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Reviews Sedimentology around Jettiesas Strategies' Prevent Sedimentation

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Abstract: *The purpose of this study was to determine texture and source of sediments in Chabahar jetties by using granulometry and determination of organic matter and calcium carbonate content. The Makranaccretionary prism is located in the Northwestern part of the Indian Ocean, in South of Iran and Pakistan. South-east Iran is the site of a rare case of young transition between subduction and collision. The project aims to show future dredging operation and infrastructure development plans at the Oman Sea ports in order to assess the challenges concerning sediments, handling of dredged sediments and fulfillment of all the plans. Moreover, concentration of oxides and elements including SiO2, Al2O3, Fe2O3, CaO, MgO, MnO, TiO2, B, Bi, As, Sr, Cr, Cu, Ni, Ba, and W in various types of sediments were determined separately. The result of geochemical studies of sediments and Putting together them with element distribution maps of bay show high concentration of some heavy elements like Cr, Sr, W, Zn, Bi, As and Cu in the margin of ShahidBeheshty and ShahidKalantari jetties in the most Southeastern part. This confirms the human activities as a main origin for the pollution.Results show a majority of the ports plan to do dredging in next 1-5 or 6-10 years with the aim of maintaining or increasing the water depth, construction works or expansion of the port area.*

Keywords: *Coastal, Oman Sea, Sediment transport, Southeastern Iran*

I. Introduction

Ports play an important role in handling of goods and transportation of the passengers in the Oman Sea Region. To maintain the function of a port and to face future challenges, such as heavier cargo and bigger boats, both maintenance and expanding actions are needed. Ports usually have a governing body referred to as the port authority, port management, or port administration. Port authority is used widely to indicate any of these three terms.The port of Chabahar is located in the south of Sistan and Baluchistan Province.Bay of Chabahar is considered as largest bay in coast line of Oman Sea. It has length of 17km, width of 20km and maximum depth of 20m at its mouth.Shahid – Kalantary and ShahidBeheshti jetties are two important ports in Chabahar. Because of its establishments and ease of access to ocean as well as Oman Sea and Persian Gulf, long ago it was the centre of business, trade and navigationSpatial transition between subduction and continental collision is by itself unstable and often a transform fault will develop to accommodate the differences in tectonic setting as the Chaman fault in central Asia does (Lawrence et al., 1992).Transit ports of Chabahar and Konarak in its Eastern and Western sides respectively are also the largest Iranian ports of Oman Sea.The Makranaccretionary wedge stretches from Iran to central Pakistan and off the south coast of this area (Schluter et al., 2002). It has been formed by the subduction of the oceanic portion of the Arabian Plate beneath Eurasia and is built up by sediments scraped off the Arabian Plate since early Tertiary (Berberian and King, 1981; Harms et al., 1984; Kopp et al., 2000). Subduction was probably initiated during Palaeocene (Platt et al., 1988) and accretion started during Eocene times (Byrne et al., 1992). The modern Makranaccretionary prism has developed since Late Miocene (Platt et al., 1985; Platt et al., 1988), and is still propagating seaward at a rate of ~10 mm yr-1 (White, 1982). Two features make this accretionary wedge unusual: (1) the sediment thickness on top of the oceanic crust is extremely high (at least 6 km); and (2) the dip angle of subduction is extremely low (~5 degrees, Jacob and Quittmeyer, 1979; Byrne et al., 1992; Carbon, 1996). The Oman Sea is anoffshore area and also a marginal Sea. It connects to Arabian Sea and Indian Ocean from the west. Makran Coastal Highway is a 653 km-long coastal highway along Pakistan's Arabian Sea coastline. The length of Oman Sea about 653 km in internal zone of Iran.There seem to be three possibilities: one, the entire western segment is mostly deforming aseismically (Bayer et al. 2006); two, the subduction process is no longer active on this segment (Vita-Finzi 2002; McCall 2002); and three, the western segment is locked and is capable of generating a plate boundary earthquake (Byrne et al. 1992; Mokthari et al. 2008; Musson 2009). The last assumption is based on the fact that the coast on the western part appears to have been uplifted as shown by a terraced topography and that the plate convergence also shows a more or less uniform velocity (*23 mm year-1, relative to Eurasia), evidenced by GPS measurements (Masson et al. 2007). The perceived locked status of the western segment and its unknown tsunamigenic potential has important implications on the hazard and risk assessment for the North Arabian shores (e.g., Wyss and Al-Homoud 2004).Sedimentation occurred usually from soil erosion in at catchment area. The sedimentation level of severity was depending on the type of soil, topography, rainfall intensity and vegetation cover. From an economics perspective reservoir were assets that provided services across a period of time. While sedimentation reduced the storage volume, it also reduced the benefits that could be derived from services provided by the reservoir over time and ultimately shortened its economics life (Andawayanti et al., 2011).The quantitative understanding of hydrodynamic and sediment transport on intertidal mudflats were important for the management of estuaries and environmental protection (Sakanshi& Tamaki, 2009). The sediment transport and hydrodynamics on the mudflats were influenced by processes with a range of times scales due to freshwater discharge, tides, and wind waves their interactions (Andawayanti and Suhardjono. 2010).

Port was a construction which was straight upright at coast and located at both sides of estuary. This construction was functioned for decreasing the groove shallowing of the both sides by coastal sediment. The usage of river estuary as sailing groove and sedimentation at estuary could disturb the coastal traffic. Long port (for example ShahidBeheshti and ShahidKalantari) had the end outside of breaking wave. This type was effective to prevent entering sediment to estuary, but construction cost was so expensive. Therefore if the function was only for flood control, the usage of this type was not economic unless if the area that had to protect was very important (Triatmodjo, 2008).

IMO has always been recognized that the best way of improving safety at sea is by developing international regulations that are followed by all shipping nations and from the mid-19th century onwards a number of such agreements were adopted. Several countries proposed that a permanent international body should be established to promote maritime safety more efficiently. In 1948 an international conference in Geneva adopted a convention formally establishing IMO (the original name was the Intergovernmental Maritime Consultative Organization, or IMCO, but the name was changed to IMO in 1982). The International Maritime Organization (IMO) is a specialized agency of the United Nations which is responsible for measures to improve the safety and security of international shipping through cooperation and to prevent marine pollution from ships. It is also involved in legal matters, including liability and compensation issues and the facilitation of international maritime traffic. IMO also has an extensive technical co-operation program which concentrates on improving the ability of developing countries to help themselves.This paper deals with three subjects on coast sediment. The first is the fundamental topics of coast sediment movement in nature; the second is to predict the silting thickness in approach channels and basins or to find ways for reducing siltation in them; the third is to discuss the effectiveness of accelerating accumulation by using groins and offshore structures.

II. Material and methods

In this research had been used the following methods:

1. Office and library studies: At this stage, books, theses, articles, reports and geological maps related to the subject studied.

2. Field Studies: At this stage, several field visits, sampling, photographed and documented in structural geology features is done.

3. Laboratory studies: At this point, the following steps were taken.

3.1. Sample preparation: In the method, about 200 gr of sediments have been taken and soaked in distilled water for 24 hours. This stage of experiment separates grain from each other. Of course, based on sediment grain size and primary amount of sediments, this amount may change. Then, to prevent from flocculation of clay and lack of crashing of shell fragments, the samples were inserted in an ultrasonic mixer.

3.2. The method for measurement of grain diameters: In this method had been used wet Sieve analyzer and Laser beam diffraction. At first, to measure the diameter of coarse grains of sediment samples, vibratory sieve shaker is used (Fig.5). This device uses wet method for granulometry of sediments within an average time of 30 minutes for each sample. Sieves having bigger and smaller opening retain in higher and lower levels, respectively. Meanwhile, the diameters of opening of these sieves are based on ASTM and Ø scales. After granulometry of sample by sieve shaker, remaining grains on sieves were emptied on pyrex dishes. Then, they are heated and dried witgin temperature of 70° C. the weight of different fraction of samples were measured by a digital scale and mentioned in granulometry graph. After rinsing each sample by sieve shaker, sieves having mesh of fine opening were inserted in ultrasound bath to cleanse the mesh opening from sediments. Then the sieve will be ready for another experiment. Before granulometry of sediments the sample weight is clarified. After collection of remaining sediments in the sieve of 63µ, they were prepared for Analysette 22, microtec model made in Fritsch Company. Finally, the grain and particles percentages and the diameters were measured and results were automatically represented by a graph. All granulometry equipment belongs to the sedimentology laboratory of the Geological Survey of Iran.

Fig. 6) laboratory equipmentin this research

3.3. Mineralogy, morphometry and morphoscopy: Sediments in certain portions (i.e. 63µ, 250µ, 500µ and 2000µ) were selected for mineralogy, morphometry and morphoscopy. This study was carried out by Nikon microscope and maximum magnification of 94.5 (603× 1.5 × 10). Photographs were prepared form specific and important cases.

III. Data analysis, interpretation and conclusions:

After obtaining the results of previous steps, the results with each other by *sediment grain size analysis software*. The results of two devices were combined with each other and then charts and graphs based on Ø and millimeter were plotted. Granulometry graphs were plotted based on Ø. After determination of sediment type, sedimentary statistical parameters were automatically calculated. These parameters can be median, mode, skewness, kurtosis, standard deviation, etc.

IV. Structural geology and Geographical location of study area

Chabahar is situated on the Makran Coast of the Sistan and Balouchestan province of Iran and is officially designated as a Free Trade and Industrial Zone by Iran's government.The geographical coordinates of the study area are as follows; Latitudes: from 25° 17´ 28´´N to 25° 17´31´´N and Longitudes: from 60° 38´ 15´´E to 60° 38´35´´E (Fig. 1). In general, the port of Chabahar is located in an area that has warm and humid summers and moderate winters.with an area of Chabahar11km^2, the geographic parallel port the port of Miami in Florida peninsula America and climatic conditions similar to the Port of Miami port is the maximum average annual temperature of 34 degrees Celsius and the mean minimum temperature of 10 degrees Celsius.

Fig. 1) Image of ShahidBeheshti&ShahidKalantariporst.

It is one of three ranges in the mountain ranges system. The range's peaks are 2,000–3,000 metres (6,600–9,800 ft.) in elevation. Mirani Dam across the Dasht River forms a reservoir in the range. Makran Coastal Highway is a 653 km-long coastal highway along Pakistan's Arabian Sea coastline (Fig. 2). The Makran is one of the largest accretionary wedges on Earth. Located in SE Iran and South Pakistan, it extends ca. 1000 km from the Strait of Hormuz in the west to near Karachi in the east. The width of the wedge is 300-350 km from the offshore front of deformation to the depressions of JazMurian in Iran and Mashkel in Pakistan. More than half of the wedge is exposed on land. The other half, the active, frontal one, is below sea level.Makransubduction zone is an accretionary prism which is known as an important division of the Iranian Playeau based on its tectono-sedimentary characteristics (Falcon, N. L., 1974). The zone is composed of E W trending mountains which extend from the Oman Sea margins to Jazmurian Depression and its western boundary is separated from Zagros Collision zone by Oman Line (Minab Fault). The Makran continental margin of Iran in the Gulf of Oman forms the seaward margin of a folded and faulted accretionary sediment and colored mélange wedge which extends several hundred kilometers inland. There are three important geologic features in southeastern Iran: (i) the Makranaccretionary prism; (ii) the JazMurian depression, which is located at the southern end of the Lut Block north the Makranaccretionary prism; and (iii) a zone of Cenozoic volcanic and plutonic rocks of andesitic to rhyolitic composition (Farhoudi and Karig, 1977). The outcrops in the area are calcareous mudstone (former marls) and marine terraces and plateaus which are composed of two levels, and the city of Chabahar, is located on them.

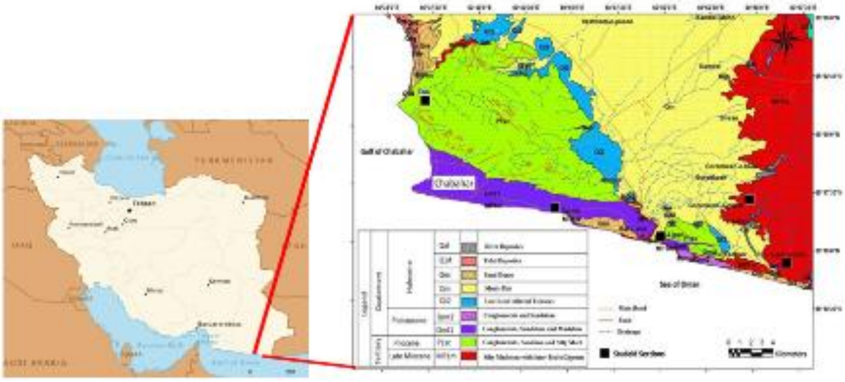

Fig. 2) Geological and Geographical location of study area

The Makran Trench is the physiographic expression of a subduction zone which lies along the southwestern coast of Baluchistan (Pakistan) and Iran, where the oceanic crust of the Arabian Plate is subducting beneath the continental crust of the Eurasian Plate.In the Makran region, the Arabian Plate subducts beneath the Eurasian Plate at ~4 cm/yr. This subduction is associated with an accretionary wedge of sediments which has developed since the Cenozoic (Kopp et al., 2000).To the west, the Makran Trench is connected by the Minab Fault system to the Zagros fold and thrust belt (Regard et al., 2010).To the east, the Makran Trench is bounded by the transpressional strike-slip Ornach-Nal and Chaman Faults, which connect to the Himalayan orogeny (Fig. 3). The entire Makransubduction zone was initially considered to be structurally homogeneous and consequently deforming uniformly (Byrne et al. 1992).

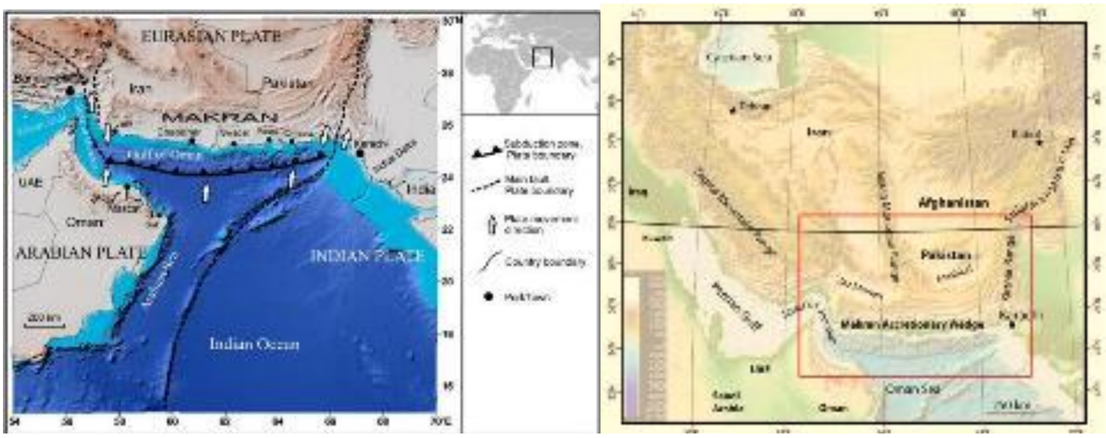

Fig. 3) Geographic location ofMakranaccretionary wedge in the frame of the surrounding mountain ranges. Makransubduction zone, formed by the convergence between the Eurasian and the Arabian Plates (Shah-hosseinia et al., 2011; Marine Geology)

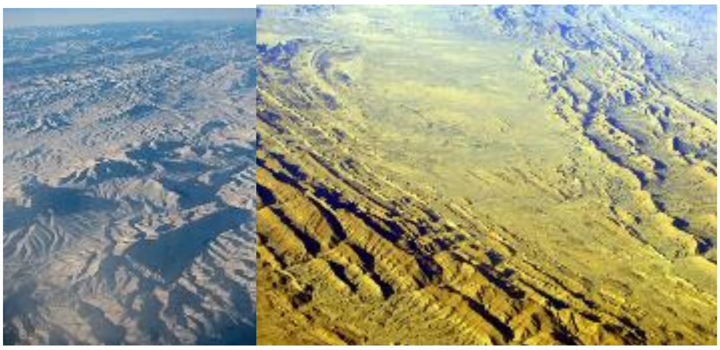

Fig. 4) Aerial view of the Central Makran Range, in southwest Iran.

The recent sediments of the Oman Sea are detrital riverine, biogenic and loess deposits. Detrital riverine sediments originate from Lipar, Tees, Parak and some of the small rivers of northern coasts. Lows deposits are mainly supplied by southeast winds, namely "monsoon" here. Dust storms bring plenty of fine-grain detrital materials from coastal plains, northern deserts, Pakistan and Indian desert to the Oman Sea.

V. Economic significance

Chabahar is Iran's closest and best access point to the Indian Ocean. Having two important commercial ports, ShahidBeheshti and ShahidKalantari, in the eastern shore of Chabahar Gulf located in the province of Sistan and Balochistan beside the warm water of the Oman Sea and the Indian Ocean, and being adjacent to two countries of Pakistan and Afghanistan and having access to the international waters, and CIS countries and also being adjacent to Free Trade-Industrial Zone, Chabahar port performs the role.The executive operations of each port of ShahidBeheshti and Shahidkalantari embarked on 1983 and by completion of 4 berths became operational. Chabahar port called Tees (Tees) port in the past was considered as one of the most important ports of Iran and Middle East in the Makran Sea from the Achaemenids era. In that era, the cargoes have been brought from Eastern Asia and India to the Tees port and were sent to different regions such as Middle East, Middle Asia and the Caucasus. For this reason, Chabahar is the focal point of Iranian development of the east of the country through expansion and enhancement of transit routes among countries situated in the northern part of the Indian Ocean and Central Asia (Fig. 5).Nowadays, Chabahar port has been considered as the forehead of the eastern development route and the gate of the international North-South Corridor in order to fulfill the general policies goals of the Regime of Islamic Republic of Iran and the emphases of the supreme Leader based on the development plan of the Chabahar port as the only oceanic port of the country. In this regard, the development plan of the Chabahar port was accomplished in 5 phases on 2007. The hope is that with the development of transit routes, and better security and transit services, the benefits will reach the local residents. Chabahar's economic sectors are fish industries and commercial sector, fishery sectors with the largest amount of country's fish catch, mainly located out of the Chabahar Free Trade-Industrial Zone. Growing commercial sector located at free trade area with high potentiality to turn to a place that would connect business growth centers in south Asia (India) and Middle East (Dubai) to central Asian and Afghanistan market. The government plans to link the Chabahar free trade area to Iran's main rail network, which is connected to Central Asia and Afghanistan as well.

Fig. 5) ShahidBeheshtiport as one of the focal point of Iranian development

VI. The sedimentation process

Rivers and seas carry suspended sand and soil along with them as they flow toward the ocean. The higher the water velocity, the greater are the speed of the water, its energy and capacity to move soil, sand and even rocks. When the velocity of the water decreases, it loses energy and the non-floating materials drop to the bottom of the river channel. Materials that fall to the bottom of a liquid are called sediments. There are different types of sediments clay, silt, sand, gravel, etc. As stream or river velocity slows, heavier materials, like sand and gravel, will settle out first. In still water, harbors and backwater areas silts and clays will settle out. If enough sediments deposits to build a shallow spot on the river or ocean bottom, it forms shoals. A shoal in a navigation channel that causes the bottom to become shallower than is shown on nautical charts is a safety hazard. If a vessel grounds or strikes the shoal, the vessel and its content may be damaged. In serious situations, the environment can be damaged if the ship's cargo is spilled into the waterway. Therefore, dredging of sediments is usually required.

Under water excavation is called dredging. Dredging of sediments is sometimes required in order to maintain depth of the ports or excavate the contaminated sediments. In addition, dredging is essential to maintain navigation in ports and harbors as well as for the development of port facilities (Helsinki Commission, 2007). There are different methods to handle dredged sediments, that in some cases beneficial use of dredged sediments is preferred rather than disposal. Using dredged sediments in road construction, using dewatered silt to cover disposal sites, filling harbor basins and mines etc. are some examples of beneficial use of dredged sediments. Fig. 6 shows different handling options for dredged sediments, both beneficial type and disposal type.

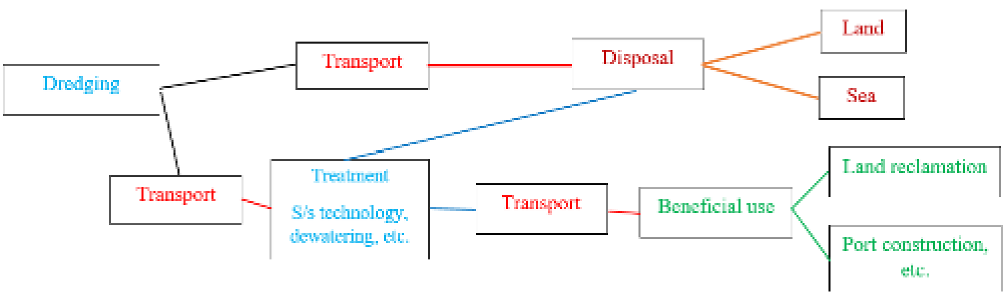

Fig. 6. Different possibilities for handling and locating of dredged sediments, either the beneficial use or disposal of the dredged sediments

VII. Discussion and Results

Natural waterways exhibit shallow areas and deep areas that may shift as flows change, sediment supply changes, or features migrate. They may naturally be deep enough in some locations to accommodate navigation, but often have at least some areas shallower than navigable depth. Ports are usually built close to shorelines where water is naturally shallow and so they tend to suffer sediment deposition that reduces the depth available for navigation. The prediction of sedimentation processes involves two main elements: The sediments carried into the basin or towards the channel, caused by horizontal circulation cells at the port entrance, tidal filling and emptying, density driven flows and natural sand bypassing around breakwater heads and the trapping efficiency of the basin or channel, depending on the geometry, dimensions, orientation and sediment characteristics. Some ports have no significant sediment deposition, either because they are built in water naturally deeper than needed for navigability, because the sediment supply is very small, or because the waterway's currents sweep the sediment away (Berenbrock&Tranmer, 2008.). Coastal and estuarine ports are seldom in this category. The purpose of this study was to determine texture and source of sediments in Chabahar jetties, by using granulometry and determination of organic matter and calcium carbonate content. Data that were collected in this study included data of wind, existing port design, ebb tidal, sediment, and stream.Evaluating the hazard potential of the Makransubduction zone requires understanding the previous records of the large earthquakes and tsunamis.Sediment problems in coast engineering can be divided into two aspects. One is to avoid or reduce silt deposition in deepened water area, another is to accelerate silt deposition where groins or offshore structures have to be built to accumulate sediment in the sheltered areas.On the north shores of the bay, sand on the beach is picked up by strong winds from the sea, and driven inland as dune fields. Small trees have been planted in the entire area behind the beach on the west side of Water Desalination Plant to slow migration of sand. The size fraction larger than sand (granules, pebbles, cobbles and boulders) is collectively called gravel, and the size fraction smaller than sand (silt and clay) is collectively called mud (Table 2). There are different types of sediments at the ports included in the inventory, such as silt, clay, sand, gravel, etc., but sediments are mainly the mixture of sand, clay and silt at the ports. In addition, there are different types of contamination at the ports included in the inventory, which some of the ports are aware of and some are not. While there are some other ports that do not have any contaminated sediments. The respondent ports reported different types of contamination such as, TBT, dioxin, mercury, copper, zinc aromatic hydrocarbons, HOS etc.

Table 2) the distinction between grain size and mineral composition in sedimentary rock nomenclature (Folk, R.L., 1954)

Wentworth size class	Micrometers (μm)
Mud	<62.5
Very fine sand	62.5-130
Fine sand	130-250
Medium sand	250-500
Coarse sand	500-1000
Gravel	>1000

Beach deposits of the region have good sorting and negative skewness, while eolian sand dunes have better sorting and positive skewness.

Fig. 7) Seabed on southeast part of the bay, depth 10 m. Bivalve shells cover the entire surface.

Fluid mud was originally thought to only be present in a few locations throughout the world, but it has been observed in numerous locations and is now known to be a common occurrence. Fluid mud normally forms in layers near the bottom of lakes, canals, estuaries, and other coastal waters but can occur in any water body that contains a sufficient amount of fine-sediments and experiences low intensity flow. These layers of fluid mud can be very thin or can be several meters thick depending upon the conditions at a given site. Its formation can be due to rapid settling of fine sediment flocs and to wave or vessel induced agitation of a soft mud bed. In lakes, bays, and estuaries, the coarser non-cohesive sediment tends to deposit upstream leaving the fine cohesive sediment, such as fluid mud, to be transported further downstream before it is deposited. Since fluid mud, in many cases, is just an intermediate stage in the deposition process it can be directly linked to sediment build-up and shoaling problems. In some cases there is so much deposition from fluid mud that ports cannot dredge rapidly enough to keep the waterway clear.

VIII. Conclusion

1. Silty sand and sandy silt are two sediment types in Chabahar Bay.
2. The sands and silts are dominated by Siliciclastic sediments of quartz, calcite, feldspar, rock and oyster shell fragments. These sediments have a moderate to well sorting, platykurtic kurtosis and positive skewness.
3. Some of shell fragments come from intra-basin and others are clastic. The clastic shell fragments are mostly originated from the upper part of the marine terraces and have been transported into the Bay by the wind or water erosion.
4. The calcite grains are also abundant clastic sediments. Seasonal rivers such as Namak, Shour and Parak entering Chabahar bay from the Northwest which carry high amounts of silt and sand particles, after passing through the marl and limestone units, bring large amounts of carbonate particles into the Chabahar bay basin.
5. Analyses of major elements revealed that the dominant source may have been from felsic and intermediate rocks. This sediment is product of long washed recycled sediments after several uplifting stages in active Makransubduction zone.
6. Beach deposits of the region have good sorting and negative skewness, while eolian sand dunes have better sorting and positive skewness.
7. This study shows that a large quantity of clean and contaminated sediments are expected to be managed in the Oman Sea Ports for the upcoming years.
8. At least 5-8 million m^3 of contaminated sediments are estimated to be dredged and handled in the shahidBeheshti and ShahidKalantari ports, if assumptions are made conservatively.

9. Dredging of sediments is sometimes required in order to maintain depth of the ports or excavate the contaminated sediments.
10. Sediment problems in coast engineering can be divided into two aspects. One is to avoid or reduce silt deposition in deepened water area, another is to accelerate silt deposition where groins or offshore structures have to be built to accumulate sediment in the sheltered areas.
11. The prediction of sedimentation processes involves two main elements: The sediments carried into the basin or towards the channel, caused by horizontal circulation cells at the port entrance, tidal filling and emptying, density driven flows and natural sand bypassing around breakwater heads and the trapping efficiency of the basin or channel, depending on the geometry, dimensions, orientation and sediment characteristics.
12. Despite its resource value, too much sediment or the wrong kind of sediment can also cause economic and environmental damage.

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