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Characterization and Classification of Desert Depressions Soils in Najaf Province

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***Abstract*:** Three pedons were selected based on the area of the depression in the south desert of Najaf province which located between ˚31 ¯54˝2 and ˚ 29¯49 ˝56 latitude north and ˚44 ¯29 ˝40 and ˚42 ¯46 ˝35 longitude east and represented by Al-Hayadia, Farea Alsalam and Om Al-Habara depressions to characterize and classify the soils of these depressions. A semi-detailed soil survey was conducted using free-lance soil survey method depending on the variance of the observed traits particularly topography, texture, soil colour and natural vegetation. Pedons were detected and morphologically described and a disturbed soil samples were obtained from each horizon for the purpose of conducting physical and chemical analyses, as well as undisturbed soil samples to study the micro-morphological characteristics. There was increase in the total clay content with depth in the pedons of depressions to the level that meets the conditions for the formation of Argillic clay horizon, which was confirmed by the results of micro-slices as the total clay content in the alluvial horizons increased than in the loss horizons. The outcome also indicated that there was increase in calcium carbonate content in all samplesand calcic horizon was formed in most of study pedons. There was decrease in salt content in all studied horizons (0.09-1.24ds.m^{-1}). The gypsum in the soils ranged between 1.55 to 13.38%. Current study results showed the Typic Calciargids in first and second pedons, and Typic Haploargids in the third pedon.

***Keywords*:** Desert depressions, Gypsum, Pedons, Iraq

The western plateau region within Najaf province is one of the dry areas and occupies a large area of this province (Al-Jasany and Abd Al-Zahra 2020). Southern desert lands of Iraq represented about 76114 km^2 or about 1877120 ha which represented approximately 17% of the total area of the whole country and the arable lands about 40000 ha. The height of this area rises 100 -1000 meters above sea level, it also includes the Iraqi desert from a climatic point of view where a dry climate prevails and it constitutes the equivalent of 70% of the country climate. The area of depressions occupies 75970.35 km^2 from the total area of the southern desert (Al-kazaly 2020). Desert depressions are known as floods which are flat surface land lower than the level of neighboring areas and filled with sediments coming from the valleys or the surrounding hills through running water or torrential rains when heavy rain fall occur as these valleys penetrate the area or end there (Al-Ageely 2014). Al-Isawy et al (2019) indicated the most important natural characteristics of the desert depressions selected for agricultural investment especially those related to the nature of their geological formation and characteristics of the surface and soil as they have a direct impact on agricultural operations and chemical and physical properties of soil and groundwater. These two most important variables is affecting agricultural production in terms of water quality and the amount of water and its content of salts, mineral elements, as well as the texture and nature of the soil composition. Al-Hadithi and Al-Dabag (2008) classified the desert depression soils according to the modern American system within the scope of young or newly formed. These soils were affected by drought conditions which were reflected in the lack of moisture necessary for the activity of biological and chemical weathering processes as has negative effects on its diagnostic horizon. Al-Mohsen (2015) classified depression soils in southern desert from Muthanna province to Aridisols order, Argids sub-order, Calciargids great group and Vertic Calciargid sub-great group. The justifications and reasons for choosing the depressions for the study are the investment of desert areas especially the lowland areas in Najaf desert for agriculture which are characterized by good soils that increases the agricultural lands and thus reflects on the national economy and reduces the state of land degradation. Current study aims to classify and characterize the soils of desert depressions in Najaf province.

MATERIAL AND METHODS

Three pedons were selected based on the area of the depression in the south desert of Najaf province as the area of big depression between 600 to 1000 ha, medium size depression between 100 to 300 ha and the small depression is less than 100 ha (Fig. 1). Soil samples were obtained from each horizon and were air dried and sieved with 2mm sieve and kept for laboratory analysis. Undisturbed soil samples were obtained to study the micro-morphological characteristics.

Physical measures: The particle size distribution of soil samples was estimated using Hydrometer method described in Richards (1954).

Fig. 1. Study area of southern desert from Google earth

Chemical estimations: pH in soil water extract (1:1) was estimated following Mckeague (1978) mentioned in Raein et al (2003). Electric conductivity of soil water extract (1:1) was measured using conductivity bridge following Richards (1954) method which described in USDA (1954). Calcium carbonate was estimated using Jackson (1958) procedure. Gypsum was estimated using spectrophotometer (Richards 1954). Cation exchangeable capacity was measured according to Page et al (1982), while, the organic matter was estimated following Black and Walkely which described in Jackson (1958).

Micro-morphological characteristics: Micro-morphological characteristics were studied for undisturbed soil samples of horizon pedons by using thin section (Brewer (978).

RESULTS AND DISCUSSION

Morphological properties of study horizons: Thef morphological description indicated a variation in some morphological properties of each pedon of study area due to the influence of local factors particularly the topographic location, the area of depressions, the conditions of sedimentation and geomorphological processes. These factors helped to determine difference in the nature of the great morphological characteristics which are the type, thickness and arrangement of horizons that make each pedon and the accompanying distinctive characteristics of each horizon.

Pedon number (1) Al-Hayadia depression: This pedon is located in Al-Hayadia depression and rises 68 meters above sea level and has high content of lime and a lower content of gypsum as well as the presence of small pebbles were also observed within the horizons of this pedon. The depression area was about 5 ha located 40 km from Najaf city. The surface of the land is flat and has dry climate with lack of rain. This pedon is exploited by cultivation wheat, eggplant and maize. The description of morphological characteristics showed that the arrangement of horizons in this pedon was Ap, B_{tk}, B_t and C as indicated by presence of gain horizons type B, a process of transferring colloidal materials including clay and calcium carbonate from the upper horizons towards the lower horizons to the level at which the conditions for the formation of calcic horizon. Therefore, the soil of this pedon is considered developed soil as it affected by the condition of the torrential waters in this area and their movement within the soil body during the drought period as well as the agricultural use which helped in the movement of soil components towards the sub horizons by improving soil permeability and increasing porosity. The thickness of surface horizon was 12cm and the thickness of alluvial horizons reached 68cm.

The texture of Ap horizon was loamy-sandy, loamy-clay-sandy for B_{tk} horizon and loamy-sandy for B_t and C horizons. The variation of texture types in horizons of this pedon may be attributed to the effect of alluvial and loss processes that worked on the movement of the clay separated inside horizons (West 2000). This pedon showed morphological characteristics that reflect desert conditions in terms of lack of moisture and high temperatures which was reflected in the color of the soil as the wavelength of horizons Ap and B_{tk} was light yellowish brown (d, 4/6 YR 10), while, the color in B_t and C horizons was changed to very pale brown (d,4/7 YR 10). The reason for the change of colors in these horizons is due to the high content of calcium carbonate in them which act as a diluting agent for dark colors or the nature of mineral composition, the lack of organic matter, moisture and the accumulation of lime and gypsum in these horizons. Many white spots were found on horizon B_{tk} especially at 44cm depth in the form of gypsum nodes and calcareous spots and on C horizon at 70cm depth. In addition to a complete layer of limestone in the form of powder in this horizon. The difference in the color of the soil between different pedons and horizons in the same pedon reflects the state of variance that exists between the components of the soil and the nature of the internal conditions of those horizons especially the type and quantity of soil particles as well as its content of organic matter (Soil Survey Staff 1999). The soil was of a block type with sharp angles in horizons Ap and C and stability was medium due to the increase in the proportion of sand and the lack of organic matter with an increase in the content of calcium carbonate. In B_{tk} and B_t horizons, the construction of soil was of a block type with sharp angles with great clarity or stability and this is due to the high content of the separated clay in this horizon, in addition to the increase in loss and alluvial processes. There are many medium-sized pores in all horizons of this pedon andfor roots, were very fine and numerous in horizon Ap, and medium and few in horizon B_{tk}, fine and few in B_t horizon and rootless in horizon C. The

texture of the soil in all horizons was little to very hard in the dry state, very brittle in the wet state and low in viscosity in very wet state, and the boundaries between horizons were clear and flat (Fig. 2 and Table 1).

Morphological description of pedon1

Soil classification: Typic Calciargide

Date: October 24,2020

Location: The middle of Al-Hayadia depression 40 km from Najaf city

Vegetation: Wheat, barley, maize and palm trees

Climate: Desert

Physiography: Najaf desert/Western plateau

Topography: Flat

Height: 68 meters above sea level

Origin matter: Calcareous sedimentary

Land use: Exploited for cultivation of wheat, barley, maize and palm trees

Describer: Sarah H. A. Al-ameedee and Ayad K. Ali

Additional notes: The presence of small pebbles in small amounts within horizons

Pedon number 2 Farea Alsalam depression: This pedon is located in the middle of Farea Alsalam depression as its area about 300 ha and it is 66.6 km from Najaf city and it rises 207 meters above sea level, unexploited agriculturally but has natural vegetation cover. The origin matter is calcareous and has a high content of calcium carbonate. The forth horizon in this pedon consists of a layer of stone and limestone blocks, the surface of the land is flat and has dry climate with lack of rain and the soil is shallow because of the rocky cut. The arrangement of horizons in this pedon was A, B_{tk}, and B_t and

Fig. 2. Morphological of pedon1

the color of soil was strong brown (d,6/5 YR 7.5) for A and B_{tk} horizons, while, it was light brown (d,4/6 YR 7.5) in B_t horizon. There was large variation in the texture where it was loamy-clay-sandy in horizon A, clay-sandy in B_{tk} and loamy-sandy in B_t horizon. The variation in texture in the vertical direction came as a result of the effect of sedimentation process from floods. In addition to the effect of alluvial and loss processes which in turn helped in variation in the distribution of soil separations and the difference in texture (Al-Mushhady 2003). The construction of the soil was of a block type with no angles and medium stability in horizons A and large in other horizons, the size of soil construction was fine. The predominance of few coarse roots were observed in horizon A and decreased significantly with depth, as for the pores, they were numerous and of precise size. The texture of the soil in all horizons was little to very hard in the dry state, very brittle in the wet state and low in viscosity in very wet state, and the boundaries between horizons were clear and flat (Fig. 3, Table 2).

Morphological description of pedon2

Soil classification: Typic Calciargide

Date: October 29,2020

Location: The middle of Farea Alsalam depression 66.6 km from Najaf city

Vegetation: Natural vegetation cover

Climate: Desert

Physiography: Najaf desert/Western plateau

Topography: Flat

Height: 207 meters above sea level

Origin matter: Calcareous sedimentary

Land use: Non-exploited for cultivation (desert land)

Describer: Sarah H. A. Al-ameedee and Ayad K. Ali

Additional notes: The soil is shallow because of the rocky cut

Pedon number 3 Om Al-Habara depression: This pedon is located in the middle of Om Al-Habara depression with an estimated area of 1000 ha and it is 157.52km from Najaf city and it rises 268 meters above sea level, the surface of the

Table 1. Physical and chemical characteristics of pedon 1

Horizon	Depth /cm	Description
Ap	0-12	Light yellowish brown (10 YR 6/4 , d), sandy loam, moderate fine angular blocky, slight hard (d) very friable (m) slightly sticky and slightly plastic (w). Common medium pores. Many fine roots, clear smooth boundary.
B_{tk}	12- 50	Light yellowish brown (10 YR 6/4, d), sandy clay loam, strong fine angular blocky, hard (d) very friable (m) slightly sticky and slightly plastic (w), common medium pores, few medium roots, many accumulation of calcium carbonate and nodules gypsum at the depth of (44)cm, clear smooth boundary .
B_t	50 – 80	Very pale brown (10 YR 7/4,d), sandy loam, and common fine white mottles, strong fine angular blocky, slight hard (d) very friable (m) slightly sticky and slightly plastic (w), common medium pores, few fine roots, common fin white mottle and an entire layer of lime in the form of a powder at the depth of (70)cm, Clear smooth boundary.
C	+80	Very pale brown (10 YR 7/4,d) sandy loam, moderate fine angular blocky , slight hard (d) very friable (m) slightly sticky and slightly plastic (w), common medium pores, no roots, clear smooth boundary.

land is flat and it has dry climate with lack of rain, the land unexploited agriculturally but has natural vegetation cover. The arrangement of horizons in this pedon was A, B_{t1}, $B_{t2}$and B_{t3} and this pattern of arrangement indicates the presence of developed soils as a result of the nature of locational conditions of this pedon which helped to activate alluvial and loss processes in it. The thickness of A horizon was 14cm and 56cm in horizon B. The texture of horizons did not differ so much as horizon A texture was loamy-clay-sandy, while was clay in B_{t1}, $B_{t2}$and B_{t3} horizons. The appearance of soft texture in most horizons of this pedon may be attributed mainly to the sedimentary origin material rich in fine particles, in addition to gain and loss processes that helped in redistributing it within horizons of pedon (Al-Mohsen 2015). The color of all horizons soil was brown (d,4/5 YR 7.5), the construction of the soil was of a block type with no angles and medium stability in horizons A and strong stability in other horizons.The size of soil construction was very large and there was a large variation in roots and pores from A to B_{t1}. The texture of the soil in all horizons was little to very hard in the dry state, very brittle in the wet state and low in viscosity in very wet state The boundaries between A and B_{t1} horizons were interlaced wavy and between B_{t2} and B_{t3} horizons were clear and flat (Fig 4.,Table 3).

Morphological description of pedon3

Soil classification: Typic Haploargids

Date: October 29, 2020

Location: The middle of Om Al-Habara depression 157.52 km from Najaf city

Vegetation: Natural vegetation cover

Climate: Desert

Physiography: Najaf desert/Western plateau

Topography: Flat

Height: 268 meters above sea level

Origin matter: Sedimentary

Land use: Non-exploited for cultivation (desert land)

Describer: Sarah H. A. Al-ameedee and Ayad K. Ali

Physical properties: The predominance of clay and silt particles in all pedons as the clay percentage reached between 13.5 to 45.5%, when the lowest as in horizons 1 and 2 of first pedon and the highest was in the third horizon of third pedon (Table 4). This may be attributed to the conditions of sedimentation and the location of the pedon (Ndewy 1983), in addition to the low topographical location and the wide area of the depression.The effect of area and topographical location on the distribution of soil particles, where there was a dominance in clay particles with depth and exceeding of other depressions in which the area is less as a result of receiving large amounts of torrential water. Similarly, the proportion of sand increased in the depression with a smaller area, while, the depression that had a medium area increased it contains clay, silt followed by sand. Results also showed the presence of Argillic horizon in all study pedons in the depressions either has large, medium or small area due to the locational conditions and loss and alluvial processes activities.

Chemical characteristics: The f pH of most of study horizons ranged between 7.01 to 8.19, and the lowest was in the surface horizon of first pedon which located in the depression that has small area, while, the highest was in third

Fig. 3. Morphological of pedon number 2 and the natural vegetation cover

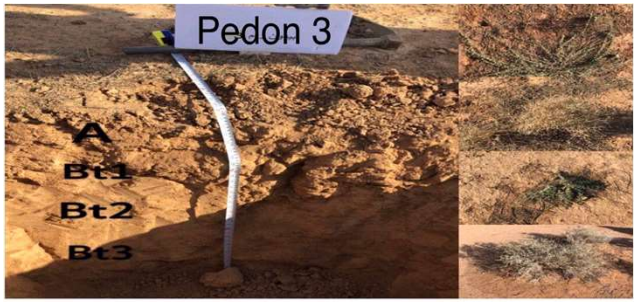

Fig. 4. Morphological of pedon number 3 and the natural vegetation cover

Table 2. Physical and chemical characteristics of.pedon 2

Horizon	Depth /cm	Description
A	0-15	Strong brown (7.5 YR 5/6,d), sandy clay loam, moderate fine Sub angular blocky. Slightly hard (d) very friable (m) slightly plastic and slightly sticky (w). Common fine pores, few coarse roots, clear smooth boundary.
B_{tk}	15-30	Strong brown (7.5 YR 5/6,d), sandy-clay, strong fine sub angular blocky, hard (d) very friable (m) slightly plastic and slightly sticky (w). Common fine pores, no roots, common fin white mottle and an entire layer of lime in the form of a powder, clear smooth boundary.
B_t	30-60	Light brown (7.5 YR 6/4,d), clay loam, strong fine sub angular Blocky, slightly hard (d) very friable (m) slightly plastic and slightly sticky (w). Common fine pores, no roots, clear smooth boundary.

horizon of third pedon within the depression of large area. These values are in the natural level of pH of Iraqi soils and it identical to what Bready (1974) indicated that the degree of pH in soils of dry and semi-dry areas ranges between 7-8. The salinity values ranged between 0.09 to 1.24ds.m^{-1}. This may be due to increasing of salinity level in studied soils is attributed to the good natural drainage condition of study soil which helped to dissolve and wash salts out of the soil (Al-Husayni 2010).

The content of calcium carbonate of pedons of depression soils was very high with a status of homogeneity in its vertical distribution and the proportions of those carbonate ranged between 35.75 to 66.75%. This may be attributed to the nature of the calcareous material, in addition to the lack of rainfall which leads to a weak redistribution of carbonate in the soil (Ibrahem 2007), and to the addition operations as a result of the sedimentation of transported materials from other sites by transporting factors such as water and its sedimentation in the subsurface horizons, causing an increase in calcium carbonate. All study pedons showed the quantitative and descriptive criteria required for the formation of lime horizon for calcium carbonate represented by calcic horizon as stated in Soil Survey staff (2010, 2014). As the accumulation of carbonate minerals is considered one of important processes in dry and semi-dry areas and is important indicator for soil classification (Khresat 2001; Pal et al 2003).

CEC values ranged between 5.00 to 40.60cmol.kg^{-1} as the highest value recorded in the second horizon of second pedon and the lowest in the second horizon of third pedon (Table 5). The reduction of cation exchangeable capacity in these pedons may be attributed to the decreasing of organic matter, the presence of calcium carbonate and its increase with depth as well as the presence of clay minerals of low ECE.This is in agreement with Al-Rawi (2005) and Sleman and Abd Al-Jabar (2012). The clay particles contribute actively in increasing cation exchangeable capacity in these soils . There was a decreasing in the content of organic matter in all study pedons as it ranged between 0.11 to 0.68%, where the lowest value was in 1, 2 and 4 horizons of first pedon, and the highest in the second horizon of second pedon. The reduction may be attributed to the lack of vegetation cover and dry climate desert with high temperatures which play significant role in the oxidation of organic matter (Konen et al 2003).There was a decreasing in gypsum content in surface horizons in general with little

Table 3. Physical and chemical characteristics of pedon 3

Horizon	Depth /cm	Description
A	0-14	Brown (7.5 YR 5/4,d), sandy clay loam ,moderate medium sub angular blocky. Slightly hard (d) friable (m) plastic and slightly sticky (w). Many fine pores, many fine and few coarse roots, interlaced wavy boundary.
B_{t1}	14-48	Brown (7.5 YR 5/4,d),clay, strong coarse sub angular blocky. Hard (d) friable (m) plastic and slightly sticky (w). Few fine pores, few coarse roots, interlaced wavy boundary.
B_{t2}	48-70	Brown (7.5 YR 5/4,d(, clay, strong very coarse sub angular blocky, hard (d) friable (m) plastic and slightly sticky (w). very few very fine pores, no roots. Clear smooth boundary .
B_{t3}	+70	Brown (7.5 YR 5/4,d), clay, strong very coarse sub angular blocky, hard (d) friable (m) plastic and slightly sticky (w). Very few very fine pores, no roots. Clear smooth boundary.

Table 4. Physical characteristics of pedons

Pedon No.	Location	Land Use	Land area	Horizon	Depth (cm)	Percent			Texture
						Sand	Silt	Clay	
1	Al-Hayadia	Exploited agriculturally	5 ha	Ap	0 - 12	64	22.5	13.5	Sandy loam
				B_{tk}	Dec-50	66.5	10	23.5	Sandy clay loam
				B_t	50 - 80	76.5	5	18.5	loam Sandy
				C	80+	74	12.5	13.5	loam Sandy
2	Farea Alsalam	Unexploited agriculturally	300 ha	A	0-15	71.5	7.5	21	Sandy clay loam
				B_{tk}	15-30	51.5	12.5	36	Sandy clay
				B_t	30+	41.5	20	38.5	Clay loam
3	Om Al-Habara	Unexploited agriculturally	1000 ha	A	0-14	59	15.5	25.5	Sandy clay loam
				B_{t1}	14-48	44	13	43	Clay
				B_{t2}	48-70	44	10.5	45.5	Clay
				B_{t3}	70	39	13	48	Clay

increasing in the subsurface horizons. The gypsum percentage in pedons ranged between 1.55 to 13.38% as the lowest value was recorded in the third horizons of second pedon, and the highest value in the second horizon of first pedon. This may be attributed to the increasing of calcium sulphate in the water of wells that irrigates the soil of this pedon as this area is exploited agriculturally unlike other pedons, or the dissolved of some minerals that contain calcium sulphate which leads to release sulphate and calcium the exchange with sodium ions (Sancho et al 2008, Silvera et al 2009, Vyshpolsky et al 2010, Al-Ganmy 2015).

Micro morphological features: The third horizon of first pedon consists of quartz, feldspar and rock pieces, in addition to clay and iron oxides in small percentage (Fig. 5). The porosity was presented as wholes between grains and gaps type bugs due to dissolution. The clays appeared in the form of round clay films linked to the system of pores. The pedons in medium and large depressions showed some micro morphological evidences that refer to the movement of part of soil contains from surface horizons toward subsurface horizons as a result of alluvial and loss processes, and one of these evidences is the presence of Argillic in second and third pedons (Fig. 6, 7). The second horizon of third pedon showed some gain and loss appearances (Ferri-Argillans, Orgaargillans), in addition to quartz, rock pieces, while its porosity was presented as gaps type vugs (Fig. 7).

Classification of study soils: Soils of study area were classified according to the modern American system (Soil Survey staff 2009) to sub great group level, as these soils are under Aridisols order. The determination of this order depends on the presence of diagnostic horizons and soil properties.

Aridisols order: Soils in this order are distinguished by Aridic moisture system as the average of water loss through evaporation and transpiration more than the average of rainfall in most months of the year in study area which ranged between 90 t0 100ml annually when the soil is dry with no moisture for long time. The soil temperature system was very hot (hyperthermic) in the study area.

Sub order Argids: This included soils that contain clay

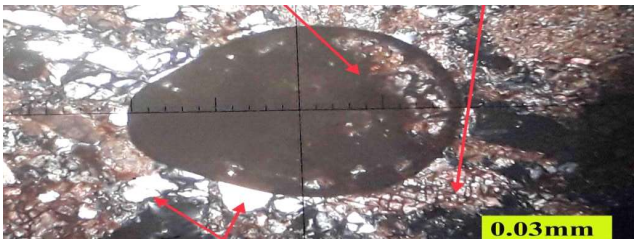

Fig. 5. Clay films and quartz in second horizon of first pedon

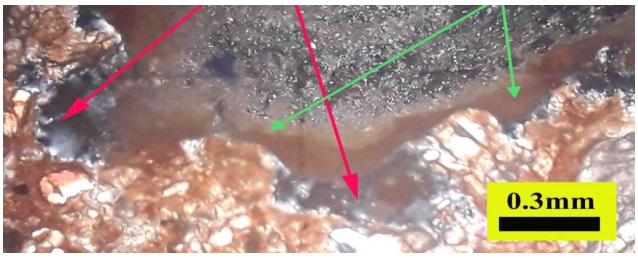

Fig. 6. Sediment clay films in a crescent shape

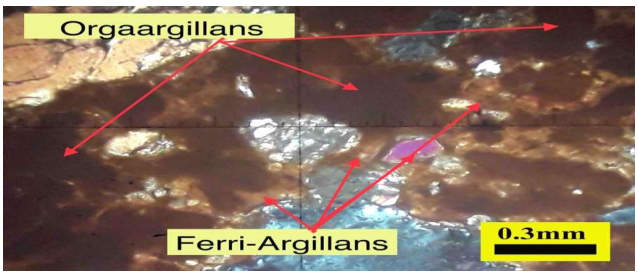

Fig. 7. Iron oxides and organic matter mixed with clay in second horizon of third pedon

Table 5. Chemical characteristics of pedons

Pedon No.	Location	Land Use	Land area (ha)	Horizon	Depth (cm)	PH	EC $ds.m^{-1}$	Caco3 (%)	Gypsum (%)	CEC $cmolc.\ kg^{-1}$	O.M (%)
1	Al-Hayadia	Unexploited agriculturally	5	Ap	0-12	7.01	1.18	56.25	13.07	23.27	0.11
				B_{tk}	Dec-50	7.19	1.08	61.75	13.38	18.49	0.11
				B_t	50-80	7.12	0.94	50	12.3	7.82	0.34
				C	80	7.16	1.24	58.75	12.11	22.01	0.11
2	Farea Alsalam	Unexploited agriculturally	300	A	0-15	7.97	0.09	48	5.09	31.22	0.34
				B_{tk}	15-30	7.98	0.09	53.5	1.65	40.6	0.68
				B_t	30	8.01	0.13	35.75	1.55	23.43	0.45
3	Om Al-Habara	Unexploited agriculturally	1000	A	0-14	7.53	0.15	60.5	6.6	28.57	0.11
				B_{t1}	14-48	7.91	0.09	60.5	4.79	5	0.45
				B_{t2}	48-70	8.07	0.09	62.75	6.39	26.54	0.34
				B_{t3}	70	8.19	0.09	66.75	4.22	23.76	0.45

horizon especially Argillic, decreasing of gypsum content, organic matter, salt content and locational factors was helped in the movement of some soil contains to the down such as clay which leads to increase subsurface horizons content of clay compared to surface horizons (Soil Taxonomy 1999).

Calciargids group: The most important great groups diagnosed within the sub order Calciargids and contain calcic horizon within the 150cm from soil surface. The great group Haploargids that represented other soils of Argids order was not present great group characteristics. The characteristics of sub great group were identical with the great group thus classified as Typic Calciargids and Typic Haploargids.

CONCLUSIONS

Characteristics of studied depressions soils are good for agriculture with low salinity level and acceptable drainage. The area of depression and water staying period was determined the main soil properties. All study pedons were affected by alluvial and loss processes of clay and lime, as well as the presence of argillic and calcic horizons. Morphological, chemical and physical properties indicated that most study soils are belong to Aridisols order, Argids sub order, Calciargids and Haploargids great groups and Typic Calciargids and Typic Haploargids sub great groups.

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