

Carbonate minerals in the north western coast of Egypt, their formation and stability conditions

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ABSTRACT

Formation and stability conditions of carbonate minerals in some arid soils of Egypt were studied. The soils are generally calcareous with prominent carbonate accumulations at different depths. In some cases they are satisfying the requirements of calcic or petrocalcic horizons. The Northwestern coast at Mersa Matruh area is selected for the study. The parent rock of the soils is the upper Miocene limestone and the parent materials are transported along Wadis to the coastal plain and alluvial fans. Carbonates dissolution and precipitation are due to CO_2 (p) of atmospheric origin and rain water acidity. The pH of the soils is generally moderately alkaline, ranging between 7.3 and 7.9. The dissolution of carbonate minerals (e.g., calcite) is demonstrated in the following equations: ($\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$) ($\text{H}_2\text{CO}_3 \rightarrow \text{H}^+ + \text{HCO}_3^-$) In the presence of Ca from (primary) carbonates together with other calcium bearing minerals, the reactions are; ($\text{CaCO}_3 + \text{H}^+ \rightleftharpoons \text{Ca}^{2+} + \text{HCO}_3^-$) ($\text{HCO}_3^- + \text{Ca}^{2+} \rightleftharpoons \text{CaCO}_3 + \text{H}^+$) Mineral composition of the carbonates of the soils include Calcite and Ankerite $\text{Ca}(\text{Mg.Fe})(\text{CO}_3)_2$ in general, together with oxide minerals as quartz and wollastinite? (CaSi_2O_5). Dolomite and Magnesite are suspected in another trace of the same area represented by profile 1 in the same region. The most important elemental composition of the soils has the following sequence $\text{Si} > \text{Ca} > \text{Al} > \text{Fe}$ which is corresponding to the size fraction and parent materials. Important trace elements (ppm) were found in the analyses such as S, Cr, Zn, As, Zr, Ni and Rb. Soil gels extracted were found of negligible amounts denoting poor weathering of silicate minerals in general. Stability conditions as exemplified by dissolution-precipitation processes are greatly affected by acid and redox conditions. All samples are falling in the moderately alkaline - positive oxidation fields (aerobic condition) in the plotted diagrams.

Keywords: carbonate; minerals; arid; Stability; Formation; redox potential.

INTRODUCTION

Calcareous soils of Egypt are predominantly found in the Northwestern coast and at Sinai Peninsula. Carbonate minerals are scarcely studied in our calcareous soils, a case which encourages this study. It is very important to differentiate between primary and secondary carbonates to assess the extent of weathering and stability of these minerals. The calcic horizons existing in some soils of the Western coast of Egypt are reported to accumulate at surface and subsurface horizons with a significant magnitude of calcium carbonate. The pedogenic evidence of these accumulations is the presence of secondary carbonate forms such as masses, coatings, nodules and concretions. These accumulations are not necessarily formed below the surface of these soils. Hammad, M.A. (1964) and Hammad and Abdel Salam (1968) found a relationship between the presence of this horizon and its situation in the landform.

As dissolution and precipitation phenomena depend on pH and Eh (reduction – oxidation potential) conditions, it became

necessary to explain this phenomenon under arid surface conditions where complete leaching is lacking.

REVIEW OF LITERATURE

Carbonate minerals are a major reservoir in the global carbon cycle (So et al., (2020). Due to carbonates importance in geological and anthropogenic realms, research on carbonate characterization and quantification is of interest.

Soil carbonates originate from several sources or combinations of sources (Dregne, 1976) either directly in the form of carbonates, or by a solution-precipitation mechanism. The most common sources and mechanisms are:

Parent Material

The most direct method is inheritance from the parent material. The principal requirement is insufficient leaching to remove carbonates from the solum.

Dissolution of Ca-bearing Minerals

The common context is dissolution of more soluble minerals, such as gypsum or anorthite

(Ca-silicate), within the immediate soil and precipitation of calcite.

Mineralization of Plant Materials

Plant recycles Ca to the surface. Calcium released by decomposition of residues reacts with CO₂ charged H₂O to form CaCO₃.

Wind Deposition

Carbonate materials are transported some distance, suspended in air, and are deposited on the surface as dust or in rain. Subsequent relocation within the soil by solution and precipitation is possible.

Rain

Calcium ions enter the soil in rainwater and subsequently combine with HCO₃⁻ associated with CO₂ charged H₂O (Rabenhorst *et al.*, 1984).

Surface water

Natural surface H₂O or irrigation H₂O can contain Ca²⁺ that reacts with CO₂ charging H₂O to form carbonates.

Ground Water

Ground water may move through carbonate-containing soils or substrata and bring either Ca²⁺ or HCO₃⁻ ions into the soil, where they combine to form CaCO₃ when the soil dries or the temperature rises.

Mineral carbonation of CO₂

Oelkers *et al.*, (2008) showed that a survey of the global carbon reservoirs suggests that the most stable, long-term storage mechanism for atmospheric CO₂ is the formation of carbonate minerals such as calcite, dolomite and magnesite.

Lippmann (1973) stated that one of the main problems in studying the origins of carbonate minerals in soil is deciding which minerals are formed through pedogenic processes (secondary) and which are the remains of the original parent material (primary). The most abundant carbonate minerals in sedimentary rocks are calcite and dolomite, followed by siderite and (Fe-bearing dolomites), some lacustrine deposits contain carbonates.

Pedogenic carbonates nearly always are aggregates of silt-sized calcite crystals, however. The microcrystalline forms are readily identified by optical microscope, either in thin section or grain mount. Sand-size crystals of calcite or dolomite are inherited from the parent material. Aragonite also can be

inherited from soil parent materials. Aragonite is commonly associated with Holocene or Pleistocene sedimentary deposits, fresh shells, or animal skeletal material, and is not common to sediments of Tertiary age or older. Occasionally, aragonite has been identified with pedogenic processes.

Sherman *et al.*, (1962) reported dolomite formation in soil, and this is the only report of pedogenic dolomite. Hoven *et al.*, (2002) found that in arid environments, significant amounts of calcium (Ca) are stored in pedogenic carbonates that develop in soils. There are two sources for Ca in pedogenic carbonates in soils: local parent material and dust deposited on the surface.

In sea water studies, Berner (1975) showed that Mg²⁺ inhibited Calcite crystal growth but had no effect on aragonite crystal growth. Magnesium ions could be incorporated into the crystal structure of Calcite to form Dolomite of marine origin. Thus, when Mg²⁺ to Ca²⁺ ratios in the soil solution is high, Aragonite may become the most stable carbonate mineral.

Dolomite usually is associated with sediments older than Pleistocene. Exceptions to this were discovered in formations in South Australia (Alderman 1965), the Bahamas (Shinn *et al.*, 1965), the Netherlands Antilles (Deffeyes *et al.*, 1965), and the Persian Gulf (Illing *et al.*, 1965), Bahamas (Shinn *et al.*, 1965), the Netherlands Antilles (Deffeyes *et al.*, 1965), and the Persian Gulf (Illing *et al.*, 1965).

MATERIALS AND METHODS

Egypt's North-western coast forms a discontinuous belt about 20 km wide, extending for about 500 km between Alexandria and El-Salloum near the Libyan border. Five soil profiles were chosen to represent the soils of the studied area; their location is shown in Figure 1. and their coordinates in Table 1 together with a rock sample.

Chemical and physical analyses.

Chemical and physical analyses of the 2.5:1 soil water extracts were analyzed according to standard methods as outlined by Jackson (1973), Richard (1954), and Black (1965).

Mineralogical and Elemental Analyses:

X-Ray analysis of carbonate minerals (XRD), powder method on total soil samples, using Pan Analytical apparatus (XRD), carried

out from 20° 2θ to 70° 2θ on the 6 selected samples of Mersa Matruh and Sidi Barrani.

Elemental analysis were carried out using XRF technique on the same 6 selected samples (profile 4layers1, 2and3), (profile 5layers 1, 2 and 3) and rock of the Northwestern coast (RN).

Soil gels in the previous selected soil samples including Al₂ O₃, Si O₂, Fe₂ O₃ were extracted using Na- dithionite originally by the method of Aguilera and Jackson (1953), and were determined in the extract by XRF analysis of Pan Analytical.

RESULTS AND DISCUSSION

Chemical analysis of the soil

Chemical analyses were carried out using soil water extract of 1:2.5. The results are shown in Table (2) of the total soil profiles studied. The soils of the North western coast are generally moderately alkaline at a pH ranging from 7.2 to 7.9. Soils are non-saline having an EC of 0.21- 0.48 ds/m), while previously reported values of these soils had values around 2.6 ds/m (Hammad, 1964).

Calcium carbonate percentages in the studied soils of the Northwestern coast are very high in general (16.72-40.98%). However, the values of the profile layers are almost the same. Organic matter in these soils is negligible. Values of pH in other studied areas are relatively higher as compared to those of the northwestern coast (7.8-8.5)

Mineral composition of carbonates

As mineral composition is only representing X-ray traces from 20 °2θ to 70 °2θ, X-ray d spacings will be in this range demonstrating primarily carbonate minerals and some oxides, mainly iron oxides.

Carbonate minerals of the selected horizons of the studied soils -(profile 4layers1, 2and3), (profile 5layers 1, 2 and 3) and the rock sample of the Northwestern coast (RN) are almost of the same composition. They consist of calcite (CaCO₃), and Ankerite (calcium magnesium iron carbonate). The strongest X-ray lines as reported in many literatures (e.g Kostove 1968) of the former minerals, Calcite CaCO₃

$$3.03^{(10)}-2.28^{(7)}-2.09^{(7)}-1.910^{(9)}-1.873^{(8)}$$

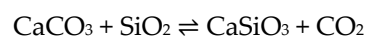
Calcite mineral is crystalline in hexagonal system while its isomorph aragonite is orthorhombic. Mn, Fe, Sr, Co, Zn, Ba, and Pb may partially substitute for Ca as with Dolomite CaMg (CO₃)₂. Transferring calcite to

dolomite is known as dolomitization in a digenesis process in which Mg is partially replacing Ca. Concerning siderite (FeCO₃); complete replacement of iron with Mg to form magnesite is possible. Calcite – dolomite – siderite are forming a solid solution where mineral like ankerite (calcium magnesium iron silicate Ca(Mg,Fe)(CO₃)₂) could form in this way.

The discussion previously demonstrated could explain the presence of ankerite in the composition of the carbonate minerals in these profiles. However, iron origin in the last mentioned mineral is not obviously explained because of the absence of characteristic X-ray peaks of iron oxides or otherwise.

X-ray diffractograms and (XRD) and d-spacings are demonstrated in Figure (2) and Table (3).

The composition of area that is represented by profile 4, second layer (4L2) is consisted of a mineral called calcium silicate (CaSi₂O₅). Formula like this is similar to wollastinite Ca₃Si₃O₉, which is usually found in contact metamorphic limestones and marbles through the interaction of dissociated CaCO₃ and SiO₂ as explained by the following equation ;



Contact metamorphic zones are not until now reported in the geology of the limestone plateau through which this wadi is carved.

Some d- spacing's outlined in the represented tables and diffractograms may belong to minerals other than carbonates, e.g. the 4.276 line in the soils of the upper layer of profile 4. Because carbonate minerals within 40-70 °2θ are only considered, such lines are neglected.

Carbonate minerals composition of the layers of profile 5 is almost consistent with other profiles of the region. They are composed of calcite, quartz and ankerite. The last regular pattern is in agreement with the calcareous soils of the northwestern region. A nearby rock sample designated RN (rock of the Northwestern coast) was analyzed mineralogically by XRD Table (3) and chemically by (XRF). Mineral composition of this rock includes quartz, calcite, ankerite and Ca, which is supposed to be the common parent rock of calcareous soils mainly of the Northwestern littoral (Mersa Matruh).

Elemental composition of the studied soils

X-ray fluorescence XRF analyses of the soil of profiles 4 and 5 of Northwestern coast were

performed (Table 4). The aim of this analysis is bi-objective. First object was to confirm the mineralogy in general of the investigated soils. Second, is to suggest the ability of replacement of cations in carbonate minerals. If we arrange the elemental composition of samples in descending order. The following sequence are given; $Si \rightarrow Ca \rightarrow Al \rightarrow Fe$.

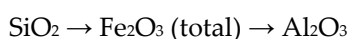
Elemental composition of the rock sample RN is dominated by (Ca) followed by magnesium, silicon and aluminum, and iron. A pattern in agreement with the calcareous soils of the northwestern regions.

Weathering and soil development

The main weathering products in soils include what is called soil gels. These are composed of free iron, silica and aluminum oxides as extracted by suitable extractants. The results are shown in Table (5). The aim of this analysis is to assess weathering of soil minerals under prevailing condition.

In order to assess soil development in the studied calcareous soils, the approach comprised; accumulations of carbonates in the form of calcite or petrocalcic horizons and the presence of soil gels. In arid soils the extent of weathering is very low; hence values may be very low. Because mineral composition of our soils is including surprisingly iron in a carbonate mineral (ankerite), the origin was not confirmed by the presence of any iron oxides in the range of 20-70 $\mu\text{g/g}$. The ankerite mineral was also found in the rock sample.

Composition of soil gels as shown in Table (5) has the following decreasing order sequence.



Higher silicon oxide values are corresponding with sandy texture (reddish aeolian sand). This explanation is only concerning soils of the Northwestern coast.

Weathering and stability conditions of carbonate minerals in the soil aqueous system.

Chemical weathering in arid soils is not leading to the formation of B horizon of clay, oxides, or organic compounds due to weathering and translocation of products. The intensity of weathering could hardly ends with the carbonate accumulations and their leaching to lower depths in soil profiles. Movement of leached carbonate products are moved and precipitated at upper or lower layers according to their location in the terrain.

The accumulation of carbonates in the forms of calcic and petrocalcic horizons is significantly associated with type of landscape and relief. Hammad, (1964) explained the formation of carbonates (caliche) obviously as being formed in upper parts of some hills and ridges, alluvial fans and coastal plains. The reference designated to their origin as reliefogenic.

Dissolution - precipitation and stability conditions as reported by several investigators (Garrels, R.M, and Christ, C.L. 1965) are generally controlled by acidity and redox reactions, the relation is shown in the Eh - pH diagrams. The widely important diagram is known as pourbaix diagram which demonstrates the thermodynamic stability areas of different mineral species in an aqueous solution as a function of pH and electrochemical potential scales (Eh). Redox potential (Eh) referred to hydrogen electrode and denoting electron activity in the system intended. It is sometimes referred to as pE and defined similarly to pH as the negative logarithm of electron activity.

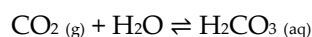
The coordinate diagram of the two variable systems (pourbaix diagram) was originally used with hydrosphere as PE against pH. The PE is then expressed as $= -\log a_e$. In the diagram, the redox potential axis is the vertical and designated as Eh

The redox potential of the system represents its ability to change electrons. When the potential is high (> 0 volts), the system tends to remove electrons from the species (oxidizing conditions). When the potential is low (Eh < 0 volts) reducing conditions prevail (ability to supply electrons to the species).

The pH of the system describes its ability to supply proton (H^+) to the species and is plotted as the horizontal axis. As well-known when pH is less than 7, the concentration of the protons is high and the pH is low.

The soil like other natural environmental aqueous systems under surface conditions is exposed to water (e.g. H_2O rain water) as a solvent and air CO_2 .

As our concern is carbonate minerals in soil environment, H_2CO_3 acid is formed by the dissolution of CO_2 (g) in water according to the equation:



The equilibrium constant of the equation is then:

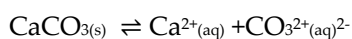
$$K_{CO_2} = \frac{a_{H_2CO_3^*}}{P_{CO_2}} = 10^{-1.46} = (298.15k, 1$$

bar)

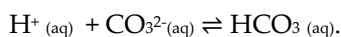
Assuming that $a_{CO_2(g)} = P_{CO_2(g)}$

CO₂ sources in soils are mainly atmospheric and organic matter decay. The rain water would be even more acidic in response to a higher P_{CO₂} in the atmosphere as other acid solutes (e.g. sulfuric acid and nitric acids formed in atmosphere by oxidation of SO₂ gas and nitrogen due to anthropogenic activities).

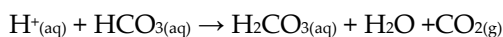
Carbonate minerals mainly calcite as found in the studied samples are going dissociation in natural aqueous solutions (say in soil water system) to:



When hydrogen proton of an acid, the following equilibrium reaction occurs;



If enough acid is present the following reaction occurs;



Most of the previous reactions are reversible, hence we could understand that the origin of CO₂ (g) is not only from atmosphere, but also from dissolution of carbonates present in the soil which tends to provide H⁺ (aq). The pH of the soil is consequently a function of these reactions.

Considering of oxidation reaction conditions, aqueous solutions are not having free electrons, rather, oxidizing and reducing agents (Cl, Cu, H₂, Fe, Zn, Al, Mg, Na etc.) provide electrons for reduction and lose electrons for oxidations. The reactions are called Redox reactions. The activity of these reactions is measured by electrode potential as previously referred to.

Consequently, the most important controls of carbonate solubility are P_{CO₂} and pH which are inversely correlated. In other words the precipitation of calcite is favored by a decrease in P_{CO₂} or an increase in pH so that and by looking at pH-Eh diagram of some natural environmental systems (including soils) there is a fence of dissolution-precipitation of calcite mineral according pH-Eh values. Concerning soils, important consideration should be taken to define conditions of Redox-pH conditions

As considering our studied soils, the two measured parameters are recorded in table (6) and plotted in Figure (3).

CONCLUSION

Calcareous soils of Egypt are extending to wide regions at east and west of the Nile River at both sides of flood plain.

The only evident criteria of any soil development in these soils is the occurrence of carbonate accumulations either satisfying the requirements of calcic, petrocalcic or regular accumulations increasing or decreasing with depth.

Coordinates of the soil profiles of the studied area had the values between 27° 55' 11.9"E, 30° 58' 29.6"N and 26° 7' 35.8" E, 31° 34' 37.9"N.

Soils of the Northwestern coast are moderately alkaline and nonsaline. Equivalent calcium carbonates in general are very high (16.9% ≈ to 41.0%). Soil profiles of Ras El Hekma are sandy in general while other profiles are of sandy clay loam and loamy sand textures.

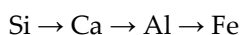
Carbonate accumulations precipitated in arid soils are usually considered as secondary carbonates. Therefore, accumulations of carbonates in the studied soils especially those of the western Mediterranean coast are mostly considered as pedogenic. Their dissolution is controlled by CO₂ pressure and the slight change in pH as a result. Leaching and evaporation is depending on air-soil temperature. The carbonate accumulation depth occurrence is consequently dependent on terrain elevation. In lower terrain, basins, rain water catchment areas, alluvial fans, horizons are found at lower depths. Conversely high position in the terrain brings the accumulations at or near the surface.

Carbonate mineral composition of the soils of the Northwestern coast include Calcite and Ankerite in general together with quartz, and CaSi₂O₅ (Wollastonite?). The rock sample collected from this region has some general composition including Calcite, Ankerite and (Dolomite?), together with quartz. The composition did not differ considerably. Differentiation between primary carbonates i.e. those found in parent rock and secondary carbonates found as accumulations is not always rational.

Total chemical analysis of the studied soils was undertaken to confirm mineral composition of carbonates and to give

inference of profile minerals not encountered in carbonate analysis.

Elemental composition in the form of oxides has the following sequence in descending order in the soils of the Northwestern coast;



To assess soil development, the approach comprised carbonate accumulation and soil gels (free iron oxides, silica, alumina) as extracted by suitable extractants. Carbonate accumulations are prominent than soil gels probably due to almost neutral to moderately alkaline under aerobic conditions.

Stability conditions of carbonate minerals in soils were assessed by acidity (pH) and oxidation-reduction conditions. It was found that very slight acid conditions and oxidized conditions (+Eh) are controlling precipitation-dissolution processes.

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Table 1: coordinates of the soil profiles of Northwestern coast area (GPS reading).

Id	Region	Valley name	Long	Lat
1	Ras El Hekma	Al Tagah	27° 55' 11.9" E	30° 58' 29.6" N
2	Ras El Hekma	El Debaa	27° 50' 55.0" E	31° 3' 22.5" N
3	Marsa Matrouh	Al Heshify	26° 58' 42.1" E	31° 23' 27.9" N
4	Marsa Matrouh	Al Halazin	26° 50' 47.1" E	31° 21' 1.2" N
5	Sidi Barrani	EL Heriga	26° 7' 35.8" E	31° 34' 37.9" N

Table 2: Chemical composition of the soils of the Northwestern coast area.

Profile code	Depth cm	pH	EC dS/m	Soluble Cations (meq/l)				Soluble Anions (meq/l)				CaCO ₃ %	OM %
				Na ⁺	K ⁺	Ca ⁺²	Mg ⁺²	CO ₃ ⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻		
Ras El Hekma: Wadi Al Tagah													
1	0-50	7.58	0.21	1.02	0.08	0.50	0.50	--	1.00	1.01	0.09	40.98	0.13
	50-100	7.58	0.24	1.13	0.27	0.50	0.50	--	1.00	1.12	0.28	40.56	-
	100-150	7.69	0.36	1.57	0.53	1.00	0.50	--	1.00	1.41	1.19	35.07	-
Ras El Hekma: Wadi El Debaa													
2	0-50	7.79	0.21	1.02	0.08	0.50	0.50	--	1.00	1.01	0.09	26.33	0.20
	50-100	7.69	0.25	1.07	0.43	0.50	0.50	--	1.00	1.01	0.49	29.34	-
	100-150	7.77	0.23	1.07	0.23	0.50	0.50	--	1.00	1.01	0.29	23.16	-
Marsa Matrouh: Wadi Al Heshify													
3	0-50	7.17	0.34	1.61	0.29	1.00	0.50	--	1.00	1.41	0.99	16.9	1.11
	50-100	7.45	0.30	1.39	0.11	1.00	0.50	--	1.00	1.21	0.79	18.17	-
	100-150	7.63	0.22	1.09	0.11	0.50	0.50	--	1.00	1.01	0.19	22.14	-
Marsa Matrouh: Wadi Al Halazin													
4	0-40	7.53	0.33	1.45	0.35	1.00	0.50	--	1.00	1.41	0.89	22.15	0.97
	40-90	7.51	0.30	1.21	0.29	1.00	0.50	--	1.00	1.17	0.83	27.87	0.82
	90-120 ⁺	7.59	0.29	1.18	0.22	1.00	0.50	--	1.00	1.05	0.86	26.80	-
Sidi Barrani: Wadi ELHeriga													
5	0-35	7.71	0.26	1.09	0.51	0.50	0.50	--	1.00	1.07	0.53	18.81	0.36
	35-80	7.91	0.31	1.53	0.57	0.50	0.50	--	1.00	1.41	0.69	19.9	0.27
	80-115 ⁺	7.82	0.48	2.67	0.63	1.00	0.50	--	1.00	2.52	1.28	16.72	-

Table 3: Mineral composition of the studied area.

Sample code	Compound Name	Chemical Formula	Mineral Name
4L1, 4L2, 4L3, 5L1, 5L2, 5L3, RN	Calcium Carbonate	CaCO ₃	calcite
4L1, 4L2, 4L3, 5L1, 5L2, 5L3, RN	Silicon Oxide	SiO ₂	quartz
4L1, 4L2, 4L3, 5L1, 5L2, 5L3, RN	Calcium Magnesium Iron Carbonate	CaMg _{0.32} Fe _{0.68} (CO ₃) ₂	ankerite
4L2	Calcium Silicate	CaSi ₂ O ₅	wollastinite

4L1 (4= profile number, L=layer)

Table 4: Total chemical analysis of the soils of Northweterern coast.

Sample code. Constituents wt. %	4L1	4L2	4L3	5L1	5L2	5L3	RN
Na ₂ O	0.185	0.154	0.160	0.311	0.292	0.283	0.205
MgO	2.37	1.99	1.98	1.88	2.05	2.00	8.53
Al ₂ O ₃	11.20	11.00	9.97	8.19	8.76	8.79	0.474
SiO ₂	45.00	36.90	34.00	56.70	49.00	39.40	4.50
P ₂ O ₅	0.359	0.358	0.257	0.263	0.313	0.365	--
Cl	0.0098	0.012	0.008	0.016	0.020	0.016	0.490
K ₂ O	2.84	3.24	2.87	2.68	3.09	3.10	0.074
CaO	15.00	16.80	22.90	15.20	18.30	23.00	44.60
MnO	0.115	0.189	0.146	0.082	0.124	0.134	--
TiO ₂	0.917	1.02	1.08	0.761	0.918	1.12	--
Fe ₂ O ₃ ^{tot.}	7.19	11.20	9.45	3.61	5.58	7.20	0.560
L.O.I	14.60	16.90	16.9	10.00	11.30	14.10	40.40

4L1 (4= profile number, L=layer)

Table 5: total chemical analysis of the studied area.

Sample code. Constituents wt. %	4L1	4L2	4L3	5L1	5L2	5L3	RN
Al ₂ O ₃	--	1.45	1.04	--	--	2.37	--
SiO ₂	0.99	3.38	2.63	1.07	1.15	5.30	1.13
Fe ₂ O ₃ ^{tot.}	0.11	0.12	0.09	0.08	0.07	1.62	0.067
Balance on H ₂ O	99.95	99.75	99.81	99.94	99.94	99.54	99.94

Table 6: Eh-pH values of the soils of the studied area.

Profile code	Depth (cm)	Eh (v)	pH
Ras El Hekma: Wadi Al Tagah			
1	0-50	0.15	7.58
	50-100	0.26	7.58
	100-150	0.32	7.69
Ras El Hekma: Wadi El Debaa			
2	0-50	0.74	7.79
	50-100	0.73	7.69
	100-150	0.79	7.77
Marsa Matrouh: Wadi Al Heshify			
3	0-50	0.65	7.17
	50-100	0.61	7.45
	100-150	0.44	7.63
Marsa Matrouh: Wadi Al Halazin			
4	0-40	0.70	7.53
	40-90	0.62	7.51
	90-120+	0.61	7.59
Sidi Barrani: Wadi ELHeriga			
5	0-35	0.61	7.71
	35-80	0.62	7.91
	80-115+	0.79	7.82

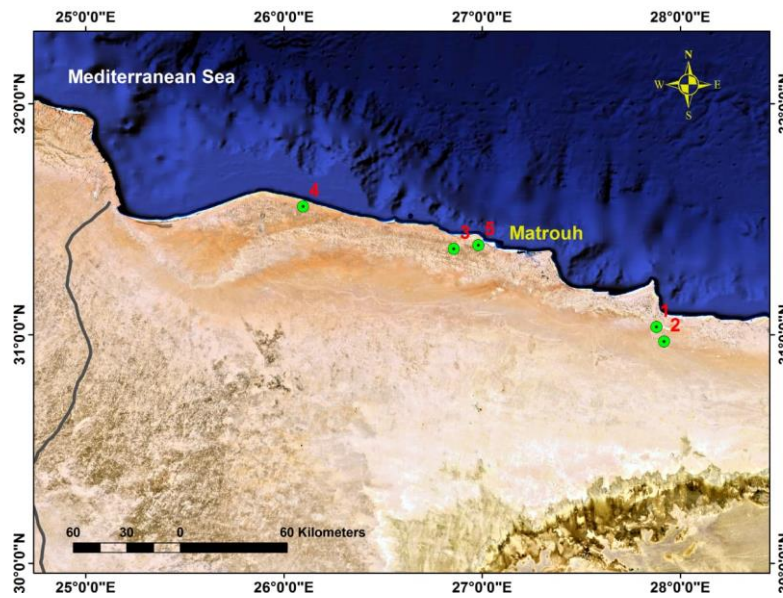
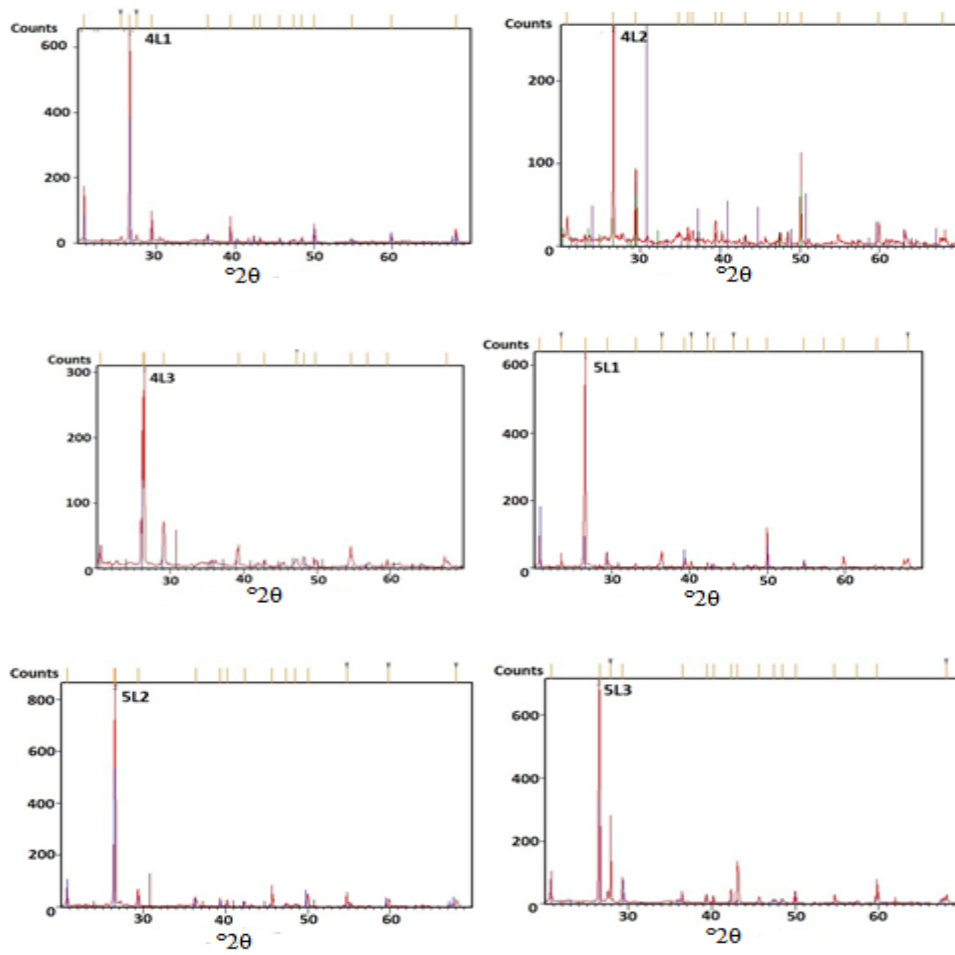


Figure 1: Location of the studied soil profiles.



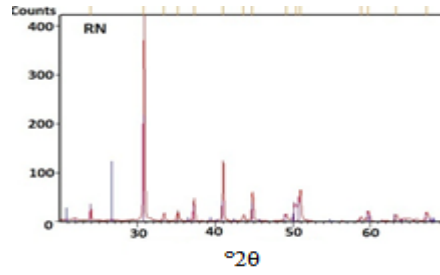


Figure 2: X-Ray (Cu Kα) diffraction pattern of the studied area.

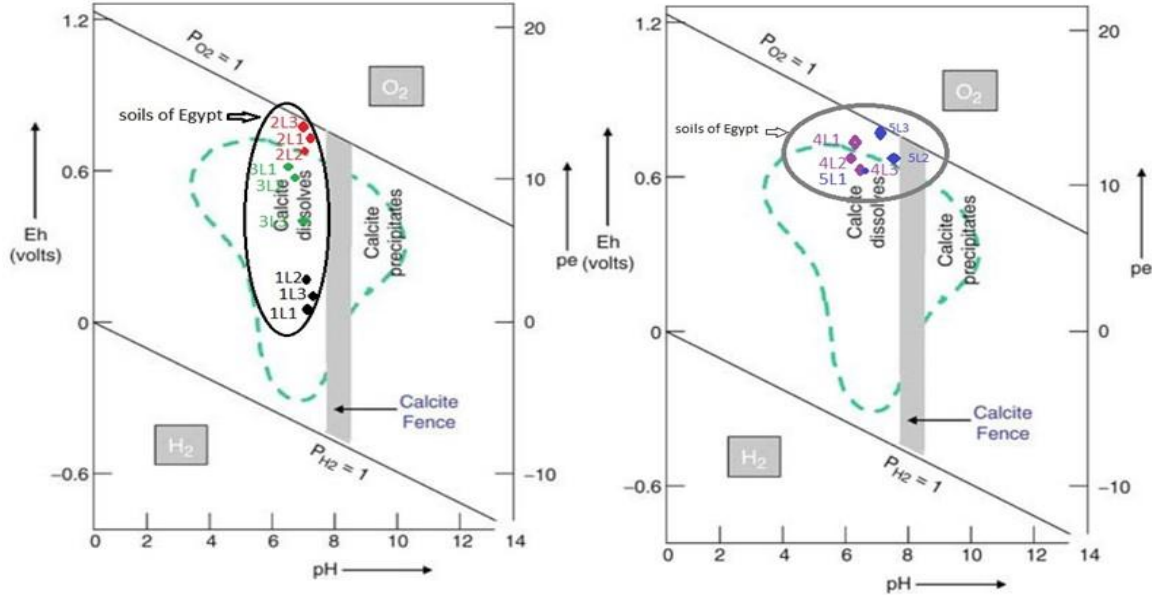


Figure 3: Eh-pH diagram of the Soils of the Northwestern coast area.

ظروف تكوين وثبات معادن الكربونات في الساحل الشمالي الغربي بمصر

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الملخص

تمت دراسة ظروف تكوين وثبات معادن الكربونات في بعض الاراضي الجافة في مصر. تكون التربة بشكل عام كلسية مع تراكمات كربونية بارزة على أعماق مختلفة. وفي بعض الحالات تلمي متطلبات الأفاق الكلسية أو البتروكلسية. تم اختيار الساحل الشمالي الغربي بمنطقة مرسى مطروح للدراسة. الصخور الأمية للتربة هي الحجر الجيري العلوي من العصر الميوسيني ويتم نقل المواد الأمية على طول الوديان إلى السهل الساحلي والمراوح الغرينية. يرجع انحلال الكربونات وهطول الأمطار إلى ضغط ثاني أكسيد الكربون من أصل جوي وحموضة مياه الأمطار. يكون الرقم الهيدروجيني للتربة قليلاً بشكل عام، ويتراوح بين 7.3 و 8.5. يظهر انحلال معادن الكربونات (مثل الكالسيت) في المعادلات التالية: $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ ($\text{H}_2\text{CO}_3 \rightarrow \text{H}^+ + \text{HCO}_3^-$) في وجود الكالسيوم من الكربونات (الأولية) مع معادن أخرى تحمل الكالسيوم، تكون التفاعلات: $\text{CaCO}_3 + \text{H}^+ \rightleftharpoons \text{Ca}^{2+} + \text{HCO}_3^-$ ($\text{HCO}_3^- + \text{Ca}^{2+} \rightleftharpoons \text{CaCO}_3 + \text{H}^+$) وتشتمل التركيبة المعدنية لكربونات التربة على الكالسيت والأنكرت $\text{Ca}(\text{Mg,Fe})(\text{CO}_3)_2$ بشكل عام بالإضافة إلى معادن الأكسيد مثل الكوارتز و CaSi_2O_5 . يشتهر في وجود الدولوميت والمغنيسيت كأثار أخرى للقطاع I في نفس المنطقة. يحتوي التركيب العنصري الأكثر أهمية للتربة على التسلسل التالي $\text{Fe} < \text{Al} < \text{Ca} < \text{Si}$ والذي يتوافق مع الملمس والمواد الأمية. تم العثور على العناصر النادرة الهامة (جزء في المليون) في التحليلات مثل S و Cr و Zn و As و Zr و Ni و Rb فيما يتعلق بتربة الساحل الشمالي الغربي. بينما تحتوي تربة شمال وادي النطرون على آثار من S و Sr و Zr. تم العثور على المواد الهلامية من التربة المستخرجة بكميات ضئيلة مما يدل على سوء التجوية لمعادن السيليكات بشكل عام. تتأثر ظروف النبات كما يظهر في عمليات الذوبان والترسيب بشكل كبير بظروف الحموضة والأكسدة و الاختزال. تقع جميع العينات في الاراضي قليلة القلوية الموجبة الاكسدة (الظروف الهوائية) في المخططات المرسومة.

الكلمات الاسترشادية: الكربونات, المعادن, الجفاف, الثبات, جهد الاكسدة والاختزال.