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Characteristics of some Vertisols in Egypt

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SIX SOIL profiles representative of some Vertisols in Egypt have been investigated to reveal their main characteristics of these soils. Five soil profiles (nos. 1-5) were taken from the cultivated soils of the Nile Valley and Delta and one profile was taken from the non cultivated ones in Kharga Depression. The results show that all the profiles have cracks when dry. The depth and width of the cracks varied from one location to another depending on the clay content, moisture condition and salinity. Gilgai microrelief was difficult to be recognized in the cultivated soils under study due to the levelling processes. In non irrigated soils, the gilgai is very common. Slickensides were present in the irrigated Vertisols of the Nile Valley and Delta at the depth between 30 and 80 cm however, in the non irrigated Vertisols of Kharga Depression, the slickensides are present throughout the whole profile to the depth of 110 cm. Soil structure was mainly granular in the surface layers and parallelepiped in the subsurface ones in the soils of the Nile deposits; the Vertisols of Kharga Depression have mainly parallelepiped structure. The data of mechanical analysis indicate that the studied soils have more than 30% clay. Some chemical properties were discussed. The cultivated clay soils of well drained conditions in the Nile Delta are classified as Torrerts. They belong to Haplotorrerts at the great group level. The non cultivated Vertisols are classified as Torrerts at the suborder level. They belong to the Calcitorrerts at the great group level.

Keywords: Vertisols, Characteristics, Nile Valley and Delta, Egypt .

Egypt is located in arid region. Its climate is characterized by its hot dry summer, the maximum temperature may reach 35° and mild winter and the minimum temperature may reach 6 ° with an average of about 21°. The rainfall is low; it reaches about 150 mm in the northern coast and decreases gradual to reach about 20 mm in Cairo. The agriculture is depending mainly on irrigation from the River Nile.

Vertisols are wide distributed in Egypt; they occupy about 35% of the area of the Nile Valley and Delta, (Hamdi *et al.*, 1982). They are also present in some depressions in the western desert.

According to the (USDA, 2003) Vertisols are soils that have the following features; 1) A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral

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soil surface, that has either slickensides or wedge-shaped peds; and 2) A weighted average of 30 percent or more clay (mainly smectites) in the fine-earth fraction; 3) Cracks that open and close periodically; and 4) Gilgai microrelief unless irrigated.

Concerning the classification of Vertisols, six suborders are recognized in the Vertisols order USDA (2003). They are differentiated by aquic conditions, soil moisture regime, and the cracking characteristics of the soil. Although the formative elements for soil moisture regimes are used in naming Xererts, Torrerts, Usterts, and Uderts, the names do not necessarily mean that the soils have those soil moisture regimes. Several soil moisture regimes are considered at subgroup level ranging from dry to wet conditions.

The aim of this work is to study the characteristics of Vertisols in Egypt under irrigation and non-irrigation conditions and to discuss their classification.

Material and Methods

Six soil profiles were studied from different locations to represent the Vertisols of Egypt; four soil profiles (No. 1- 4) are from the Nile Delta; one profile (No. 5) from the Nile Valley and one profile from Kharga Depression (No. 6). Location of the studied profiles is shown on the map (Fig. 1).

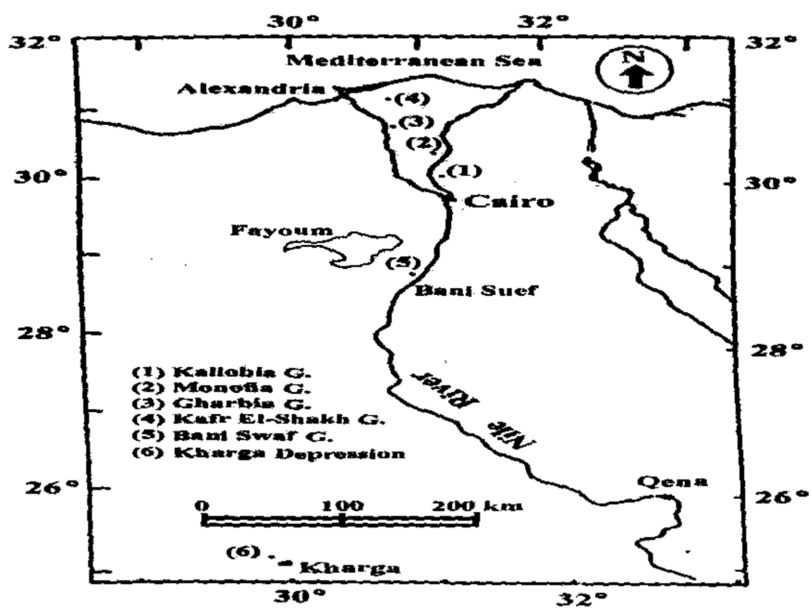

Fig.1. Location map of the studied soil profiles.

In each location a profile was dug to a depth of approximately 120 cm. The profiles were described morphologically according to FAO (1990). Special attention was paid to the crack characteristics (*i.e.*, width, depth, shape, and abundance) gilgai microrelief and the presence of slickensides.

Soil samples were collected from the profiles for different analyses. The samples were air dried and the less than 2 mm particles were used for physical and chemical analyses. The mechanical analysis was carried by pipette method . Calcium carbonate was determined using the Collins Calcimeter. Some physical and chemical analyses of the soil samples were carried out according to Jackson (1973) and Richards (1954).

Results and Discussions

Soil morphology

Morphological description of the studied profiles

The soils of the alluvial Nile deposits are represented by profiles 1 to 5 which are characterized by remarkable cracks specially in the dry conditions (the end of growing seasons) and soil color ranges from dark brown and dark grayish brown. Soil texture varies from silty clay loam, clay loam, silty clay to clay. Structure varies from granular in the surface layers to blocky in the subsurface layers with distinct slickensides (Table 1).

Profile No. 6 in Kharga Depression is formed from lacustrine deposits and is characterized by soil color from brown to yellowish brown, clay texture, blocky structure, slickensides and many gypsum crystals in the subsurface layers.

In the following paragraphs these is a description of the field observations for the most prominent morphological characteristics of the studies profiles.

Cracks

Vertisols by definition (USDA, 2003) have at some periods in most years, cracks that open to the surface or to the base of the plow layer or surface crust, and are at least 1 cm wide at a depth of 50 cm unless the soil is irrigated. Cracks in Vertisols with granular surface horizons become partly filled with granules from this layer during the dry season.

In irrigated Vertisols, represented by profiles 1 to 5, the cracks appear at soil surface in hexagonal and partially hexagonal patterns of rounded edges. They are mainly about 2 cm width and 60 cm deep, and are partially filled with surface materials and some plant residues. Profiles 1 and 2 are taken from areas cultivated with cotton or maize on rows. In such conditions the cracks in furrows are rather deeper and wider than those in the higher positions. Similar observations were obtained by Ahmed (1983).

TABLE 1. Morphological characteristics of the studies soil profiles.

Prof. No.	Horizon/ depth cm	Profile description
1	Ap (0 – 30)	Dark brown (10YR 3/3) moist; silty clay loam; granular structure; cracks (3 cm); coarse roots; clear boundaries.
	Ac (30 – 60)	Very dark grayish brown (10YR 3/2) moist; clay; subgranular blocky structure;cracks; distinct slickensides; fine roots; lime nodules; diffuse boundaries.
	C1 (60 – 100)	Very dark grayish brown (10YR 3/2) moist; clay; subgranular blocky structure; few cracks; distinct slickensides; few fine roots; diffuse boundaries.
	C2 (100 - 130)	Very dark grayish brown (10YR 3/2) moist; clay; subgranular blocky structure; distinct slickensides.
2	Ap (0 – 30)	Very dark brown (10YR 2/2) moist; clay loam; granular structure; many cracks (5 cm); coarse roots; clear boundaries.
	Ac (30 – 60)	Very dark grayish brown (10YR 3/2) moist; clay; blocky structure; cracks; distinct slickensides; fine lime nodules; many fine roots; diffuse boundaries.
	C1 (60 – 90)	Dark brown (10YR 3/3) moist; clay; blocky structure; few cracks; some slickensides; fine root; diffuse boundaries.
	C2 (90 - 120)	Dark brown (10YR 3/3) moist; clay; subangulare blocky structure; few slickensides.
3	A (0 – 5)	Very dark brown (10YR 2/2) moist; silty clay; massive; salt crystals; clear boundaries.
	Ac (5 – 30)	Very dark brown (10YR 3/2) moist; clay; blocky structure; distinct slickensides; few lime accumulations; many fine root; diffuse boundaries.
	C1 (30 – 75)	Very dark brown (10YR 3/2) moist; clay; blocky structure; few lime accumulations; diffuse boundaries.
	C2 (75 – 125)	Very dark brown (10YR 3/2) moist; clay; subangulare blocky structure; few cracks; distinct slickensides.
4	Ap (0 – 25)	Dark grayish brown (10YR 4/2) moist; silty clay; granular structure; cracks (3 cm); few fine nodules; few root; clear boundaries.
	Ac (25 – 50)	Dark brown (10YR 3/3) moist; clay; blocky structure; distinct slickensides; few cracks; few root; diffuse boundaries.
	C1 (50 – 75)	Dark grayish brown (10YR 4/2) moist; clay; blocky structure; few distinct slickensides; some lime accumulations; few root; diffuse boundaries.
	C2 (75 – 110)	Dark grayish brown (10YR 4/2) moist; clay; blocky structure.
5	Ap (0 – 25)	Yellowish brown (10YR 5/4) moist; clay; granular structure; cracks (2 cm); diffuse boundaries.
	Ac (25 – 50)	Yellowish brown (10YR 5/4) moist; clay; blocky structure; cracks; common slickensides; many lime formations; many gypsum crystals of needle shape; diffuse boundaries.
	C1 (50 – 75)	Yellowish brown (10YR 5/4) moist; clay; blocky structure; cracks; few slickensides; many gypsum crystals; diffuse boundaries.
	C2 (75 – 120)	Brown (10YR 5/3) moist; clay; blocky structure; gypsum crystals.
6	A (0 – 30)	Yellowish brown (10YR 5/4) moist; clay; blocky structure; few lime accumulations; cracks; some spots of anhydrite; diffuse boundaries.
	Ac (30 – 60)	Brown (10YR 5/3) moist; clay; blocky structure; slickensides; many gypsum crystals; clear boundaries.
	C1 (60 – 90)	Brown (10YR 4/3) moist; clay; blocky structure; slickensides; many gypsum crystals; sharp boundaries.
	C2 (90 – 120)	Brown (10YR 4/3) moist; clay; ; blocky structure; slickensides; many gypsum crystals.

Furthermore there are more cracks in the furrows than in the higher places because the differences in moisture content between wet and dry periods are more remarkable. In the higher places the surface is affected by self mulching, so that the subsurface layers have always higher moisture content compared to those in furrows. The relatively high moisture content permits the formation of intensive cracking. In the areas cultivated with Berseem (Alfalfa), represented by profiles No. 3 and 4, the cracks are narrower (1 - 2 cm) and less deep (30 - 40 cm) than those in the areas planted with cotton and maize. The moisture conditions of the soil due to irrigation affect the depth and the width of cracks. The cracks in profile No. 5 are even much narrower and shallower. They are 1.0 cm wide and 25 - 30 cm deep. This is due to the moisture.

In non irrigated Vertisols, represented by profile No. 6 from Kharga Depression, many cracks are present at the surface layer (Fig. 2). The cracks are very wide from 10 to 20 cm and very deep (reaching 110 cm). Most of these cracks are filled completely or partially with surface granules moved down by gravity from the crack sides or by any other mechanical action (wind, animal, man, ..). In some locations the cracks are connected at a depth of about one meter due to churning of the whole pedon leaving hollows (about 30 cm in width) which is called locally "Nawoase" (Fig. 3). These hollows are wide enough to allow some small animals such as rats or rabbits to escape inside them. The absence or rare precipitation does not allow the cracks to close. However, in some years heavy rainfall causes the close of the cracks.

Gilgai microrelief

Gilgai is the microrelief that is typical of clayey soils that have a high coefficient of expansion with changes moisture content and that also have distinct seasonal changes in moisture content. The microrelief consists of either a succession of enclosed microbasin and microknolls in nearly level area, or microvalleys and microridges that run up and down the slope. The height of the microridges commonly ranges from a few centimetres to 1 m (USDA, 2003).

The gilgai formation is difficult to be recognized in the irrigated Vertisols due to the continuous levelling of soil surface for better distribution of irrigation water. However slight formation could be observed in the cultivated fields under certain crops at the end of their growing season due to the continuous effect of swelling and shrinkage processes. In non irrigated Vertisols of Kharga Depression, the formed gilgai microrelief is very common.

Slickensides

Slickensides are polished and grooved surfaces that are produced by one mass sliding past another. Some of them occur at the base of a slip surface where a mass of soil moves downward on a relatively steep slope. Slickensides are very common in swelling clay in which there are marked changes in moisture content (USDA, 2003). Studies on the Vertisols from different places in Egypt revealed the presence of slickensides in the subsurface layers of the Vertisols of the Nile Delta, and in some soils of Kharga Depression (Labib, 1970).

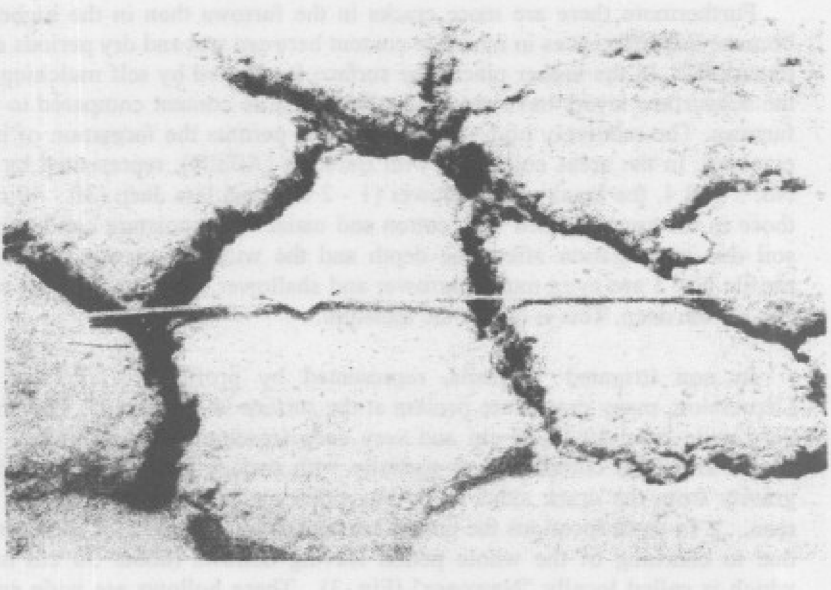

Fig.2. Cracks of Vertisols in Nile Delta.

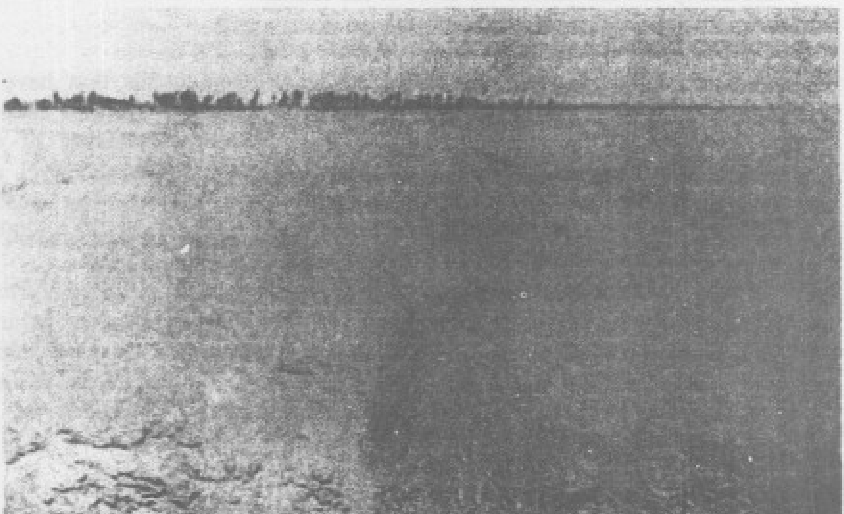

Fig.3. Very wide and deep cracks, Kharga Depression .

The polished surfaces (slickensides) could be observed on the soil aggregates in all soil profiles under study. The depth at which slickensides are present and their abundance differ from one profile to another.

In the Nile Delta and Valley, most of soil aggregates present at depths between 50 and 80 cm have polished surfaces.

In Kharga Depression, slickensides are present throughout the whole profile below the surface layer. Most aggregates have well developed and distinct slickensides in all layers to the depth of 110 cm. The very deep cracks are the main factor affecting the distinction and development of slickensides throughout the different layers of profile No. 6.

Yaalon & Kamar (1978) reported that the depth of the soil at which the development of slickensides is active determined largely by the depth of cracking.

Soil physical properties

Soil structure

Irrigated Vertisols of the Nile Delta and Valley have two types of structure in the surface layer (0 - 30 cm) depending probably on the irrigation system. Mainly loose, medium to coarse granular structure in profiles No. 1 and 2 where the furrow irrigation system is applied. Fine to medium subangular to angular blocky structures are observed in the surface layer of profiles No. 3 and 4, which are irrigated by the basin system. The aforementioned structure types had been observed by De Vos *et al.* (1969). Similar observations were also recorded by Wahab (1969) and Abdel Rahman (1972) in their study on the clay soils of the Nile Valley. The subsurface layers (30 - 60 cm) of the irrigated soil profiles have mainly parallelepiped aggregates which are broken giving rise to angular and subangular blocky structures in profiles No. 1, 2 and 5 or wedge like structure as in profiles No. 3 and 4. According to Ahmed (1983) the parallelepiped structure which is formed from coarse prisms is strongly affected by the width and depth of the cracks. In the soils cultivated by the row system, the parallelepiped structure is formed from coarse prisms broken to smaller subangular to angular blocky aggregates. Abdel Rahman (1972) observed the parallelepiped structure in subsurface layers (30 - 60 cm) of some Vertisols profiles of the Nile Valley. In the irrigated Vertisols under study, the deeper layer (below 75 cm) has subangular to angular blocky structure. This may be due to the overburden which increases the packing and density of the soil, so that the fractional resistance to shearing is greater than in higher layers. Thus shear planes would be less numerous in the deep layers, particularly when the profile has uniform fine structure.

In non-irrigated Vertisols of Kharga Depression one profile under study has a well developed wedge shape structure in the whole soil profile. In profile no. 6, the surface layer (0-30 cm) has a moderate, coarse angular blocky structure. The subsurface layers (30 - 120 cm) have wedge-shaped aggregates broken to strong fine angular blocky structure in the upper part, while in the lower one the aggregates are rather coarse.

Shrink- swell potential

In the studied soils, swelling and shrinking influence formation or destruction of favourable structure. Swelling in some soils helps to cause destruction of aggregates and loosing their identity. On the other hand, shrinking favours formation of aggregates from large mass of soil initially in poor structure.

Swelling may also be of considerable importance during heavy irrigations as a serious reduction in infiltration rate may occur. Good soil structure and soil moisture relations are very essential for maximum production of field crops on fine textured soils.

Soil texture

Particle size distributions of the studied profiles are shown in Table 2 . Data indicate that all samples under study have more than 30 percent clay which fulfils the requirement of the Vertisols. (USDA, 2003). Clay content recorded in Vertisols of Egypt differs greatly from one location to another and even within the same profile. It ranges from 30 to 70% or more, without any particular trend with depth. Ahmed (1983) reported that variations in clay content with depth are not due to clay migration but rather inherited from the parent material.

The sand fraction of the soil profiles located in the Nile Delta is less than 20 percent, except in very few cases. Sand content decreases with depth profiles (No. 2 - 5), and it is mainly of fine size (50 - 125μ). The highest content of total sand is found in profile no. 6, from Kharga Depression, as it ranges from 30.3 to 43.9 percent and is almost of very fine size (125 - 50 μ). The surface layer of that profile has the highest sand content. This may be due to a local difference in the depositional pattern.

The silt content ranges between 20.7 and 50.2 percent, in the Vertisols of the Nile Delta and Valley (profiles No. 1 - 5). There is a slight variation in silt content from one layer to the other in different profiles, but it decreases generally with depth. The Vertisols of Kharga Depression, (profile No. 6) have increases of silt content with depth, from 8% in the surface layer to 30.1% in the deeper one.

In the Vertisols of alluvial origin, (profiles No. 1 to 5) the clay content is higher than 30% and increases with depth to 66.6%. About 80% of the total clay is in the fine fraction (< 1.0 μ). The clay content in the Vertisols of Kharga Depression ranges from 36.7 to 51.8%, and more then 75% of the clay is in the fine fraction.

Generally, it could be concluded that the variation in clay content with depth is more likely to be due to the sedimentation processes

Soil chemical properties

Organic matter content in the studied profiles is generally low and decreases with depth reaching its minimum in the C horizons. The surface layers have values between less than 1% up to 2.6 %, (Table 2) depending on land use and the cultivated crops. Profile No. 6 has the lowest content of organic matter (0.2 - 0.4%) due to the very arid condition and absence of plant cover.

The pH values of the studied Vertisols range between 7.8 and 8.5. In most profiles pH values increase with depth. The values increase locally with increasing ESP values except in very few cases.

All irrigated Vertisols under studies are non-saline, as the EC values less than 1.26 dS/m. The non-irrigated Vertisols, represented by profile No. 6, are considered moderately saline soils, as EC values in its surface layer is 9.31 dS/m and decreases with depth. This salinity is inherited from the parent material, which is formed from lacustrine deposits.

TABLE 2. Particle size distribution of the studied soil profiles.

Profile No.	Depth (cm)	Particle Size Distribution %				Texture class	pH 1:2.5	EC dS/m	O.M. %	$CaCO_3$ %
		Sand	silt	Clay						
		2000-50 µ	50-2 µ	2-1 µ	< 1 µ					
1	00-30	18.5	50.2	6.6	24.7	Silty clay loam	8.0	0.21	1.1	3.0
	30-60	20.0	37.8	13.9	28.3	Clay	8.0	0.18	1.1	2.8
	60-100	21.0	34.9	8.3	35.8	Clay	8.1	0.17	0.9	2.4
	100-130	17.3	32.4	10.2	40.1	Clay	8.0	0.19	0.4	2.1
2	00-30	21.3	41.1	7.4	30.2	Clay loam	8.0	0.57	2.8	2.4
	30-60	6.7	33.9	11.6	47.8	Clay	8.0	1.26	1.1	1.7
	60-90	8.9	36.5	11.4	43.2	Clay	8.0	1.03	0.9	1.7
	90-120	7.5	37.3	10.2	45.0	Clay	8.0	0.99	0.8	2.3
3	0-5	13.3	41.3	15.2	30.2	Silty clay	7.8	0.32	1.6	6.0
	5-30	11.5	39.7	10.8	38.0	Clay	7.9	0.24	2.4	5.6
	30-75	11.6	32.2	15.1	41.8	Clay	8.3	0.28	1.0	5.8
	75-125	4.3	31.4	11.9	52.4	Clay	8.4	0.40	0.8	3.8
4	00-25	15.4	35.1	13.9	35.6	Clay	8.4	0.38	1.6	6.4
	25-50	9.2	24.2	15.8	50.8	Clay	8.4	0.41	1.2	4.3
	50-75	14.6	20.7	11.1	53.6	Clay	8.5	0.57	0.8	5.3
	75-110	6.8	34.2	12.1	46.9	Clay	8.5	0.56	0.8	2.3
5	00-25	15.3	42.9	8.9	32.9	Silty clay	7.8	0.43	0.9	3.3
	25-50	11.4	48.1	6.2	34.3	Silty clay	8.0	0.71	0.5	3.4
	50-75	12.5	38.8	10.5	38.2	Clay	8.0	0.67	0.4	3.0
	75-120	9.4	36.2	9.7	44.7	Clay	7.9	0.42	0.3	2.8
6	00-30	43.9	8.0	28.0	20.1	Clay	7.9	9.31	0.4	17.5
	30-60	30.7	18.8	20.0	30.5	Clay	8.1	6.90	0.3	20.0
	60-90	30.3	18.6	24.1	27.0	Clay	8.2	5.65	0.2	12.5
	90-120	32.7	30.1	22.3	14.9	Clay loam	8.3	4.67	0.2	16.5

Cation exchange capacities of the studied soil samples are rather high. They range between 30.7 to 84.5 meq/100 g soil. The increase in CEC values corresponds to an increase in clay content. Regarding to the exchangeable cations, Table 3 shows that calcium and magnesium are the dominant cations on clay complexes followed by sodium. Exchangeable potassium is present in lower quantities.

Calcium carbonate content of Vertisols of the Nile Delta and Valley (profiles No. 1 to 5) ranges from 1.7 to 6.4% (Table 2). Part of these carbonates is of pedogenic origin as revealed from the morphological study. Other part is transported with the irrigation Nile water which has about 1.5 percent calcium carbonate.

Vertisols of Kharga Depression (profile No. 6) have a high content of calcium carbonate, as it ranges between 12.5 to 20% throughout the profile. This profile which is formed from lacustrine origin has high shale content.

Soluble cations are predominated by Ca^{++} followed by Mg^{++} or Na^{+} in all profiles except profiles No. 3 and 4 in which Na^{+} is predominant followed by Ca^{++} and Mg^{++} (Table 3). Potassium is found in minor amounts in all the samples. Soluble anions consist mainly of SO_4^{--} and Cl^{-} and very minor amounts of HCO_3. Carbonate ions are absent in all the studied profiles.

TABLE 3. Soluble and exchangeable ions of the studied profiles.

Prof.	Depth	Soluble cations (meq/100 g soil)				Soluble anions (meq/100 g soil)			Exchangeable cations meq/100 g soil			C.E.C.
No.	(cm)	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	CO_3^{--} + HCO_3^-	SO_4^{--}	Na^+	K^+	Ca^{++} + Mg^{++}	meq/100 g soil
1	00-30	2.10	0.21	16.18	3.79	0.23	2.26	19.79	0.9	0.9	32.1	33.9
	30-60	1.60	0.27	16.45	1.39	0.17	2.26	17.28	11.1	1.1	32.5	44.7
	60-100	1.90	0.43	11.25	0.82	0.14	7.51	6.75	11.5	1.7	31.1	44.3
	100-130	2.00	0.40	11.10	1.11	0.17	6.81	7.82	13.2	2.1	35.9	51.2
2	00-30	4.20	0.26	18.78	4.94	0.56	4.51	23.17	4.7	1.0	28.3	34.0
	30-60	24.70	0.51	24.45	16.09	1.89	2.26	61.60	11.5	2.1	21.9	35.5
	60-90	21.70	0.21	21.07	3.17	1.63	2.26	40.26	11.8	0.8	20.5	33.1
	90-120	20.10	0.31	20.61	3.15	1.87	2.17	41.12	15.7	1.9	27.6	45.2
3	0-5	1.40	0.04	0.84	0.79	2.17	0.42	0.48	5.4	5.2	44.1	54.7
	5-30	1.10	0.02	0.76	0.65	1.36	0.83	0.34	5.9	4.7	45.7	56.4
	30-75	1.40	0.01	0.37	0.40	1.77	0.25	0.16	6.9	4.6	43.9	55.5
	75-125	2.50	0.02	0.22	0.27	2.11	0.83	0.07	10.3	4.9	54.4	69.6
4	00-25	2.90	0.04	0.42	0.38	1.88	1.25	0.61	7.1	5.5	39.7	52.3
	25-50	2.60	0.04	0.30	0.32	1.55	1.08	0.63	7.8	5.4	41.4	54.7
	50-75	3.00	0.18	0.09	0.23	1.36	2.08	0.06	14.0	5.8	45.1	64.8
	75-110	3.20	0.11	0.08	0.23	1.59	1.67	0.36	16.2	6.3	61.9	84.5
5	00-25	1.10	0.04	2.15	1.19	1.01	1.51	1.96	5.3	0.4	32.8	38.5
	25-50	1.20	0.18	6.40	3.09	1.15	3.69	6.03	4.21	0.3	33.9	38.5
	50-75	0.40	0.03	2.05	1.93	1.07	1.51	1.83	9.31	0.3	30.1	39.7
	75-120	1.30	0.02	1.38	1.15	1.15	2.25	0.45	13.01	0.2	32.1	45.3
6	00-30	4.10	0.63	80.68	19.23	54.51	1.51	47.62	11.8	2.0	16.9	30.70
	30-60	4.09	0.53	63.95	18.97	64.42	10.92	12.80	11.0	2.3	18.9	32.20
	60-90	5.55	0.47	59.10	17.61	16.42	2.25	64.06	10.4	2.2	19.8	32.40
	90-120	3.55	0.46	41.98	16.54	10.39	2.25	49.89	12.1	2.5	22.6	37.24

Pedogenic formations

Calcium carbonate nodules have been observed in most of the studied profiles. Different forms of calcite accumulation could be recognized in the field. In Vertisols of the Nile alluvium deposits, calcite is mainly present as lime segregations of white color, which are common in all layers with some accumulation in the middle layers. Two types of lime nodules are observed in the field; white, soft and rounded or irregular calcitic nodules. The latter is present in the deepest layers of some profiles (No. 3 and 4) which have a reduction condition leading to precipitation of Fe-Mn hydroxides in and around the calcite nodules (FitzPatrick, 1983 and Rabie *et al.*, 1981). In Kharga Depression, hard and rounded lime nodules are observed in profile No. 6.

Gypsum could be observed only in profile No. 6, as needle shape crystals grown on the lower side of the soil aggregates forming large pockets. Most of the soil peds in this profile have these gypsum crystals. The presence of gypsum crystals seems to be of pedogenic origin. They could formed as follows: 1) parent material rich in Ca^{+2} and SO_4^{-2} ions; 2) in the past, under higher rainfall, the profile was saturated with water and the soluble salts diffused in the whole profile; 3) with gradual evaporation due to the high temperature in the dry periods, gypsum crystals could grow in the spaces left after shrinkage of the soil peds.

Classification of the studied vertisols

According to the obtained results, all the soils under study could be classified as Vertisols, as they have more than 30% clay in all layers, cracks of about 2 cm or more wide that extend to a depth of 50 cm or more when dry, slickensides and parallelepiped shaped structure at some depths below the surface and lacking any diagnostic horizon or duripan. Concerning the gilgai microrelief, it was observed only in the non-cultivated soils of Kharga Depression. In the irrigated Vertisols of the Nile Valley and Delta it could not be observed, due to the continues plowing and leveling of these soils. In USDA (2003) it was proposed to consider gilgai microrelief as a complementary requirement for the Vertisols.

Although the cultivated Vertisols of the Nile Delta and Valley (profiles No. 1 - 5) receive about 5,000 m^3/acre annually during their continuous cultivation, yet, they are classified as Torrerts at the suborder level because of the Torric moisture regime of the region. At the great group level they can belong to the Haplotorrerts.

Concerning the non cultivated Vertisols of Kharga Depression they could be classified as Torrerts at the suborder level and Calcitorrerts at the great group level according to the presence of the calcic horizon with 100 cm of the soil surface (Table 2).

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صفات بعض اراضى الفيرتيزول فى مصر

مصطفى محمد قطب ، رأفت رمضان على وفايز صليب حنا

قسم الاراضى واستغلال المياه – المركز القومى للبحوث– القاهرة – مصر.

تشير بعض الدراسات إلى ان اراضى الفيرتيزول Vertisols قد تمثل حوالى ٣٥٪ من اراضى وادى ودلتا النيل.

تم أخذ عدد ٤ قطاعات أرضية ممثلة لأراضى الفيرتيزول فى الدلتا وقطاع واحد ممثل لاراضى وادى النيل وقطاع واحد من الواحات الخارجة. تم وصف القطاعات الارضية مورفولوجيا واخذ عينات تربة ممثلة لإجراء التحليلات المعملية عليها.

تشير نتائج الفحص الحقلي الى أن جميع الاراضى المدروسة تحتوى على تشققات Cracks فى حالة الجفاف وان عمق وعرض هذه التشققات يختلف من مكان الى اخر على حسب المحتوى من الطين والمحتوى الرطوبى والملوحة. وان الطبوغرافية الدقيقة Gilgai microrelief صعب ملاحظتها في الاراضى المزروعة نظرا لعمليات التسوية المستمرة المرتبط بالعمليات الزراعية ، فى حين انه يكون واضحا فى الاراضى غير المزروعة.

لوحظ وجود أسطح الانزلاق Slickensides فى الاراضى المدروسة فى الوادي والدلتا على عمق من ٣٠ الى ٨٠ سم ، فى حين انها تتواجد بطول القطاع حتى عمق ١١٠ سم فى قطاع الواحات الخارجة.

البناء الارضى حبيبى فى الطبقة السطحية و parallelepiped فى الطبقات تحت السطحية فى اراضى الرواسب النيلية. اما اراضى الفيرتيزول المدروسة بالواحات الخارجة فلها بناء parallelepiped فى كل القطاع الارضى.

تشير النتائج الى ان الاراضى تحت الدراسة تحتوى على ٣٠-٧٠٪ طين. وأن الاراضى جيدة الصرف صنفت على انها Haplotorrerts وذلك حسب التقسيم الامريكى ٢٠٠٣ ، وان الاراضى غير المنزوعة بالواحات الخارجة تتبع Calcitorrerts .