dunes, the water generally ranges from 5 to 10 m below the surface depending on the height of the dunes.

3.1.2.3. Quality of water : The quality of water in the several aquifers found in the area varies widely. Depending on the hydrogeological conditions, the content of dissolved solids may vary from a few hundred to several thousand parts/million. Water quality also varies with season, being best after winter rainfall and worst in late autumn before the begining of the rainy season.

3.1.3. Soil conditions.

The mapping of soils of El Omayed test-area in the present study was based on already published informations (ABD EL KADER *et al.* 1981 ; FAO 1970), analysis by photo-interpretation and through Landsat satellite imageries and the data collected in the field (ISMAIL *et al.*, in preparation, 1983).

Detailed pedological study of this area was realized at the scale of 1 : 25 000. Typical samples were collected and analysed for the most important elements. Other transects were studied using the same method to get sufficient information about the soils of the area and their spatial distribution. A preliminary soils map could then be established and compared with other cartographic documents which were already prepared particularly that of the vegetation. Another field study was carried out for checking and improving the preliminary map, by observation, sampling and complementary analysis.

With new observations, land determinations and analysis of some samples, the map of land resources was etablished. Finally, a field study carried out in cooperation with specialists from other disciplines enabled phytosociologists , agronomists and pedologists to compare the documents proposed by each team and to cross-check their observations.

3.1.3.1. Conditions of soil evolution.

The effect of climatic conditions, geomorphology, vegetation and human activities on the recent evolution of soil are dealt with elsewhere. Therefore, only a few important geological and geomorphological features are reviewed here.

Pedological evolution observed in El Omayed test-area is not simply the result of the evolution of soils. In fact, it started, a long time ago for most of the soils, and certainly under more active pedogenetic conditions. During that time, new littoral formations and lacustrine or lagoon sands and clay sands, often saline deposits were produced in the North. They were more or less modified by wind action. Eolian deposits are remodelled from various origins, often due to recent tectonic phenomena in proximity to the coast and close to the border of the Nile Delta.

3.1.3.2. Pedological units.

The pedological units (Fig. 6 & 7) are defined and grouped here on the basis of the French Pedological Classification System (CPCS, 1967). This system is of a morphogenetic type and, in the case of these dry zone soils seems well adapted to the present study, particularly when it is visualized from the management point of view (problems of saline soils, more or less hydromorphic soils ... etc). Also, the nomenclature of each unit in USDA Soil Taxonomy (1975) is given. The French classification of each unit is determined for the family level which is defined by the characteristics of the parent material of each soil and even for the serie level.

In the case of El Omayed test-area, it is necessary to lay stress on the origin of sand deposits, particularly those due to wind action, and on their lime content, in the upper horizons. Accordingly, three categories of soils may be distinguished : excessively calcareous soils containing more than 60 % carbonate (S") ; very calcareous soils, containing from 20 to 60 % carbonates (S') ; and calcareous soils with less than 20 % carbonates but, containing at least some calcareous elements (> 2 to 3 %) (S).

The soils are classified as it follows :

a) Raw mineral soils

These are formed of more or less weathered rock at the surface ; the differentiation of horizons is very limited. They are very poor in organic matter. In El Omayed test-area, they are of non-climatic origin, but the aridity conditions of their formation do not foster their evolution. They are formed by the following two processes :

. Erosion : this process is the main factor causing the slowing down of the evolution in the case of the soils formed from the consolidated calcareous oolitic dunes. They are Lithic Torriorthents ; they do not have practical agricultural value.

. Addition : from eolian and colluvial sand, chiefly along the inland ridges. The soils are moderately thick to deep, and the addition process is still, more or less, regularly active. They may be constituted by excessively calcareous medium, and coarse sand (S") ; they are very dry. Others are constituted by very calcareous elements (but less calcareous than the previous ones and often of finer texture). Their hydrologic characteristics are not so bad. In this case as in the other one, they are named "Typic Torripsamments" ; they may be useful for agriculture.

b) Slightly evolved soils

. Modal grey sub-desertic soils : These already exhibit some slight differentiation of horizons. This is mostly demonstrated through their physical properties (porosity and induration in particular) and by the relative distribution of saline elements through their profile. The content of these elements is often relatively higher at the surface, sometimes calcium carbonates and gypsum which may accumulate in depth but only in pseudo-

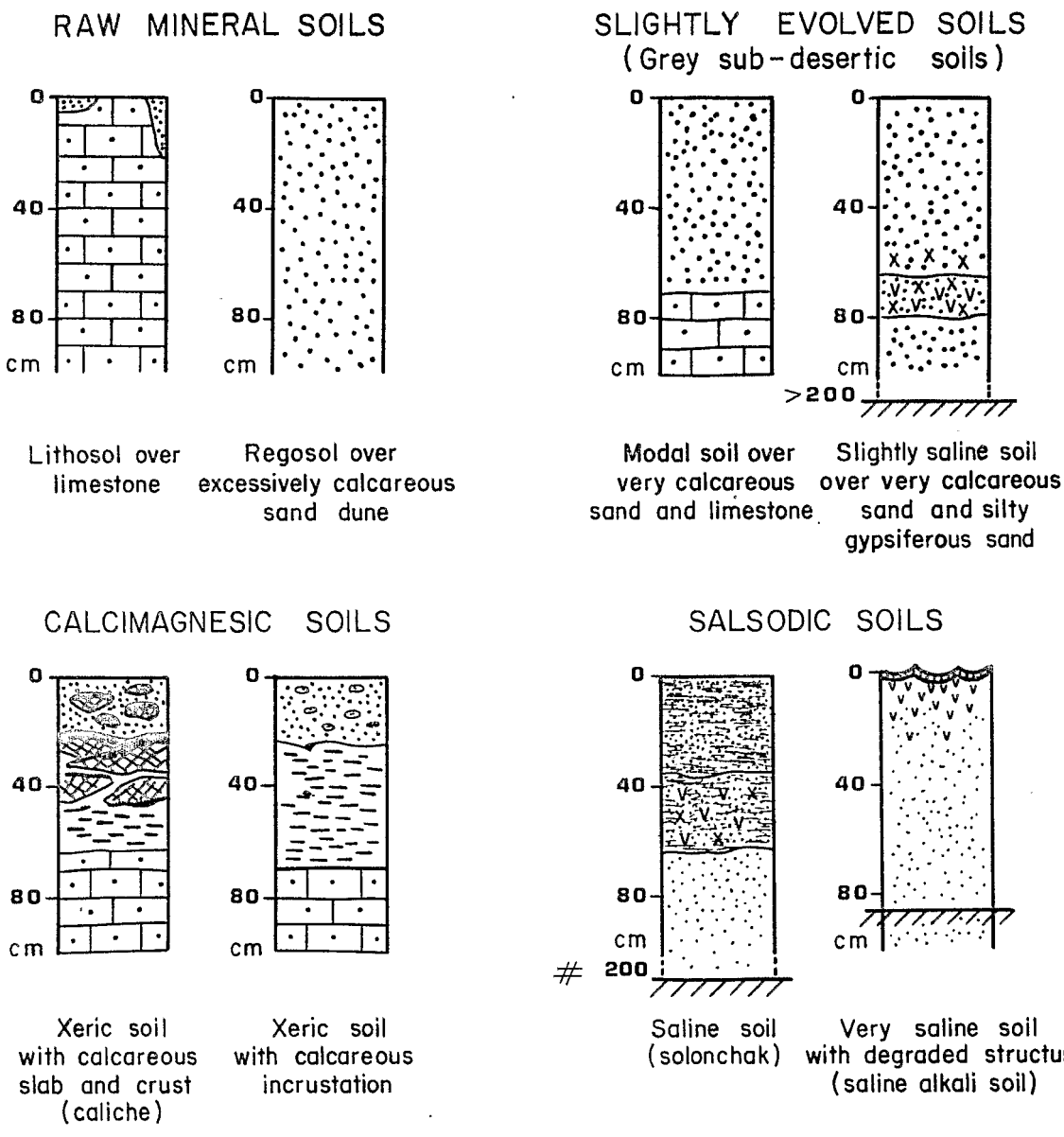
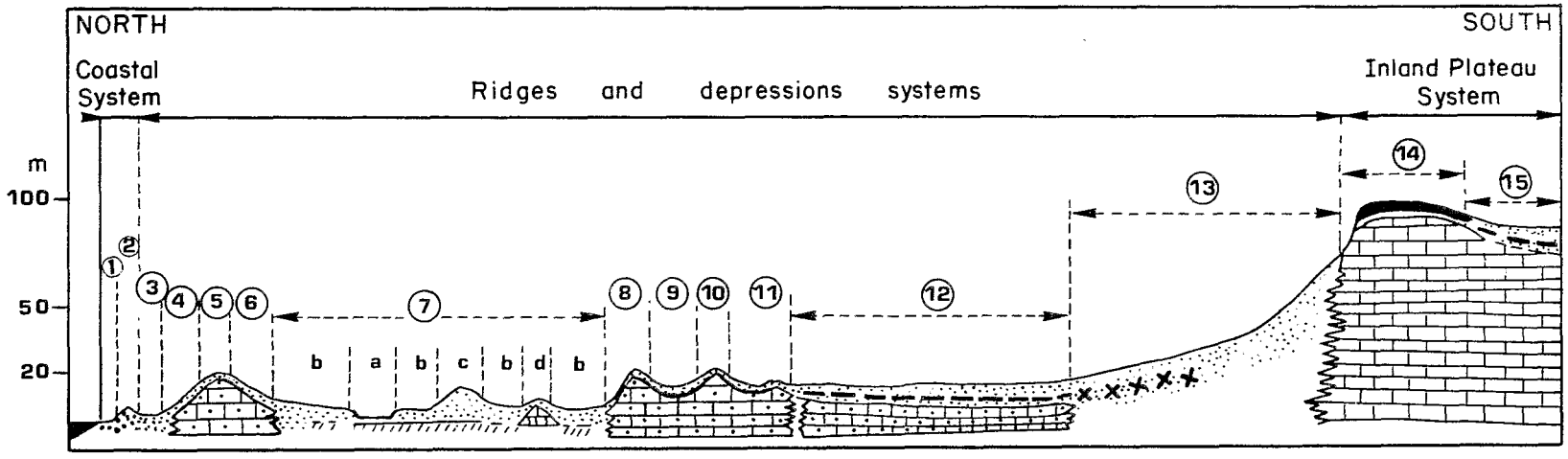


Figure 6 - MAIN SOIL PROFILES



Physiographic units

COASTAL SYSTEM
- 1 - Beach
- 2 - Coastal sand dune

RIDGES AND DEPRESSIONS SYSTEMS
- 3 - First depression
- 4 - Northern slope of first rocky ridge
- 5 - First rocky ridge (1 RR)
- 6 - Southern slope of first rocky ridge
  - a) salt marsh
  - b) hummocky depression
  - c) sandy meso deposits
  - d) sandy indurated convexities
- 7 - Saline depression
- 8 - Second rocky ridge (2 RR)
- 9 - Inter-ridges sandy slopes
- 10 - Third rocky ridge (3 RR)
- 11 - Southern sandy slopes
- 12 - Non saline depression
- 13 - Sandy glacis (gullies)

INLAND PLATEAU SYSTEM
- 14 - Cliff and outcroup of Inland plateau
- 15 - Undulating sandy surface

Pedological features

- Excessively calcareous sand
- Very calcareous and calcareous sand
- Calcareous amas and nodules
- Calcareous incrustation
- Calcareous slab
- Water table
- More or less oolitic limestone
- Calcareous sandstone

Figure 7 - PHYSIOGRAPHIC UNITS AND PEDOLOGICAL FEATURES OF EL OMAYED (SCHMATIC)

SOIL MAP

EL OMAYED TEST-AREA

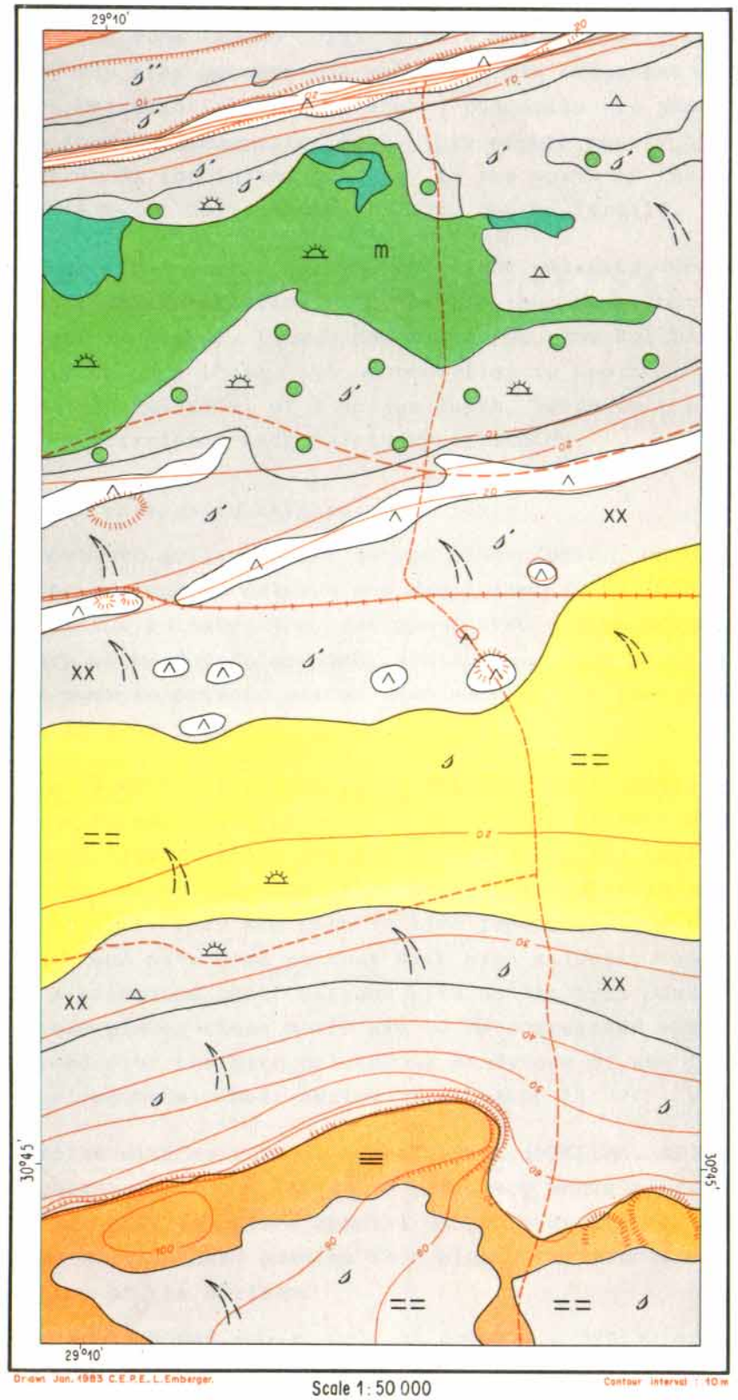


Figure 8

LEGEND

SOIL CLASSIFICATION OF THE DIFFERENT UNITS OF THE MAP (BASED ON FRENCH SOIL CLASSIFICATION AND USA SOIL TAXONOMY)

Class	Sub-Class	Group	Sub-Group	Family	U.S.A. Soil Taxonomy	Representation
Raw mineral soils	Non climatic	by erosion	Lithosols	Over limestone (consolidated oolitic dunes)	Lithic torriorthents	^
		by addition	Eolian	Over excessively calcareous sand dune and actual oolitic dunes	Typic torripsaments	
Slightly evolved soils	Climatic	Grey sub-desertic soils (xeric)	Modal (locally, moderately deep lime accumulation in amas and nodules) sometimes associated with calcimagnesic soils	1) Over very calcareous sand from mixed origin a. colluvial from consolidated oolitic dunes b. eolian from continental sand 2. Over calcareous sand, essentially from continental origin	Typic torripsaments	
			With salinity properties (saline)	Over very calcareous sand from a mixed origin and silty gypsiferous sand	Calcic gypsiorthids	
Calcimagnesic soils	Carbonated	Xeric	With calcareous slab and locally saline by patches	Over hard calcareous sandstone	Typic paleorthids	
			With calcareous incrustation and often salt-affected in depth	Over sand and marine calcareous sandstone	Typic calciorthids	==
Salsodic	Soils with non-degraded structure	Solonchaks with calcimagnesic complex (Ca - Mg)	Saline soils, with friable surface	Over calcareous silty sand and shelly clayey sand	Typic calciorthids	
	Soils with degraded structure	Non-leached	Very saline alcali hydromorphic soil, with friable surface, gypsum thin crust or pseudo-sand by places	Over very calcareous sand and shelly clayey sand	Typic salorthids	

SYMBOLS OF THE PEDOLOGICAL FEATURES

PARENT MATERIAL

^ Limestone (consolidated oolitic dune)

TEXTURE :

Sandy texture (calcareous sand)

Sandy texture (very calcareous sand)

Sandy texture (excessivelly calcareous sand)

m Silty sand texture (to sandy silt)

THE MORPHOLOGY OF THE SURFACE

Wind blown sand

Hummocks

More or less stabilized microdunes (0.5-1 m high)

PEDOLOGICAL INDICATIONS

XX Calcareous amas and nodules

== Calcareous incrustation

Calcareous crust (caliche) and slab

mycelium, friable amas and nodule forms (POUGET, 1980). Sometimes in El Omayed area there are some intergrades between these soils and either less poor in organic matter sierozems or calcimagnesic soils.

Most often they are thick (1-1,5 m), but may overlay more or less saline clay deposits from lagoon origin ; this may be mostly observed in the northern part of the area between the ridges of old indurated coastal oolitic calcareous dunes. Particularly to the south, the soils are sometimes associated in patches with some calcimagnesic soils. This occurs mostly over the sandy glacis which surrounds the inland plateau, to the south of the test-area. Here also the soils are Typic Torripsamments. They can be fertile.

. Grey sub-desertic soils with slight salinity. These soils are analogous in their characteristics with the previous ones, but their salts and gypsum content is higher, though not excessive. The soluble salts accumulated at the surface, but their high content lies in depth from where they come. The gypsum accumulation, at a medium depth, leads to the formation of amas. They may be correlated with Calcic gypsiorthids.

c) *Xeric carbonated calcimagnesic soils*

These evolved soils exhibit a type of evolution, which is strongly dominated by high content of calcium and magnesium. In El Omayed area, they are calcareous at the surface. They contain a strong lime accumulation in depth in the form of hard nodules, incrustation and even caliche or slab. They are not so poor in organic matter than most of the previous ones and their structure is also stable.

. Soils with calcareous slab. These are thin soils, mostly 15 to 30 cm deep to the calcareous crust or slab, and more or less splitting at their base (POUGET, 1980). Their evolution started in the Early Quaternary, but is still going on. Through that thickness, their organic matter content may be up to 0.8 - 1 %. They are rich in lime fragments from the calcareous crust or the slab and have some patches with high salinity. In these patches soils may give a saturated paste extract with an electric conductivity up to 50 mmhos. In these places these soils are to be correlated with salsodic soils. They spread over the hard calcareous sandstone of the inland plateau, and are Typic paleorthids. Their agricultural value is very limited.

. Soils with calcareous incrustation (RUELLAN, 1970). In El Omayed test-area the calcareous accumulation is also very ancient; it may be from the Middle Quaternary. They exhibit a special characteristic to the deepest horizons of the soil : large hard nodules in a highly calcareous matrix without complete hardening of the horizon.

This processes may appear only at about 1 m depth, or sometimes near the surface (20-50 cm). Very often they are slightly saline at medium depth, but in their deepest horizons they may form a saturated paste extract with a conductivity as high as 15 mmhos. Therefore they may be classified in a slightly saline soils subgroup.

They mostly develop in the "inter-ridges" zone between the dissected old indurated coastal dunes and the sandy glacis bordering the inland plateau scarp. They also extend further south.

Both soil types, being slightly salf-affected or not, are Typic calciorthids. Their fertility level, in most cases is medium ; but sometimes is low, depending on the thickness of horizons over B_{ca} and on salinity.

d) Salsodic soils (AUBERT, 1975)

These soils have a high content of soluble salts (conductivity in saturated paste extract more than 8 mmhos for the surface, and more than 16 mmhos in depth). Some of them retain a stable structure, while others do not, at least in a great part of their profile, where their structure becomes diffuse through the effect of sodium.

. Salt-affected (saline) soils with a non-degraded structure. These are derived from calcareous silty sands, over saline clay sands rich in shell detritus. The last material has a lagoon origin. Their salt profile is descendent or intermediate. They are very calcareous at the surface, and have a lime accumulation at a medium depth. Sometimes also, the same process plays a role at the surface, but only slightly. Even with an unstable structure when humid, they are relatively well drained. They are also Typic calciorthids.

They extend in the northern depression between the two indurated coastal dunes. Because of their low position, they would be very difficult to drain and to manage for agriculture.

. Very saline alkali-soils. The structure of these soils is degraded from the surface because of their high content of exchangeable sodium. They also are very rich in sodic soluble salts (chlorides and sulphates). Here and there, mostly around nebkhas, the surface is transformed into pseudosand ; somewhere else it is covered by a thin crust of salts with a gypsum pseudomycelium. In other parts of its profile, the soil is compact and massive, mostly less below 75 cm deep where it becomes more and more clayey ; its structure becomes strictly diffuse. These soils are mostly hydromorphic in depth. Their salt profile is ascendant, and they are very calcareous. They are Typic salorthids.

The surface where they are observed is not very extended, except in the elongated lowest part of the northern depression between the indurated coastal dunes. Practically they have no economic value, mostly because their drainage would be too difficult and their desalinisation would need too much water.

3.1.3.3. Other informations shown on the map.

By some additionnal signs, the map (Fig. 8) shows the following :

. Special soils parent-materials. These are indurated calcareous oolitic sandstone of the coastal dunes, and clay sand with gypsum crystals.

These characteristics are used in the soil classification at the family level.

. Some aspects of the surface morphology, in the form of superficial cover of wind blown sand, nebkhas, and more or less stabilized microdunes.

. Soil texture : in the soil classification it is used at the family level. The map shows in particular the excessively calcareous, very calcareous, and moderately-weakly calcareous sandy soils, and of soils of finer texture mostly silty or seldom silty clay.

. Special pedological characteristics, which correspond to various types of accumulation of saline or calcareous elements.

3.1.4. Land use and Plant Cover (natural and artificial)

The vegetation of the "western coastal region" of EGYPT has been extensively studied since the papers of OLIVER in 1937 (ATTA 1953 ; TADROS 1953 ; LONG 1955 ; TADROS and ATTA 1958 ; AYYAD 1973 ; AYYAD and AMMAR 1974 ; AYYAD 1976 ; KASSAS 1979 ...).

From the phytogeographic and floristic point of view this region is referred to as the Marmarica region. It is estimated that (about 1000 species) approximatively 50 % of the Egyptian flora is found in this region. It has a long history of human pressure which has been so heavy in the past that with only a few exceptions, all spontaneous flora is represented by small shrubs and herbs. Very few shrub species which are either very rare or only found in sites with extreme environmental conditions (high salinity and water logging) are found in this region (e.g. *Tamarix* sp.). Some individuals of a few species may grow up to more than two meters in height (e.g. some *Atriplex* sp., some *Lycium* sp., *Nitraria retusa*). The human activities have gradually eliminated all the tall plants. When establishing a land cover map, human interference has to be considered as an important ecological factor, which influences the present state of the vegetation and cultivation.

3.1.4.1. Land cover.

The land cover map provides a combination of the present state of plant cover (natural vegetation and cultivated plants) and the degree of artificialization which represents the level of the human pressure upon land resources. The procedure and legend used in building up such a map have already been described in details for this part of EGYPT (LONG, 1979 ; LE FLOC'H 1979, 1981). A short description of this procedure will be presented here. It consists of an objective and quick description of isophenic areas (described for their various features) as they are delineated on aerial photographs and then checked in the field. These features are mainly related to :

- the present state of vegetation (e.g. type of plant formation, dominant species), and
- the degree of artificialization.