Chapter 1

INTRODUCTION

The Kachchh basin is an E-W trending paleo-rift graben comprising seismic activities and geomorphologically unique landscapes (Biswas 1993; Biswas 2016; Biswas 1999). The Great Rann of Kachchh area is bounded by Kachchh Mainland Fault (KMF) on the southern extent, the presence of the Arabian sea marks the western extent whereas the eastern part is delimited by the presence of the Thar desert. The saline landmass is widely spread in the Kachchh area and the low-lying areas are salt encrusted. The Great Rann of Kachchh (GRK) is a large fault bounded subbasin within the Kachchh paleorift basin located at the western continental margin of India (Figure 1.1). The sediment fill of the GRK basin comprises a Tertiary and Quaternary period. The vast flat hyper saline landscape of the GRK has that the information on the nature of the sediments remained unknown till some studies in deep core in the last decade (Maurya et al., 2013; Khonde et al., 2016;2017). The western continental margin of India along the Gujarat state is ~1600 km long and comprises of several marginal marine basins such as Gulf of Khambat, Gulf of Kachchh; Little and Great Rann of Kachchh, that are largely unexplored on these aspects for the Holocene time. At present, this entire region falls into arid to hyper arid climatic zone, meaning that it receives very sparse and sporadic rainfall (Prasad et al., 1997; Merh, 2005). We have tried to explore one of the most important marginal marine basins, the Great Rann of Kachchh (GRK) which once acted as a Gulf of Arabian Sea.

The Great Rann comprises a unique example of Holocene sedimentation (Merh, 1995). The plain of Banni represents huge mudflats that are flat, almost gradientless saline grassland covering an area of about 3000 sq km raises 3 to 10 m above the Rann surface. The Banni plains in all probability correspond to a raised mudflat (Kar, 1995; Maurya et al., 2016). Parts of the Banni are believed to be evolved as a mixed zone as a result of interaction between the marine processes operating in the north and fluvial deposition by the rivers draining the Kachchh Mainland in the south. The presence of gullies and incised fluvial channels on the elevated eastern part of the Banni Plain are indicative of the latest phase of uplift (Biswas, 1974). The Rann represents filled up gulfs of a Holocene Sea, marking the sites of ancient river mouths. Historical accounts also suggest that there was a navigable sea belonging to archaeological sites of the Harappan civilization including the port town of Dholavira. Till now there is no information that exists on the sediment comprising the Banni plain apart from the few geomorphological details.

PURPOSE AND SCOPE

Present work is an attempt to understand the overall palaeoenvironmental changes along with geological evolution of the Great Rann of Kachchh (GRK) basin using comprehensive field studies and multiproxy studies on two deep cores obtained from the difficult terrain of the Great Rann (Khonde, 2014). The study was carried out on the subsamples obtained from the cores at a regular interval of 2 cm.

The Great Rann of Kachchh basin has accumulated huge piles of sediments throughout the Holocene period. The flat landscape of the Ranns is variously described as 'intriguing' to 'unique' to 'without any counterpart in the world (Burnes 1835, Roy and Merh 1981). In local dialect, the term 'rann' means 'saline wasteland'. In general, the Great and Little Ranns are considered to be uplifted floor of the former gulfs (Merh 2005, Maurya et al. 2008). The Great Rann of Kachchh is an E-W trending gulf which is joined by the Arabian Sea on the west while on the eastern side it is delimited by the Little Rann of Kachchh which is believed to be the landward extension of the Gulf of Kachchh (Figure 1.1).

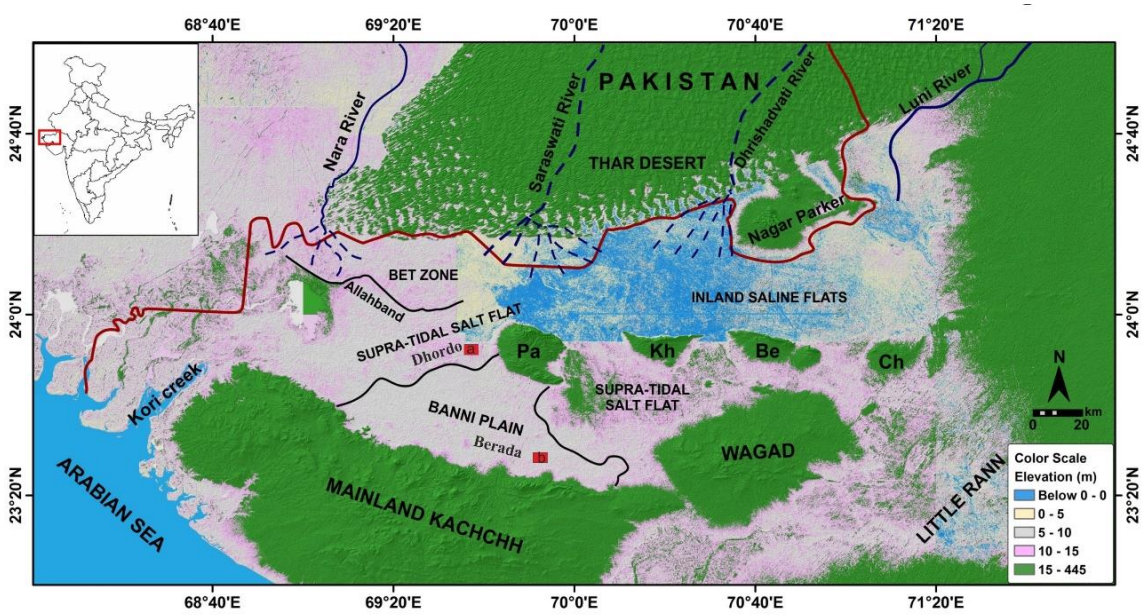

Figure 1.1 Location map of Great Rann of Kachchh basin showing geomorphic zone based on modern inundation pattern and present and paleo river channels (modified after Khonde, 2014). Red square (solid) a and b represents the Dhordo core and Berada core location. Pachham Island (Pa), Khadir Island (Kh), Bela Island (Be), Chorar Hill (ch)

The Basin was believed to be the part of gulf and was submerged under the sea due to the rapid sea-level rise after the Last Glacial Maximum (LGM). The sedimentation during the Holocene period includes the paleoclimatic/palaeoenvironmental controls and the palaeo-depositional events. This sediment accumulation was accompanied by seismic

activities which triggered sediment deposition throughout the Quaternary period. It was believed that sediment was brought into the basin through then flowing rivers like Saraswati (Malik et al., 1999) along with contributions from the still active rivers like Luni on the west and Nara River on the northern side which now lies in present Pakistan. This opens the debate for the discussion on the cause of this huge sediment accumulation during this period. Some of the reasons laid down by the researchers for this activity point toward the seismic cause and palaeoenvironmental influence during the Quaternary period. The research also suggests the basin experienced high sedimentation during the Holocene period.

The western continental margin of India comprises several gulfs like the Gulf of Kachchh and the Gulf of Khambat where the Great Rann of Kachchh is believed to have been raised as a part of a paleo gulf. To understand the depositional environment and the evolution of the basin we need to understand the role of past climate and the sea level variation in the area. The changing sea level is a key aspect related to depositional conditions as it has a direct influence on a particular area. The GRK basin is categorized as a meso tidal affected area on the global prospect where the height of the highest tide is less than 2 m. Due to its low and almost negligible surface elevation, the sea inundates more than 60 kilometres landward added by the strong flowing west to the east wind. Based on the tidal range the Great Rann of Kachchh is divided into 4 zones namely Bet Zone, Linear Trench Zone, Banni plain and Great Barren Zone (Roy and Merh, 1981).

Therefore, the debate on what could be the possible cause has to include an in-depth analysis of the palaeoclimatic implications and its role during the Holocene period. The cause of the high sedimentation rate during this period resulted in the huge pile of sediment. The overall evolution of the GRK and depositional environment has not been addressed properly. Unfortunately, studies that adequately describe the Quaternary sediments Ranns of Kachchh in terms of lithostratigraphy, depositional processes and palaeoenvironments are non-existent.

OBJECTIVE

The present study was undertaken to address the following objectives.

1. Reconstruct subsurface stratigraphy and palaeoenvironmental changes in the Great Rann of Kachchh.

2. Reconstruct the Holocene evolutionary history of the Great Rann of Kachchh

STUDY AREA

The western continental margin of India along the Gujarat state is - 1600 km long and comprises several marginal marine basins such as Gulf of Khambat, Gulf of Kachchh; Little and Great Rann of Kachchh, that are largely unexplored in these aspects. At present, the region falls in the arid to hyper-arid climatic zone (Prasad et al., 1997; Merh, 2005). We explored one of the most important marginal marine basins, the Great Rann of Kachchh (GRK) which was once a shallow gulf in northern. The Great Rann of Kachchh presents one of the best examples of Quaternary basins that provided sedimentation in fault controlled and tectonically active basins.

Location

The Dhordo core is recovered from the Dhordo village situated in the Great Rann of Kachchh Latitude: - N 23°49’ 37.9”; E 69° 39’ 09.0”to explore the changes from the central part of the basin. The Berada core recovered from Umedpar village in Great Rann of Kachchh situated at the southern margin of the basin Latitude: - N23° 28.9’ 12”; E 69° 54’ 36.34” to explain the changes from the southern flank of the basin. The study from the two cores can be correlated to know the evolution and change of the Great Rann of Kachchh basin (Figure 1.1).

Communication

The area within the Kachchh Seismic zone has a reasonably good network of metalled roads. The Ahmedabad-Kandla National Highway is the only national highway passing through the Kachchh district which connects it with other parts of the country. Some of the important state highways which connect Kachchh with the other districts are the Bhuj-Anjar-Gandhidham road, Bhuj-Mandvi Road and Bhuj-Desalpar-Roha-Naliya-Jakhau road. The small towns and villages are also well connected with a dense network of roads. The Great Rann and Banni plain from a largely inaccessible terrain. However, Banni plain is crisscrossed by several tracks connecting various villages which are motorable in the dry season. The rail link is also available through Lakadiya-Bhachau and Gandhidham-Bhuj rail routes. Bhachau and Bhuj are the major railway stations from which other parts of the area can be accessed by the roads. Bhuj Airport is the only nearest working civilian airport. The navigation through the ship is not available due to its hostile conditions along with low gradient surface morphology under the sea and lack of stagnant seawater depths. The tidal limit of the sea is restricted to a few kilometres towards the landward side. In fact, the limitation of the tidal waves reaches to near about only ~30 km

towards the land but due to its low carrying capability or energy, it lacks sufficient depths for ship navigation.

Physiography and drainage

Physiographically, the study area can be divided into a hilly terrain of Northern Hill Range, Wagad, and Island belt, gently undulating terrain of the Samakhiali-Lakadia plain, Banni plain and the Great Rann. The Northern Hill range marks the northern margin of the Mainland Kachchh which abuts against the Banni plain in the north. The straight north-facing escarpment forming the northern margin of the range is the most conspicuous landscape feature of the area. This escarpment marks the geomorphic expression of the Kachchh Mainland Fault, the most significant geomorphological feature of the study area. The Northern Hill Range shows typical mountainous terrain with structurally controlled topography and deep valleys. The Jhura hill forms the highest which is located in the westernmost segment of the study area. The hill range gradually loses its elevation towards the east and disappears below the Samakhiali-Lakadia plain. The low-level flat saline terrain of the Banni-Great Rann sub-basin represents the recently uplifted floor of a palaeo-gulf. The chain of islands comprising the Pachham, Khadir, Bela and Chorar islands together are termed the Island belt. Pachham island forms the westernmost island which is characterised by a hill range lying north and south margins of the island. The two-hill range is separated by a central valley along which the major drainages of the region flow. On the contrary, the Bela and Khadir Island is characterized by the tilt block type of structure with a stream northern margin and a gentle back slope. Both the islands are characterized by southward flowing parallel drainage.

Climate

The Kachchh region is known for its arid to hyper-arid climatic conditions. The annual rainfall is about 250-400 mm/year, spread over the entire monsoon months of June to September. May marks the hottest month of the year when the day temperature reaches up to 48^{o}C while January forms the coldest month of the year when the temperature may dip below 10^{o}C. The range of wide temperature fluctuations is on account of the Tropic of Cancer passing through the Kachchh region. During summer, violent storms are frequently noticed in the area though they are of short duration. NW disturbances may result in prevailing of the cold wave which may result in lowering of temperature below the minimum level. Humidity generally remains high throughout the year which is more in the coastal parts.

Flora

The Kachchh region is very poor in vegetation because of scanty rainfall. The semi-arid desertic climate favours the growth of thorny and non-thorny trees and shrubs which includes Jal-salvador, Ganzi grenia, whereas thorny species include Baval, Kher, Acacia, etc. Where in the Acasia Arabia (Gandobaval) covers a major portion of the terrain. The coastline exhibits swamps vegetated with mangrove forests and grasses covering dunes and sand flats. The main varieties of flora found in the study area are – Avicennia officinalis (Tavar, Tarvariyan), Leptadenia spartium (Khip), Casuarina Equisetifolia (Saru), Halopyrum mucronatum (Dariyai Kansdo, Dariyai Kans), Melia azadirachta (Limbdo), Acacia arabica (baval), Cassia auriculata (Aval), Sporobolus indicus (Velari charchar), Sueda maritima (Lano, Luno), Euphorbia tirucalli (Thor, Kharsani Thor, Dandalio Thor) Leucoena glauca (Laso baval, Vilayati baval) Butea frondosa (Kesuda no jhad), Zizyphus jujuba (Bordi), Acacia jaquemonti (Tal bavari), Acacia leucophlaea (Harmo baval), Tamarindus indicus (Amli), Sapindus emarginatus (Aritha), Cactus indicus (Hathlo thor), Ficus bengalensis (Vad), Eugenia jambolana (Jambu) etc. Wheat, Cotton, Bajara, Jowar, Mag and Math are common agricultural crops along with various fruits and vegetables.

Fauna

The vast land of Kachchh has a long seashore and vast desertic conditions which provide Kachchh with an extraordinary variety of wildlife attracting a large number of avifaunae. The chief domestic animals found in the area are horses, camels, oxen, cows, buffaloes, sheep, goats and asses. The wild animals of the region include Panthera pardus (Panther), Chinkara (Gazella Gazella) (local name Chinkara) and the wild asses (Equus Onager Indicus) were found near the Little Rann of Kachchh. Nilgai or Blue Bull (Bojh), Wild Boar or Jungli Budhar (Sus Scrofa), Indian Wolf (Canis Lepus), Jackal or Shiyad (Canis Auresug), striped Hyena or Jharak (Hyena Hyonna), Desert Hare or Sasla (Lepus Nigricollis Outchensis), Indian Fox (Vulpe Bengalenisis), Mongoose (Herpestes Smithi), besides some jungli cats, desert cats, Pangolin, Indian Porcupine and long-eared hedgehog are also found in Kachchh. The Indian Hare (Lepus nigricollis) is commonly found in the open fields. The Caracal is the rarest animal found in Kachchh. Many kinds of reptiles including snakes are also found in Kachchh. Some commonly found reptiles are Crocodile or Mugger, Monitor Lizard or Patla Gho, Kachchh Rock Gecho (Garodi), Desert Monitor Lizard, spiny-tailed lizard or Sanda (Uromastyx Hardwicki), flat-tailed lizard or Khann,

Starred Tortoise and freshwater turtle (Lissemus Puctata) along with several varieties of snakes both: Poisonous and Non-Poisonous. Black Krait, Black Cobra (Najatripudians), Russels Viper (Vipera Russeli), Saw Scaled Viper (Echlis Carinatus), Sea Snake (Hydrophis Spiralis) etc. are poisonous snakes, while Python (Python Molurus), Sand Boa (Eryx conicus), Rat Snake (Piyas Mucosus), Royal Snake (Zamenis Diadema) etc. are non-poisonous snakes. The resident and migratory birds are commonly found in Kachchh. The migratory birds are found plentiful during the winter season in the organic-rich zone of the coastal flats bordering the Gulf of Kachchh and the vast saline expanse of the Little Rann of Kachchh.

People and occupation

Kachchh district is inhabited by various groups and communities. Around~ 80% of its population resides in the rural area so people are mainly dependent on agriculture and cattle rearing. The economy of the region is agro-based, and the region is famous for its craftwork. The construction of many big ports in the coastal parts of Kachchh has initiated the rapid industrialization between Gandhidham-Mundra and Bhuj-Bhachau during the recent time, which has provided another window of opportunity for the people to earn their livelihood.

APPROACH AND METHODOLOGY

The broad methodology adopted for carrying out the present study was as follows.

1. Available geological and subsurface data on the Ranns of Kachchh was collected and critically evaluated to delineate the deep-seated subsurface structural features and infer the nature of basement configuration.

2. Satellite data combined with field checks were used for studies on geomorphology and inundation patterns of the Ranns.

3. Rann sediments exposed in the form of vertical cliffs along the various island margins were also investigated in detail for inferring depositional conditions and environments.

4. All samples collected were subjected to sedimentologic, micropaleontological and chronostratigraphic studies to infer the palaeoenvironmental conditions.

5. Core drilling was carried out in Great Rann at two sites that were selected based on geomorphologic studies two continuous cores up to ~60m and ~50m depths.

6. The cores are sliced into two equal halves with one half used for sampling while the other half is preserved in sub-zero temperatures. The sampling for both cores was done at 2 cm intervals.

7. Selected core samples were subjected to multidisciplinary studies like textural, geochemical, isotopic, clay mineralogical, stratigraphic and micropaleontological studies for deducing palaeoenvironmental conditions in the Great Rann.

8. Few samples of the cores were sent for AMS dating to WHOI, USA, few were dated from the IUAC, New Delhi and PRL, Ahmadabad.

9. The data generated was synthesised and critically evaluated to reconstruct the Quaternary evolutionary history of the Ranns of Kachchh.