MICROMORPHOLOGICAL CHARACTERIZATION OF SALT AFFECTED SOILS OF ALNAJMI AGRICULTURAL PROJECT IN MUTHANNA GOVERNORATE\SOUTHERN OF IRAQ

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ABSTRACT

Alnajmi Agricultural project, Muthanna, Iraq, featured with wide salt affected soils, although it is considered as a significant project for irrigated agriculture. Salt affected soils in this project were studied in different methodologies. Micromorphology descriptive study was conducted to get more information about the salinization process in this project. Eight pedons out of twenty-five ones were selected to be examined micromorphologically. Six of these pedons were salt affected, while the other two were none salt affected soils. As a comparison among those eight pedons, saline soils showed different features related to microstructure and porosity, besides coatings as salwans (salt cutans) and calcitans (carbonate cutans). Paleosalinization process showed clear salwans in examined soils, while recently salinized soils showed weak features of salt coatings. Carbonate coatings were found in all samples due to the nature of the soil formation in arid and semi-arid regions. None salt affected soils did not show salt coatings, while they showed carbonate minerals coatings.

Keywords: calcitan, salwan, cutan, salinization, thin section
***Part of M.Sc. thesis of the 1st author.**

التشخيص المايكرومورفولوجي للترب المتأثرة بالأملاح في مشروع النجمي الزراعي في محافظة المثنى/جنوب العراق

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المستخلص

يتميز مشروع النجمي الزراعي، المثنى، العراق، بترب واسعة التأثر بالملوحة، على الرغم من أنه يعتبر مشروعًا مهمًا للزراعة المروية. تمت دراسة التربة المتأثرة بالأملاح في هذا المشروع بمنهجيات مختلفة. تم إجراء دراسة وصفية ميكرومورفولوجية للحصول على مزيد من المعلومات حول عملية التملح في هذا المشروع. تم اختيار ثمانية بيدونات من أصل خمسة وعشرين بيدونا لفحصهم بشكل مجهري تحت المجهر المستقطب. ستة من هؤلاء البيدونات كانت متأثرة بالأملاح، في حين كان البيدونين الاخرين غير متأثرين بالأملاح. وبالمقارنة بين تلك البيدونات الثمانية، أظهرت التربة المتأثرة بالأملاح سمات مختلفة تتعلق بالبناء الدقيق والمسامية، فضلا عن الاغلفة مثل الاغلفة الملحية (السلوان) والاغلفة الكلسية (الكالسيتان). أظهرت عملية التحلل الملحي وجود اغلفة ملحية واضحة في التربة التي تم فحصها، بينما أظهرت التربة حديثة التملح سمات ضعيفة للأغلفة الملحية. تم العثور على الاغلفة الكلسية في جميع العينات بسبب طبيعة تكوين التربة في المناطق القاحلة وشبه القاحلة. لم تظهر البيدونات غير المتأثرة بالأملاح مظاهر تواجد الاغلفة الملحية الا انها اظهرت بصورة واضحة تواجد الاغلفة الكلسية.

كلمات مفتاحية: اغلفة كلسية، اغلفة ملحية، اغلفة طينية، عملية التملح، الشرائح الرقيقة
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INTRODUCTION

The study of micromorphological features in saline soils has been paid less attention in the past decades due to the lack of expertise in that field besides the size of work needed to prepare samples in thin section and microscopy examination. Bronnikova (5) had interpreted the micromorphological features of Soils and Regoliths, and he confirmed the difficulties in identifying the anthropogenic microfeatures in time besides how to relate these microfeatures to the agricultural activities. In salt affected soils, it needs more attention to prepare samples for examination due to the solubility of salts thoroughly (18). Soluble salts including gypsum are frequently occur in arid and semi-arid regions Dultz and Kuhn (8), although gypsum occurrence could be found in xeric, ustic, and aridic moisture regimes Hashemi and Khademi (13). In 1976, Hanna And Stoops (12) studied the micromorphology of salt affected soils of the north Nile delta to gain more information about the salt affected soils besides the process of salinization, where the most characteristic of morphological features they found were diffuse iron oxihydrate glaebules in the gleyed horizons, halite cutans (Salwans) on most fissures and ped surfaces, lenticular gypsum crystals and thin surface crusts, while porous microstructure with many biopores, the moderately drained soils exhibit a crumby microstructure composed of a packing of small pellets were found in poorly drained soils. Amit and Yaalon and Yang et al, (1,28) tried to document the micromorphological differences in salts occurrence in regosols of Negev deserts in Israel. Low amounts of prismatic gypsum crystals were found in young and mature regosols while fibrous gypsum was only found in mature regosols of gravel formations. Halite cubes and powder were found in mature soils with supersaturated soil solution. vughy, channel and massive microstructure and their b-fabric were mainly crystallitic were found in saline – sodic soils of the west of Urmia Lake Chakherloo(6), he also found clay and salt cutans in the studied soils. Calcium carbonate and salts were found as fillers to the pores beside the crystallization occurrence of them in soils Moazallahi and Farpoor (19) had studied the micromorphological features of soils along climotopo sequence in Kerman Province, Central Iran. They confirmed that dissolution of gypsum led to high accumulation in pores of aridisols, while calcite coating and infilling were found in some other samples of different highly rain isobars areas of inceptisols. Neyestani and Farpoor (20) investigated micromorphology Of Saline-Gypsiferous Soils in Kheirabad Playa, Sirjan where they observed euhedral gypsum crystals and calcite coatings in gypsic and calcic horizons of the playa geomorphic position. Farooq (11) was focused on a case study of Cholistan Desert in India to seek its classification and micromorphology, and he referred to the devoid porosity in soil due to the high accumulation of salts of sodium as they were classified as sodic soils and related that to the chemical and physical destructive nature of these salts. This study is focusing on describing the micromorphological features of the salt affected soils in Alnajmi agricultural project as compared to none salt affected soils. The micromorphological study results of some salt affected souls that Heeshan et al., (14) results of the microscopic studies of clay and calcareous horizon in northern Iraqi soils confirmed the presence of intermittent clay films intertwined with iron oxides around the soil courses or in the pores of the soils in Erbil province. Two pedons in Erbil province showed ferri-argillans weakly around peds and the inner walls of pores in the argillic horizon, and that was related to the pedoturbation processes due to the existence of smectite group clays (1:2) besides, the biological activity that disperses these clay coatings (23). Results of the field morphological description and microscopic studies of some soil series in Baiji city, central Iraq, as well as the results of laboratory analyzes confirmed existence of gypsan and calcitan coats, which confirms influence of soil by original sedimentation sources resulting from the Makhoul mountains series, which affected the Soil formation of study area (15). Wheib and Ibrahim (25) studied the micromorphological identification of salt affected soils in mid Mesopotamian plain and they confirmed the existence of calcitans and salwans in thin section study. Many studies seek the effect pf soil salinity on

soil properties and affecting plant growth (24, 26), also some researchers characterized the salic, calcic, and gypsic horizons in arid and semi-arid soils (26, 27, 29, 30)

MATERIALS AND METHODS

Area this study: Al-Najmi project is located at Al-Muthanna Governorate, as a part of the southern alluvial plain in Iraq, confined between longitudes 44º 26′ 00 and 45º 10′ 00″ and latitudes 31º 30′ 00 and 31º 40′ 00″. The total area of the project, including residential areas and water bodies, is estimated at 25,000 hectares, (14). 25 pedons were excavated and 25 more surface samples were taken. Figure (1) shows the study area and the locations of the pedons and surface samples from the map of Iraq. In this study 8 pedons were selected to study the micromorphological features where 6 pedons were salt affected soils and other two pedons were none salt affected soils chosen for comparison.

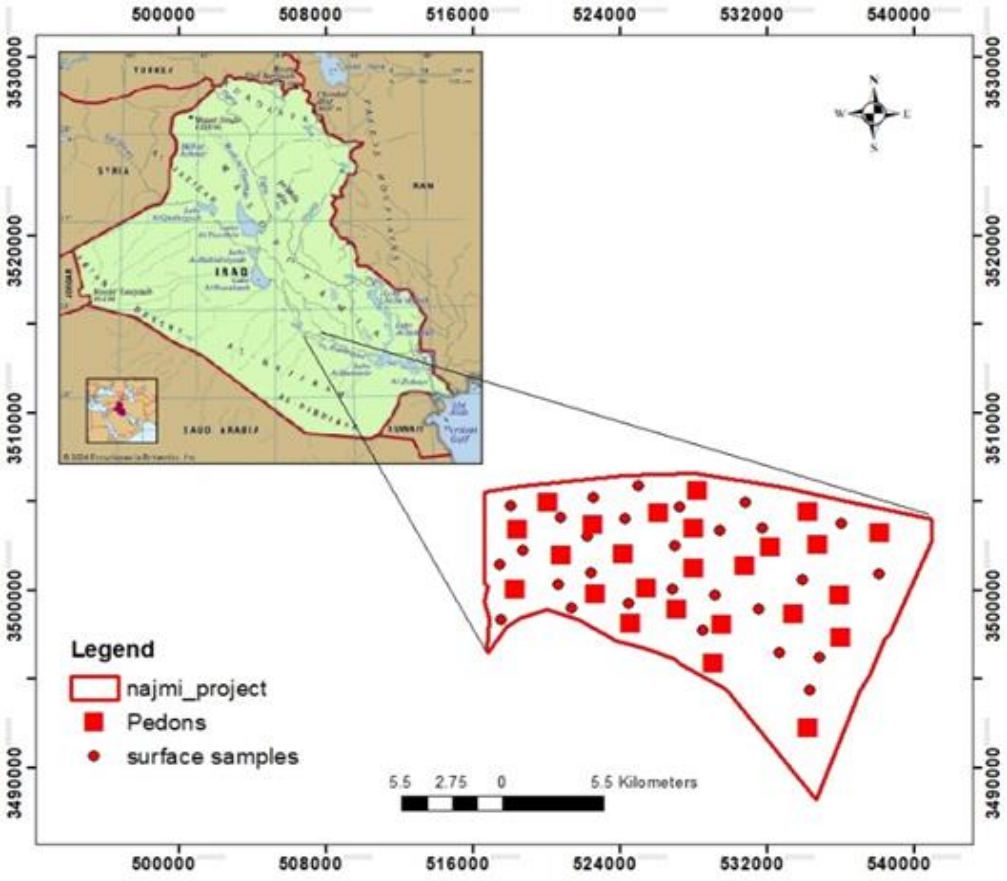

Figure 1. Map of Iraq showing the area of study, pedons and surface samples

Micromorphological examination of soil thin sections: The slides for microscopic examination of soil diuretics were prepared by selecting a soil ped with known direction, saturating it with a resinous substance, hardening it for the purpose of cutting it to a thickness of 0.01 mm, and pasting it on a glass slide for the purpose of examination under a polarizing microscope according to the method described in Brewer(4) and using the description method used in (22) The selected pedons for this study were (2^{nd}, 4^{th}, 6^{th}, 11^{th}, 15^{th}, 17^{th}, 20^{th}, and 23rd).

RESULTS AND DISCUSSION

An accurate morphological examination analysis was conducted for selected samples of the study pedons of the first horizons representing the horizon A affecting and affected by the agricultural activities, while the second representing the horizon of C1 as parent material horizon. The pedons that were selected are the second, fourth, sixth, eleventh, fifteenth, seventeenth, twenty-third, and twenty-third pedons, as the sixth and twenty-third pedons represent soils unaffected by salts, while the rest of the pedons represent strongly saline soils.

Second Pedon: Figure (2) shows microscopic examination images of soil slices (micromorphology) of the A1 horizon of the second pedon. This horizon was morphologically and chemically identified as being a saline horizon (Az). The figures show that the presence of salts in high quantities on this horizon leads to accumulations in very large pores, metavughs, but during the preparation of the sample, large parts of the salts were washed away, although it left a significant salt covering surrounding the walls of the pores identified as salt cutans (Salwans). Another sample also showed a high presence of gypsum crystals in different shapes, with a needle-shaped predominance and powder like, which indicates a secondary deposition of this compound. This horizon was characterized by a variety of large and small pores, in addition to the fact that the construction in it refers to localized deposited materials of weak homogeneity, and the distinguishing feature of the results of the micromorphological examination is the presence of salwans and lime coatings surrounding the walls of large pores and clay particles. The results of the field morphological examination confirm findings of the micromorphological examination of the soil peds in terms of the presence of carbonate minerals and gypsum in this horizon. It is noticed from the accumulation of carbonate minerals that there is an appearance of calcium carbonate of animal origin (oolitic calcite) where that lead the understanding to the ancient human activities in this area. As for the second horizon C1, it showed micromorphological characteristics that differ somewhat from the characteristics of the upper horizon, in which channel pores and fine pores appeared clearly and are common in clay textures, as well as large pores. The microstructure was also characterized as porous or spongy due to the prevalence of all the pores in it. Some other micromorphological manifestations, such as the Salwan coats surrounding of the walls of the large pores, also appeared, the Calcitan coatings surrounded the walls of the fine pores clearly. Despite the preparation of the sample with water and the cutting operations it undergoes, a portion of the plasma was evident in the canal pores, which showed quantities of dissolved salts in them. Iron oxides were also occurred in the A horizon associated to clay plasmic fabric. Clay fabric was marked anisotropic between cross nicols which means their crystal structures vary with direction which also refers to the mechanical behaviour of these clays in soil, where such anisotropy can be attributed to selective orientation of clay particles during consolidation process occurring through sedimentation process that arranges the clay particles and results in bonds such that the material acquires the characteristic of cross-anisotropy with the axis of symmetry along the direction of consolidation Pietruszczak and Morz, Saada and Shook (21,23) ، Glaebules were characterized in thin section, where concretions of lime materials were found in C horizon and that could be related to the parent materials and it confirms the occurrence of parent materials in paleo-environments of cretaceous vertebrate materials transported and deposited in different age Del papa,et al., Eggleton (7, 9).

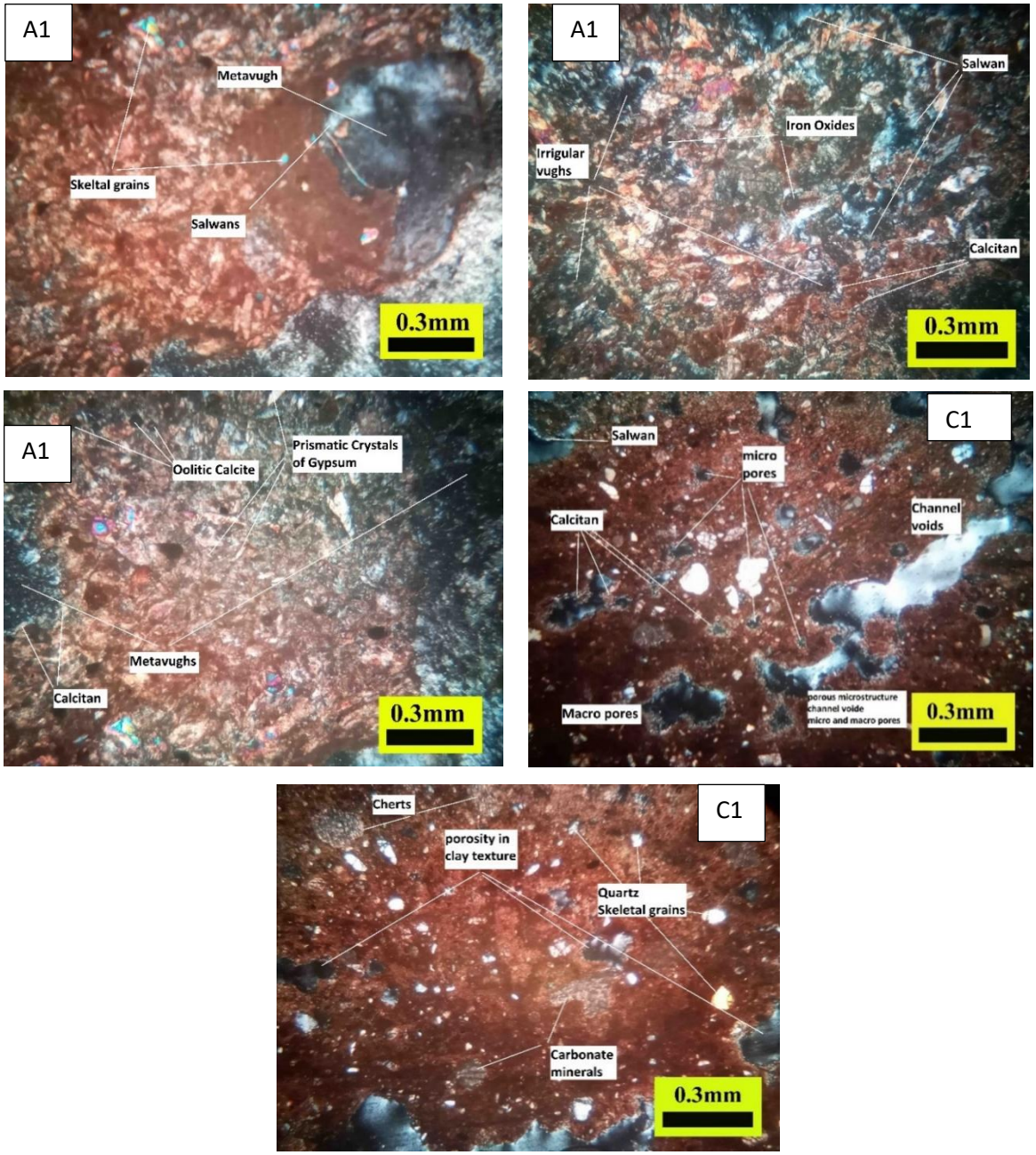

Figure 2. Micromorphological description of the second pedon, A and C1 horizons

Fourth Pedon: Figure (3) shows the micromorphological slides of the fourth pedon of the upper horizon A1 and the subsurface horizon C1. The A1 horizon was clearly distinguished by the presence of large-sized pores in it, in addition to the presence of salt coatings (salwans) resulting from the increasing accumulation of salts in this horizon. This horizon was also characterized by the appearance of the mineral halite (sodium chloride) clearly under the examination of polarized microscopy, as well as a clear presence of calcitans on the edges of the structural crystals and the walls of the internal pores. As for the C1 horizon, it was distinguished by the presence of irregular and channel pores, as well as a clear appearance of large pores (metavugh). There was a clear appearance of traces of plasma consisting of salts dissolved in the soil solution and accumulated around the walls of large pores, as well as the presence of calcitans in them. The salt coatings (salwans) can be distinguished from limestone by means of a polarizing microscope, as the salt coatings show dark colors cross nicols, while it appears in the form of high interference colors when cross nicols and the reason is due to the nature

of the crystallization of these minerals, as the salt films (salwans) fall in the homogeneous cubic isotropic crystallization system, while the lime films (calcitans) fall in the hexagonal anisotropic crystallization system for crystals of lime or carbonate minerals in general Aquilano,et al., Bader and AL_Garib (2,3). Some spots of iron oxides were present in this subsurface horizon, in addition to the presence of oolitic carbonate minerals of animal origin clearly in this slide.

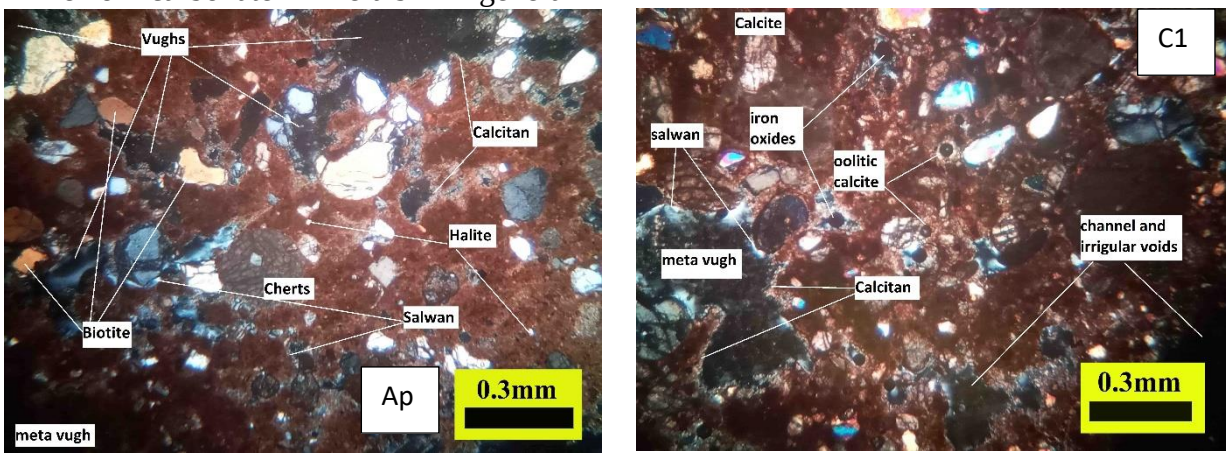

Figure 3. Micromorphological description of the fourth pedon, Az1 and C1 horizons

Sixth Pedon: Figure (4) shows the results of the micromorphological examination of the slices of the upper horizon Ap and the subsurface horizon C1. The horizon was characterized by a clear blocky structure due to human activity of plowing, especially on the upper horizon, with clay particles scattered as part of the matrix, and a clear appearance of skeletal grains such as quartz, calcite and feldspar minerals, as well as a clear appearance of the green color chlorite which refers to occurrence of phyllosilicate minerals that they are common in low-grade metamorphic rocks transported and deposited then after Ehlmann,et al.,(10). The pores of these two horizons are fine due to the clay texture soil, despite the appearance of pores of other sizes. Also, lime coatings appeared on the C1 horizon in clearly, enveloping some walls of large pores and some skeletal particles that refers to the secondary precipitation from soil solution in arid and semi-arid regions Lal , Wheib and Ibrahim (17,25). Salwans (slat coatings) were absent in this pedon because it is characterized as none salt affected soils.

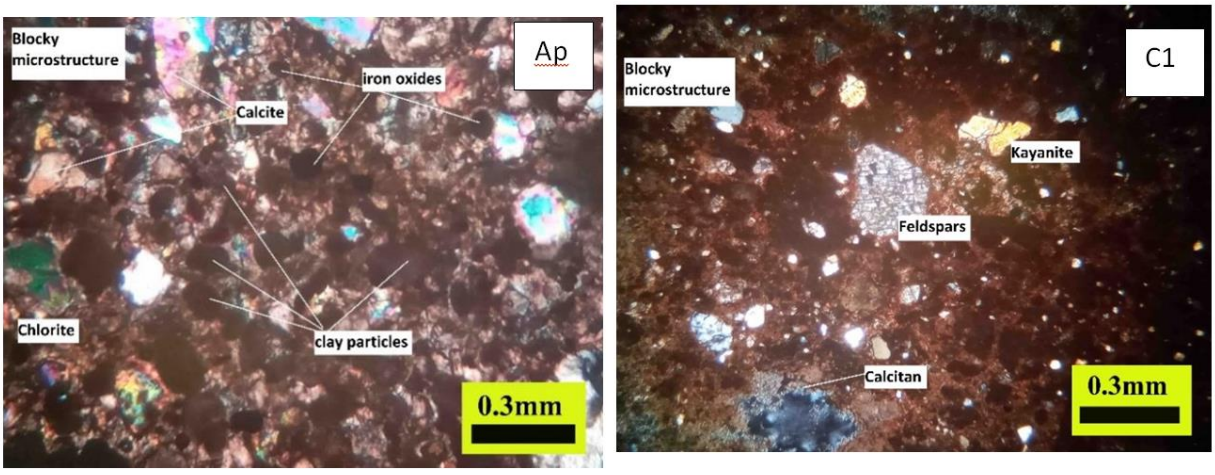

Figure 4. Micromorphological description of Sixth Pedon, Ap and C1 horizons

Eleventh pedon: Figure (5) shows the results of the micromorphological examination of the upper horizon A1 and subsurface C1 in the eleventh pedon. The upper horizon shows a clear appearance of large pores Vughs with the spread of large-sized pieces of quartz skeletal minerals, and despite the fact that this horizon is affected by salts, but it did not show the characteristic of salt coatings on the walls of pores or structural particles, but the fine calcite particles were clearly scattered in it as a part from the matrix on the slide. The subsurface

horizon also shows very large pores around which are spread the matrix consisting of carbonate minerals, with a slight appearance of salt coatings. The microstructure in these two horizons is characterized by being blocky and Vughy blocky pores. The lack of clear saline coatings could be related to the recent accumulation of salts where time did not allow for the formation of saline casings.

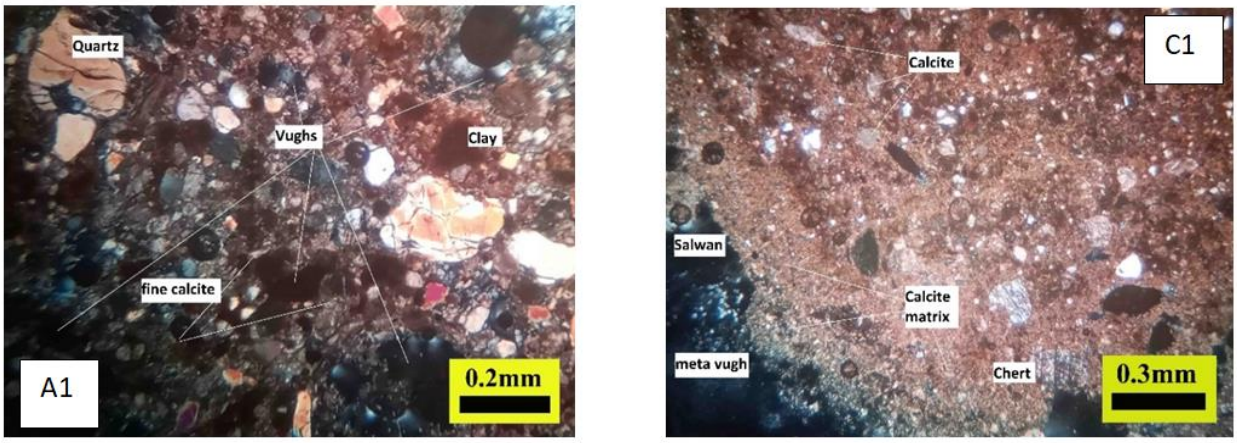

Figure 5. Micromorphological description of the eleventh pedon, A1 and C1 horizons

Fifteenth pedon: Figure (6) shows the results of the micromorphological examination of the slices of the A1 and C1 horizons of the fifteenth pedon. The results of the upper horizon slice indicate the presence of salt coatings, which is evidence that this horizon is affected by the process of salinization for long periods, which allowed the development of salt coatings (salwans) around the walls of pores and particles. Also, the presence of calcitans indicates prolonged processes of secondary sedimentation of carbonate minerals from soil solution. The upper horizon A1 was characterized by a fine porous Vughy structure, while the subsurface horizon C1 was distinguished by a clear canal structure. The channel pores were also characterized by being filled with salts. Also, the pores were very large and covered with a clear salt sheath.

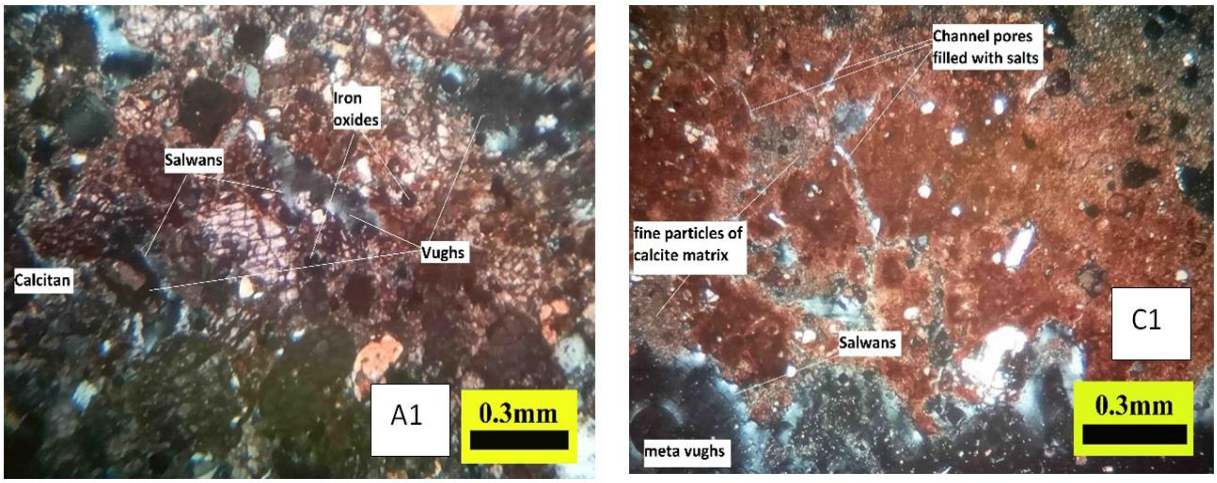

Figure 6. Micromorphological description of the fifteenth pedon, A1 and C1 horizons

Seventeenth pedon: Figure (7) shows the results of the micromorphological examination of the seventeenth pedon slices of the upper horizons Az1 and the subsurface horizons C1. The upper horizon is highly sensitive to salt, as the soil salinity value reached 70.84 dS m^{-1}. The results of this horizon slide showed clear accumulations of the halite mineral (sodium chloride), as well as the development of salt coatings around the walls of pores and structural particles. The construction of this fine horizon was characterized as porous Vughy. As for the subsurface horizon C1, it showed fine pores scattered widely, as despite the texture of this horizon of medium coarse texture, the pores spread in it are of a fine type, and the reason may be due to the compaction process taking place on this horizon as a result

of ancient agricultural operations as well as overgrazing in the study area In general, the microstructure of this horizon was characterized by being massive to blocky.

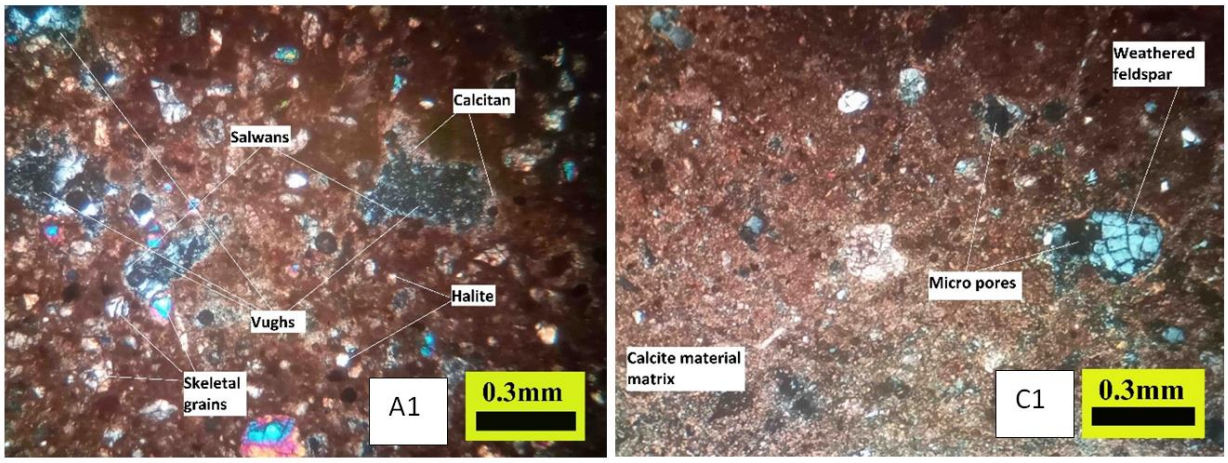

Figure 7. Micromorphological description of the seventeenth pedon, A1 and C1 horizons

Twentieth pedon: Figure (8) indicates the results of the micromorphological examination of the upper horizon A1 and subsurface C1 in the twentieth pedon. The microstructure of the upper horizon was characterized by being blocky with large pores, due to the presence of very large pores in different areas of the slides. The salt coatings did not appear clearly on this horizon, but the dissolved salts appeared in the large-sized pores clearly, and this is evidence of the movement of salts as a result of the capillary property to the top and the lack of development of the salt coatings indicates that the salinity of this horizon is newly formed. Characteristic of this horizon is the presence of gypsum grains in the skeletal minerals. There was also a clear presence of fine lime grains as part of the matrix and in the form of calcareous coatings around the walls of the large pores. As for the subsurface horizon, it was characterized by large channel pores as well as vughy pores spread throughout the slide. There were spots of iron oxides, in addition to the presence of calcite in high proportions, as the structure was characterized as Vughy gaps in this horizon. The reason for the prevalence of large-sized pores in the canal or porous varieties is due to the coarse textured soil in this pedon, in which large-sized pores are common compared to fine textured soils. The saline and calcareous coatings (salwans and calcitans) were weakly present on this horizon.

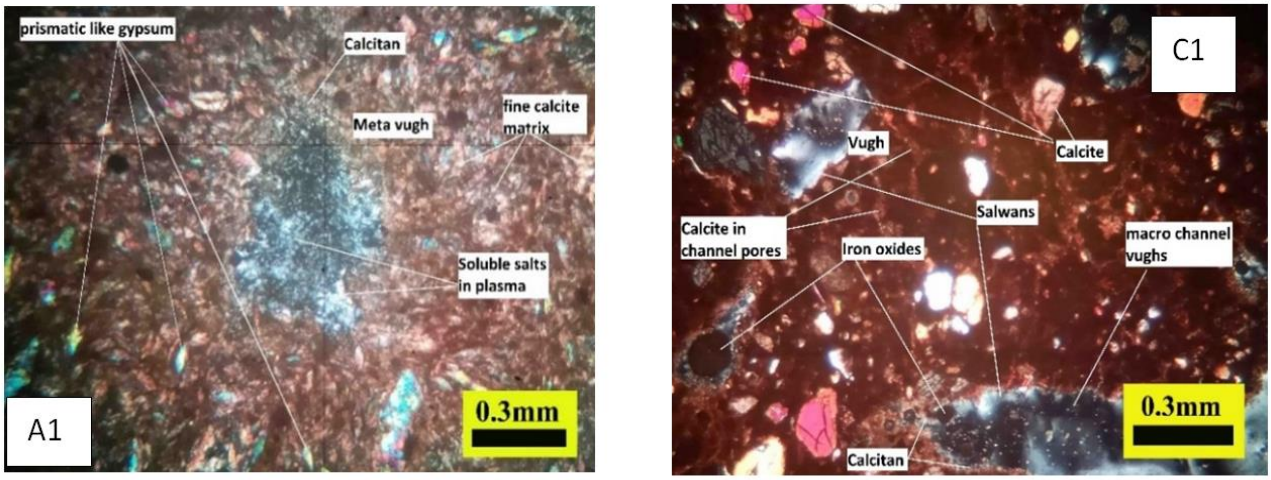

Figure 8. Micromorphological description of the twentieth pedon, A1 and C1 horizons

Twenty-third pedon: Figure (9) indicates the results of the micromorphological examination of the slides of the twenty-third pedon of the upper horizon Ap and subsurface C1. Both horizons are characterized by cavities structure, as large pores predominated in both horizons, especially in the subsurface horizon, and the presence of carbonate minerals in the soil matrix was observed on the upper horizon, while relatively large pieces of carbonate

mineral crystals were found in the subsurface horizon. The horizons are distinguished by the absence of saline or lime coverings, and the reason is due to the low salt concentration in both horizons. A clear presence of weathered feldspar crystals appeared.

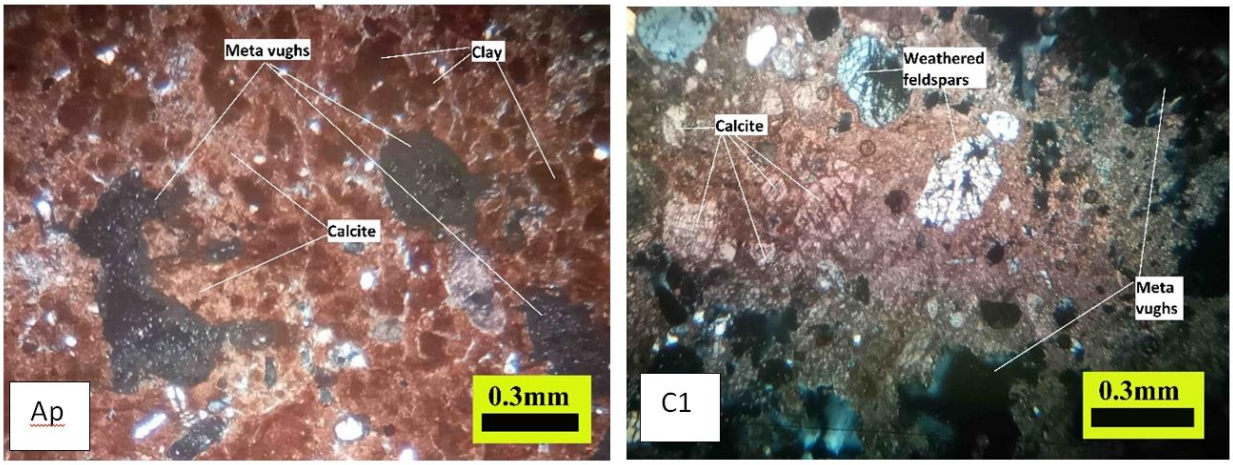

Figure 9. Micromorphological description of the twenty third pedon, A1 and C1 horizons

CONCLUSIONS

Saline soils showed clear features of developed salwans (salt coatings) and calcitans (carbonate coatings) with different kind of microstructure, while none saline soils showed only calcitans under the micromorphological examination of thin section. Recently salt affected soils did not show features of salwans. Farmed soils has shown spongy and vughy porosity, also some salt affected soils showed metavughs and vughy microstructure due to the salt effect in soil structure. Soil texture has a clear impact on microstructure and porosity distribution in thin sections.

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