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ENVIROMENTAL MONITORING OF NORTH SINAI WITH EMPHASIS ON FACTORS AFFECTING THE SALINITY OF SOME SEDIMENTS

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ABSTRACT- Saline and alkaline sediments are common in several arid areas of the world. Such sediments controlled mainly by the content and distribution of water soluble salts through sediment profile. The content of these salts and their distribution are very vital for uses and soil improvement.

Twenty two sediment profiles according to the lithofacies units collected from North Sinai area and arbitrarily classify the sediment profiles into two horizons. The depth of surface samples is 0 - 30 cm and the depth of the subsurface samples is 30 - 100- cm. The chemical analysis of water soluble extracts (1:5) for forty four sediments include different cations and anions together with pH, calcium carbonate and organic matter contents presented in different maps to disclose their relative distribution.

The chemical data revealed that, there are different factors affecting the chemical properties of the North Sinai sediments such as parent materials, saline subsoil water, hydrology, climatic factors, human activity and surface relief or topography.

INTRODUCTION

Recently, the governmental authorities undertook great efforts for the reconstruction of Sinai (Fig. 1), where North Sinai sector takes the precedence over the other sectors in Sinai due to its considerable potentialities and strategic location.

The most quite promising portions in North Sinai Sector from the natural resources are the eastern bank of the Suez Canal, El-Tineh Plain, South El-Qantara Shark, Rabaa and Bir El-Abd as well as the coastal shoreline. In these localities some saline sediments presented in dissected areas much effected the potentialities and development of North Sinai.

Many research have studied the geomorphology, sea erosion, paleogeography, sedimentology, mineralogy, structure, neotectonic, soil and hydrogeology of North Sinai such as Sneh and Weissbrod (1973), Elwan et al. (1983), Emery et al. (1988), El-Shazly et al. (1975), Nageb (1992) and Yousef (1998 and 2000). However, detecting the factors that effected the salinity of some sediments are still not enough to construct a sound basis for future development.

SAMPLES AND METHODS

Yousef (2000) divided North Sinai lithologically (Fig. 2) into:

1- Littoral unit that includes recent beach, coastal sand dune, coastal lagoon, old beach, salt accumulation and recent tidal subunits.
2- transitional deltaic unit that includes deltaic, aeolian and swamp subunits.
3- Transitional continental unit that includes inland aeolian, alluvial deposits of desert wadis, playa lake like and mobile sand dune subunits.

Twenty two profiles collected (Fig. 3) based on the lithofacies classification of North Sinai by Yousef (2000). Each profile represented by two horizons, surface horizon of the top from 0 to 30 cm and subsurface horizon from 30 to 100- cm from the ground.

The collected samples dried and the chemical analyses carried according the following methods:

- Total carbonate determined volumetrically as soluble residual using HCl (1:3), collin calcimeter and calculated as calcium carbonate (Piper, 1950).
- Organic matter determined using H_2SO_4, $FeSO_4$ according the procedure of Wolky and Black described by Jackson (1958).
- PH measured in (1:2.5) using Allied type PH Meter Model 830.

- Electric conductivity determined using Fisher EC Meter after Black (1965).
- Calcium and magnesium ions determined by titration against versenate (EDTA) using ammonium purpurate as an indicator for calcium and eriochrome black -T for calcium plus

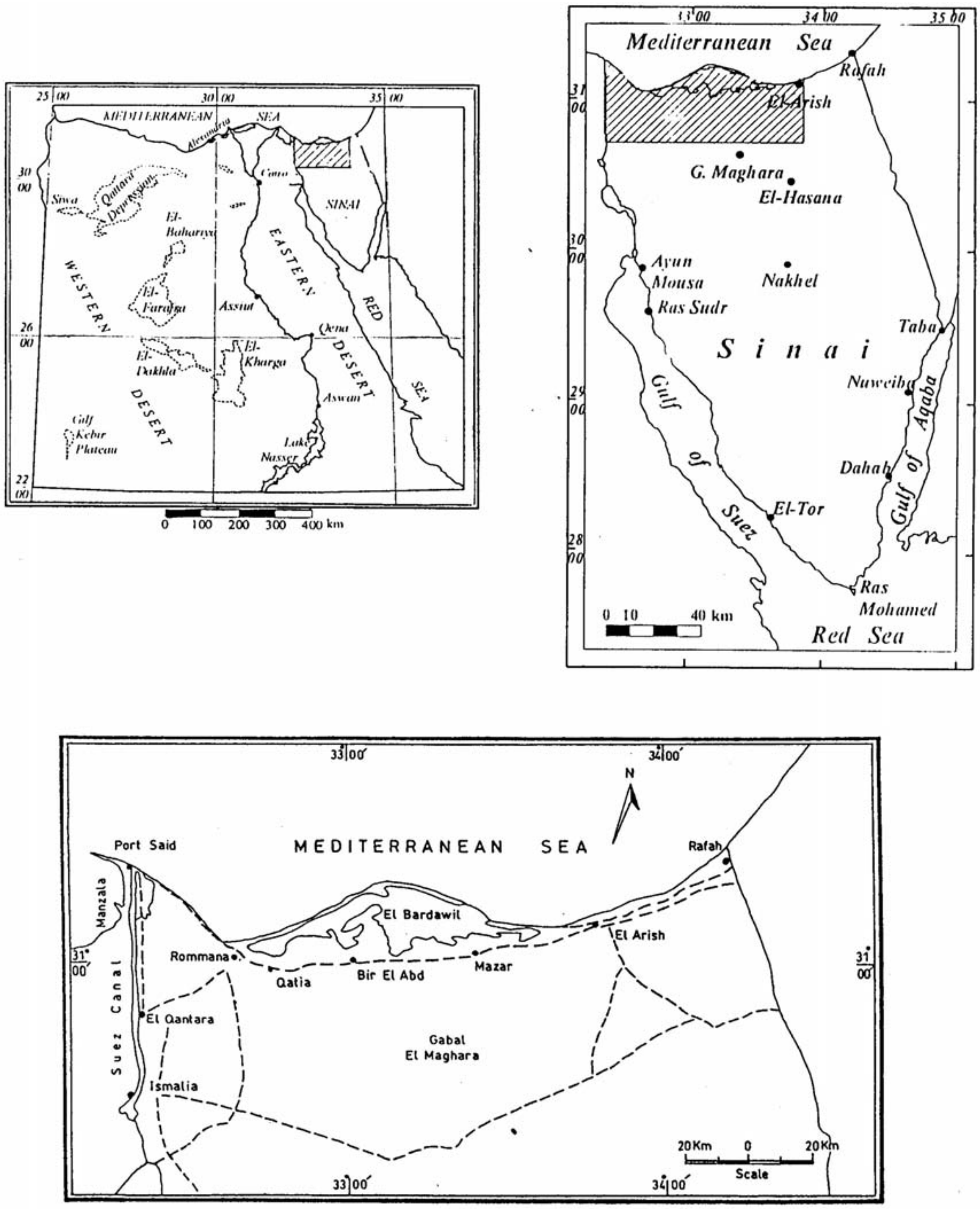

Fig. (1): Location map of the studied area.

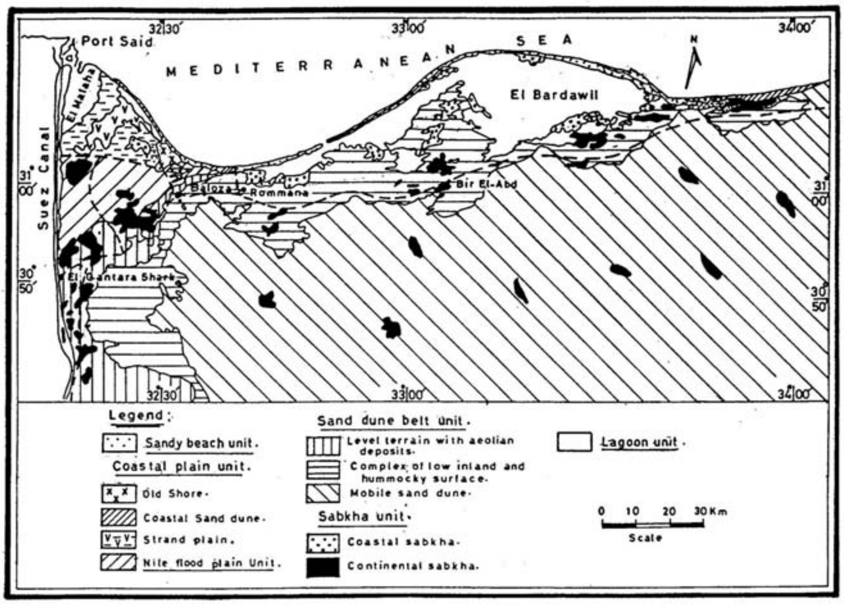

Fig. (2): Geomorphology of North Sinai

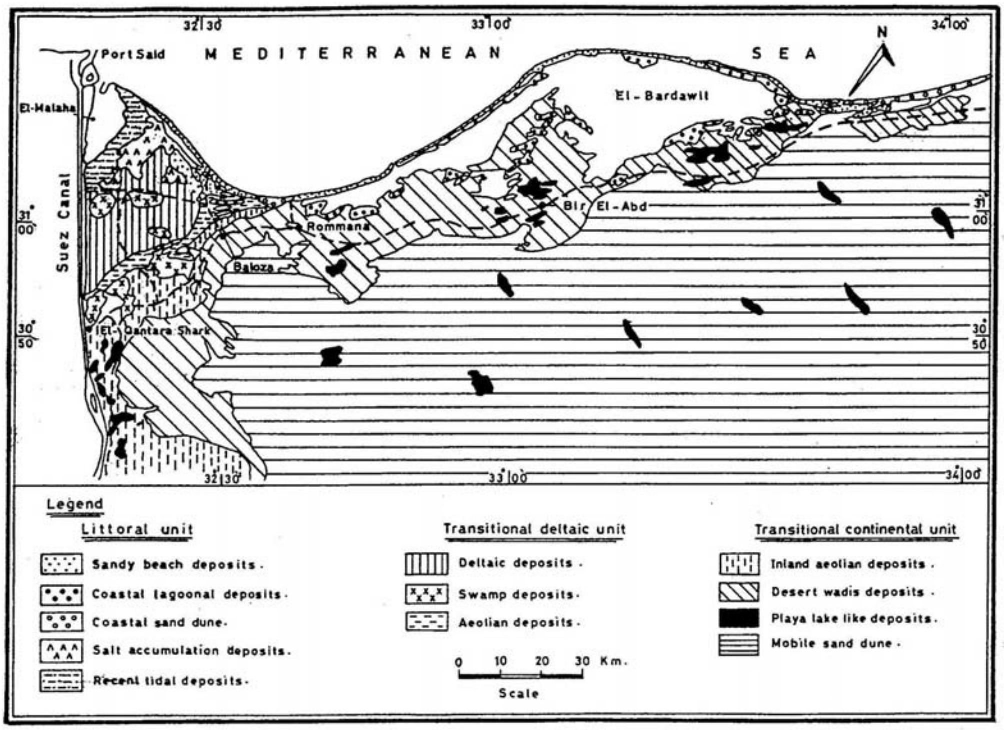

Fig. (3): Lithologic units of North Sinai.

magnesium, Jackson (1956).

- Sodium and potassium ions determined using Coring 400 Flame Photometer, Jackson (1958).
- Carbonate and bicarbonate determined by titration against H_2SO_4 using phenolphthalein as an indicator for Co_3^{--} and methyl orange for HCO_3^-.
- Chloride determined by Mohr's method, Jackson (1958).
- Sulphate determined by subtraction of the sum of chloride, bicarbonate and carbonate from the sum of cations.

RESULTS AND DISCUSSION

1- CHEMICAL ANALYSIS:

The data of chemical analysis of water soluble extracts (1:5) for forty four sediment samples together with PH, calcium carbonate and organic matter contents are tabulated in Table (1). Values of pH, EC, different cations and anions presented in different maps to disclose their relative distributions.

A- PH

The soil reaction (pH) ranges from 6.25 to 9.3 in the surface layer, while ranges from 6.25 to 9.1 in the subsurface layer (Table 1), e.g. from acidic to strongly alkaline.

The pH distribution contour maps of the surface and subsurface layers (Fig. 3) shows increase mainly south, east and northward in littoral and transitional continental deposits, while decrease westward in transitional deltaic deposits. The increment of alkalinity is possible related to the effect of salt water intrusion, shallow saline subsoil water and lagoonal deposits as well as lake of drainage system. It tends to increase mainly with depth (Table 1).

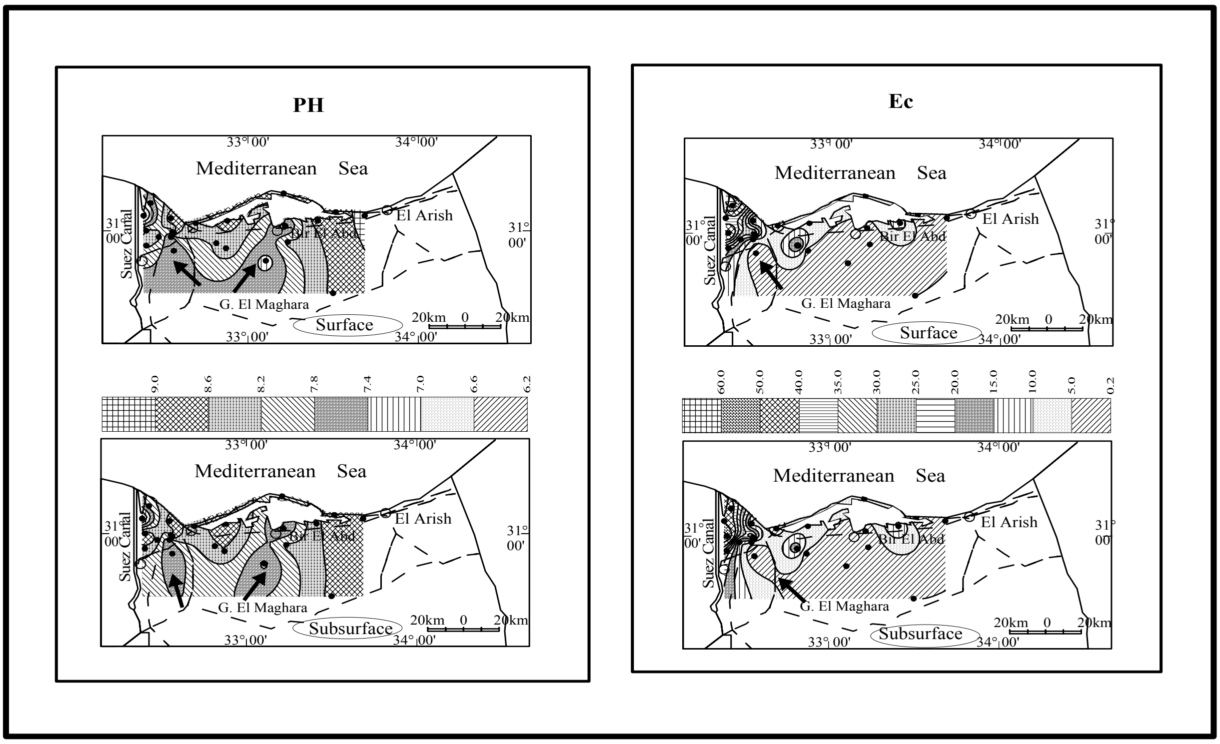

Fig. (4): PH and electric conductivity distribution contour maps of North Sinai sediments, Egypt.

B- EC

The salinity of the studied sediments ranges from slightly saline (0.23 to 64.7 mmhos/cm) in the surface layer and highly saline (0.23 to 63.8 mmhos/cm) in the subsurface layer (Table 1).

The salinity distribution contour maps of the surface and subsurface layers (Fig. 3) shows decrease north, east and southward in the littoral and the transitional continental deposits. While, the salinity increases westward in the transitional deltaic, salt accumulation and recent tidal deposits. The high salinity of these sediments probably attributed to shallow saline subsoil water, salt water intrusion, El-Malaha lagoon and the water upward flow by capillary effect as well as the presence of thin surface and subsurface salt layers. It is mainly decrease with depth (Table 1).

Table (1): Chemical analysis (1 : 5) for some sediments inNorth Sinai, Egypt.

A= Surface layer B= Subsurface layer

Lithofacies unit	Lithofacies subunit	Profile	PH		EC		Anion (meq/L)						Cation (meq/L)								O.M.		CaCO3	
							HCO_3^-		Cl^-		SO_4^{--}		Ca^{++}		Mg^{++}		Na^+		K^+					
			A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Recent	1	8.7	8.9	0.6	0.23	0.8	0.8	4.8	0.9	0.5	0.5	1.6	0.35	0.6	0.6	3.0	1.1	0.7	0.8	2.0	2.9	0.4	0.5
Littoral	beach	2	9.3	7.8	9.2	9.84	2.0	2.0	45.0	42.0	45.0	54.4	16.7	6.6	16.7	19.9	50.0	61.6	8.6	10.3	3.7	2.1	6.0	1.4
		3	8.3	8.26	1.5	1.55	1.5	1.0	11.4	12.4	2.4	2.5	0.7	0.2	0.25	0.6	13.6	13.9	0.8	0.9	0.6	2.1	3.4	6.0
	Coastal sand dune	4	9.2	8.98	0.8	1.6	0.8	0.9	6.8	12.4	0.7	3.1	0.2	0.5	0.3	1.0	7.8	14.3	0.13	0.2	2.1	2.2	0.3	0.7
	Coastal	5	8.8	8.5	13.3	16.5	4.0	5.0	100.0	127.0	29.0	32.5	12.8	10.9	1.2	22.2	113.9	121.0	5.2	10.5	3.1	7.4	9.4	9.3
	lagoon	6	8.85	9.10	8.0	8.25	6.0	10.8	61.0	61.3	13.2	20.45	7.9	8.0	9.9	14.0	58.6	53.1	7.4	7.4	4.0	4.9	1.4	0.8
unit	Old beach	7	8.9	8.8	9.22	7.89	2.4	1.4	55.5	49.8	34.3	27.8	6.6	3.6	14.6	12.8	63.4	56.0	7.6	6.6	1.2	1.3	8.0	4.8
	Salt accumulation	8	7.6	8.0	64.7	43.5	1.0	1.5	533.0	387.5	107.0	108.0	29.6	5.0	69.8	181.0	531.0	226.3	16.3	9.7	0.05	0.65	0.05	0.65
	Recent tidal	9	6.25	6.25	31.8	49.2	1.75	2.3	283.6	441.0	32.2	48.0	25.6	16.5	30.0	49.5	257.7	410.5	4.4	5.8	5.8	1.1	17.6	17.6
	Deltaic	10	8.3	9.0	55.0	63.8	12.5	20.0	528.8	608.1	8.0	9.9	62.0	60.0	89.8	39.2	329.2	436.6	69.0	97.0	2.3	1.5	11.8	11.6
Transitional		11	8.05	8.16	33.9	30.6	5.0	5.6	302.2	272.4	31.8	28.6	33.7	27.8	98.0	82.0	106.7	166.8	33.7	29.4	5.0	5.6	9.8	17.0
	Aeolian	12	8.35	8.5	20.8	12.8	3.5	2.0	141.0	62.0	63.6	64.1	34.5	9.1	49.4	20.1	110.1	83.7	15.05	14.2	5.8	6.1	10.4	7.0
		13	8.9	9.1	18.5	15.6	8.0	7.7	145.6	126.7	31.6	21.1	30.1	8.6	43.3	21.6	96.0	112.8	15.8	12.7	3.7	5.1	5.9	5.3
deltaic	Swamp	14	8.25	8.5	22.1	28.8	5.8	6.0	20.40	269.0	12.0	13.0	34.2	34.0	33.6	49.8	131.0	172.7	22.2	30.7	4.6	4.8	6.6	0.8
		15	7.3	7.3	8.3	7.4	1.05	0.85	74.0	66.5	7.75	6.9	5.5	5.5	9.2	8.8	66.2	57.1	2.0	1.8	9.3	10.4	6.4	3.6
	Inland	16	8.25	8.5	23.2	19.9	3.35	6.0	135.6	144.6	93.3	39.1	34.7	19.5	14.0	23.9	163.4	124.6	20.0	21.7	3.2	6.1	7.7	10.6
	aeolian	17	7.51	7.51	0.82	0.82	1.0	1.0	6.25	6.25	0.95	1.0	0.8	0.8	0.7	0.7	6.35	6.4	0.35	0.4	0.8	0.85	0.8	0.8
	Desert	18	8.6	8.6	1.30	1.29	2.0	2.0	3.0	3.0	7.9	7.9	5.4	5.4	2.1	2.1	5.3	5.3	0.10	0.10	0.5	0.6	0.7	0.7
Transitional	wadis	19	8.3	8.3	0.24	0.24	1.4	1.4	0.4	0.4	0.6	0.6	0.4	0.4	0.25	0.25	1.6	1.6	0.11	0.10	0.7	0.9	0.7	0.7
	Playa lake	20	7.18	7.28	4.10	3.4	1.0	0.9	36.4	30.2	3.7	2.9	3.1	2.5	2.7	2.1	34.8	29.1	0.5	0.2	4.1	2.3	2.4	1.5
continental	like	21	7.18	7.28	2.4	0.9	0.9	0.7	20.7	7.7	2.5	1.0	2.4	2.3	5.3	0.2	15.8	5.3	0.6	0.5	2.7	2.4	4.4	2.6
	Mobile sand dune	22	8.7	8.7	0.23	0.23	0.8	1.0	1.3	1.1	0.3	0.3	0.5	0.5	0.2	0.2	1.5	1.45	0.1	0.13	0.6	0.6	0.6	0.62

C- ANIONS

Anion (meq/L)	Surface		Subsurface	
	Minimum	Maximum	Minimum	Maximum
HCO_3^-	0.8	12.5	0.7	20.0
Cl^-	0.4	533.0	0.4	208.1
SO_4^{--}	0.3	107.0	0.3	106.0

Bicarbonate, chloride and sulphate maps decrease mainly north, east and southward in the littoral and the transitional continental deposits, while increase westward in the transitional deltaic, salt accumulation and recent tidal deposits (Fig. 4).

They tend to mainly to decrease with depth except the coastal sand dune, coastal lagoon and deltaic subunit deposits that increase with depth (Table 1). The increment probably related to the effect of salt water intrusion, shallow saline water, El-Malaha lagoon, evaporite, lagoonal and sabkha deposits.

D- Cations

Anion (meq/L)	Surface		Subsurface	
	Minimum	Maximum	Minimum	Maximum
Ca^{++}	0.4	62.0	0.35	60.0
Mg^{++}	0.2	98.0	0.20	181.0
Na^+	1.5	531.0	1.45	436.0
K^+	0.1	69.0	0.10	97.0

Calcium, magnesium, sodium and potassium distribution contour maps of the surface and subsurface layers (Figs. 5 and 6) show mainly increase westward in the transitional deltaic, salt accumulation and recent tidal deposits, while mainly decrease north, east and southward in the littoral and the transitional continental deposits. The increment probably related to the effect of shallow saline subsoil water, salt water intrusion, El-Malaha lagoon, relative low relief and lagoonal, evaporite and sabkha deposits.

Calcium and sodium tend mainly to decrease with depth (Table 1). Magnesium and potassium increase mainly with depth except old beach, transitional deltaic and playa lake like deposits that decrease with depth (Table 1). This probably related to their relative low relief and the enrichment of these areas with plants in compared with others.

E- ORGANIC MATER AND CALCIUM CARBONATE

The main sources of organic matter in the studied area are sea organisms and natural vegetation, while the main sources of calcium carbonate are evaporite deposits and shell fragments.

Percent %	Surface		Subsurface	
	Minimum	Maximum	Minimum	Maximum
O.M.	0.05	9.3	0.6	10.4
$CaCO_3$	0.05	17.6	0.62	17.6

Organic matter and calcium carbonate distribution contour maps of the surface and subsurface layers (Fig. 7) show mainly decrease north, east and southward in the littoral and the transitional continental deposits, while increase mainly westward in the transitional deltaic and recent tidal deposits. The increment of organic matter probably related to the effect of sea organisms and old vegetation roots, while the increase of $CaCO_3$ probably related to the effect of evaporite deposits.

Organic matter tends to increase with depth (Table 1). Calcium carbonate decrease with depth except the deltaic and aeolian deposits that increase with depth probably related to the effect of underlain evaporite deposits.

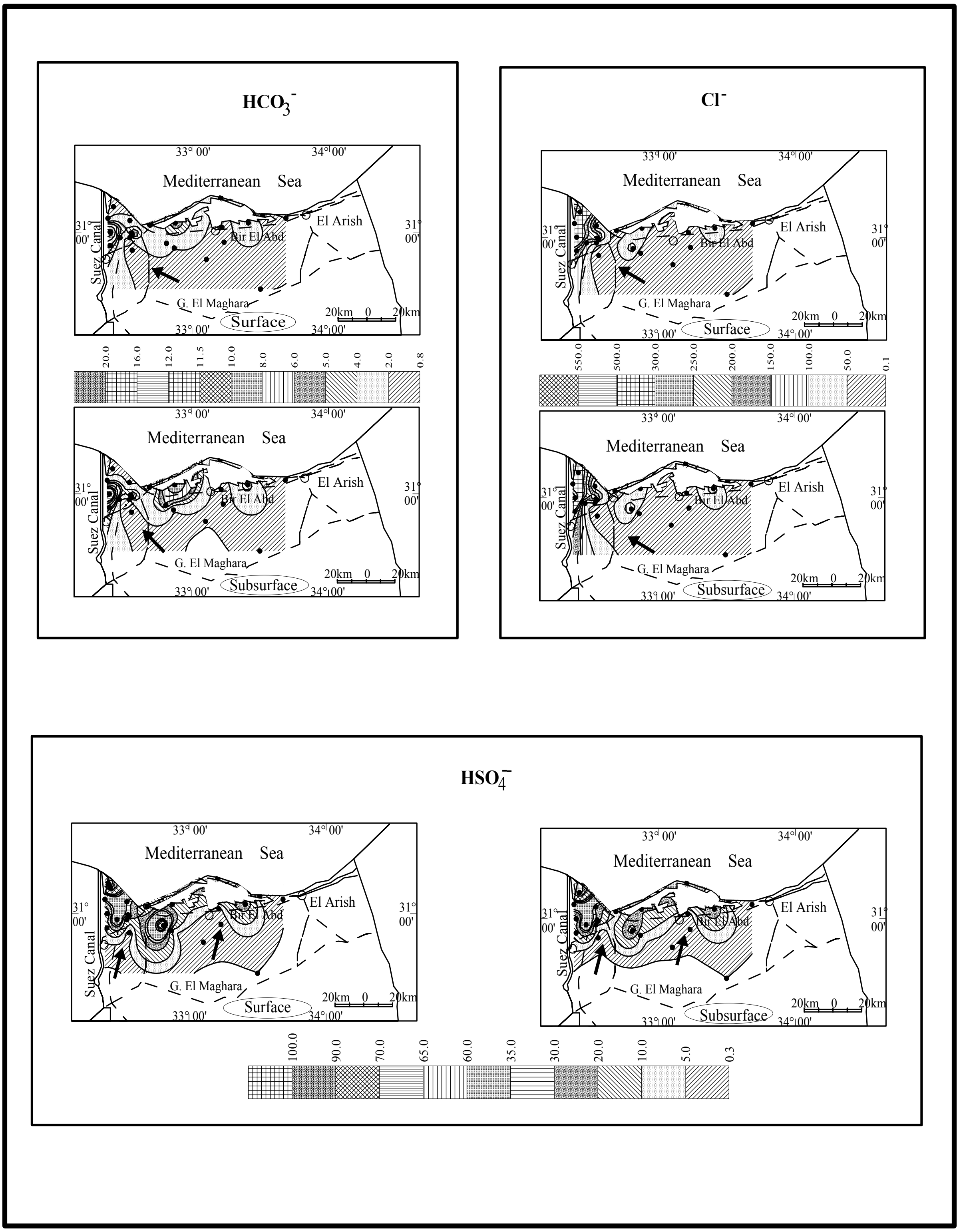

Fig. (5): Anions distribution contour map of North Sinai, Egypt.

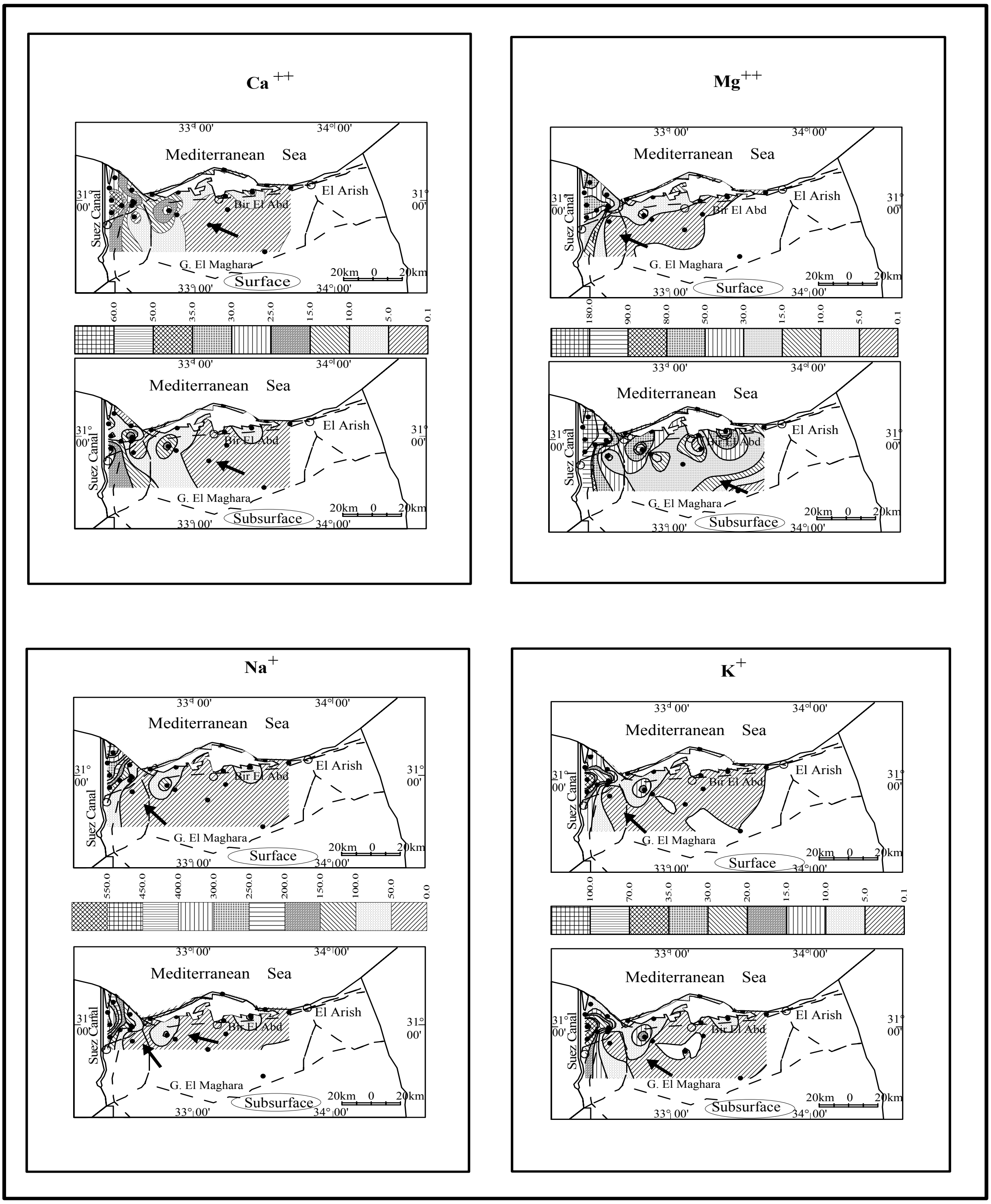

Fig. (6): Cations distribution contour map of North Sinai, Egypt.

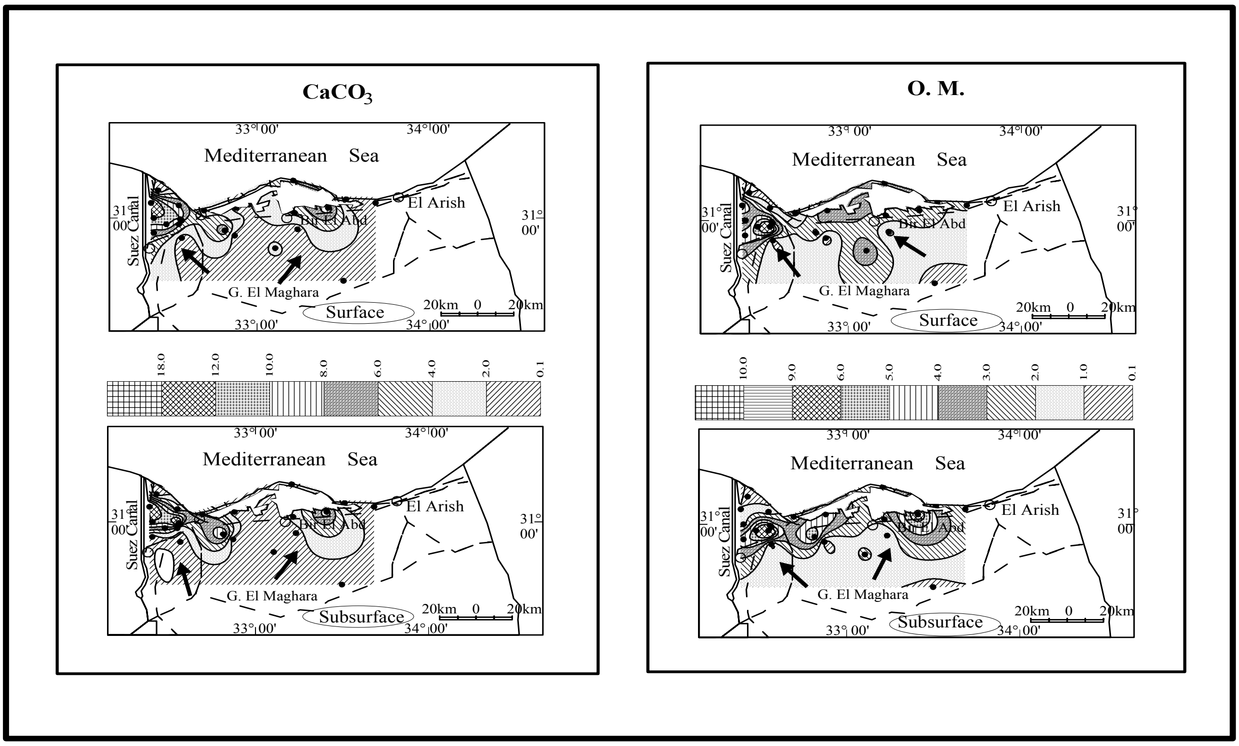

Fig. (7): Calcium carbonate and organic matter distribution contour maps of North Sinai sediments, Egypt.

2- FACTORS AFFECTING THE CHEMICAL PROPERTIES OF THE STUDIED SEDIMENTS

Salt affecting sediments are those containing soluble salts in quantities or qualities sufficient to interfere with the growth of most crops. However, there are several factors involved in the formation of salt affecting sediments such as parent rocks, texture or lithology, topography or surface relief, saline subsoil water and climate.

The following a brief discussion about such factors:

A- PARENT MATERIAL

The sediments of North Sinai derived according to Yousef and Hassanein (2000) from:

- Southern basement and sedimentary rocks.

The sediments eroded and transported through desert wadis during the rain fall seasons. They deposited in the southern and eastern parts forming the transitional continental deposits. These sediments characterized by low salinity specially that derived from the basement rocks.

- Ethiopian Plateau rocks.

The eroded sediments transported by the River Nile (Palusaic and Tanitic Branches) during high rain fall seasons forming the transitional deltaic deposits in the northwestern part of the studied area. These sediments characterized also by low salinity, but affected by shallow saline subsoil water, El-Malaha lagoon and salt water intrusion to become saline.

- Ethiopian Plateau and marine sediments.

The eroded sediments transported through the River Nile and deposited in the Nile Delta. Sea processes eroded the Nile Delta Coast and redistribute Nile sediments with marine sediments in the northern part forming the littoral deposits. The littoral deposits are mainly saline due to the effect of the sea processes during transportation and deposition.

B- TEXTURE OR LITHOLOGY

Thomas (1939) reported that, salts accumulate in amount toxic to plants at surface of medium textured sediments when the water table is as deep as 200 cm. Jackson et al. (1955) also mentioned that, salt accumulated near the surface of sandy sediments if the water table isn't deeper than 100 cm.

In shallow water table, the texture of sediments is very importance for the salinity of the sediments due to the effect of capillary. Where, the coarse grained texture sediments are mainly porous and characterized by low capillary, while the fine grained texture characterized by high capillary. According to Yousef and Hassanein (2000) the transitional continental sediments (Fig. 2) characterized mainly by low capillary due to their coarse texture (coarse and medium sand). While, the capillary of the transitional deltaic deposits (Fig. 2) is high due to their fine texture (silt and clay).ý The capillary of the littoral sediments is low except the relatively low relief area of the very fine sand that characterized by relatively high capillary.

The high capillary of the northwestern fine texture part (transitional deltaic deposits) with shallow saline water table (14-50 cm from the ground) led to form salt crust on the surface. While, the presence of salt crust on the surface in the northern low areas (littoral deposits) is due to the effect of sea storms with high evaporation. But, the presence of salt crust on the surface layer in the southern and eastern relatively low relief areas (playa) are due to the effect of shallow water table and long rate of evaporation during Pleistocene and Holocene times.

C- SALINE SUBSOIL WATER

The subsoil water in the studied area is very close to the ground surface. It is very shallow in the north (less than 75 cm) and gets deeper southward. The irregularity in depth to subsoil water attributed to local variation in the surface relief and the sediment texture (Yousef, 1998). He added that, the salinity of the subsoil water varies from 4.2 mmhos/cm in the southern part to about 275 mmhos/cm in the northern part, that is, increase northward.

D- TOPOGRAPHY

Jenny (1941) pointed out that, the sediments on slopes and high elevation tend to be less affected by salinization processes than those located in depressions. Richards (1954) reported that, sea is the source of salts in the low lying sediments along the sea margin. He added that, saline sediments located usually in areas subjected to water intrusion in river deltas and other low lying lands near the sea.

The studied area is generally flat about 1.0 m above sea level in the northwestern part with some low lying areas. While, the eastern and southern parts characterized by irregular topography with ground elevation ranges from 2 to more than 90 m. The effect of topographic relief of the studied is the very significant role upon the salinity of the sediments. These appear in the saline and extremely saline sediments in the northern relatively low relief areas and the non saline to slightly saline sediments in the southern and eastern high relief areas.

E- ARIDITY AND CLIMATE

Harris (1915) mentioned that, small quantities of salts may cause profound changes in chemical and physical characteristics of the sediments. Fridman (1958) stated that, the rate of evaporation is seriously high if water table is shallower than 100 cm.

The studied area highly affected by the arid climate (low rain fall, high temperature and high evaporation) that led to form lagoons, sabkhas, lacustrine and salt marshes under the effect of shallow saline subsoil water and salt water intrusion.

CONCLUSION

The obtained data showed that:

1- Topography, saline subsoil water and salt water intrusion are the main factors of the salinization of the studied sediments.

2- Shallow saline subsoil water is the main source of the salt layer on the surface in the northwestern part (clayey texture). While, sea storms are the main sources of salt layer in the northern part (sandy texture). But, the presence of salt crust in the low relief areas in the southern and eastern part is due to shallow water table and long rate of evaporation.

3- Before reclamation of the studied area must lowering the saline subsoil water by drainage network and perfects the salt water intrusion.

4- The anion concentrations are mostly in the following decreasing order of abundance $Cl^- > SO_4^{--} > HCO_3^-$. The cations concentrations are in the following decreasing order of abundance Na > Mg > Ca > K, but are Na > Ca > Mg > K in the southern and eastern parts.

5-Add agricultural gypsum ($CaSO_4.2H_2O$) to change past of the caustic alkali carbonate into sulphate and overcome the problem of high degree of alkalinity. Accordingly, high sodium concentration reduced and calcium ion concentration increased.

6- Before reclamation must remove the salt crust.

7- Leaching of highly saline soils and/or selection of salt tolerant crops.

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