

Sediment dispersal in the macro tidal Gulf of Kachchh, India

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Abstract

Studies of sub-bottom physiography, tidal parameters and characteristics of the sediment in the Gulf of Kachchh have been made. The tidal range becomes progressively higher in the inner gulf with associated high magnitude currents. The bathymetry of the inner gulf is marked with U and V shaped cuttings extending in the parallel clays, deposited in an earlier phase of deposition. In the outer gulf, there exists a palaeo-channel, buried under 18 m thick sediments (in the central region). Existence of this channel manifests to the change in the environment of deposition in the gulf, in the recent past. Based upon the physiographic, granulometric and clay content variations, and prevalent hydrodynamic regime in the gulf, the sources of the sediments and their dispersal patterns have been determined and presented. The results of the study have application for sequential interpretation of satellite images for separating out macro-tide induced temporal and spatial changes in the dispersal patterns and physiographic changes in the Gulf of Kachchh.

1. Introduction

The gulf of Kachchh is a large tidal body (area 7235 km²). It has a width of about 75 km at the mouth and narrows down abruptly into three major creek systems with an intricate creek system at 22°55'N Latitude; 70°15'E Longitude. The gulf is macrotidal with a tidal range of about 4 m at the mouth, which increases to about 7.37 m in the inner creeks due to depth and

width factors. Due to a high tidal range and associated currents, geologic processes in the gulf are complex. Since the gulf is located in the arid area with an average rainfall of about 50 cm y⁻¹, the fluvial source discharging into the gulf are short and estuarine with very insignificant discharge. In the present work, physiographic changes in the inner gulf and associated sediment dynamics are evaluated and presented.

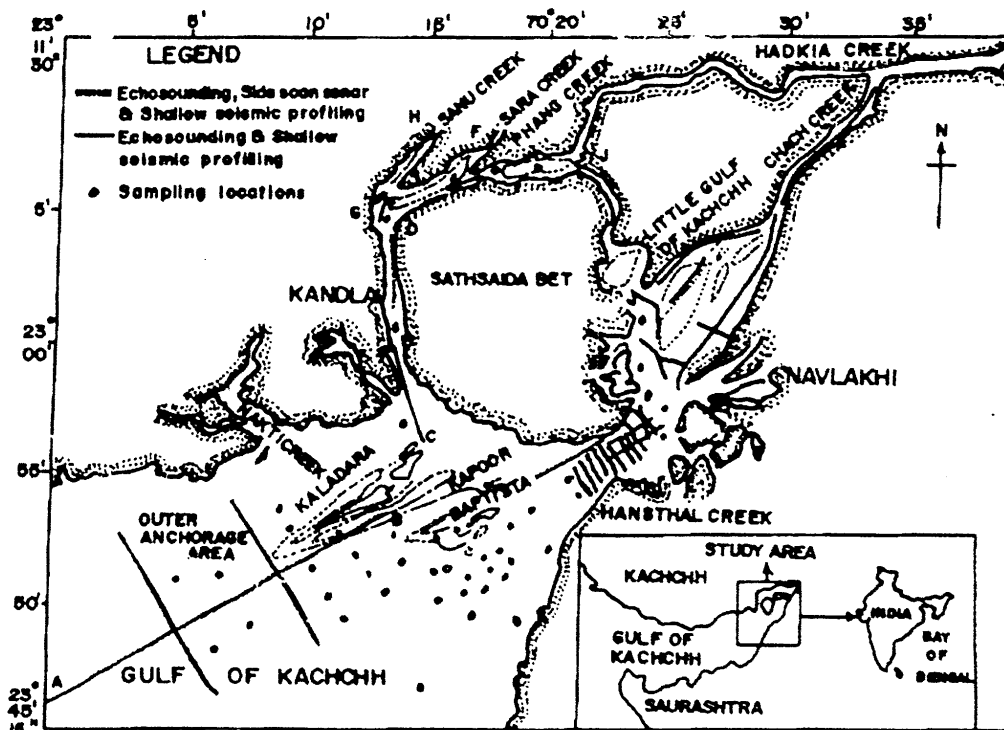


Fig. 1. Locations of survey lines and surficial sediment stations. Generalized physiography of the study area is also presented.

Sedimentological tools are used to understand the source and supply of the sediments into the different regions of the gulf.

2. Methodology

Subbottom physiography of the area is determined from the geophysical surveys undertaken in the gulf (Fig. 1). Details of the surveys have been described in Chauhan and Vora (1990). The temporal and spatial changes in the physiography and shoreline are determined comparing the physiography of the Hansthal creek given in the Admiralty Chart of 1950 and in the present survey as per the methods described in Pattanshetti et al. (1993). Sediment map of the gulf is prepared based upon the granulometric studies of surficial sediments as shown in Fig. 1. The clay mineral analyses and quantification are based upon the standard methods as described in Chauhan (1999).

3. Results and Discussions

The subbottom profiles of the, Kandla, Sara, Phang and Hansthal Creeks, and outer gulf are presented in Figs. 2-3. The outer gulf, in general, has even physiography with deposition of terrigenous detritus in 3-4 parallel reflectors of about 18 m thickness. Buried

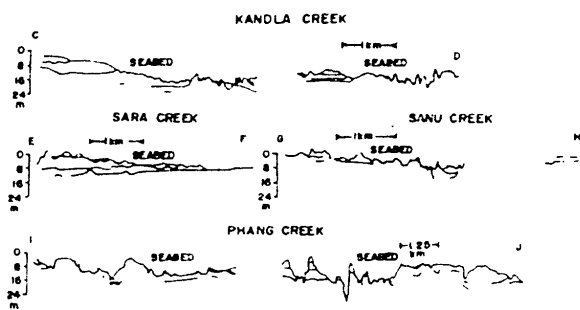


Fig. 2. Sub-bottom profiles of Sara, Sanu, Phang and Kandla Creeks. For the locations of the profiles refer Fig. 1. Note U and V shape cuttings extending through the underlying reflectors.

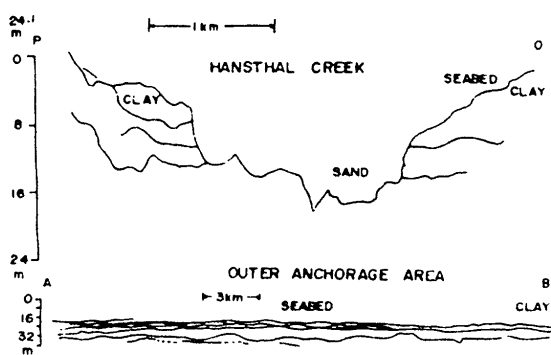


Fig. 3. Same as Fig 2, but for the Hansthal Creek and Outer gulf. Note parallel and even reflectors in the outer gulf. The Hansthal Creek has deep axial channel with eroding flanks.

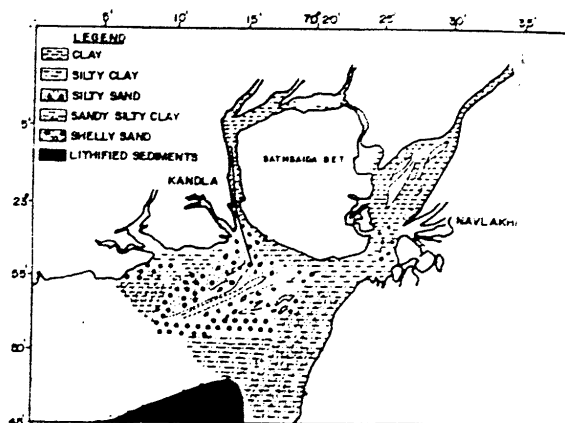


Fig. 4. Surficial sediment distribution in the study area. Note the presence of coarse sediments in the outer gulf.

under these sediments is a palaeo-channel, which appears to be the extension of the present day axial channel exposed at the mouth of the gulf. The inner creeks, however, have uneven and rugged physiography. U and V shape cuttings and scouring marks (5-6 m) extending through evenly deposited 15-18 m thick sediments have been observed in these creeks (Figs. 2-3).

The sediment distribution in the gulf is presented in Fig. 4. The sediments of the outer gulf are predominantly sandy to silty-sand, whereas the sediments of the inner creeks are predominantly clays – silty-clays. In the area off the mouth of the Hansthal and Kandla Creeks, the sediments are coarser ($M_z = 0.6$ to 1.2ϕ), and are devoid of clay size fraction. In the inner gulf, particularly in the inner creek, clay fraction is > 60 per cent. From these results, it is inferred that the quantum of coarse detritus is optimum in the outer gulf, and gradually reduces from the outer gulf to the inner creeks. Deposition of sandy detritus in the outer gulf, particularly off the mouth of Kandla and Hansthal Creeks, is intriguing due to prevalent high-energy environment there. It may also be inferred that this deposition is rather recent, and prior to it the area was experiencing erosion as deduced from the existence of a buried channel in the outer gulf. The component analysis of these sediments demonstrates that these are largely consist of bioclasts. It may therefore be inferred that the source of these sediments is from the coralline reefs located on the southern flank of the outer gulf, and there is an inland influx of terrigenous detritus.

In the gulf, the tidal amplitude increases from the mouth to the inner creeks. Also, the currents are stronger in the inner creeks than in the outer gulf (Sharma and Devashayam, 1985). The uneven physiography of the inner gulf, with isolated channels, and V and U cuttings extending down to 5 –6 m in this region of the gulf (Fig. 2), therefore is a manifestation of prevalent

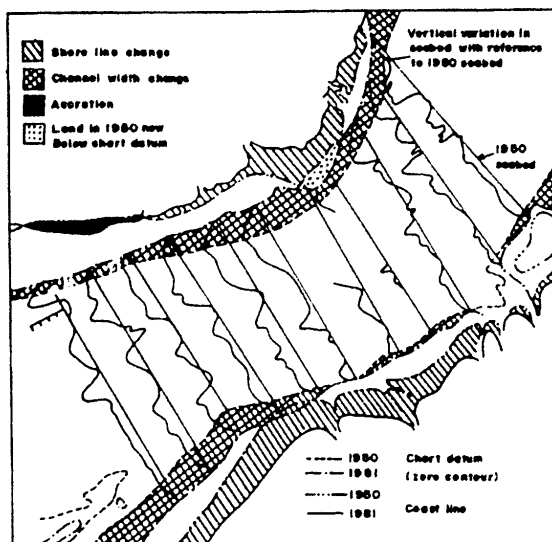


Fig. 5. Physiographic changes (in the span of 30 years) in the Hansthal Creek.

high energy environment associated with macrotidal regime and strong currents. However, clays texture is dominantly observed in the creeks, which have strong (2.5-4.5 knots) currents (Gokhle and Kanetkar, 1988). Also, the gulf is located in the arid zone with scanty rainfall (500 mm y^{-1}), and the fluvial discharge into the gulf is rather low (Sharma and Devashayam, 1985). A significant supply of the sediments to the gulf, either by the fluvial sources discharging into the gulf or from the adjacent landmass is, therefore, ruled out.

The results of the present studies suggest that there is an inland transfer of the sediments. Since the tidal range increases as tide propagates into the inner gulf, deposition of the sediments by the flood tide and associated high currents of > 2.5 knots needs further elaboration. The presence of fine sediments (which normally deposit in calm, low energy environment) in the creeks that are undergoing the large scale scouring is also intriguing, particularly when there is no local supply. Short term, temporal and spatial physiographic changes in the creeks have been evaluated to understand this process.

The physiographic changes in the Hansthal creek in 30-year span are shown in Fig. 5. These results sug-

gest that there is a deepening of the axial channel, and flanks are eroding. From these results it is apparent that the physiography in the entire inner gulf is mostly under erosion, and there is no possibility of these scoured sediments to be deposited in the inner gulf due to prevalent hydrography. From the lack of clays in the sediments of the outer gulf, it is also apparent that these scoured sediments are not deposited there.

The results of present surveys do not have sufficient time resolution to investigate and elucidate the mechanism of the deposition of the bioclastics from the outer gulf into inner region and sink of clays scoured from the creeks, for which studies of sediment dispersal patterns during entire tidal cycles are *sine qua non*. A further elaborated study is needed to fully understand the source to depositional pathways of these sediments using sequential satellite scenes. The results of the present study will, however, serve as an important input to interpret the sequential satellite images for coastline changes and to determine the sediment dynamics in the gulf.

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