Study on the Geomorphological Changes, Depositional Environments and Geochemical Properties of Sediment Veneer In and Around Al-Leith Area, Red Sea Coast of Saudi Arabia

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Introduction

Al-Leith area lies in the Western Province of Saudi Arabia between latitudes 20° 10'N and 20° 20'N. It occupies the coastal zone along the Red Sea (Figs. 1 & 2). The area enjoys subtropical to tropical climate and experiences seasonal monsoon rains which increase to the south. The water temperature in the Red Sea varies between 23.8°C to 24.4°C and the average salinity is 39.2 grm./liter.

Geomorphologically, the area has rugged topography with sharp ridges, V- and U-shaped gorges on the Arabian Shield area, while the coastal flat stretches for a distance of 10-30 km. The Arabian Shield forms the catchment through which most of the wadis start to flow towards west into the Red Sea.

Geologically, Al-Leith area is covered by Miocene Baid formation which is approximately 30 m thick and consists of conglomerate, sandstone, limestone, marly argillite, chert and basalt. Pliocene Ba'Han formation is approximately 35m thick and consists of conglomerate, sandstone and claystone (Hadley, 1975 and 1980; Hadley and Fleck, 1980 and Prinz, 1983).

The Principal objectives of the study are (1) to investigate the ehavior ofmajor, minor, and trace metals in marine sediments of Al-Leith area, (2) to study the sedimentology of the surficial marine sediments veneering the coastal zone, and (3) to investigate land cover and environment in Al-Leith area utilizing satellite images processing.

Previous Works

Not much work had been done on the lagoon area near Al-Leith area. Some latest research based on the geological, physical and chemical studies of the coastal lagoons of the Red Sea had been undertaken by Al-Washmi (1999); Basaham (1998); and El-Rayis (1990); Hadley (1975) and (1980); Hadley and Fleck (1980).

Method of Study

A number of sites were selected for sampling bottom sediments which include Wadi Iyar, located south of Al-Leith city; beach zone at the mouth of Wadi Iyar and near shore marine area off Wadi Iyar and it's vicinity sample labeled L's) from where 30 samples were collected for the analysis. Plastic scope, plastic spoon and grab sampler hauled from the boat, were used to collect samples from shallow sites, beach and wadi areas and deeper marine water respectfully.

For grain size determination, the technique by Folk (1980) was applied and for the statistical grain size parameters, Folk and Ward (1957) technique was applied and the calculations were made using a modified computer program GSM version 1.2, designed by Rifaat (1996).

Organic carbon was measured using sulphuric-dichromate wet-oxidation method (Walkely and Black, 1934). The non-detrital carbonate content was obtained by digesting accurately weighted powdered samples in 0.5 M HCl (1:25 w/v) for 6 hours at 60°C and then centrifuged and dried at 105°C . The weight loss is considered as equivalent of the calcium carbonate content of the sediment. The detrital content was calculated using the non-detrital content previously determined.

Trace elements were measured after the fractionation dissolution of the sediments in the 3-steps sequential procedure (adsorbed, carbonate-precipitated, and organic phases). In this part, the dynamic portion of the metals that is environmentally active is searched.

Two different techniques, false colour composite production and true colour composite, were used for the satellite image data processing to produce the maps of the Al-Leith area. In the false colour composite image method, two image compositions used in this study were bands 4, 5 and 7, which were processed using high-pass filtering system and 7,4, and 1 which were found to be the best combinations for coastal mapping and for discriminating land and water, and areas of moist soil or sabkha. In true colour composite image, the high resolution (pixel size=30 m) Landsat TM bands 1, 2, and 3 were used for seafloor mapping and for comparison with the bathymetric chart of the Al-Leith area, published by the Saudi Arabia Port Authority in (1984).

Discussion

Percentages of detrital and non-detrital content and grain size parameters of Al-Leith sediments were dentified. The mean grain size of sediments from the wadi channel (B's) ranges from 4.1 phi (coarse silt) to 1.69 phi (medium sand) with an average grain size of 3.46 phi. The beach sediments are coarser than the wadi sediments, whose average grain size is 2.55 phi. The marine sediments have grain sizes ranging from 4.43 phi (coarse silt) to 0.46 phi (coarse sand), averaging 3.5 phi. The wadi channel sediments are poorly sorted to moderately well sorted, generally strongly coarse skewed and leptokurtic; beach sediments are moderately well sorted to well sorted, near-symmetrical, and leptokurtic, while marine sediments are poorly sorted to well sorted with a general predominance of moderately well sorted sediments, coarse skewed and leptokurtic.

Mud dominates in the northeastern part of the lagoon, while patches of muddy sand are also present. The sediment consists of biogenic material of skeletal and non-skeletal remains of in-situ origin, whereas the detrital fraction is the product of the wadis and sabkhas. Quartz, feldspar and calcite are identified in the light fractions, whereas heavy minerals found in abundance are derived from the igneous and metamorphic rocks of the Arabian Shield. The biogenic materials of coral debris, molluscs and coralline algae, and the carbonate-rich coastal rocks, make an important contribution to the carbonate contents of the sediments of the littoral zone.

The variability in texture and composition along the study area is controlled by the physical processes, reworking by wind and wave generated

currents at the mouth of the wadis and longshore drift paralleling the shoreline. The coarser materials at the outlets of the lagoon is due to winnowing action where they were subjected to move to and fro along the beach while fine particles are removed further away into deeper parts of the sea. Fine particles are the products of the wadis, wind, and wave actions while some are caused by boring animals.

Manganese, zinc and cadmium are selected for geochemical study in the Al-Leith area. Manganese which forms the hard acceptors, is a major but non critical constituent of the sediments. In the wadi sediments, it is present in the carbonate-hydrous oxide and organic phases in equal proportion .
In beach sediments, it is present chiefly in the organic phase followed by the precipitated phase. In marine sediments, it is present in higher concentrations both in the precipitated and organic phase. It's abundance in sediments in ratios are : marine (65.69 ppm) > beach (48.20 ppm) > wadi (39.53 ppm). High manganese content in the marine sediment is due to deposition of manganese oxides, particulate organic matter and Mn-bearing mineral grains. Trend analysis shows that Manganese oxides increases in Wadi Iyar sediments especially where the wadi enters the sea, where the changes in the pH-Eh values causes precipitation leading to higher manganese content.

Zinc is a minor, intermediate acceptor and toxic metal. The partition of this metal is similar in wadi, beach and marine sediments. It is enriched in the carbonate-hydrous oxide followed by organic phases and its close relationship in carbonate sediments, indicates that it is present in the carbonate forms . Its relative abundance in sediments is as follows: Marine > wadi > beach . The

enrichment of zinc in marine is due to adsorption of Zn^{2+} on sedimentary particles of particulate organic matter (Rifaat et al., 1992).

Cadmium is present in trace and forms soft acceptors and very toxic constituent of the sediments. It is chiefly non-lithogenous and is enriched in carbonate as oxide phase followed by the organic phase. The metal is present in sediments as cadmium carbonate . The relative abundance of cadmium in sediments is: marine > wadi > beach . Rifaat (1996), reported the values of manganese, zinc and cadmium to be 16.81, 7.7 and 2.3 ppm in sediments from uncontaminated marine area north of Jeddah.

The landsat image interpretation , shows that the present day topography of the Al-Leith Shelf consists of a number of different features including northwest-southeast trending depressions (Al-Leith lagoon) and two main types of shallow sea bottom type (sand and coral reef). Shoal areas are less than 10m and where it is covered with sand, it is represented by blue image. The coral areas up to 0.5m of Al-Leith area is mapped by using false image bands 457, which is represented by red colour. Landsat image also shows the large reef areas in the emergent parts of Al-Leith lagoon and western part of the lagoon. No reefs are developed along the mainland, probably due to active sedimentation which retards the growth of corals. The most significant reef development is on offshore, occurring as fringe reefs such as Jabal Al-Leith and as patch reefs on the shoal areas .

The sabkhas are distinguished by blue-green colour due to adsorption of band 7 and high reflectance of bands 4 and 1. Wet soil or sabkha

areas appear as brown due to adsorption of band 7 and reflectance 59% and 10% of bands 4 and 5 respectively.

Vegetation is displayed by red colour due to high reflectance (100%) of band 4 (0.76-0.9 μm) and adsorption of wavelengths (1.55-1.75 μm) and (2.08-2.35μm) in bands 5 and 7 respectively.

Conclusion and Recommendation

The grain size of the wadis are from coarse silt to medium sand and are poorly to moderately sorted, generally, strongly coarse skewed and leptokurtic. The beach sands are coarser which have an average of 2.5 phi, and are moderately sorted to well sorted, near-symmetrical and leptokurtic. The marine sediments range from coarse silt to coarse sand with an average grain size of 3.5 phi, and they are poorly to well sorted sediments, and coarse skewed and leptokurtic.

Total carbonate is mostly biogenic origin whereas organic carbon is derived from plants and associated debris brought in by the wadis. The source of sediments are brought by the wadis which drain through the igneous and metamorphic rocks of the Arabian Shield, the mineral composition of which are diversified, whereas quartz is abundant in fine-medium sands and is transported by wind.

Manganese, zinc and cadmium are found in abundance in carbonate hydrous oxide followed by organic phases, especially in marine sediments.

Landsat image shows many features including islands, emergent coral reef islands and reef and sand shoals, and sea floor depressions. Major depression or lagoon is the northwest and southeast depression of the Al-Leith lagoon which runs parallel to the Red Sea trough in the west and the shoreline in the east. No reefs were found on the mainland coast. Wet areas of the sabkha, coastal rocks and vegetation are identified as absorbed by the infrared band 7.

The presence of zinc, manganese and cadmium in sediments of Al-Leith area, is considered to be governed by several factors including the ineral phases present, the organic contribution to the sediments both as tests and organic remains, the trace and major metals composition of sediments, the processes of metal supply to the sediments, the metal influxes (input and output), the physicochemical conditions of the ambient environment, and the controlling processes of metal fractionation.

The sediments of Al-Leith are not yet subjected to the stress of human activities as deduced from the low critical and toxic metal contents (zinc and cadmium) in the mobile phases of the sediments.

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دراسة على التغيرات الجيومورفولوجية والبيئات الترسيبية والخواص الجيوكيميائية لرسوبيات منطقة الليث الواقعة على ساحل البحر الأحمر للمملكة العربية السعودية

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المستخلص : يختص هذا المشروع بدراسة الخواص الترسيبية والجيوكيميائية والجيومورفولوجية للسهل الساحلي لمنطقة الليث التي تقع على ساحل البحر الأحمر السعودي . وتمتاز المنطقة بكثرة الاودية التي تصب حمولتها من الفتات القاري في البيئة البحرية . وقد تـم دراســة الخصــائص النسيجية لرسوبيات المنطقة الشاطئية وأحد الأودية الرئيسية كما تم تعيــين الأشــكال الكيميائيــة المختلفة لعناصر المنجنيز والزنك والكادميوم في تلك الرسوبيات هذا وقد تم وصــف الظــواهر الجيومورفولوجية والجيولوجية للمنطقة بإستخدام صور الأقمار الصناعية والمسح الحقلي .

وقد وجد أن محتوى الكربونات الكلية يرجع إلى الأصــل العضــوي أمــا المحتــوى العضــوي للرسوبيات فيرجع إلى البقايا النباتية والأحيائية الموجودة بالمنطقة والمنقولة بواسطة الوديان . وقد تم التعرف على مصدر تلك الرسوبيات التي يرجع أصلها إلى تجوية صــخور القاعــدة الناريــة والمتحولة ، بينما تشير دراسة حبيبات الكوارتز في جزء الرمال المتوسطة الحجم إلى أنها انتقلت بواسطة الرياح .

كما دلت الدراسات الجيوكيميائية على تواجد عناصر المنجنيز والزنك والكادميوم والتــي يعتمــد تركيزها على محتوى المعادن الشائعة ، ومحتوى المواد العضــوية والكربوناتيــة ، والعمليــات المتحكمة في تزويد المنطقة بالرسوبيات ، والخواص الفيزيوكيميائية لماء البحر والعوامــل التــي تتحكم في التوزيع التجزيئي للعناصر النادرة في الرسوبيات . هذا ويدل تركيز تلك العناصــر أن المنطقة الشاطئية لليث لم تتعرض بعد للتلوث الناجم عن النشاط الإنساني نظرا لقلة تركيز العناصر السامة مثل الكادميوم والزنك في الرسوبيات . وقد أظهر تحليل الصور الفضائية للمنطقة تواجــد العديد من الظواهر الجيومورفولوجية مثل جزر الشعاب المرجانية والمناطق الرمليــة الضــحلة والمنخفضات المغمورة تحت قاع البحر والحواجز الرملية إلى جانب مسطحات المد والمستنقعات السبخية والسهول الطينية والمناطق النباتية والرملية والصخرية التي تغطي النطاق الشاطئي لمنطقة الليث .