
2	A	0-10	7.5YR 5/4	massive	slightly hard	few 5Y 7/8 jarosite and 7.5YR 2/2 ferric iron rich mottles	clear smooth	Plinthic Kandiudalfs
	Bt1	10-40	7.5YR 4/6	massive	hard	many clay films, many 5Y 7/8 jarosite mottles	gradual wavy	
	Bt2	40-60	2.5YR 3/6	1 f sbk	very hard	many clay films and many 5Y7/8 jarosite mottles	clear smooth	
	C	60-80	5YR 6/2	massive	hard	many 7.5 YR 2/2 ferric iron rich mottles		
3	Az	0-20	7.5YR 4/4	massive	slightly hard		abrupt smooth	Plinthic Kandiudalfs
	2A	20-30	7.5YR 6/4	1 f sbk	hard	many 5Y 7/8 jarosite mottles	clear smooth	
	2Bt	35-85	5YR 6/6	2 m sbk	hard	many clay films, many 5Y 7/8 jarosite and common 7.5YR 2/2 mottles	gradual wavy	
	2C	85-150	5YR 6/4	massive	very hard	many 7.5YR 2/2 ferric iron rich mottles		

f = fine m = moderate sbk = subangular blocky

Table 2. Particle size distribution of the studied soils.

Profile No.	Horizon	Depth (cm)	C. Sand (%)	F. Sand (%)	Silt (%)	Clay (%)	Texture
1	A	0 – 20	25.30	58.51	7.30	9.15	S
	A2z	20 – 40	17.30	43.10	22.80	15.51	SL
	Btz1	40 – 80	19.35	23.13	27.17	30.10	SCL
	Bt2	80 – 110	23.10	27.70	22.15	27.30	SCL
	C	110 - 150	23.30	37.10	20.10	17.35	SL
2	A	0 – 10	27.10	60.13	6.18	6.15	S
	Bt1	10 – 40	25.00	55.17	12.17	10.35	LS
	Bt2	40 – 60	23.21	45.13	15.10	14.80	SL
	C	60 - 80	23.17	63.20	7.25	6.27	S
3	Az	0 – 20	6.32	25.18	28.15	40.35	C
	2A	20 – 35	26.07	35.25	23.51	15.17	SL
	2Bt	35 – 85	17.26	27.01	25.18	30.55	SCL
	2C	85 - 150	27.22	35.11	21.17	16.50	SL

Table (3) EC$_e$ values, soluble ions and gypsum contents for the studied soils.

Profile No.	Horizon	Depth (cm)	ECe (dS/m)	Soluble ions (meq/l)								Gypsum %
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO3^{--}	HCO 3^{-}	Cl^{-}	SO4^{--}	
1	A	0 – 20	19.3	65.1	41.3	80.1	2.7	0.0	0.7	110.3	80.1	2.1
	Az2	20 – 40	30.1	95.7	55.1	150.3	3.1	0.0	0.3	200.1	100.3	1.5
	Bzt1	40 – 80	33.5	100.1	60.3	171.3	3.5	0.0	0.3	201.5	123.3	1.7
	Bt2	80 – 110	22.5	70.3	60.5	90.1	2.1	0.0	0.2	150.1	71.7	1.9
	C	110 - 150	17.3	59.1	30.3	81.3	1.7	0.0	0.3	100.1	70.3	1.5
2	A	0 – 10	3.5	11.5	7.1	17.3	1.3	0.0	0.3	20.1	15.3	1.5
	Bt1	10 – 40	9.5	20.7	20.3	45.7	1.5	0.0	0.5	55.7	35.1	1.3
	Bt2	40 – 60	10.1	29.9	21.7	51.3	2.1	0.0	0.4	71.3	30.1	1.5
	C	60 - 80	13.5	33.7	27.5	71.9	1.3	0.0	0.3	90.7	45.1	1.1
3	Az	0 – 20	25.1	80.1	40.3	130.1	1.5	0.0	3.1	151.3	99.5	1.5
	2A	20 – 35	9.3	28.3	18.1	45.1	1.0	0.0	0.5	60.1	33.7	0.7
	2Bt	35 – 85	4.5	13.1	9.1	23.1	0.9	0.0	0.3	30.1	15.3	0.3
	2C	85 - 150	3.5	9.7	7.3	17.1	0.7	0.0	0.3	19.1	13.7	0.5

Table 4. Chemical properties of the studied soils.

Profile No.	Horizon	Depth (cm)	pH (1:2.5)	pH after 24h	$CaCO_3$ (%)	Exchangeable cations (meq/100g soil)				Exchangeable acidity (meq/100g soil)		CEC cmol_c/kg	Base Sat. %
						Ca	Mg	Na	K	Al	H		
1	A	0 – 20	4.51	4.47	0.3	1.16	0.80	0.50	0.20	0.03	0.01	2.70	95
	Az2	20 – 40	3.90	3.84	0.2	1.50	1.00	0.40	0.11	1.10	0.49	4.30	70
	Bzt1	40 – 80	3.70	3.65	0.2	2.30	1.20	0.33	0.30	3.30	0.67	8.10	51
	Bt2	80 – 110	3.70	3.63	0.2	2.20	1.10	0.70	0.60	2.10	0.60	7.30	57
	C	110 - 150	3.83	3.75	0.3	1.70	0.90	0.30	0.31	1.20	0.39	4.80	67
2	A	0 – 10	5.40	5.41	0.4	0.90	0.65	0.20	0.16	0.12	0.07	2.10	91
	Bt1	10 – 40	4.32	4.25	0.3	1.00	0.60	0.35	0.15	0.70	0.20	3.00	70
	Bt2	40 – 60	4.30	4.26	0.3	1.20	0.80	0.20	0.13	1.33	0.44	4.10	57
	C	60 - 80	4.50	4.42	0.4	2.85	0.50	0.35	0.30	0.40	0.10	2.50	80
3	Az	0 – 20	9.00	9.10	3.2	10.21	7.10	7.29	2.50	-	-	27.10	100
	2A	20 – 35	5.21	5.15	0.5	1.50	0.90	0.50	0.41	1.35	0.44	5.10	65
	2Bt	35 – 85	4.50	4.45	0.3	2.65	1.50	0.50	0.43	3.30	0.97	9.25	55
	2C	85 - 150	4.71	4.65	0.3	1.25	0.75	0.33	0.26	0.81	0.30	3.70	70

Table (5) Micromorphological description of the studied soils.

Profile No.	Horizon	Related description	Plasmic fabric	Pedological features
1	A	Granular	-	-
	Az2	Agromoroplasmic	Skelsepic	-
	Bzt1	Porphorosklic	Skelsepic, vosepic	Skel-ferriargillans
	Bt2	Porphorosklic	Skelsepic, vosepic	Skel-ferriargillans, vughy hypoferrans
	C	Agromoroplasmic	Skelsepic	Skel-ferriargillans
2	A	Granular	-	-
	Bt1	Intertextic	-	Skel-ferriargillans, vughy manganiferrans
	Bt2	Agromoroplasmic	Skelsepic, vosepic	-
	C	Granular	-	-
3	Az	Porphorosklic	Skelsepic, vosepic	-
	2A	Agromoroplasmic	Skelsepic, vosepic	Skel-ferriargillans
	2Bt	Porphorosklic	Skelsepic, vosepic	Skel-ferriargillans, vughy hypoferrans
	2C	Agromoroplasmic	Skelsepic, vosepic	Skel-ferriargillans

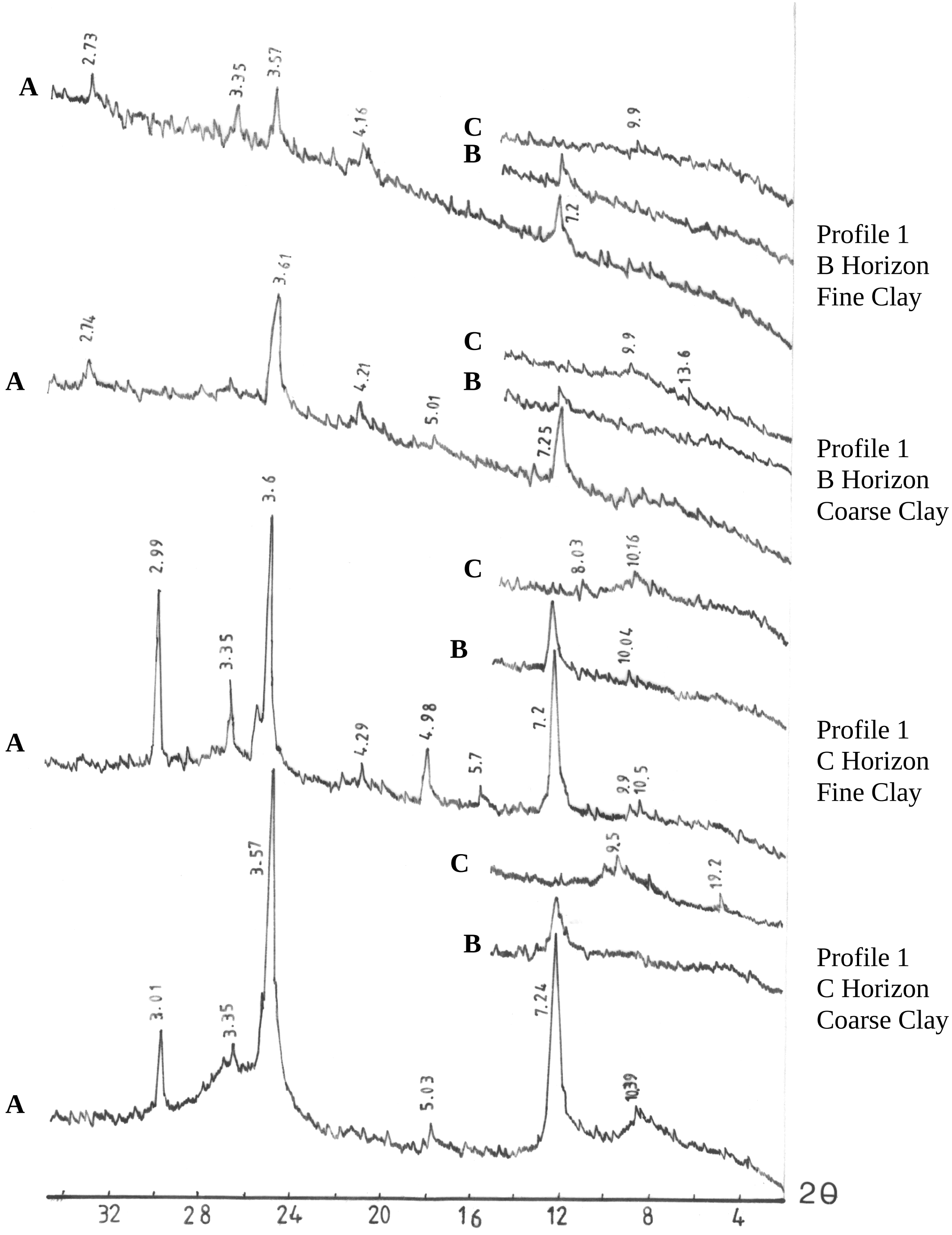


Figure (1) X-ray diffraction patterns of profile 1 (clay fractions).
A = Mg- air dried B= Mg + glycerol salvation C= K+ heating at 550 ºC

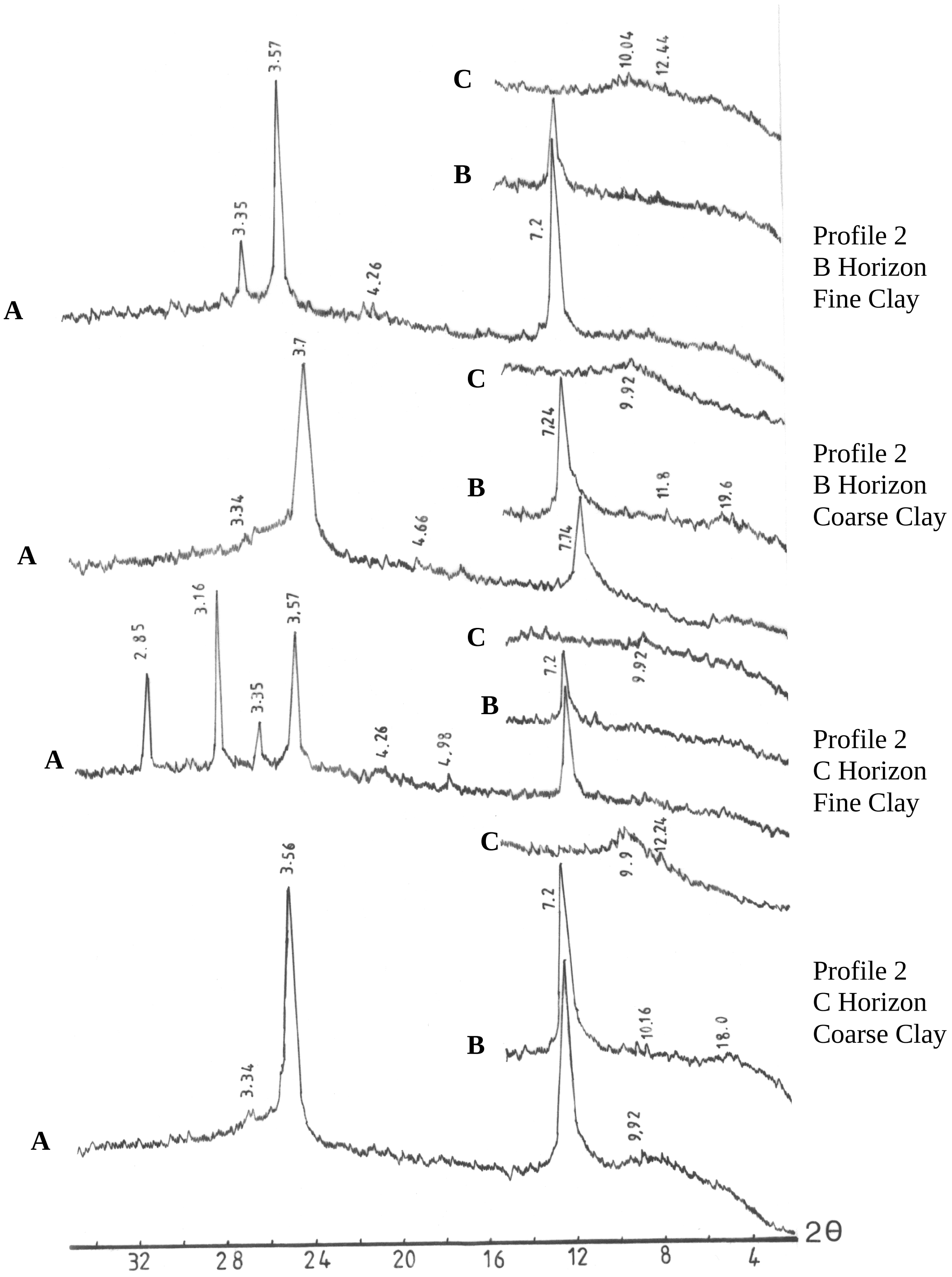


Figure (2) X-ray diffraction patterns of profile 2 (clay fractions).
A = Mg- air dried B= Mg + glycerol salvation C= K+ heating at 550 ºC

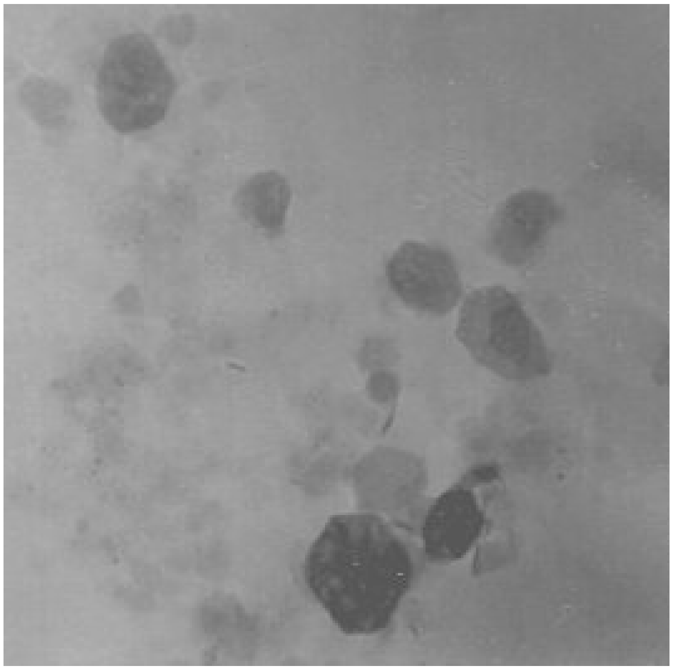


Figure (3) Dominant well formed kaolinite crystals in the studied clays.
Transmitted electron microscope 50 000X.

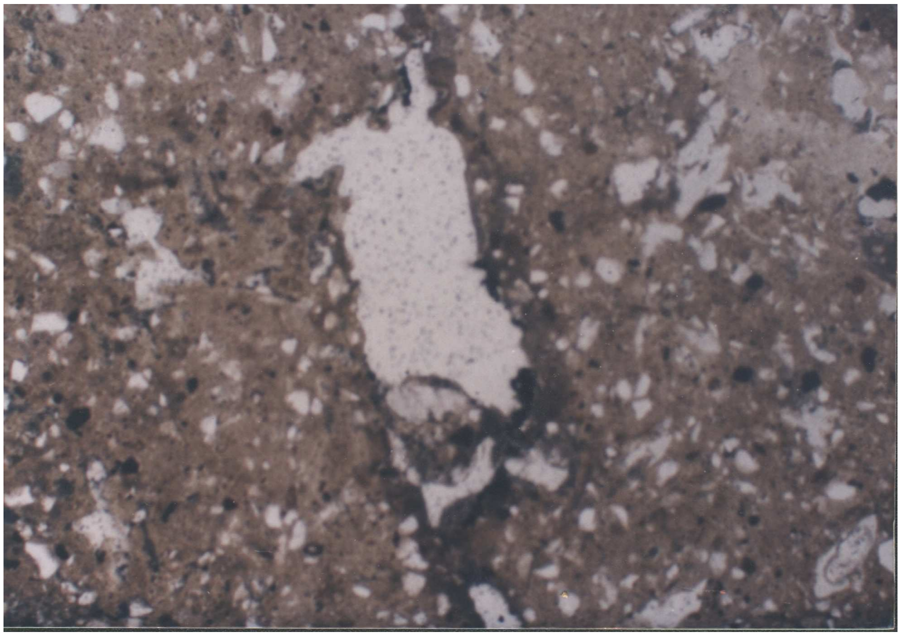


Figure (4) Vughy manganiferrans. Thin section under crossed polarizers, 80X.

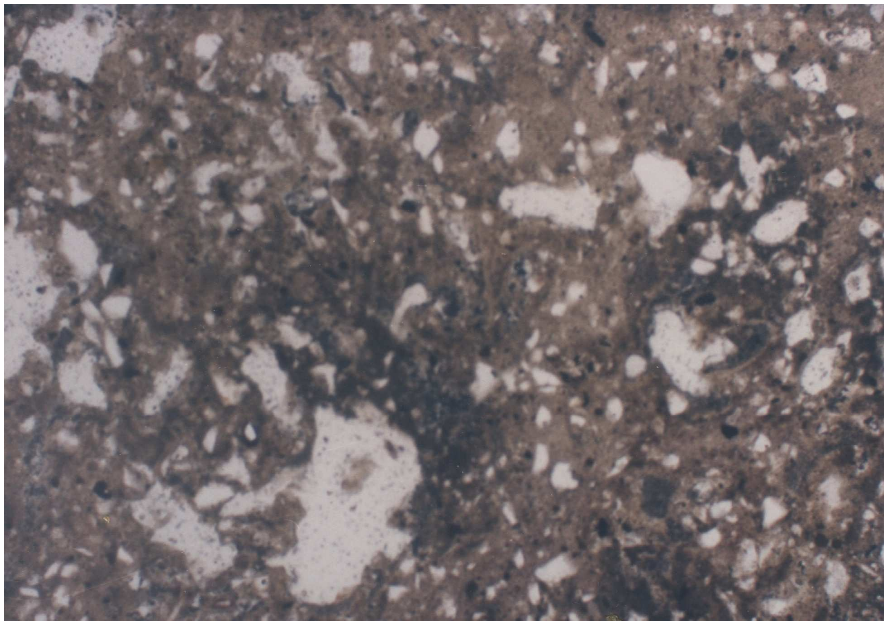


Figure (5) Vughy hypoferrans. Thin section under crossed polarizers, 80X.

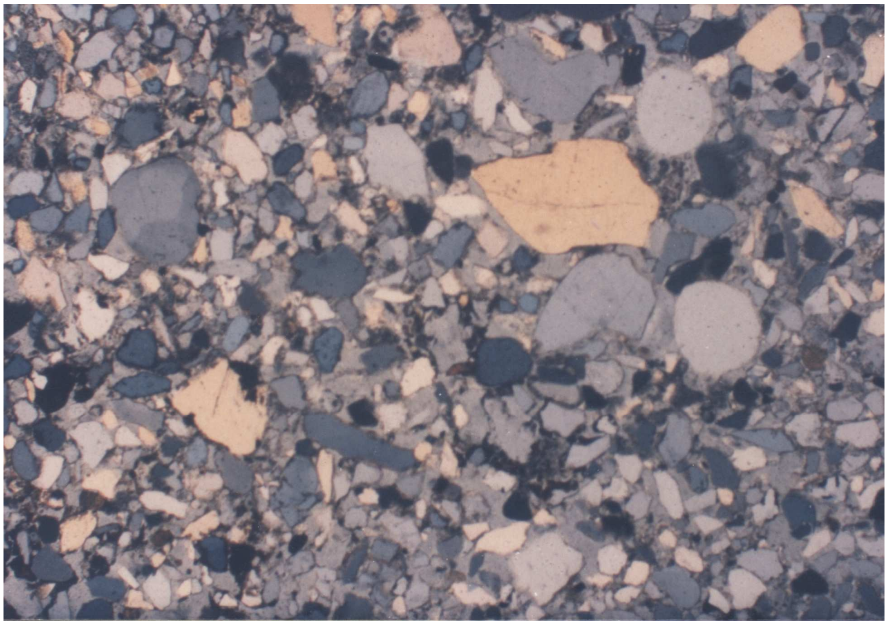


Figure (6) Skel ferriargillans. Thin section under crossed polarizers, 80X.

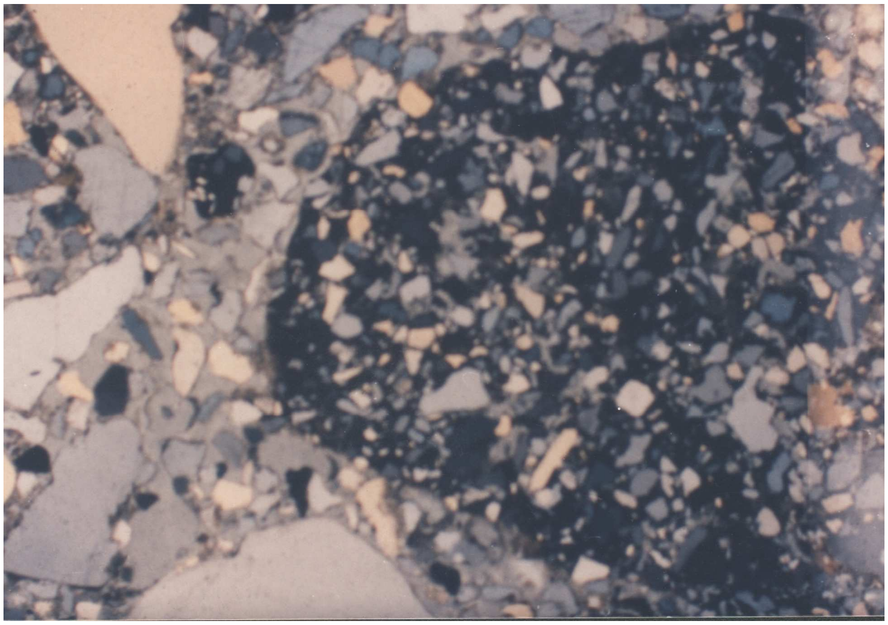
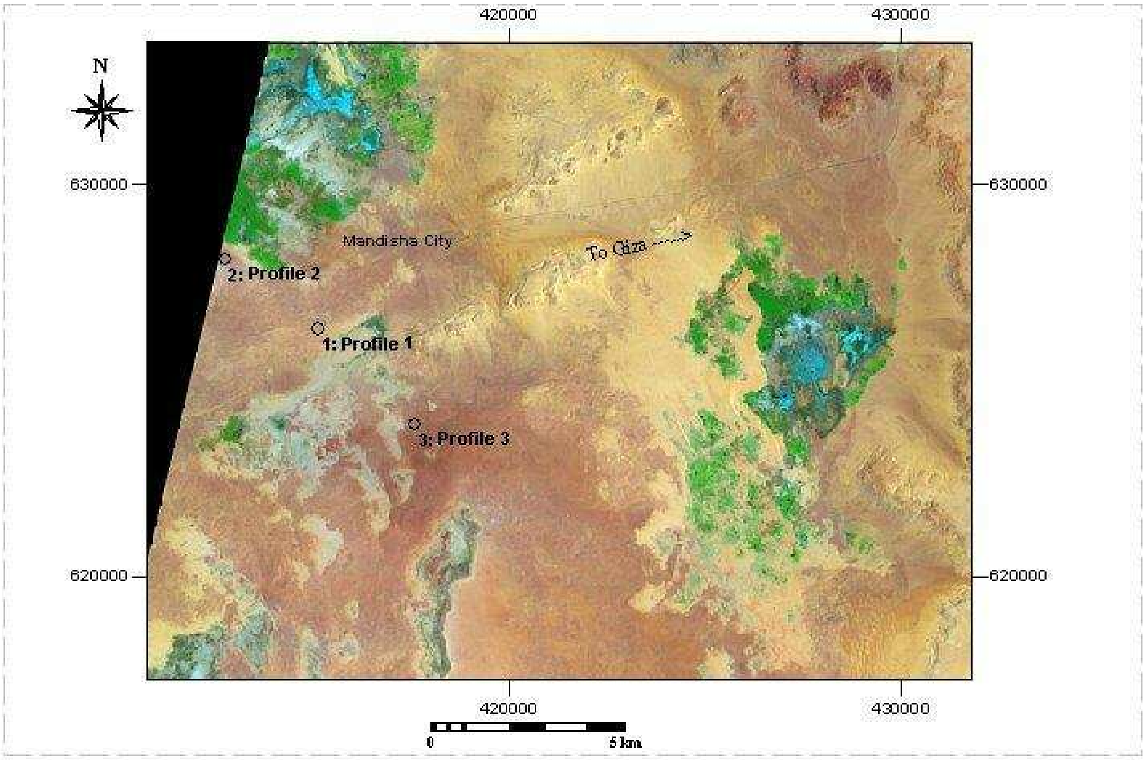


Figure (7) Undulic plasmic fabric and nodules of quartz grains cemented by iron oxides. Thin section under crossed polarizers, 80X.



Map 1 : Location map of the studied soil profiles overlaid on Land Sat TM image 741, (1998).

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دراسات على نشأة وتقسيم وتقييم بعض الأراضى الناشئة على الحجر الرملى الحديدى الواحات البحرية ، مصر

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تتميز الأراضى المصرية عامة بأرقام حموضة تقع فى المدى القلوي والقلوى الخفيف نظرا لظروف الجفاف السائدة والتى تشجع تراكم القواعد فى التربة .إلا إنه توجد بعض الحالات الشاذة لبعض الأراضى التى توجد بها حموضة موضعية أو مكتسبة نظرا لتركيبها المعدنى ولظروف تكوينها .اختيرت لهذه الدراسة ثلاثة قطاعات أرضية حامضية تقع فى الواحات البحرية بمحافظة الجيزة بمصر. وقد تراوحت قيم pH لهذة الأراضى بين 3.63 إلى 5.15 فيما عدا الأفق السطحى للقطاع رقم 3 حيث كانت قيمة ال pH له 9.1 وقد وصلت الحموضة المتبادلة لأيونى الألومنيوم والهيدروجين الى 3.3، 0.97على الترتيب. وقد أظهر الوصف الحقلى لهذه الأراضى وجود أفلام الطين مما يدل على غسيل الطين وتجمعه فى القطاع الأرضى مما يؤدى إلى تكوين الأفق الطينى Kandic horizon. كما أظهر أيضاً الوصف الحقلى وجود معادن أكاسيد حديد و ال jarosite. بينما أظهر الفحص كل من الأشعة السينية والميكروسكوب الألكترونى سيادة معدن طين الكاؤولينيت الذى هو أحد مظاهر الأراضى الحامضية، كما أكد الوصف الميكرمورفولوجى وجود أغلفة الطين (نقل الطين وتجمعه خلال القطاع الأرضي) وأغلفة أكاسيد الحديد مع الزمن. وقد تم تفسير ذلك نتيجة تعرض المنطقة لظروف بيئة رطبة فى العصور الجيولوجية القديمة والتى أنتجت مظاهر هذا التطور فى القطاع الأرضى والتى احتفظت به التربة تحت ظروف الجفاف الحالية .وقد تم تقسيم هذة الأراضى طبقا للتقسيم الأمريكى الى “Typic Haplosalids", "Plinthic Kandiudalfs” . و تم تقييم الأراضى المدروسة إلى رتبة الأراضي الصالحة للزراعة S2، S3 تبعاً لنظام Sys and Verheye (1978) لتقييم الأراضى.