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MINERALOGY OF THE CLAY FRACTION OF SOME SOILS IN THE WESTERN COASTAL LITTORAL OF EGYPT

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Seven soil profiles were selected to study the mineralogy of the clay fraction of the sediments representing the main geomorphic units in the calcareous western coastal littoral (the coastal plain and the lagoonal depression) in an attempt to throw light on their mineralogical composition.

Identification of clay and non-clay minerals was carried out using X-ray and K_2O content. The obtained results show that the studied soils are dominated by kaolinite together with palygorskite, illite and feldspars. The other associated minerals such as smectite (montmorillonite) and vermiculite are also present, yet in variable frequencies depending on the geomorphic units on which these soils are occurred.

Keywords: clay minerals, feldspars, illite, kaolinite, montmorillonite, palygorskite, vermiculite.

The Western Coastal Littoral of Egypt extends from Alexandria (longitude 29° 50` East) to El-Sallum (longitude 25° 10` West). As a result of the growing population in Egypt, the area has attracted the attention of many government bodies for planning of several agricultural and settlement projects. Accordingly, researches dealing with soils, water resources, geology and other aspects have been initiated in many parts along the coast (El-Demerdashe *et al.*, 1971; Ghanem, 1971; Harga, 1971; Abdel-Aal *et al.*, 1979 and Beshay, 1984). However, their data are somewhat contradictory and bear controversy in opinion. Moreover, some areas are not tackled yet, or their clay minerals are not identified properly.

In the present study, the geomorphic units covering the western coastal littoral are investigated with respect to their clay mineral composition. It is essentially a comprehensive mineralogical study aiming at identifying the clay mineral assemblages in the calcareous sediments forming the different geomorphic units of the coast.

MATERIALS AND METHODS

The geomorphic units of the calcareous coastal littoral were previously delineated by Sogreah (1961). Among these geomorphic units are the coastal plain and the lagoonal depression (Fig. 1), which are used as a base for the selection of the studied profiles. Accordingly, seven soil profiles representing these geomorphic units were selected for study as follows: profiles 1, 2, 3, 5, 6 and 7 which represent the coastal plain and profile 4 represents the lagoonal depression.

Separation of the clay fraction was undertaken after applying the essential pretreatments described by Jackson (1975). For X-ray diffraction (XRD) analysis, oriented preparation was performed by depositing a clay suspension onto a glass slide (Srodon *et al.* 1986; Cuadros and Linares, 1995). XRD analysis was conducted in two steps: a qualitative step and a semi-quantitative one. For qualitative identification, XRD patterns were recorded on air-dried, glycolated samples and after heating at 550 °C for 4 hours. The second step help to identify kaolinite, which dehydroxylates between 550 °C and 600 °C and becomes amorphous to X-rays (Moore and Reynolds, 1989). The quantitative interpretation was performed on XRD patterns obtained from glycolated specimens. All XRD patterns were obtained using a Philips PW 3710 installation supplied with a horizontal goniometer and a vertical object plane, using Ni-filtered Cu radiation (40 kV operating voltage and current of 35 mA).

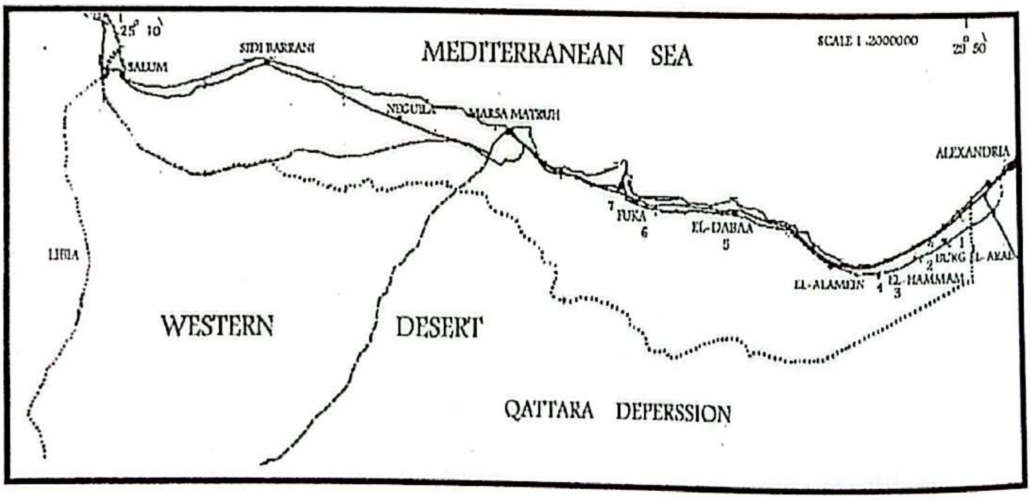

Fig.(1). Key map of the studied area in the western coastal littoral of Egypt.

RESULTS AND DISCUSSION

Data in table (1) show that the studied soils are mainly composed of sand and silt with low amounts of clay. The soils are non-saline to extremely saline where EC values ranged from 0.6 to 140.9 dSm^{-1} with the average of 12.19 dSm^{-1}. The lowest value was found in the deepest layer of profile 7 of the coastal plain of Fuka, while the highest value was recorded in the surface layer of profile 4 of the lagoonal depression of El-Hammam. The total carbonate content varies widely between 19.5 % and 66.0 %. The lowest content was observed in the surface layer of profile 4 of the lagoonal depression of El-Hammam, while the highest content was detected in the deepest layer of profile 5 of the coastal plain of El-Dabaa. The cation exchange capacity ranged between 20.5 and 52.3 $me100g^{-1}$ clay with the average of 34.4 $me100g^{-1}$ clay. The lowest value was related to the loamy sand soil of the surface layer of profile 7 of the coastal plain of Fuka, while the highest value was recorded in the loamy sand soil of the surface layer of profile 3 of the coastal plain of El-Hammam.

The mineralogical composition of the clay fraction (< 2u) separated from the representative soil profiles are shown in table (2) and figs. (2 and 3). From such table and figures, the following discussion could be worked out.

X-ray diffraction patterns of the clay fraction representing the studied soils of the coastal plain (Figs. 2a to 2e), denote that the clay minerals characterizing the soils of the Egyptian western coast are dominated by (kaolinite) which is identified by its basal reflections (001 and 002) at about 7.14 to 7.31 and 3.58 to 3.60 °A, respectively, where it constitutes 25 to 62 % of the clay minerals content. The lowest content was found in the surface layer of profile 3 of El-Hammam, while the highest content is that of the surface layer of profile 7 of Fuka. Palygorskite is detected in relatively lower amount than kaolinite where its content ranged between 1.0 and 55 % of the clay minerals content. The lowest content was found in the subsurface layer of profile 6 of Fuka, while the highest content was recorded in the subsurface layer of profile 3 of El-Hammam, this increase in palygorskite content, may be due to the presence of more favorable conditions for palygorskite formation in the subsurface layer (soluble salts and $CaCO_3$) than the surface layers (Ghanem, 1971). Illite is the third predominant mineral, as indicated by its basal reflection (001) at 10.04 °A, it constitutes 3 to 28 % of the clay minerals. The lowest content was recorded in the subsurface layer of profile 3 of El-Hammam, while the highest content was found in the subsurface layer of profile 7 of Fuka. The other associated minerals are; moderate amounts of feldspars (2 to 23 %) or traces of smectite (montmorillonite) and quartz, while vermiculite is only detected in some layers of the studied profiles in less pronounced amounts.

TABLE (1). Some physical and chemical properties of the studied profiles.

location & profile No.	depth, cm	soil separates %			textural class	CEC me100g^{-1} clay	PH (paste)	EC dSm^{-1}	$CaCO_3$ %
		sand	silt	clay					
Burg El-Arab 1	0-20	66.8	27.5	5.7	S.L	29.9	7.6	9.3	42.5
	20-50	67.5	25.1	6.8	S.L	32.4	7.5	3.4	41.7
	50-90	69.1	25.6	5.3	S.L	27.1	7.7	2.1	40.2
Burg El-Arab 2	0-20	66.1	27.0	6.9	S.L	30.2	7.5	3.5	37.1
	20-35	71.0	24.1	4.9	S.L	43.0	7.5	5.4	48.6
	35-75	77.5	21.2	1.3	S.L	28.2	7.7	3.7	46.9
	75-110	66.5	22.7	10.8	S.L	33.2	7.6	2.9	49.2
El-Hammam 3	0-30	78.6	16.9	4.5	L.S	52.3	7.8	3.3	61.3
	30-55	72.8	24.0	3.2	S.L	41.9	7.8	2.5	59.8
	55-80	67.0	21.4	11.6	S.L	42.4	7.9	1.8	60.4
	80-110	73.6	10.1	6.3	L.S	36.1	7.6	2.5	64.0
El-Hammam 4	0-5	87.8	7.1	5.1	S	31.8	7.8	140.9	19.5
	5-20	67.6	25.2	7.2	S.L	37.8	7.6	50.3	30.9
El-Dabaa 5	0-20	66.0	28.1	0.9	S.L	42.8	8.5	0.9	45.0
	20-45	68.0	21.9	10.1	S.L	37.0	8.4	0.7	47.1
	45-70	52.0	28.0	20.0	S.C.L	29.4	8.2	0.7	66.0
Fuka 6	0-15	69.3	20.4	10.3	S.L	51.0	7.9	18.1	28.2
	15-35	66.8	30.1	3.1	S.L	37.7	8.5	6.2	30.1
	35-70	67.3	28.1	4.6	S.L	32.6	8.1	6.7	34.7
	70-100	66.4	30.9	2.7	S.L	29.5	8.4	10.0	50.0
Fuka 7	0-20	74.2	24.1	1.7	L.S	20.5	8.6	3.5	32.0
	20-60	69.8	25.1	5.1	S.L	22.5	8.3	1.4	47.1
	60-100	70.8	24.3	4.9	S.L	21.8	8.7	0.6	52.3

S.L. = Sandy Loam L.S. = Loamy Sand S. = Sand S.C.L. = Sandy Clay Loam

X-ray diffraction patterns of profile 4 representing the soils of the lagoonal depression of El-Hammam are shown in fig. (3). These soils contain high amount of $CaCO_3$ and extremely affected with salts. The mineralogical composition of clay reveals no significant differences between the clay mineral types of the lagoonal and the coastal plain soils.

Considering the depthwise distribution of clay minerals, data in table (2) showed that the clay minerals of the successive layers of the same profile have similar mineral species (Table 2) with somewhat different frequencies; *i. e.* smectite increases with depth in all the studied soils except for the soils of profile 1 of Burg El-Arab and profiles 6 and 7 of Fuka where smectite content decreases with depth. On the other hand, palygorskite increases with

TABLE (2). Mineralogical composition of the studied soil clays using X-ray analysis.

location & profile No.	depth, cm	K_2O % of clay	Mineralogy						
			Sm.	Vm.	Kaol.	I	Paly.	Feld.	Qz.
Burg El-Arab 1	0-20	3.2	tr	-	++	+	+	tr	tr
	20-50	3.1	tr	-	++	+	+	tr	-
	50-90	3.2	tr	-	++	+	+	tr	tr
Burg El-Arab 2	0-20	2.6	tr	-	++	+	+	+	tr
	20-35	2.7	tr	tr	++	+	+	tr	tr
	35-75	3.0	tr	-	++	+	+	+	tr
	75-110	2.3	tr	tr	++	+	+	+	tr
El-Hammam 3	0-30	3.3	tr	tr	+	+	++	tr	-
	30-55	2.1	tr	-	+	tr	+++	+	-
	55-80	2.1	tr	-	+	tr	+++	+	-
	80-110	3.3	tr	-	++	+	++	tr	-
El-Hammam 4	0-5	2.9	tr	-	++	+	+	tr	-
	5-20	0.7	tr	-	++	tr	+	+	-
El-Dabaa 5	0-20	2.6	tr	tr	++	+	+	tr	-
	20-45	3.1	tr	tr	++	+	+	tr	-
	45-70	3.6	tr	-	++	+	+	+	tr
Fuka 6	0-15	3.4	tr	tr	+++	+	tr	+	tr
	15-35	3.3	tr	tr	++	+	tr	+	-
	35-70	3.0	tr	tr	++	+	tr	+	tr
	70-100	2.6	tr	tr	++	+	tr	+	tr
Fuka 7	0-20	1.6	-	-	+++	tr	++	tr	-
	20-60	4.8	-	-	+++	++	tr	+	tr
	60-100	4.2	-	-	++	+	tr	+	tr

Sm.: smectite I: illite Kaol.: kaolinite Paly.: palygorskite. Qz. : quartz Vm.:vermiculite
tr = traces (10%) Feld = Feldspars + = (10-25%) ++ = (25-50%) +++ = (50-75%)
++++ = (>75%) - = not detected

depth in the soil profile 6 of Fuka. Also very small amounts of vermiculite were detected in some layers of the studied profiles.

Confirmation of the X-ray analysis was made by the determination of cation exchange capacity and the potassium content, values obtained were found conformable with those outlined by Grim (1953). Fig. (4) shows a highly significant positive correlation between smectite % and cation exchange capacity, and fig. (5) shows a highly significant positive correlation between K_2O % and illite %.

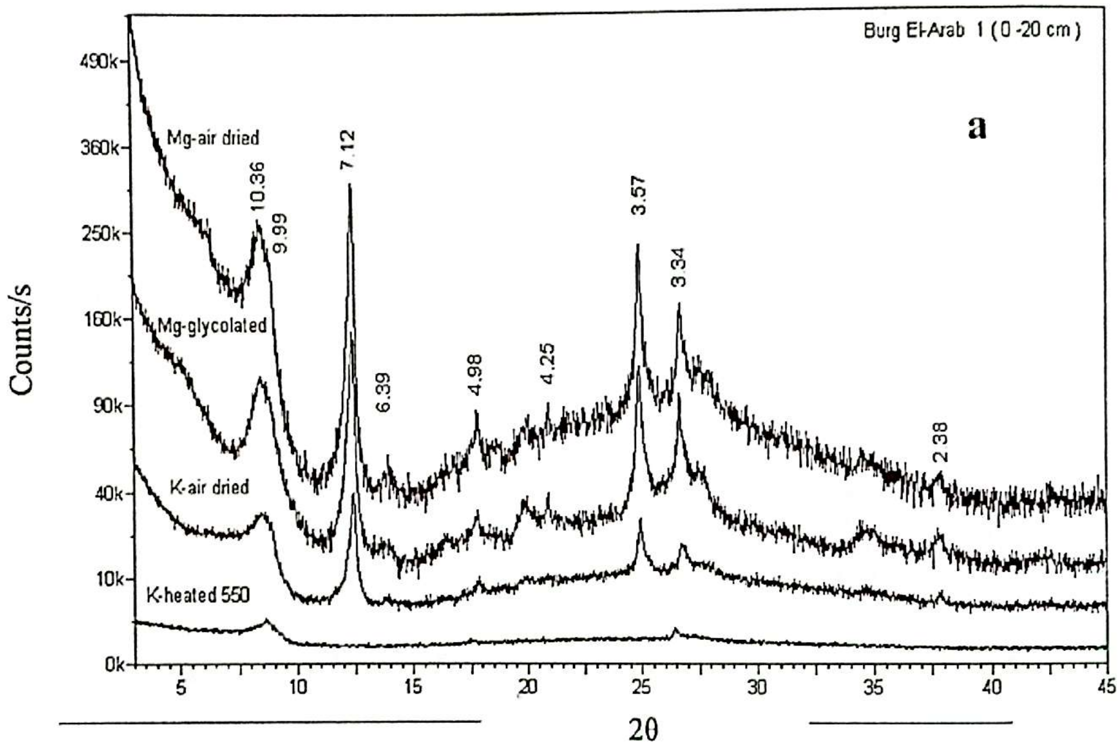

Fig. (2a). X-Ray diffractograms of the clay fraction soil representing the coastal plain of Burg El-Arab 1(0-20 cm).

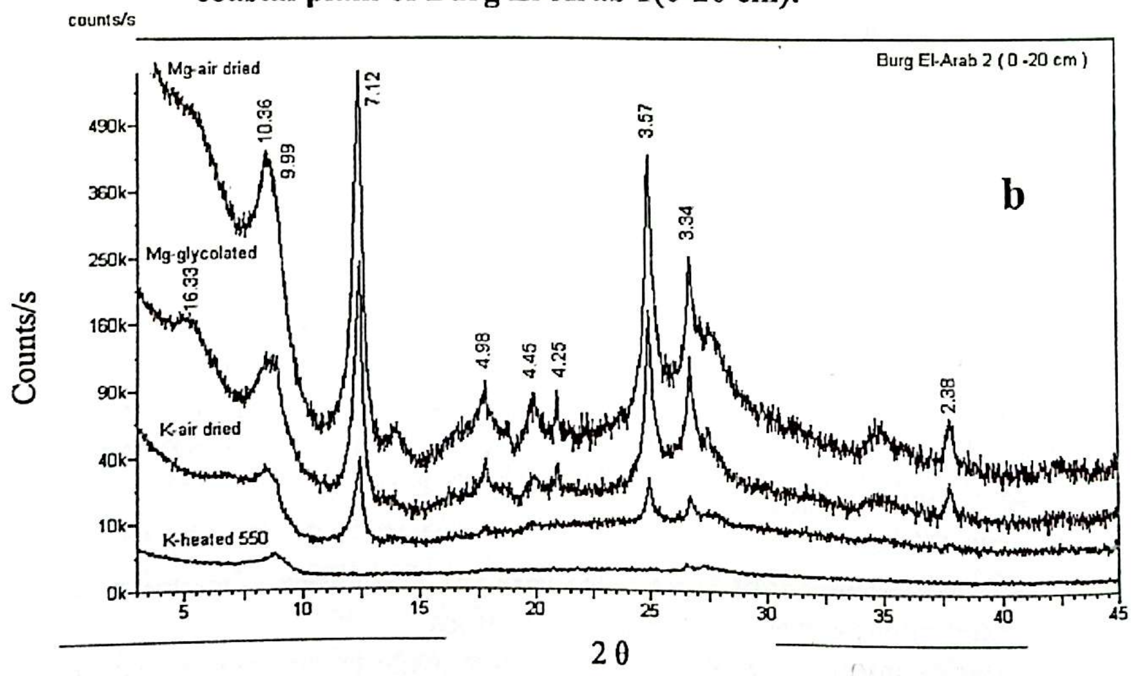

Fig. (2b). X-Ray diffractograms of the clay fraction soil representing the coastal plain of Burg El-Arab 2(0-20 cm).

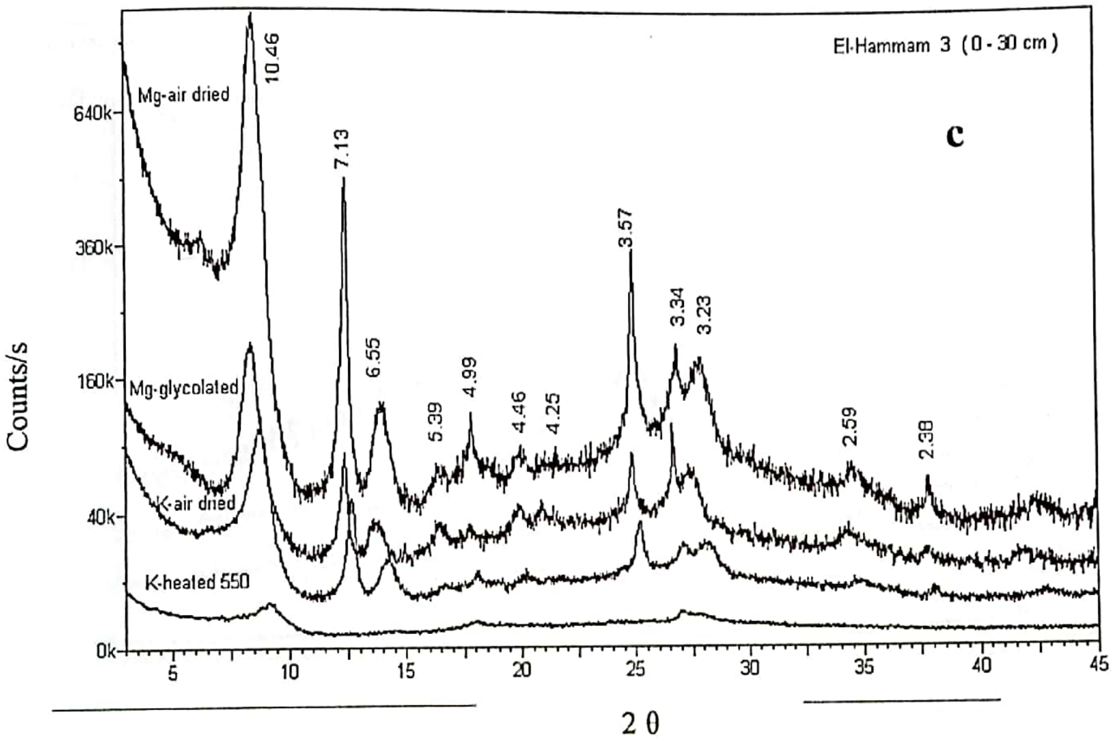

Fig. (2c). X-Ray diffractograms of the clay fraction soil representing the coastal plain of El-Hammam 3(0-30 cm).

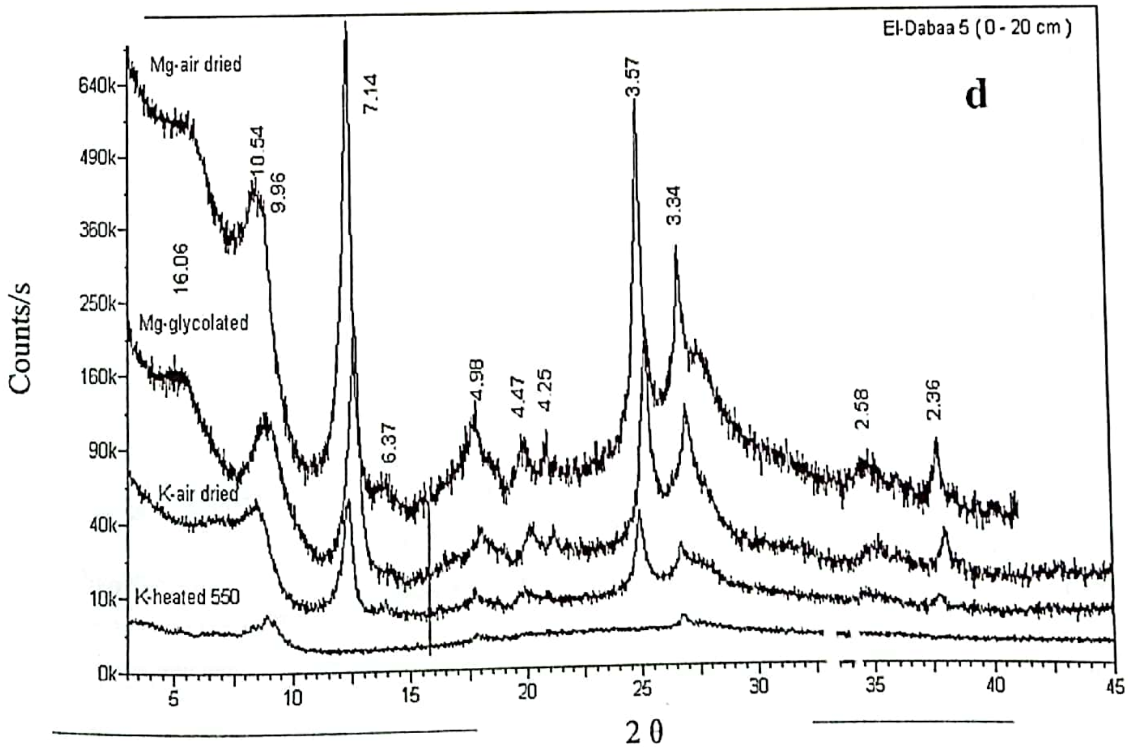

Fig. (2d). X-Ray diffractograms of the clay fraction soil representing the coastal plain of El-Dabaa 5(0-20 cm).

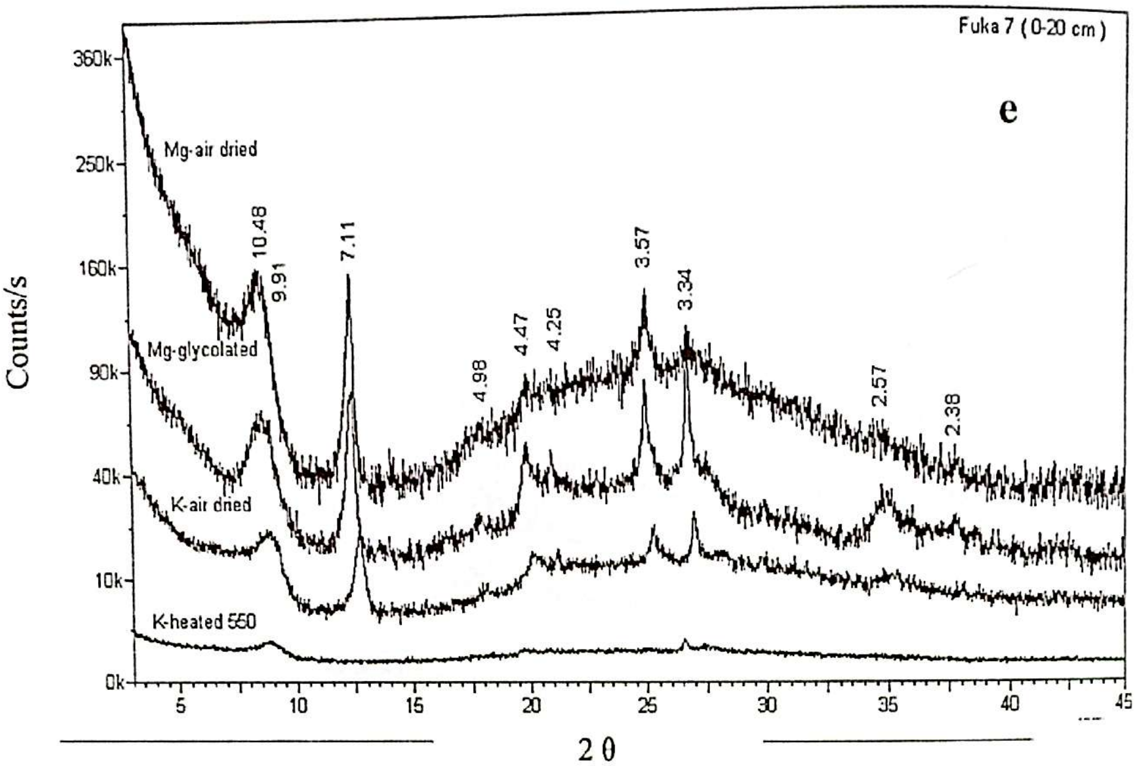

Fig. (2e). X-Ray diffractograms of the clay fraction soil representing the coastal plain of Fuka 7(0-20 cm).

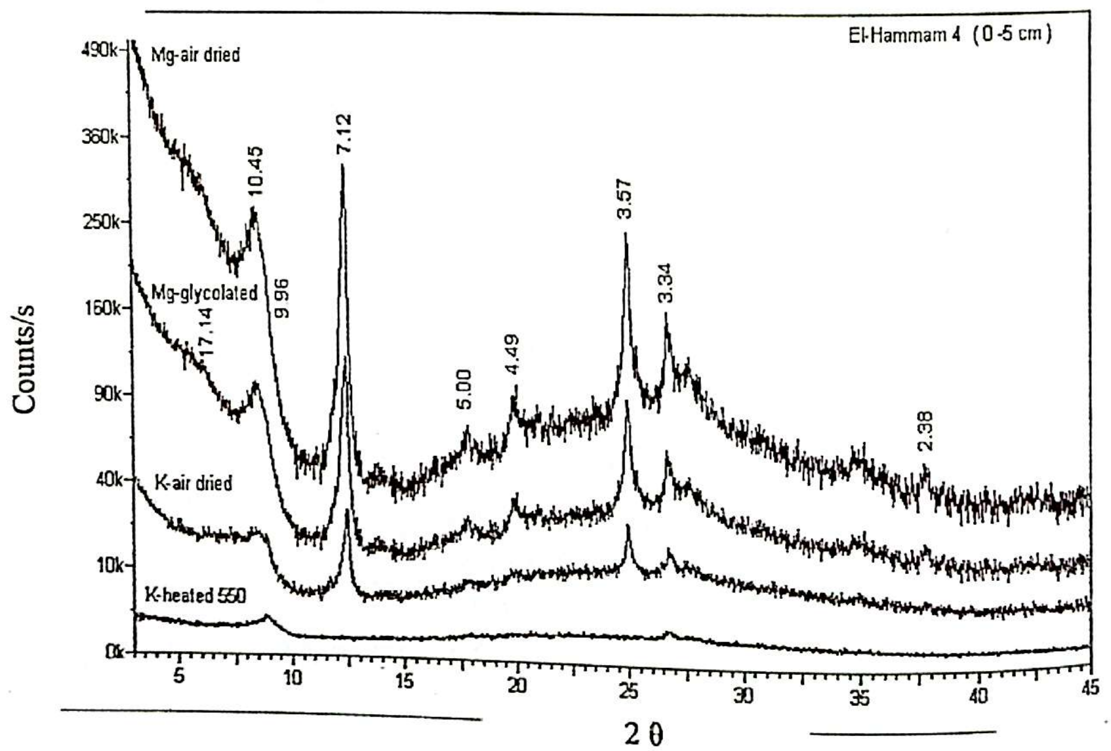

Fig. (3). X-Ray diffractograms of the clay fraction of some selected soil samples representing the lagoonal depression of El-Hammam.

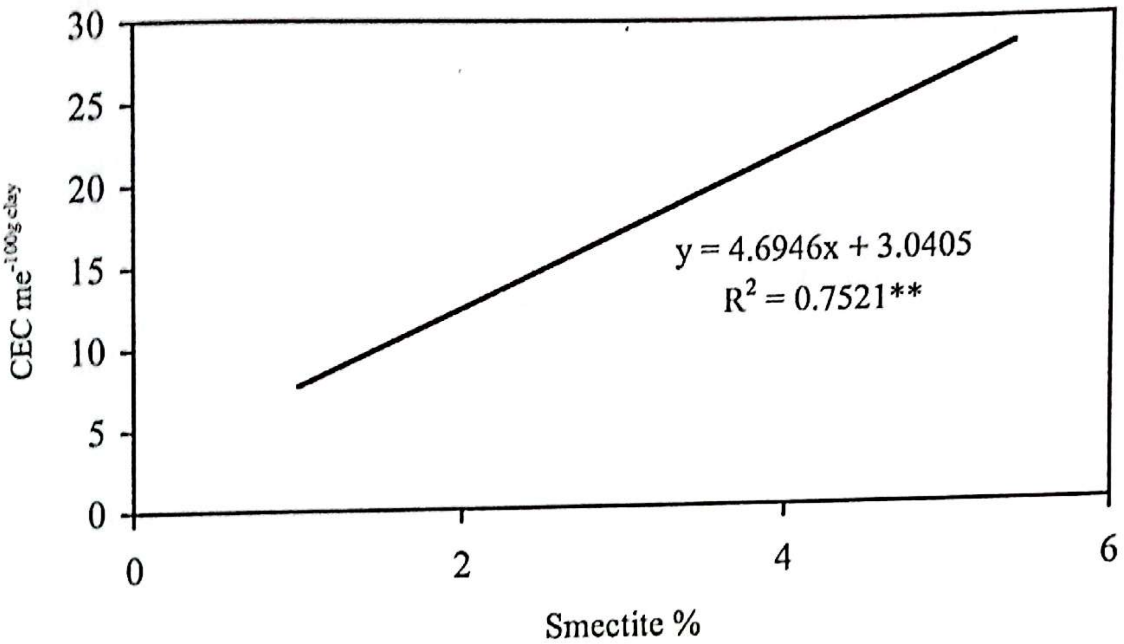

Fig. (4). Relationship between smectite % and CEC of the clay fraction of soils of the western coastal littoral of Egypt.

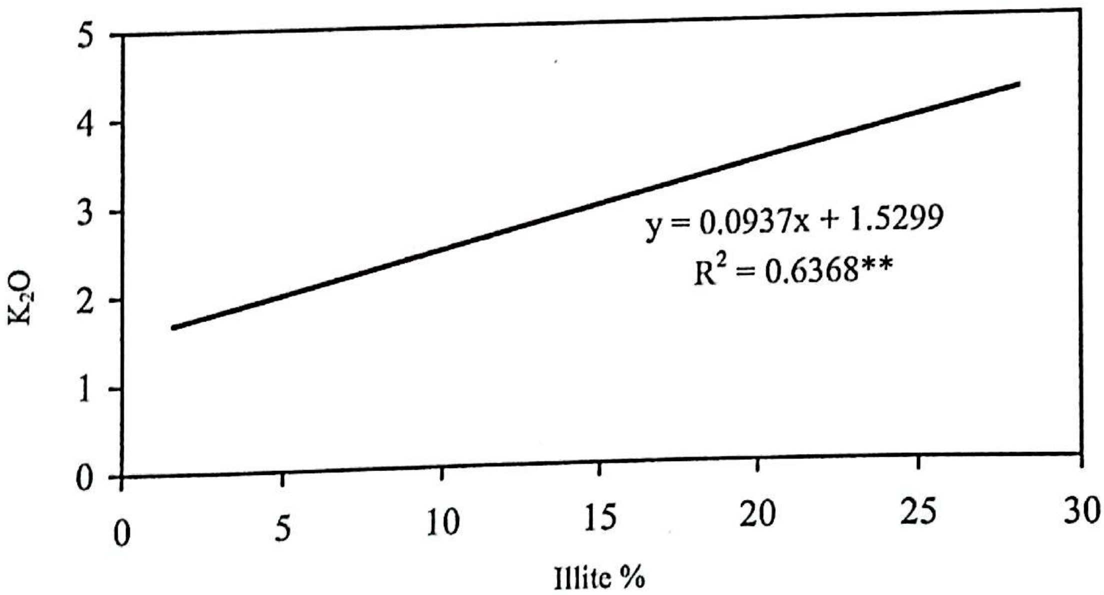

Fig. (5). Relationship between illite % and K_2O in the clay fraction of soils of the western coastal littoral of Egypt.

In order to assess the origin of clay minerals in the studied soils, the clay fractions less than 2 u were separated after the removal of $CaCO_3$ from the collected soil samples. Kaolinite, palygorskite, illite and the expected mineral at 14 °A were characterizing the limestone rocks.

Many workers discussed the origin of clay minerals in soils and rocks, e.g. Grim (1953), Weaver (1957) and Mackenzie (1967). Four modes of origin were recognized by Mackenzie (1967): 1) inheritance from the parent material, 2) alteration and degradation of primary minerals, 3) synthesis and, 4) addition.

Under the prevailing aridity and buffering action of calcium carbonate, chemical weathering is limited, so palygorskite, illite and kaolinite are most likely inherited from the parent limestone rocks. El-Kady (1970), Harga (1971) and El-Demerdashe *et al.* (1971) in their studies on Mariut and Burg El-Arab areas reached the same conclusion. It remains to assess the origin of the other associated minerals, *i. e.* smectite. Harga (1971) in his study on Mariut area reported the presence of montmorillonite in the lagoon profiles and attributed its presence to formation other than the highly calcareous one. El-Kady *et al.* (1972) believed that montmorillonite is originated from the lacustrine deposits, as it is not present in the lagoon depression.

From table (2) one can guess that smectite (montmorillonite) is not detected in the rock fragments but the occurrence of shale and marl beds in the tableland strata could possibly contribute to these minerals. It also seems more important that smectite (montmorillonite) is associated with deposition under lagoonal conditions. Similar findings were reported by Weaver (1957).

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التركيب المعدني لمكون الطين لبعض أراضي الساحل الشمالي الغربي بمصر

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أختيرت سبعة قطاعات أرضية لدراسة التركيب المعدني لمكون الطين بالرواسب الممثلة للوحدات المورفولوجية الرئيسية بالساحل الشمالي الغربي وهي : The coastal plain, Lagoonal depression وذلك في محاولة لإلقاء الضوء علي التركيب المعدني لها.

تم التعرف علي معادن الطين بإستخدام الأشعة السينية ومحتوي هذه المعادن من أكسيد البوتاسيوم. وقد أوضحت النتائج أن الأراضي المدروسة يسود بها معدن الكاؤلينيت والباليجورسكيت يليهما معدن الأليت ثم الفلسبارات، هذا بالأضافة الي بعض معادن مجموعة السمكتيت مثل المونتموريللونيت ، والفرميكوليت والتي وجدت بكميات قليلة.