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MORPHOLOGICAL, SEDIMENTOLOGICAL AND HYDROGEOCHEMICAL STUDIES OF SABKHAS IN SOUTHERN KUWAIT

ABSTRACT: AL-HURBAN A.E. & GHARIB I.M., *Morphological, sedimentological and hydrogeochemical studies of sabkhas in Southern Kuwait.* (IT ISSN 1724-4757, 2003).

Sabkhas are one of the various types of Quaternary sediments covering appreciable areas of the surface of Kuwait. They are part of a landform sequence extending from the shoreline, with barrier islands or dunes, through a lagoon before truly terrestrial systems are reached. Sabkha surfaces are extremely flat and often extends for 15 or 20 km. The sabkha deposits are essentially composed of quartz sand of variable sizes, mixed with carbonate mud and scattered crystals of gypsum, covered by salts and gypsum that are formed after rainy seasons. Some of these sabkhas are bare of vegetation, and others are vegetated. Due to the nature and mode of occurrence sabkhas are classified into two types: coastal and inland sabkhas. The surfaces of inland sabkhas are partially covered by active sand sheets caused by northwesterly winds forming blankets of variable thicknesses. The aim of this study is to identify the coastal and inland sabkhas and to study the differences in their environments by identifying the main morphological, sedimentological and hydrogeochemical features of these sabkhas.

KEY WORDS: Coastal sabkha, Inland sabkha, Morphology, Hydrogeochemistry, Sedimentology, Kuwait.

INTRODUCTION

The state of Kuwait is located in the northwestern corner of the Arabian Gulf, between Longitudes 46° 30' and 48° 30' East and latitudes 28° 30' and 30° 08' North. Kuwait is an arid region, characterized by dry hot and dusty summers, and relatively cool winters with scarce and irregular rainfall.

Kuwait was affected to a certain extent by the tectonic movements and geomorphic processes. These processes such as weathering, aeolian and coastal ones that occurred during late Pliocene-Pleistocene age. This is reflected by the occurrence of different geomorphological features along the coastal area (Kassler, 1973; Al-Sarawi & *alii*, 1993; Al-Sulaimi & El-Rabaa, 1994).

The surface of Kuwait is mostly covered by Quaternary sediments, which include Al-Dibdibbah Pleistocene gravel deposits, and Holocene sediments. These include desert surface deposits, alluvium, aeolian sands and beach and coastal deposits such as sabkha deposits, sand shoals, beach rocks and tidal flat deposits (Khalaf & *alii*, 1984b).

«Sabkha» is an Arabie term generally used for coastal flat areas extending above the high tide level and are covered by evaporite-rich clastic sediments (Khalaf & *alii*, 1984a). In the present study, sabkhas are defined as low coastal and inland areas dissecting the underlying shallow groundwater table.

The sabkha deposits are essentially composed of quartz sand of variable sizes, mixed with carbonate mud and scattered crystals of gypsum, covered by a thin veneer of salts that is formed after rainy seasons. Calcrete (locally named as Gatch) occasionally exists beneath the surface of some of these sabkhas as friable or hard-consolidated sediments. The gatch is a near surface layer containing a heterogeneous mixture of gravel, sand, mud and authigenic minerals. This is represented mainly by calcium carbonate and gypsum that originated mostly by chemical precipitation from mineral bearing waters within the pore spaces of the clastic deposits to act as cement.

Due to the nature and mode of occurrence sabkhas are classified into two types (Reda, 1986; Saleh & *alii*, 1999): coastal and inland sabkhas. The coastal sabkhas extend along the coastal strip of Kuwait in the elongated depression in Al-Jailaiah and Al-Khiran areas, and are divided into old and young sabkhas. The old sabkhas are located at the western end of the elongated coastal ridge belt that runs parallel to the coastline, while the young sabkhas are located in the inter-ridge areas (fig. 1 and 2) (Al-Hurban,

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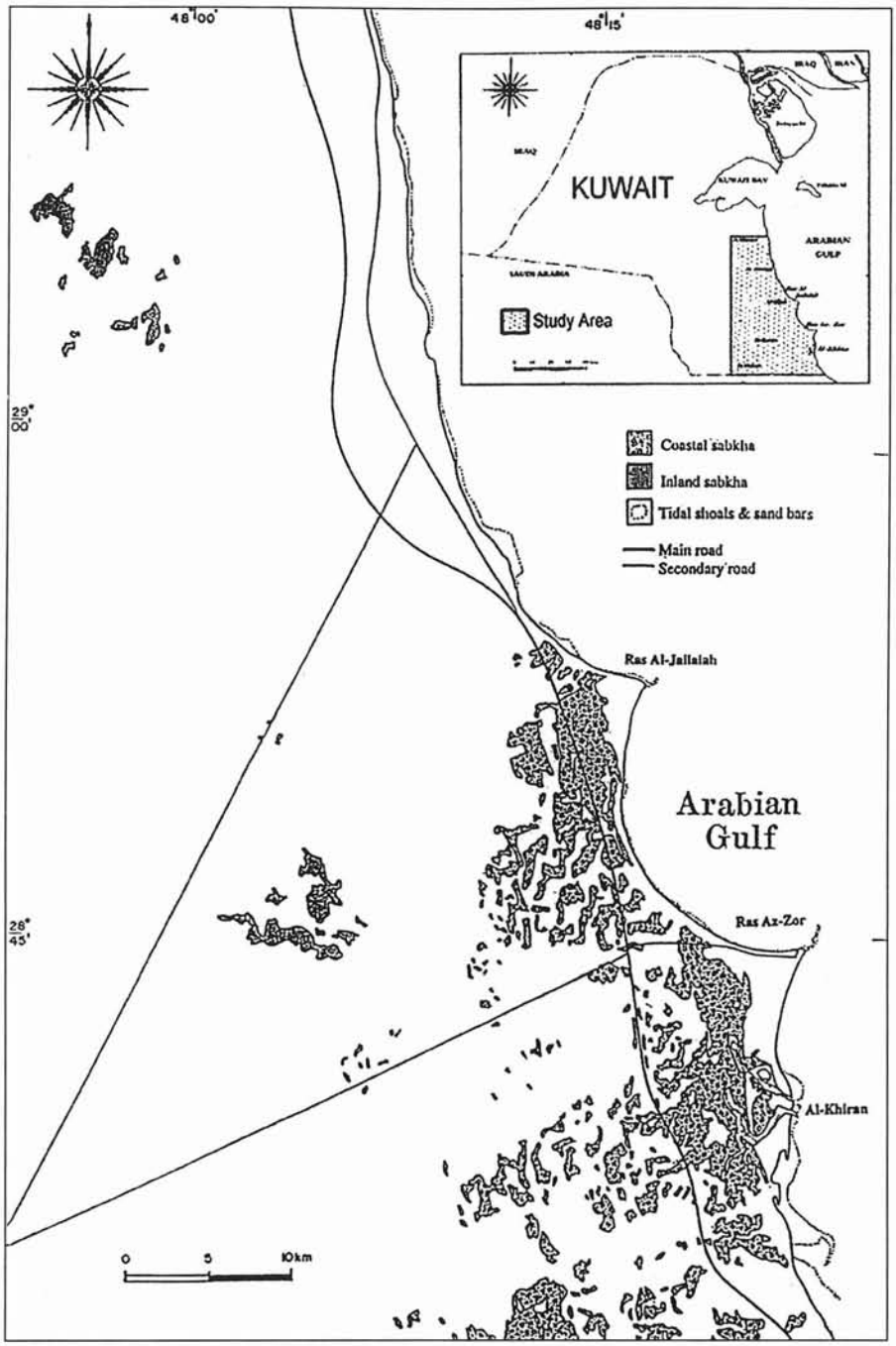

FIG. 1 - The distribution of coastal and inland sabkhas in the southern area of Kuwait.

1996). The inland sabkhas are formed in the irregular sloped in the western desert side of the coastal area.

The inland sabkhas are formed in the desert areas at distances exceeding 10 km from the coastline. Both coastal and inland sabkhas are subjected to the mobile sand invasion under the action of the northwesterly prevailing wind. The wet floors of sabkhas act as aerodynamic traps for drift sand. The drift sand occurs as thin rippled sheets or sand drifts on the sabkha surfaces.

The study area is located in the southern sector of Kuwait with a length of 80 km and a width of 50 km. It is bounded by longitudes 47° 45' 80" and 48° 5' 50" East and latitudes 28° 30' 59" and 29° 15' 00" North (fig. 1).

Objectives

The overall objectives of this study are (1) to study the main geomorphological, sedimentological and hydrogeo-

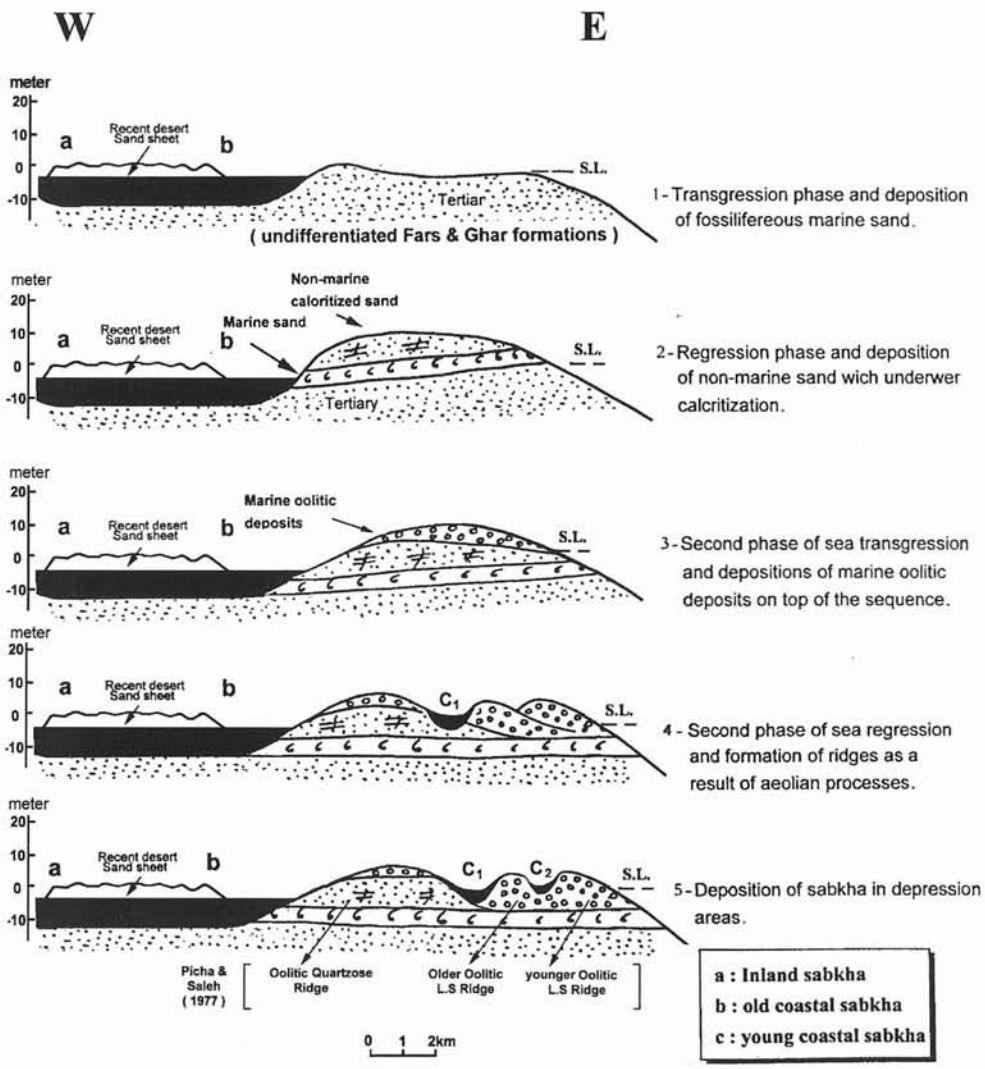

FIG. 2 - Sketch profiles showing stages of the development of the oolitic coastal ridges and sabkhas in Al-Khiran area. (After Al-Hurban, 1996, with modifications).

chemical characteristics of the coastal and inland sabkhas in southern Kuwait and (2) to identify their origin and mode of occurrence.

METHODOLOGY

Field investigation and sampling

Two N-S and E-W transects were chosen during fieldwork to cover most of the morphological features in the study area. Coastal and inland sabkhas were identified, and delineated in the study area on the basis of topographic maps of Kuwait (scale 1:50,000), 1991 aerial photographs (scale 1:29,000) and field observations.

Thirty open pits (1m deep) were developed during the fieldwork. A total of 113 samples were collected from the open pits with 4 samples from each pit with a 25 cm depth between each sample.

Laboratory Analysis

Different techniques have been carried out for the analysis of samples of both inland and coastal sabkhas such as:

1. Grain size analysis (Folk, 1954, 1974; Folk & Ward, 1957).
2. Mineralogical analysis
   1. Mineral grain counting
   2. X-Ray diffraction
   3. Heavy mineral analysis
3. Scanning Electron Microscopic Examination (SEM) (Krinsly & Doornkamp, 1973)
4. pH and Salinity measurements.

RESULTS and DISCUSSION

Formation of sabkhas is related to some pre-existing morphological features such as depressions and gentle slopes, and are distributed in the study area in different geomorphological zones. The general geomorphological setting of the study area is characterized by a complex of different morphological features. The surface of the study area is classified into 9 geomorphic zones (fig. 3). The general slope of the study area is to the east following the same direction of the whole area. By comparing figure 1 with the geomorphic zonation map (fig. 3), it can be shown that most of the coastal sabkhas are located on the elongated depression zone of Al-Jailaiah and Al-Khiran

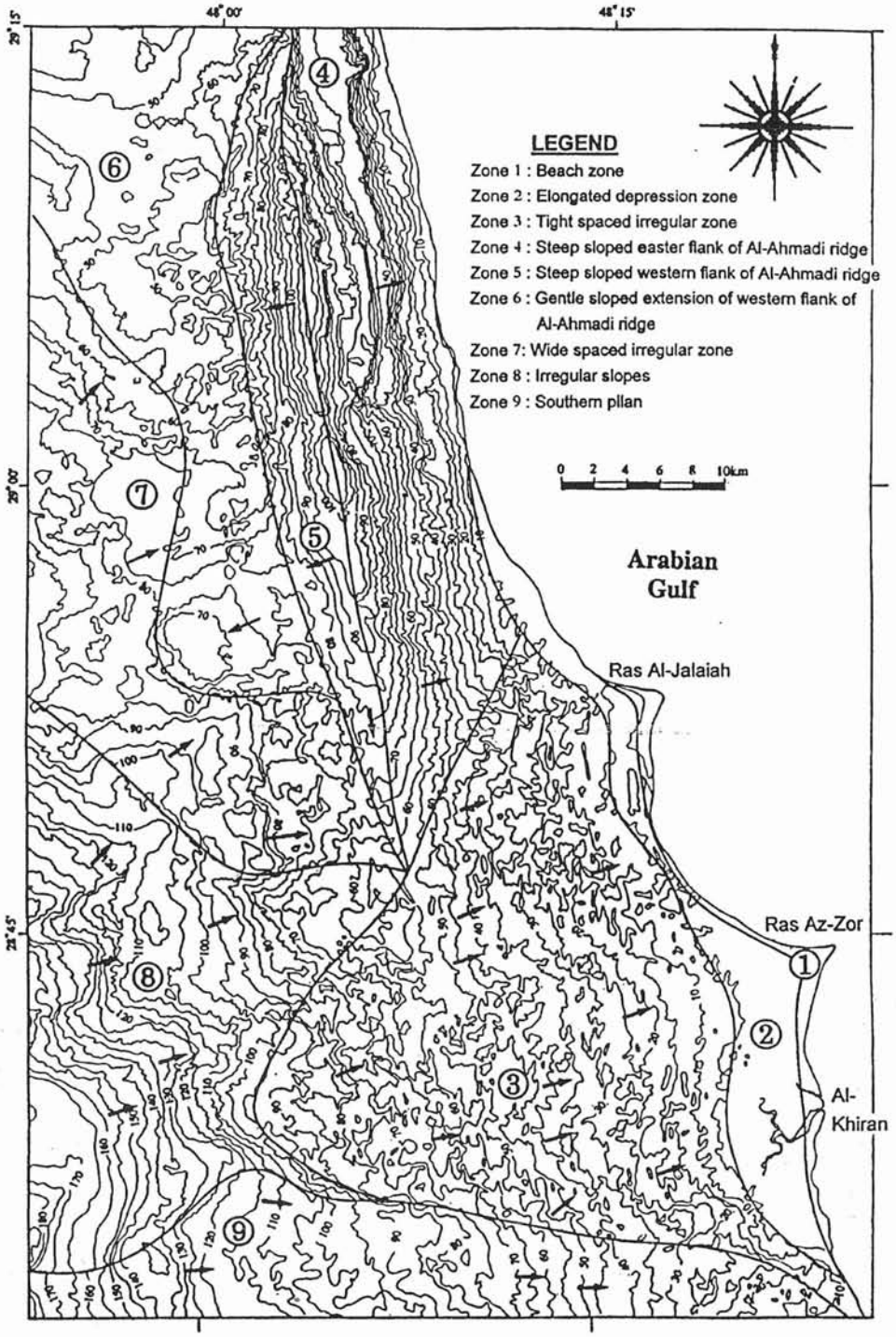

FIG. 3 - Geomorphic zonation of the study area (After Al-Hurban, 1996, with modifications).

areas. While the inland sabkhas are located on other different zones, the western gentle sloped extension of Al-Ahmadi ridge zone, the wide spaced irregular zone, and the irregular slope zone area. The surfaces of sabkhas in general and inland in particular, are partially covered by active sand deposits caused by the prevailing northwesterly winds forming sheets of variable thicknesses.

From the textural point of view, both sabkhas can be grouped in the gravelly to slightly gravelly muddy sand class. Gravel size grains are more pronounced in inland sabkhas due to its location in the desert areas, while mud size grains are more in coastal sabkha. Both sabkha sediments are mostly unimodal with a modal class of medium sand, poorly sorted, nearly symmetrical and mesokurtic.

Most of the sabkha quartz grains are wind-blown particles derived from the erosion of nearby Pleistocene-Holocene coastal ridge or/and from the sand drift by northwesterly wind. The remaining particles are marine and seem to be generated by present day processes.

Mineralogically, both coastal and inland sabkhas are composed of quartz, feldspars, gypsum and rock fragments. Skeletal fragments and oolites are present in the coastal sabkhas and are absent in the inland sabkhas (fig. 4). Based on the heavy-mineral suites, most of the sabkha sediments could be derived from the Al-Dibdibbah grave-

Mineral Grain	Inland Sabkhas (%)	Coastal Sabkhas (%)
Quartz	80.00	63.70
Feldspar	7.60	3.30
Rock Fragment	7.70	7.00
Gypsum	2.50	13.40
Skeletal Fragment	-	4.00
Oolites	-	7.10
Others	6.60	1.60

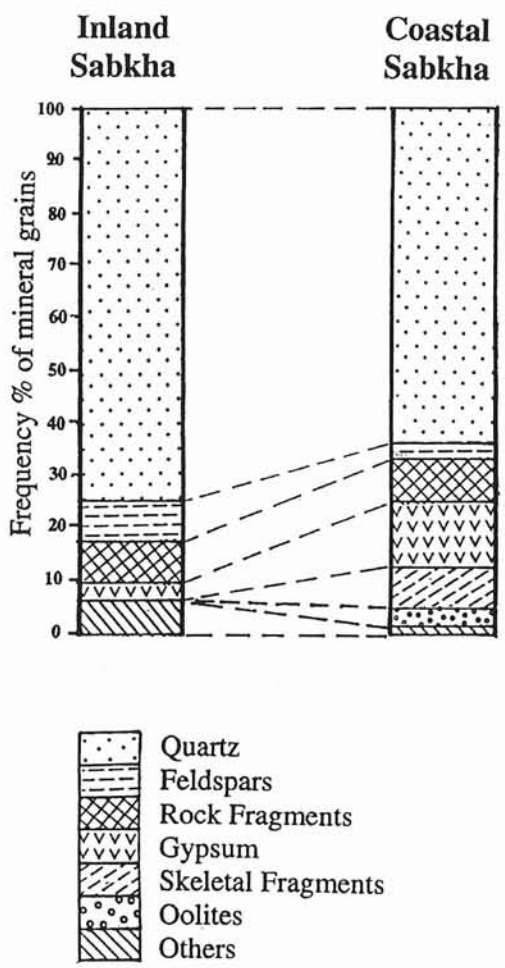

FIG. 4 - Average relative frequency percentages of the mineral grains in the medium sand size fraction of the coastal and inland sabkhā deposits.

ly pleistocene deposits that are originally coming from the Arabian Shield rocks (Gharib & *alii*, 1980). The elongated coastal fossiliferous oolitic limestone ridges are considered, also, as a secondary contributor to the coastal sabkhas sediments.

The surface features of quartz grains show the mechanical and actions. The former is mainly causedby collision effect of sand grains and glaciation as well, such as v-shaped pits, crescent like pits, coalescing pits, dish shaped depressions, upturned plates, straight and curved sutures, conchoidal fracture, and stepped cleavage planes, while the later is represented by secondary silica precipitation, deep grooves and etching pits. From the chemical analysis of TDS and salinity, the coastal sabkhas have higher percentages than inland sabkhas.

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