Coastal Geomorphology of Chabahar Bay Area

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This paper presents preliminary results of an undergoing geomorphic assessment of Chabahar Bay conducted as part of the Monitoring and Modeling Study of some Coastal Parts of Sistan and Baluchestan and Bushehr Provinces (MONITOR SB&B) project, initiated by the Ports and Shipping Organization. The first phase of the MONITOR SB&B project includes a number of investigations covering site visits, overflight, GIS analysis of historic airphotos and charts, hydrographic and topographic surveys, a 25-year wave hindcast, extensive field measurements and various 2DH and 3D numerical modeling of hydrodynamics and sediment transport of the Chabahar area. This paper summarizes our observations during a site visit completed in June 2006.

The immediate vicinity of Chabahar Bay is dominated by high-relief coastal ranges and marine headlands. These show the characteristic weathering patterns of arid environments: steep runnel-and-gulley erosional scars, talus cones, "hoodoos", and dry streambeds. There would appear to be several coarsening-upward sequences, exhibiting basically two facies: a greenish sandy siltstone and a capping sandstone redbed.

The siltstones are finely-laminated, with occasional sandy stringers and rare examples of convolute bedding. No fossils were observed in this facies, although weathered outcrop faces sometimes exhibited patterns of vertical burrowing. Although poorly-indurated, this facies is quite cohesive: in outcrop it supports very steep, deeply-eroded slopes.

The sandstone facies is medium grain size (approx. D_{50}=0.3 mm), and extremely well-sorted. The reddish colour comes from limonite coatings on the quartz grains, as well as some orthoclase feldspar grains and fragments of reddish shell material. High-angle foresets and the presence of abundant carbonate stringers suggest deposition in the shoreface. This facies is moderately well-indurated (grains may be liberated by rubbing the rock with a hand), and forms a capping unit over the siltstones, leading to some spectacular examples of steep greenish mountainsides capped with blocky red sandstones.

There has been some earlier research suggesting that the Chabahar region has been tectonically uplifted throughout the Quaternary, at the rate of approx. 0.2 mm/year (Falcon, 1947; Vita-Finzi, 1980; Reyss, 1988). Sea level in this region seems to have reached a maximum level of two to 4 meters above present levels approximately 6000 years ago and gradually retreated after about 4000 years BP. These findings are in agreement with the model studies of Lambeck (1996).

Recently, there has been a notable body of work on shoreline characteristics and sea level history of Chabahar Bay performed by Soil Conservation & Watershed Management Research Center, Tehran, and by the University of Tehran. This work has greatly increased our knowledge of this region. Gharibreza and Motamed (in press) dated several fossiliferous horizons, both in core and in outcrop. They were able to produce a Holocene sea level curve for the Bay area that features four transgressive-regressive cycles, of varying duration. The final sea level fall began about 5,000 YBP, during which sea level

gradually fell from about +3m to its present level. The rate of advance of the shoreline has been about 0.8 m/year. The time gap between berm crests here is about 230 years. Study of the neighboring Pozm Bay, another omega-shaped bay, shows a similar pattern, except in this case the shoreline has advanced 1.7 m/year since the last transgression, and the temporal spacing between berms is about 98 years.

Tectonic activity also enters the picture as short-lived phenomena such as earthquakes. On Nov. 28, 1945, a major earthquake occurred off the Makran coast, magnitude 8.0. This earthquake generated a tsunami that reached heights of 12 m, washing away villages; thousands of people were killed. This event left a deposit, characterized by a shell lag in inland areas that has been described for the Omani coast. This same deposit undoubtedly occurs in the Chabahar region.

Gharibreza and Motamed (in press) also describe the core log from a borehole some distance inland from the centre of Chabahar Bay. Their log suggests 4 transgressive-regressive cycles, with a fall in relative sea level from a high stand about 5,000 YBP. The location of the borehole was well-chosen, because it would have recorded much of the activity on the littoral fringe during the Holocene. Although four cycles are recorded, the absolute changes in sea level were not likely to have been more that a few metres.

The predominant sediments on the beach reflect the main two facies responsible for sediment production in the bay, the red (rust-stained) sandstone and the greenish sandy siltstone, with an admixture of autochthonous carbonate and local organics. Carbonate production is limited, because of the high sediment loading. Sources of the carbonate could be the dying reefs in the SE part of the Bay. Benthic observations via snorkel and scuba diving were completed on June 13, 2006. Inside the Shaheed Beheshti (SB) Port Near the oil tanks, southeast side of the bay in of depth 2 m, was muddy and several species of corals were observed (small coloniesof Acropora cf A. hyacynthisand favids. Sediment stress was very heavy: all the corals had sediment drapes over the polyps, dead patches, and heavy epiphyte infestation. The local fisherman-guide indicated that this whole shallow area was once all coral, which means all dying coral now. Between the Haft-e- Tir jetty and the new university theatre (threatened by shoreline erosion), depth 2 m, it was a highly-reticulate bioeroded hardground surface, pockmarks infilled with fine sediment. This is a dead and eroding reef flat. Scattered corals to 10 cm diameter, mostly massives and favids (5-6 species) were observed. All corals were covered with mud drapes. Halimeda was seen in small dying colonies. Most of the hardground was covered with CCA (Crustose Coralline Algae), which is a potent sediment source. Sediments sourced from these regions will be higher in carbonate content - in fact, because the reef is dying, carbonate production will be at a maximum now.

In the lee side of SB breakwater, 10 m depth, there was an abundance of fish: zebrafish, groupers (to 30cm), Acanthurids, parrotfish, barracuda, Kyphosids, Chaetodonts. The rocks were covered with barnacles and ascidians, but no coral recruits were seen, at any depth. Outside of the SB breakwater, depth 10 m, visibility was fair in the upper zone but was zero in the bottom 3 m. Very strong shore-parallel westward-directed current was felt. Bottom was megarippled sand with ripples about 15 cm high and 50 cm long.

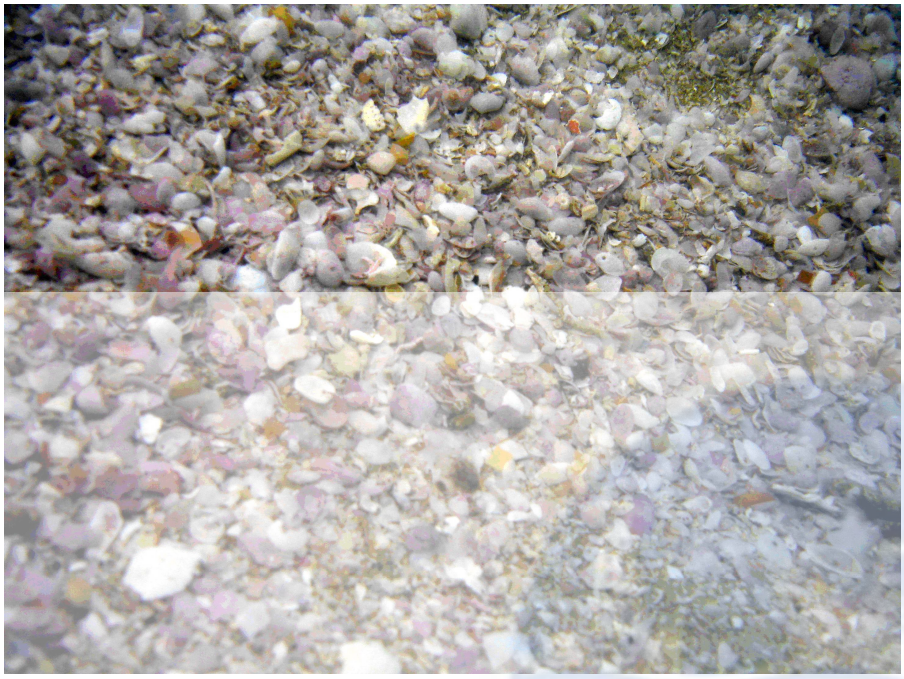

Figure 1- Seabed on southeast part of the bay, depth 10 m. Bivalve shells cover the entire surface.

The preliminary source of littoral sediment in the area is the erosion of outcrops that consist of capping red sandstones overlying greenish sandy siltstones. Cliff erosion rates (particularly between Ramin and Chabahar) therefore become an important element of a sediment budget for the bay. The beach profile inside the bay mostly consists of a mild sloping, green sand beach covered by a red sand steeper berm from approximately above the high water line. Sediment seems to be moving from south to north on both sides of Chabahar Bay.

The beach around Konarak jetty shows the classic pattern of accretion on the updrift (south) and erosion on the downdrift (north) side of the jetty. Little red sand exists on the beach to the north. The green sand/silty sand part of the profile is being scarped at the water line and the water is heavily laden with suspended sediment. South side of Konarak jetty, there was wide expanse of red sand (D_{50} of about 0.3 mm) with boats pulled up on the beach.

North of Konarak at Lifeguard Pier, there is an approximately 30 m offset from the red sand beach waterline on the north side to the south side. The red sand beach is much wider on the south side suggesting that this is the accreting/updrift side. Sample of red upper beach sand on the south side of the pier appears to be well-rounded with D_{50} of 0.3 mm based on hand lens assessment. On the north side of pier (apparent downdrift erosion zone) the red sand berm is mostly eroded and the greenish silty sand beach, with D_{50} in the 0.06 to 0.1 mm range, is visible below the toe of the narrow red sand.

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. This area has been covered with black sprayed-on mulch, consisting of fertilizer, organic matter and a small amount of oil. Dune sands can be seen migrating inland over this mulch. This black area has been buried by a 10 to 40 cm thick (average 20 cm) of wind

blown sand from the beach. Dune sand in this area is grey, owing to the absence of red sand on the beach (blocked by the desalination plant jetties).

On the southeast corner of the bay, the reach between Haft-e-Tir Fishery Port to Shaheed Kalantary (SK) jetty may be considered as a littoral cell, as there is likely little or no bypassing around either structure. Although the north end of this bay (i.e. just south of SK jetty) appears to be stable, there is a severe erosion zone further to the south in front of the university theatre building. The south end of the bay, on the other hand, is depositional.

The erosional zone of Haft-e-Tir to Kalantary Reach, adjacent to the university theatre features eroding cliffs over the past few years and the deck around the theatre building is currently only a few meters to the edge of 3 to 4 m high vertical eroding cliff. There is a natural rock outcrop on the beach just north of the theatre building. Shoreline erosion appears to start from south of these rocks, suggesting that the rock outcrops may be functioning as a natural groin holding the beach towards the SK jetty. Cliff material at this site is the greenish siltstone. The cliff has a relatively uniform composition over its exposed length with visual estimate of 5 to 10% sand/gravel (i.e. beach building material). Sand/gravel was mainly in a conglomerate layer near top of cliff and some very thin sandstone layers were horizontally layered within the siltstone. There was a notch at the base of the cliff about 40 cm deep and about 0.5 m high (visible water levels) indicating waves reach and erode toe of cliff at certain times (extreme tides) during the year. A trench was dug and showed about 30 cm red sand over the siltstone (locally known as Marn).

Although the bay is dominated by clastic sediments produced by shoreline erosion, there is significant carbonate input, especially along the eastern margins of the Bay. An understanding of the relative rates of supply is an essential element in any sediment budget: in addition, the carbonate grains themselves may be used as indicators. If the corals are indeed restricted to a small area in the SE part of the bay, then percentage coral fragments in bottom samples will be an indicator of transport.

The present assessment was based on site visit observations and literature review. Final geomorphic assessment of the study area will include GIS analysis of historic airphotos and satellite image, sediment samples, hydrographic survey, shoreline and profile surveys, extensive field measurements of hydrodynamic forces and numerical modeling which are all elements of the MONITOR SB&B project. The final sediment budget will be completed base on the above results.

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