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Effect of Parent Materials and Climatic Conditions on Development and Micromorphological Features of Some Soils in Northern Iraq

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ABSTRACT

Three pedons representing rangeland soils, located at northern Iraq ,were selected to evaluate the status of soil development and their micromorphological characteristics .Pedon 1formed from gypsiferous –calcareous parent material and pedon 2 and 3 were formed from calcareous parent material. Soil pedons were morphologicaly described and soil samples were taken from each horizon for some physical, chemical, mineralogical, and micromorphological determination. The results show some differences between the studied pedons.All soils have an ochric epipedon but they have different illuvial horizons,Pedon 1 consists of ochric and gypsic horizons ,while pedon 2 and 3 have an ochric,mollic, calcic and argillic horizons.The results indicate that there are some variations in the content and distribution pattern of most physical and chemical properties of the studied pedons. Pedon 1 show lower clay content in all horizons in comparsion with pedon 2 and 3.Total fine clay and the raito of Fine /Total clay increase in illuvial horizon and decrease with depth. Clay content and the nature of its distribution with depth meet the criteria for the formation of argillic horizon only in pedon 2 and 3.The results of thin section study indicate the presence of secondary gypsum and carbonate minerals with different forms either as single grains or as accumulations filling soil voids or coating voids with the presence of gypsan, calcitan. Few weak ferri- argillans were found around soil peds or in the internal pores surface in Btk horizons of pedon 2 and 3, this may be due to high pedoturbation processes(presence of expanding clays smectites) and biological activity disruption of the clay coating. Clay accumulation index (CI) values were 176 and 333 for p2 and p3 while B/A raitos were 0.87,1.42 and 1.59 for p1,p2 and p3 respectively, which confirm the difference of status of soil development .According to morphological, physical,chemical and micromorphological data soils of pedons 1,2 and 3 were classified as Haplogypsids , Aridic Argixerolls and Vertic Argixerolls respectively.

تأثير مادة الاصل والظروف المناخية في الصفات المايكرومورفولوجية الدقيقة وتطورها في بعض ترب شمال العراق

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الخلاصـة

تم دراسة ثلاث بيدونات غير مستغلة لتحديد حالات تطور الترب وخصائصها المايكرومورفولوجية في ثلاث مواقع مختلف من شمال العراق .البيدون الاول في محافظة صلاح الدين(تكريت) ذو مادة اصل جبسية–كلسية ،البيدون الثاني والثالث ذو مادة اصل كلسية ويقع في محافظة كركوك ومحافظة اربيل على التوالي .وصفت البيدونات مورفولوجيا ثم اخذت عينات ترب لغرض اجراء التحليلات الفيزيائية والكيميائية والمعدنية والمايكرومورفولوجية .اظهرت النتائج وجود اختلافات بين بيدونات الدراسة اذ احتوى البيدون الاول على الافق اوكرك (ochric) والافق جبسك (gypsic) فيما سادت الافاق اوكرك (ochric) ومولك (mollic) وكالسك (calcic) وارجلك (argillic) في بيدوني كركوك واربيل. اظهر بيدون تكريت انخفاضا في مفصول الطين مقارنة مع بيدوني كركوك واربيل اللذين اظهرا زيادة في الطين الكلي ونسبة الطين الكلي الى نسبة الطين الناعم مع العمق بما تستجيب مع متطلبات الافق ارجيلك (argillic) . اظهرت نتائج الشرائح الرقيقة (thin section) تواجد معادن الجبس والكلس الثانوي بشكل حبيبات منفردة

او مجتمعة في مسام التربة او بصورة مغلفة لمسامها مع تواجد (calcitan) و (gypsan). اظهر بيدوني كركوك واربيل اغشية من نوع اغشية الحديد– الطينية (ferri- argillans) بشكل ضعيف حول تجمعات التربة او على الاسطح الداخلية لمسام التربة في الافق الطيني وهذا يعود الى عمليات (pedoturbation) لوجود المعادن المتمددة(السمكتايت) من نوع 2:1فضلا عن النشاط الحيوي الذي يشتت الاغشية الطينية .دليل تجمع الطين(CI) لبيدوني كركوك واربيل 176 و333 بينما قيم تجمع الطين في الافق (B) الى الافق (A)كانت 0,87 و1.42 و1.59 في بيدونات تكريت وكركوك واربيل على التوالي مما يؤكد تباين الحالة التطورة لترب الدراسة .صنفت ترب الدراسةHaplogypsids ، Aridic, وArgixerolls Vertic Argixerolls لبيدونات تكريت وكركوك واربيل على التوالي .

Introduction:

There are approximately 200 hectares of gypsiferous soils covering the earth's surface (Nettleton,1991).Gypsiferous soils are soils that contain sufficient quantities of gypsum to interfere with plant growth.Gypsum occurs as coarse crystals ,fibrous,prismatic and lenticular gypsum in arid and semi-arid regions.This forms gives the gypsic horizon a massive surface.The accumulation of gypsum in soils is common in arid and semi-arid regions throughout the world.Soils containing gypsic horizons can form on various parent materials such as alluvium ,eolian sediments and weathered geologic formations (Taimeh,1992).These horizons can be composed of pedogenic as well as detrital gypsum.Four potential origions of gypsum accumulation in soils have been established ;(1) in-situ weathering of existing parent material(2) an oceanic source resulting in sulfate enriched precipitation (3) eolian or fluvial input of gypsum or SO_4^{-2} rich sediment,and (4) oxidation of sulfate minerals (Brenda and Van Hoesen,2002).Carbonate minerals are common constituents of many arid and semi-arid soils.Carbontes in soils may initially be subdivided in to two main groups: primary and secondary.The secondary carbonates have been variously referred to as carbonate neoformations (Dobrovolskiy,1961), authigenic carbonates (Gile et al ,1966) and pedogenic carbonates (Blokhuis et al ,1969). Presence of clay pedofeatures and calcium carbonate ($CaCO_3$) is common in soil of arid and semi-arid climates(Gile,1970,1975;Reynders,1972;Allen and Goss,1974;Eswaran and Sys,1979;El-Tezhani et al .,1984;Reheis,1987). Mermut and arnaud,1981 confirmed that neocalcanc were found typically in the carbonate accumulation zone and were generally associated with medium textured soils. This provides an opportunity to study the influence of modern climate on soil genesis;especially clay illuviation and pedogenic carbonate accumulation.The accumulation of pedogenic calcium carbonates is an important pedogenic process for arid and semi-arid regions (Sobecki and Wilding ,1983),while horizons enriched with pedogenic calcium carbonate are often the most prominent features in such soils (Gile et al.,1966).The depth of calcium carbonate leaching and the extent of calcium carbonate precipitation in the profile are functions of the orginal carbonate content ,pH,partial pressure of umulative CO_2 and accumulative quantity of infiltrating water (Allen and Whitside,1954).The presence of both calcium carbonate and oriented clay accumulation in the same horizon implies a complex history of carbonate leaching ,deposition of secondary calcite ,and clay illuviation (Smith and Wilding ,1972;Khormali et al.,2003).Aguilar et al.,1983 was observed obliteration of clay films in some parts of the argillic horizon because of the pedogenic carbonate accumulation ,especially for those clay coatings that occurred on the surfaces of sand grains and pebbles.Pal et al.,2003a reported that poorly oriented clay platelets are often found associated with $CaCO_3$ grains. Micromorphological methods is mainly used in pedology to describe the soil formation processes and specify the typology of soils (Bullock et al.,1985;Stoops,2003).Nettleton et al.,1969 stated that the clay increase in an argillic horizon may be illuvial ,but because of the disruption of ped faces ,clay orientation on the faces of peds cannot occur. Therefore ,Soil Survey Staff,1999 does not require oriented clay bodies for an argillic horizons if the COLE value is 0,04 or higher and if the soil has distinct wet and dry seasons.In this case the ratio of fine clay to total clay in the illuvial zone must be higher than 1.2 or mor than the ratio in the eluvial horizon. Soil development is considered as a genetic history of the soil and can be referred to the knowledge of the existing vegetation and climate condition ,illuviation horizon(horizon B) as an indicator of the state and ratio of humidity prevailing (Bouwman and Lemans,1995).Clay illuviation and pedogenic carbonate accumulation are one of the most important pedogenic processes for the soils. Soil development is a result of the intensity of factors and processes effects of soil formation and the surrounding circumstances lead to a redistribution of soil components through soil development eluviation and illuviation process.Thus the differentiation within the soil horizons of important critewria to explain the evolution status of the soils (Soil Survey Staff,1999). Vidic and Lobnic ,1997 pointed in their study on the arid and semi-arid soils that soil development rates depend mainly on climatic conditions,while Levine and Ciollcosz,1983 were conducted to the possibility of determining the status of soil development through the expense of clay accumulation index(CI)which is an indicator of the clay illuviation.Collins and Fenton ,1982 confirmed that the ratio between clay content value in the B horizon to the clay content value in the A horizon is an indicator to know the status of soil development .The objective of the present study were to study the effect of parent material and climatic condition on micromorphological features of some soils and its relations with pedological development through some criteria of soil development indicators.

Materials and Methods:

The study area located in northern Iraq ,under arid and semi-arid climatic conditions.Three soil pedons were selected formed from two different parent materials (Fig.1) .Pedon 1 formed from gypsiferous-calcareous parent materials and loacated between 43º 38′ 46.75″ E and 34º 40′ 44.126″ N ,5km to the north of Tikrit governorate.The mean annual temperature and mean annual precipitation are more than 22°Cand 150 mm with slightly level topography .The second pedon (P2) formed from ccalcareous parent material ,and loacated between 44º 22′ 24.6″ E and 35º 33′ 27.6″ N ,20 km to the Kirkuk governorate northern .The mean annual temperature and mean annual precipitation are 22°C and 375-400 mm with about 3-4% slope.The third pedon(P3) formed from calcareous parent materials and laying between 44º 8′ 4.91″ E and 36º 12′ 38.95″ N ,8km to the east of Erbil center.The mean annual temperature and mean annual precipitation are 20°C and 500 mm precipitation with slightly level topography .The three pedons were described mophologicaly in the field according to Soil Survey Staff,1999.For the micromorphological characterization ,thin sections were prerared from undisturbed soil samples and described according to Bewer,1976,Bullock et al.,1985,Stoops,2003.Soils were classified using the Keys to Soil Taxonomy (Soil Survey Staff,2010) .Soil samples were taken from each soil horizon to determine some physical and chemical properties.Particle size distribution analysis was determined by the international pipet method (Kilmer and Alexander,1949) .Fine clay according to (Jackson,1979),Bulk density (Black,1965) .Coefficient of Linear Extenibility (COLE) value (Brasher et al.,1966).Porosity calculated from:porosity%={1-bulk density ρb /solid density ρs }x100.Electrical conductivity (EC) ,soil pH reaction determined by 1:1 extractions ,and soluble cations and anions were determined by method described by U.S. Salinity Laboratory Staff (1954).

Organic matter (Walky-Black,Jackson,1958).Cation exchange capacity (CEC) was determined according to Savant,1994.Total carbonate according to (Richards,1954).X-Ray diffraction analysis was performed on bulk soil (U.S,geological survey).The physical function of soil development through the relation B/A which is suggested by Collins and Fenton ,1982 as well as calculating clay accumulation index (CI) suggested by Levine and Ciolkos,1983 by the following equation:

CI= (B-C)T

where :CI=clay accumulation index,B=% clay in B horizon,C=%clay in C horizon, T= thikness of the B horizon (cm).

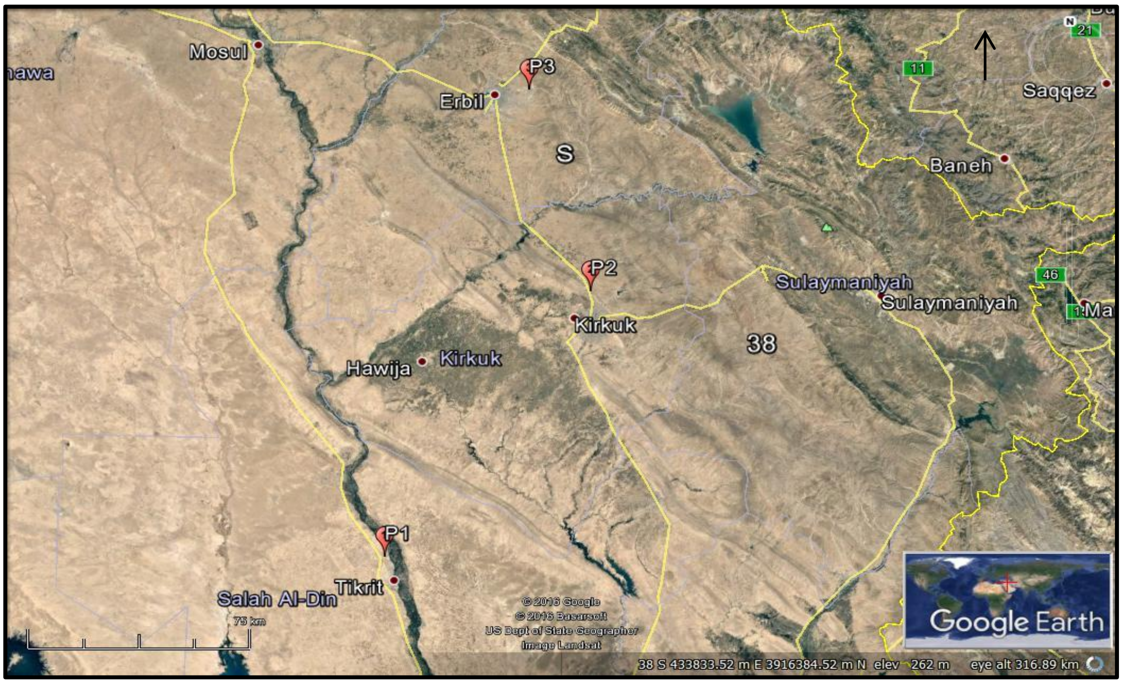


Fig.1. Location of the selected pedons.

Results and Discussion

Soil Morphological Characteristics:

Morphological characteristics of the studied pedons shows some variations in the degree of soil development represented by type and thickness of soil horizons(Table 1).All pedons show horizon sequences of A-B-C .Pedon 1 did not show the criteria of the dark color Mollic epipedon. Pdon 2 and 3 have all requirements of Mollic horizon.The surface horizons of Pedon 2 and 3 were deep ,yellowish brown for dry soil samples with more than 0.6 percentage organic matter, high base saturation percentage and good soil structure (Soil Survey Staff,2010). Morphological characteristics indicate the presence of some illuvial horizons,primarily By in P1and Btk in P2and P3.The diagnostic horizons in Pedon1 ochric and gypsic horiozons,while the P2 and P3 have mollic ,calcic ,and argillic horizons. These variations in type and thickness of diagnostic horizons reflect the effects of parent materials and climatic conditions.Pedon 1 formed from gypsifereous parent material and dry climatic condition with mean annual rainfall of 150 mm and more than 22°C .While pedon 2 and 3 were formed from calcareous parent material under more mean annual rain fall(more than 375 and 500 mm,respectively).These factores are more suitable for the formation of illuvial horizons including calcic and argillic.The results show that all pedons have an ochric epipedon with 10YR hue,and moderate value and chroma,due to the effect of arid and semi-arid conditions(Lima Neto et al .,2009).Soil colour varies from very pale brown to light yellowish brown colour in all horizons of pedon 1.While in other pedons,it range from 10YR 3/4 (d) to 10YR7/4 (d).Pedon 1 shows coarses texture classes in all horizon than pedon 2 and 3.The dominate texture classes in pedon 1 is SL while they are ranged from clay loam(CL) to clayey(C) in pedons 2 and 3,respectively.These differences reflect the effect of parent material as the study pedons are formed from different types of parent material .

Table 1 – Morphological description of soil profiles

Horizon	Depth Cm	Color (d)	texture	Structure	Consistency	boundary	Special feature
pedon 1 (Sandy skeletal, , gypsic, semiactive , hyperthermic, Typic Haplogypsids)							
A	0-22	10YR6/4	SL	1f sbk	Slightly hard	Clear wavy	Fine root ,few gypsum powdery pocket,fine pores
By	22-41	10YR6/6	SL	1msbk-mas	Hard	Gradual smooth	Fine pores, few gypsum powdery pocket ,many gypsum granular
Cy1	41-92	10YR6/5	SL	Mass	Very hard	Gradual smooth	Massive gypsum, hard
Cy2	92-120	10YR7/4	SL	Mass	Very hard	------	Massive gypsum, hard
Pedon 2 (loamy mixed,carbonatic , superactive ,Hyperthermic, Aridic Argixerolls)							
A	0-28	10YR5/3	CL	2vf gr-sbk	Slightly hard	c Clear wavy	Fine pores, cracks to depth about 60cm,width 1-2cm. fine roots
Btk	28 – 60	10YR6/5	C	3hsbk	Hard	gradual smooth	Carbonate nodules, cracks. ,,cracks
Bk	60-92	10YR6/4	CL	3vhsbk	Very hard	Diffuse smooth	Carbonate nudles ,Very hard
Ck	92-120	10YR6/4	CL	3vhsbk	Very hard	------	Carbonate nudles ,Very hard
Pedon 3 (fine, mixed ,carbonatic ,active ,thermic , Vertic Argixerolls)							
A	0-14	10YR3/4	CL	1mgr	Friable	clear smooth	Fine pores, cracks to depth more than 60cm width 1-2cm.rock fragment
AB	14-27	10YR4/4	C	2mgr	Friable	clear smooth	Fine roots,cracks,carbonate nodules,fragments
Btk	27-64	10YR5/4	C	2msbk	Slightly friable	Diffuse smooth	Fine roots,cracks,carbonate nodules,fragments
Bk	64-84	10YR4/4	C	2msbk	Friable	Diffuse smooth	Many ,cracks
Ck	84-120	10YR5/4	C	2msbk	Slightly hard	-------	carbonate nodules

f = fine , m= moderate , sbk = sub angular blocky ,mas= massive , ,gr = granular, d=dry

Physical properties:

Soil partical size distribution data of the studied pedons (Table 2) indicate a differences within each pedon and between all pedons . In general ,pedon 1 content than pedon 2 and 3 which show higher clay content .Sand content in pedon 1range from (520 to 640) gkg^{-1} ,while it ranges from (220 to 36) gkg^{-1}to ,and from 210 to 310 gkg^{-1} in p2 and p3 respectively .Clay content in pedon 1,2 and 3 ranges from (180-200) gkg^{-1},(320-420) gkg^{-1},and (400-510) gkg^{-1}respectively.In general ,the content of total clay ,fine clay and the ratio of fine clay /total clay increase from pedon 1 to pedon 2 and pedon 3.The content of total clay ,fine clay and the ratio of fine clay / total clay in pedon 1 did not show specific pattern of distribution with depth .While they increase with depth in subsurface horizons (Btk) and decrease in lower horizons of pedon2 and 3.This type of distributon may be due to the effect of pedogenic processes and to some extent to the in situ clay formation.The main pedogenic processes were pedoturbation, illuviation and lessivage causing clay translocation from the surface horizons to subsurface horizon (Btk).Movement of clay colloids through the soil profile has been investigated extensively during the past decades.Michel et al.,2010 suggested that colloid movement is affected by gravitational water drainage ,water evaporation from the soil and water profile redistribution from preferential flow paths toward the soil pores.Clay translocation by lessivage ,is generally described as beginning with chemical or physical dispersion of fine clays along a macropore,followed by downward movement as suspended load in leaching pore water and ending with deposition (Eswaran and Sys,1979).

Table 2 : physical properties of studied Pedons

Horizon	Depth Cm	Practical size distribution gr.kg^{-1}			Texture	Fine clay gr.kg^{-1}	Fine clay / Total clay	COLE Cm cm^{-1}	Bulk density gr.cm^{-3}	Porosity %	Silt / total clay
		sand	silt	clay							
P1											
A	**0- 22**	570	240	190	SL	48	0.25	----	1.37	48	1.26
By	**22-41**	610	210	180	SL	40	0.22	----	1.46	45	1.17
C_{y1}	**41-92**	640	170	190	SL	50	0.26	----	1.50	43	0.89
C_{y2}	**92-120**	520	280	200	SL	40	0.20	----	1.59	40	1.40
P2											
A	**0-28**	360	320	320	CL	120	0.39	----	1.25	52	1.00
B_{tk}	**28-60**	220	360	420	C	210	0.50	0.04	1.44	46	0.86
B_k	**60-92**	285	355	360	CL	140	0.39	0.04	1.55	41	0.98
C_k	**92-120**	310	340	350	CL	120	0.34	----	1.50	43	0.97
P3											
A	**0-14**	280	300	420	C	160	0.38	0.04	1.22	54	0.71
AB	**14-27**	330	270	400	C	145	0.36	0.04	1.3	51	0.67
B_{tk}	**27-64**	210	280	510	C	280	0.55	0.05	1.37	48	0.55
B_K	**64-84**	212	358	430	C	165	0.38	----	1.40	47	0.83
C_k	**84-120**	300	280	420	C	130	0.31	----	1.40	47	0.67

Distribution pattern of total and fine clay in all studied pedons indicates significant differences between the elluvial and illuvial horizons.The increment of clay content in illuvial horizons comparsion to eluvial horizons seems to be sufficient to meet the cretiria for argillic horizon formation in pedon 2 and 3 (Soil Survey Staff,2010).The value of the average clay content in B horizons to the average value of clay content in A horizon in more than 1.2 which meets the criteria required for the formation of argillic horizon (Soil Survey Staff,1999) .Total clay ,fine clay contents and the percentage of fine clay to total clay are at their maximum in Btk horizons and decrease with depth in these pedons. These differences related mainly to the effects of conditions and to some extent to the comparsion of parent material and to the effect of geomorphological processes.The mean annual rainfall increase from the location of pedon 1 to pedon 3 which have great effect on the activity of some pedogenic processes include transformations and translocation processes (Osman and Eswaran,1973;Bullock and Thompson,1985; Breeman and Burman,1998;Khomali et al,2003).These facts reflected by the ratio of Total silt /Total clay (Table 2) which can be used as an indication of the weathering intensity .The results indicate that more clay accumulation in pedon 2 and pedon 3 horizons than in the pedon 1.The values of silt:clay are ranged between 0.89 to 1.40 in p1 ,0.86 to 1.00 in p2 and 0.55 to 0.83 in p3.Low values of silt:clay ratio in p2 and p3 comparsion with low contents of clay in p1 indicated that it is more advanced weathering stage than the p1 .The lack of precipitation inhibits chemical weathering leading to coarse textured soil in arid regions .

Soil Development Indicators:

The results of the soil development indicators of the studied pedons (Table 3) indicate that the criteria of clay accumulation index (CI) and the ratio of clay content in the B horizon on the clay content in the A horizon (B/A) . It shows some variation in the degree of soil development among study pedons . Pedon 1 did not show a remarkable development, as reflected by the (CI) indicator, while the value of (B / A) was 0.87 due to the effects of dry conditions and gypsiferous parent material . Pedon 3 showed higher degree of soil development , the value of(CI) was 314.5

and the (B / A) 1.21 . This may reflects the effect of illuviation , and to some extent of lessivege processes , which is confirmed by the translocation of fine clay and presence of weak argillans (Fig 4) . Pedon 2 also showed some degree of soil development ,(CI) value 208, while the value of clay ratio (B / A) was 1.35 which did not meet the critrea for the formation of Argillic horizons. These results are in agreement with Collins and Fenton ,1982 and Levine and Coilkosz,1983, as pointed out that the development of soil horizons is a result of the effectiveness pedogenic processes function which lead to a redistribution of the soil components with depth. Theses results are also, in agreement with the findings of the Bouwman and Lemans, 1995, Vidic and Lobnik,1997.

Table (3) The status development for studied pedons.

Pedons	Thickness T (cm)	CI= (B-C) T	B/A (clay)	Degree of Soil Development
P1	19	----	0.87	**Very weak**
P2	32	208	1.35	**Moderate**
P3	37	314.5	1.21	**Moderate**

Chemical properties:

Chemical properties (Table 4) indicate that all pedons are non- saline with EC values less than 2.0 dSm^{-1} .They are neutral to slightly alkaline soil with pH values range from 7 to 8.12 . Organic matter tends to decrease with depth in all the studied pedons . The relative low organic matter content in P1 (0.8 gkg^{-1} to 5.5 gkg^{-1}) whereas the organic matter values in P2 and P3 relatively higher in the surficial horizons (17.2 gkg^{-1} and 18.7 gkg^{-1}) in P2 and P3 respectively due to high rainfall with more dense vegetation . Relative low cation exchange capacity (CEC) values in P1 has been shown related , mainly to high sand content and low organic matter ,and may be to the relatively high Ca/Mg ratios which indicate the dominance of kaolinite and palygorskite (Wilding ,1983) . Whereas P2 and P3 show high percentage CEC values due to the high content of clay minerals (mainly semictite and illite Fig.5) ,and slightly high organic matter content .The results indicate that gypsum contents are high in P1 due to the effect of gypsiferous - calcareous parent material and tend to be increase with depth. Gypsum content ranges between 140 gkg^{-1} in (A) horizon and 383 gkg^{-1} in the By horizon. While , pedons 2 and 3 show very low gypsum content .The results for carbonate content show a revised distribution pattern in comparison with gypsum content in all pedons .Pedon 1 shows the lowest content of total carbonate in comparison to pedons 2 and 3 and it ranges from 130 gkg^{-1} in A horizon to 80 gkg^{-1} in the Cy1 horizon and tend to decrease with depth. While ,the content of total carbonate and active carbonate tend to increase with depth in Bk and decrease in lower horizons .The amounts and the presence of visible of different forms for carbonate accumulations in subsurface horizons in pedons 2 and 3 were meet the requirement of calcic horizon formation (Soil Survey Sataff, 2010). The formation of illuvial Calcic horizon (Bk) in pedon 2 and 3 are due to calcareous parent material and more rainfall which activate the processes of decalcification in the surface horizons and increasing the solubility and translocation of carbonate minerals from the upper parts of soil pedon and accumulate them in lower parts of the pedon forming calcic horizon.

These results are in agreement with the results obtained by(Muhaimeed et.al., 2013, Muhaimeed et al.,2013. and Aziz and Muhaimeed 2016) they concluded the formation of Argillic and calcic endopedons in some soils of Iraq Northern .

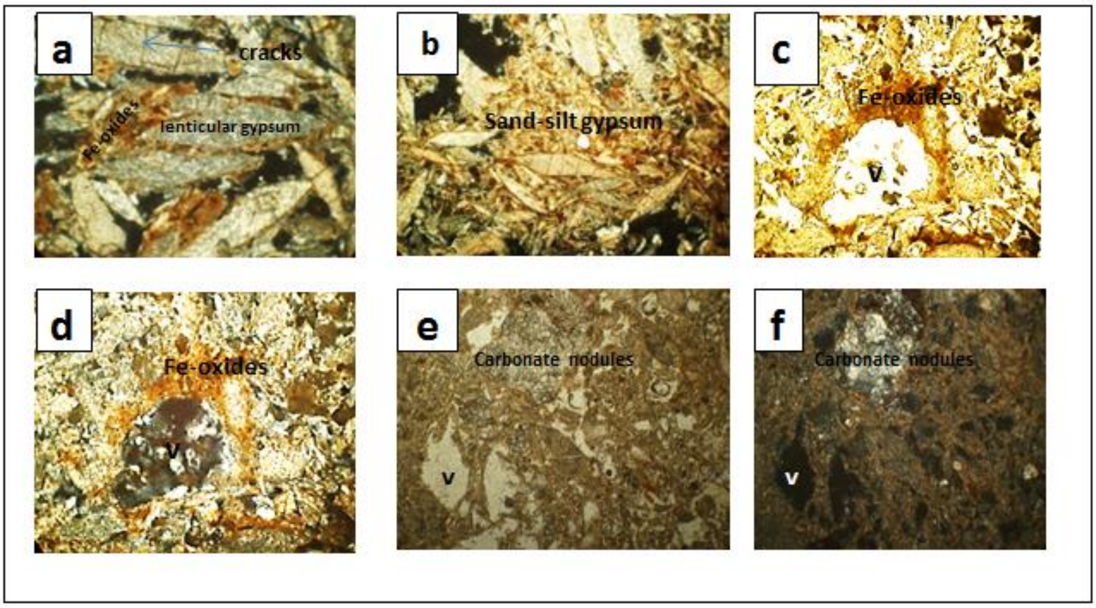
Table 4. Chemical properties of the studied soils.

Horizon	Depth Cm	EC dS m^{-1}	pH (1:1)	Organic matter gkg^{-1}	Gypsum gkg^{-1}	Total carbonate gkg^{-1}	Active carbonate gkg^{-1}	Cation exchange capacity $cmol.kg^{-1}$	Ca^{++}	Mg^{++}	Na+	K^{+}	$SO4^{--}$	Cl^{-}	$HCO3^{-}$	$CO3^{-}$
									mmol.l^{-1}							
P1																
A	0-22	1.8	8.01	5.5	140	130	43	9.8	20	6	4	0.6	22	6	2	1
By	22-41	2.0	8.12	4.0	383	100	52	8.7	18	4	3	0.4	15	8	0.8	1.5
Cy1	41-92	2.0	8.03	0.8	377	80	45	6.3	16	6	3	0.3	16	8	0.9	-
Cy2	92-120	1.9	8.02	----	332	86	22	7.3	16	7	3	0.3	18	6	1	-
P2																
A	0-28	0.9	7.0	17.2	-----	220	93	24	22	9	2	0.7	24	7	0.5	0.5
Btk	28-60	1.7	7.4	8.2	----	320	186	18	15	7	3	0.8	21	5	0.3	---
Bk	60-92	1.2	7.2	5.5	----	310	140	19	10	9	2	0.6	21	3	0.3	---
Ck	92-120	1.3	7.4	4.7	-----	230	112	18	17	10	2	0.6	21	7	0.3	----
P 3																
A	0-14	0.4	7.1	18.7	------	250	177	28	24	9	1	0.6	26	6	0.6	0.4
AB	14 – 27	0.4	7.3	9.5		285	155	24	22	9	2	0.6	25	7	0.3	-----
Btk	27-64	0.6	7.2	7.8	-------	360	197	24	19	7	2	0.8	22	5	0.3	---
Bk	64-84	0.4	7.5	5.4	------	330	134	18	16	10	1	0.8	22	5	0.4	---
Ck	84-120	0.6	7.5	5.0	--------	240	96	17	19	6	1	0.6	21	6	0.2	---

Soil Micromorphological Characteristics:

Thin sections of peds from subsurface horizons of all the studied pedons were studied to examine the degree of orientation of some soil components include clay ,gypsum and carbonate minerals . Generally, thin section results shows a good evidences for the presence of illuival gypsum and carbonate minerals , but ,there is little evidences of illuvial clay ,mainly in pedon 2 and 3 (Figures 2 ,3 and 4) . The dominant micromorphological features in pedon1 (Figure 2a) are the presence of lenticular gypsum, quartz, feldspars and heavy skeleton grain minerals and crystalline infilling inside vughs pores . Most of the sand-sized gypsum-quartz are neoformations and are the dominant form in sandy soils . Individual glaebules found in the A horizon were relatively large , rounded with a sharp boundary . Glaebules of this type were considered to be inherited from the parent material. Most of the sand-sized gypsum-quartz are neoformations and are the dominant form in sandy soils . Glaebules with sharp boundaries with some diffuse boundaries occur; in such case, it could be ascribed to dry environments . Fig.2B- represent By horizon which consist mainly of sand-silt sized ,lenticular crystal gypsum and different skeletal grains of quartz and calcite . The By horizon was usually very dense and correspond to semi-hard gypsic horizon and less porosity (45%)at the depth 41 cm .

Figure 2(C and d) shows dense imperegated vugy calcisepic fabric with a typical vughy void(black color) with and without polarized microscope light and the lenticular gypsum crystals at various sizes which are commonly associated with either pedogenic or geogenic formation . It is possible to notice Fe-oxide (sesquioxides) materials covering the gypsum crystals and the coated skeleton grains. The feature is observable in coarse textured soils , and coat the sand grains in varying thickness ,the coated ferran may not formed by illuviatiom or concentration from the soil solution ,but rather by orientation of particles from the the effect of weathering and drying cycle under arid conditions .



Fiq.2 –a- lenticular gypsum crystals with crack sand-size cemented by iron oxides ,under crossed polarizers,40 X. b lenticular gypsum crystals sand-silt size,vughs in By horizon 40X .C and d – crystalline infilling inside vughs , vughy hypoferan , lenticular gypsum crystals,in By horizon 80X d- the same .e and f - Vughy pores dominant Vughs voids , calcan infilling and carbonate nodules inCy1 horizon .Thin section under crossed polarizers, 80X.

There are strained physical weathering on some lenticular gypsum crystals which are commonly associated with dry and moist soil conditions. Fig.2,e and f showed infilling calcan (may be sparitic calcite) in the hard horizon (Cy1) . The dominant pores were vughs which associated with vughy microstructure and an increasing of Fe- oxide at uniformly throughout the horizon Cy1. (Fe-oxides) usually exist in both surface and subsurface horizons which suggests three probabilities ,first ,upward movement of the soil solution within the moistened zone during dry periods of the year (the cappillary property); second sequence the weathering –drying cycle under arid conditions and finally presence of Fe-oxides uniformly throughout the profile.

(Fig.3-a) represents A horizon of Pedon 2 showed vughy microstructure with connected vughy structure(may developed to chamber pores later) due to the effect of gass and biological activity , and different grains skeletal such as calcite, Fe-nodules, quartz, feldspar and other soil fragments (fig 5) while Fig.3-b showed dense type of impregated large nodule was completely coated by Fe-oxides as well as white quartz and calcite grains . Channels was the predominant pores .White calcic nodules were occupied the whole A horizon associated with calcareous parent material . Fig.3-c shows predominant plane-channel pores in the Btk horizon with high ferous-carbonate impregnations and white carbonatic nodules occur inside the micro-aggregates,which associated with angular to prismatic microstructure.

Fiqure(3-d) shows a nodules and soil peds hypocoating by ferrous -clay minerals in the horizon Btk. While Figure (3.e and f).

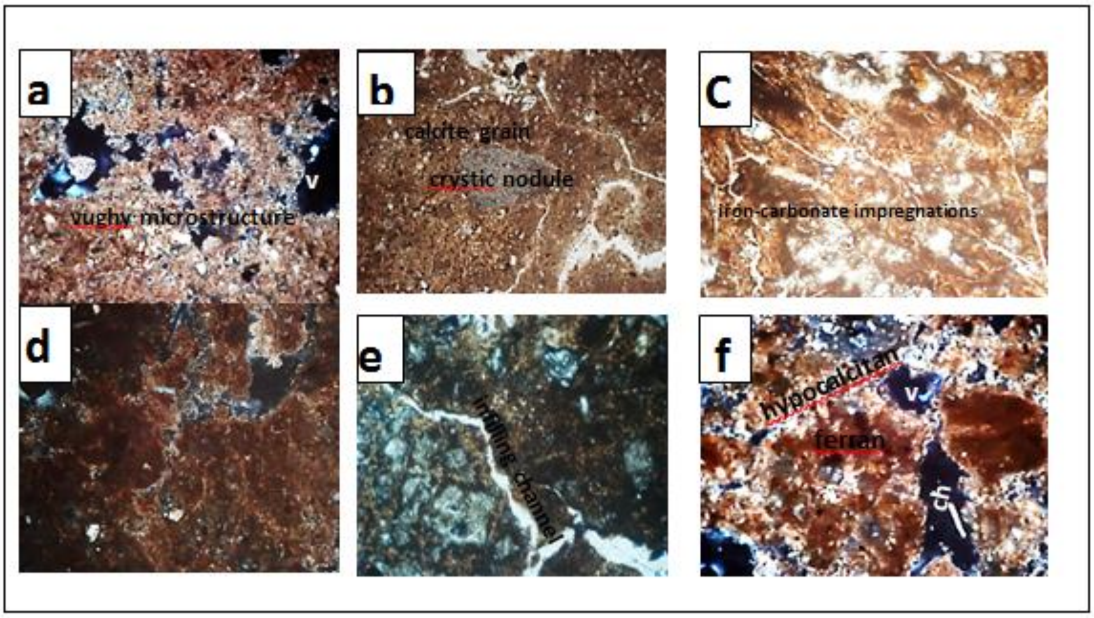
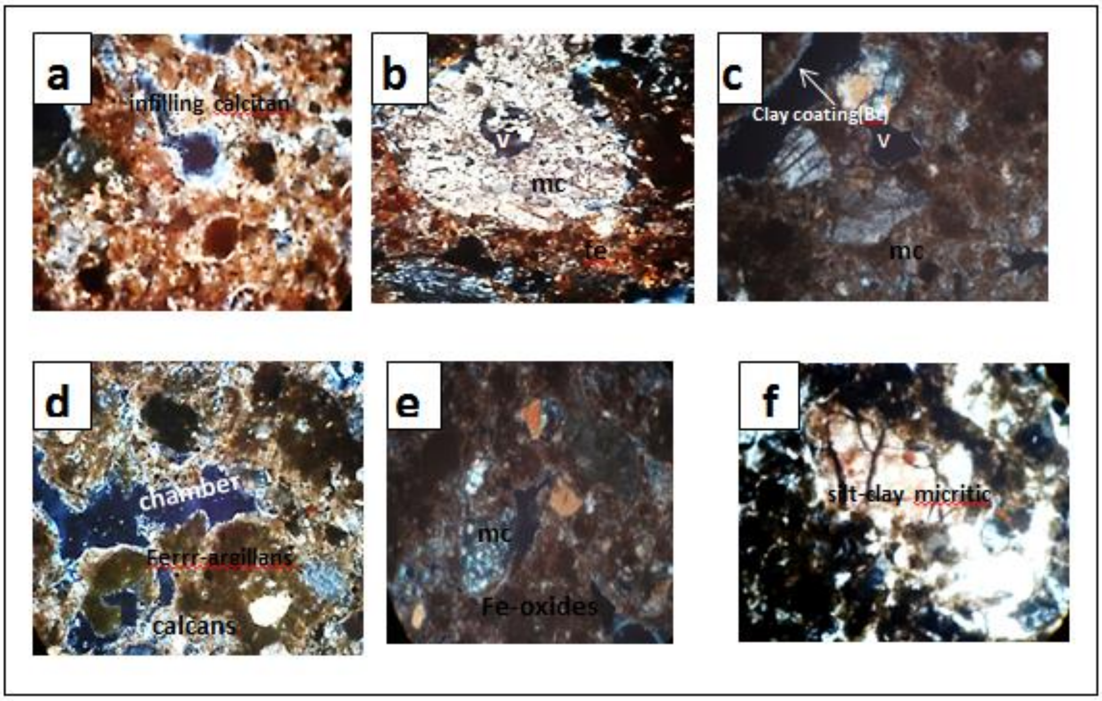


Figure 3 shows some micromorphological development in pedon 2. (a) shows a vughy microstructure in the A horizon ; b– A horizon , having angular - subangularblocky microstructure; iron impregnations and crystic nodules occur inside the micro-aggregates, (PPL, 80X).c – Btk horizon showed angular to prismatic microstructure; iron-carbonate impregnations ,plane-channal pores . d- Btk horizon showed calcitan ,having granular microstructure; peds , ferri-argillans,with mineral grains Fe-hypocoting ,vughs and chamber(ch) voids ;80X. e- Bk horizon having granular microstructure; with infilling channal voids ;80X. f- Ck horizon having hypocalcitan and ferran pedofeature ,vughs and chamber pores. ;80X .

Illustrates the white calcitans and brown ferrans hypocoating internal channel pores associated with subangular microstructure dominated in B_{tk} .The dominant micromorphlogical features in BtK represent by vughy to subangular microstructure ,calcite and quartz grains. The main sources for carbonate accumulation in the study pedons are the calcareous parent material (Gile et al., 1966; Gile and Grossman, 1968; Nettleton, 1991). As well as weathering of Ca-feldspar minerals and reprecipitation as calcium carbonate.

Pedon 3 showed some micromorphological development . The A horizon showed infilling calcitans in a vesicular channel due to nearly high precipitation about 500 mm/year (Fig 4.a and b) showed infilling carbonate (calcitans) in a void (vughs) within brown sorounding Fe-oxides in A and AB horizon . The results indicate the presence of the alluvial genetic horizon Btk due to moist climatic conditions relatively.The Btk horizon showed the evidence of clay and secondary carbonate illuviation (Table 2) .(Fig 4 c and d) showed argillans and ferri-argillanse cutan (enriched in clay 510 gkg $^{-1}$ and fine clay 270 gkg $^{-1}$) associated with voids were observed in Btk horizon , and calcitan associated with active pedogenic carbonates 197 gkg $^{-1}$(Table 3) . The (Btk) horizon also showed coating of fine micritic calcite (mc) on the upper part of the channel having granular microstructure and dense complete infillings (CI) by fine illuvial clay ; peds and nodules hypocating with ferrans, around vughs and chamber voids .Desected clay orientation can not be attributed to single genetic process , both illuviation and shrink– swell activity were involved in the orientation of clay . Pedogenic carbonate probably precipitated from the soil solution near the average depth of the wetting front or illuviated from the above horizons due to sufficient moisture content . There are four types of illuvial clay pedofeatures: (i) clay intercalations and thin clay coatings around mineral grains , (ii) disrupted clay pedofeatures occurring as remnant of earlier clay pedofeatures , (iii) clay pedofeatures occurring in voids ,and (iv) clay coatings that are intimately associated with CaCO3 coatings and nodules. This confirm the active processes of illuviation and calcification due to the role of moist climatic conditions in translocation of colloidal fragments. Figure 4 (e) for BK horizon shows a micritic calcite infilling as well as weathered nodules at different sizes and colors and brown Fe-oxides on soil aggregates. (Figure 4-f) for Ck horizon show silt-clay size nodule impregnated, physical weathering cracks associated with recycling of moist and dry due to swelling and shrinkage.

The weak clay coating in pedon 2 and 3 may be related to recycling of soil material through the shrinkage and swelling of clay minerals . Coefficient of Linear Extensibility (COLE) values were obtained only for Erbil and Kirkuk pedons at the depth that were partially illuvial clay coatings were observed, The COLE values for pedon 2 was 0.04 in Btk and BK horizons , were COLE values in pedon 3 were ranged between 0.04 in A and AB horizons to 0.05 in Btk horizon (Table 2). The shrink–swell activity was probably not high enough to disrupt all the clay coatings. Nettleton et al. (1969) indicated that COLE values could be used to indicate the stability of natural surfaces for clay orientation. If the COLE values are more than 0.04, the identification of oriented clay features can be difficult or impossible in arid and semi-arid regions.



Fiqure 4: shows some micromorphological development in pedon3. a- infilling calcitan in vesicular channel ,granular structur A horizon . PPL ,80x.b- complex pedofeature with ferran(fe) and micritic calcite(mc) in a vughs (v), in AB horizon depth 14-27 cm.PPl, 80X. c- (Btk) oriented white thin continuous clay coating along channel Btk horizon , limpid micritic calcite (mc);,vughs(v) and chamber voids;80X. d- ferri-argillans,calcans on aggregates and internal chambers and vughs voids. (PPL, 80X) . e- Micritic calcite(mc) infilling in a weathered nodules,Fe-oxides on aggregates of BK horizon . (PPL, 80X). f- dense silt-clay micritic nodules impregnate,with physical weathering cracks. (PPL, 80X)

Mineralogical Composition of the study pedons:

The mineralogical composition of some horizons (By from p1 and Btk from pedon 2 and 3) were examined by X-ray diffraction (XRD) and analyses using a Philips diffractometer with Ni-filtered CuKa radiation. The x-ray diffraction patterns of the bulk soil indicate the major dominant clay mineral for the studied soil profiles (Figures 5) . The By horizon of the pedon 1 were interstratified clay minerals of (Cl/Sm,P/Ill) and kaoalinite (7.2 A) (Al-obaidy ,2008) while nonclay minerals were quartz(3.34 A),calcite (3.04A). The occurrence interstratified clay minerals and quartz mineral is mainly related to arid conditions with high gypsum and sandy texture , this compatible with Elen et al ,2012 . Coarse skeleton grains were dominated consisting mainly of quartz, lithogenic calcite and other primary minerals (Owliaie ,2012) .Clay mineral at Btk in P2 were interstratified clay minerals of (Chl/Sm) ,illite (10.1 -10.2 A),and kaoalinite(7.2 A) ,while nonclay minerals distribution according to its dominion were quartz(3.34 A) ,calcite(3.04A) , and feldispar(3.18 A,3.7A,4.04)A.Clay mineral distribution at Btk in P3 were interstratified clay minerals (Chl/Sm), illite(10.1 -10.2 A) , and kaoalinite (7.2 A) , while nonclay minerals distribution according to its dominion were quartz (3.34 A) ,calcite (3.04A) , and feldispar (3.18 A, 3.7A, 4.04 A).

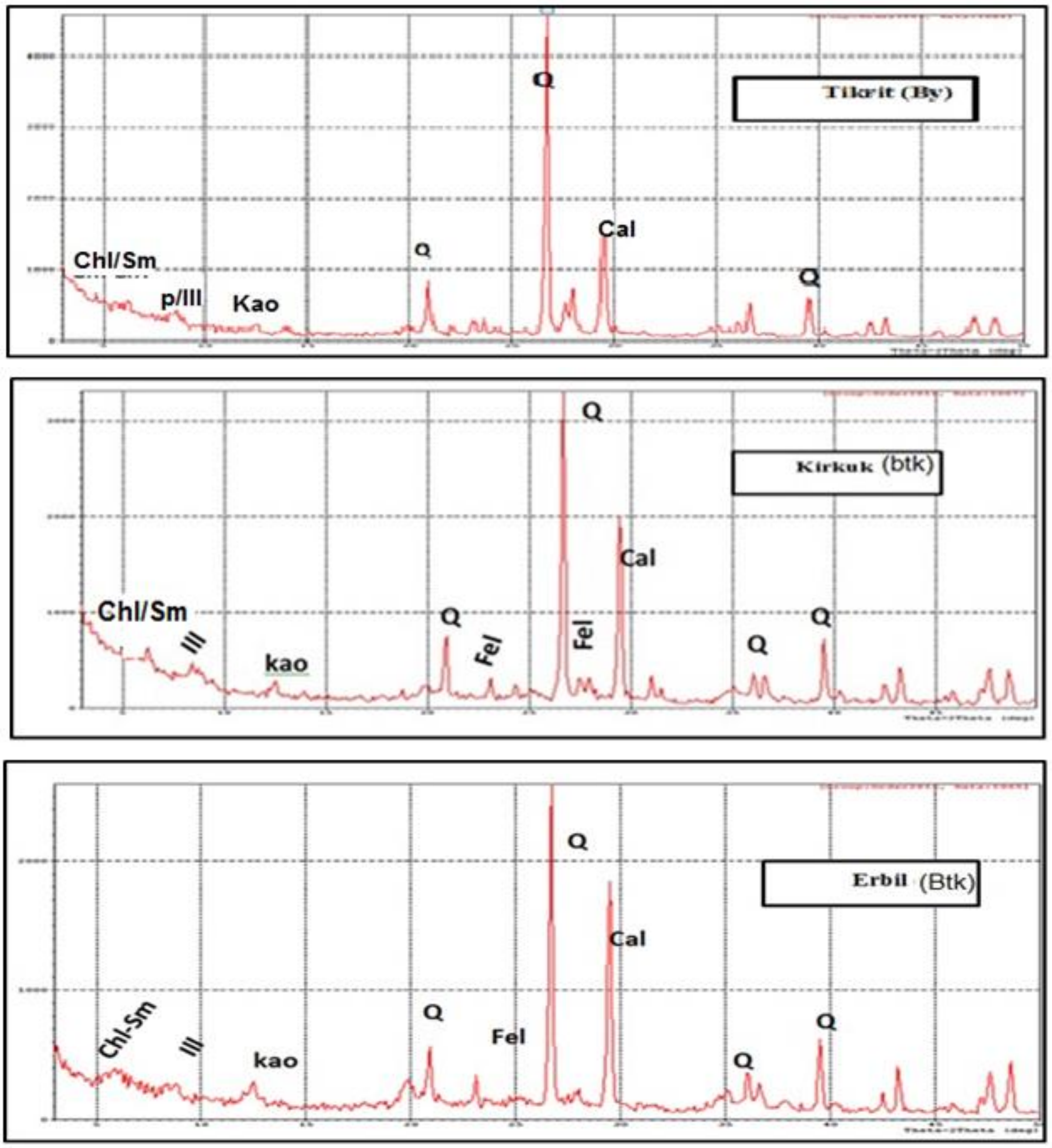


Figure 5 : X-Ray diffraction of the bulk soil of three subsurface horizons for the study pedons.chl=chlorite,Sm=semictite,kao=kaoalinite,Ill=illite,P=palykoriskite,Q=quartz,Cal=calcite,Fel= feldspar .

Classification of the study soils :

According to the morphological, physical , chemical and mineralogical data of the studied soils , soil of pedon 1 was classified as : Sandy skeletal, , gypsic, semiactive , hyperthermic, Typic Haplogypsids . These soils formed under dry climatic conditions and consist of ochric and gypsic horizons . while soil of pedon 2 was classified as : loamy mixed, carbonatic , super active ,Hyperthermic Aridic Argixerolls . These soils have an ochric epipedon and illuvial horizons of calcic and Argillic . Soil of pedon 3 was classified as : fine, mixed ,carbonatic ,active ,thermic , Vertic Argixerolls .These soils have a Mollic epipedon with Calcic and Argillic indopedons , as they formed under more rain fall with lower mean annual temperature .

Conclusions :

The results indicate that the studied pedons show some differnces in the status of soil development represented by the presence of different diagnostic horizons leading to the formation of different soil orders including Aridisols and Mollisols . The existing differences between the study soils are due to the effects of both the nature of parent material and climatic conditions.

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