Chapter – 3

Chapter 3

GEOLOGIC AND TECTONIC SETTING

TECTONIC SETUP

Kachchh region forms a crucial geodynamic part of the western continental margin of India, which has been an important site of Mesozoic and Cainozoic tectonics and sedimentation. According to Biswas (1981 and 1987) the Kutch (Kachchh) forms a peri-cratonic Mesozoic-Tertiary rift basin. The Rift evolved within the Mid-Proterozoic-Aravalli-Delhi fold belt by reactivation of pre-existing faults along NE–SW trend of Delhi fold belt that swings to E -W in the region (Fig. 1.4).

The basin evolved during the drift stage of Indian plate with the commencement of Gondwanaland breakup in Late Triassic and has two different stages, a) the Rift stage comprising subsidence along normal faults and, b) Inversion stage comprising buckling, uplift and fault related folding along the existing normal faults and along newer thrust faults on account of reverse movements (Biswas, 1987; Biswas and Khatri, 2002, Mathew et al. 2006). It is believed that due to continued northward movement of Indian Plate and rebound from the collision front with Eurasian Plate in the north, stresses continually increased in the Indian Craton which at times resulted in faulting and seismicity in the Kachchh region (Biswas 1987, Mathew et al. 2006).

Contradicting prevailing views, on the basis of seismicity and faulting pattern observed in Western India, Stein et al (2002) proposed that possibly a micro-plate (named as Sind Block) is breaking off the Indian Plate. Based on distribution of seismicity they suggested comparatively rigid and less seismically active block bordered by Bhuj fold-and-thrust belt to the south and Sulaiman range to the north (Fig. 3.1). The western boundary of this proposed block is drawn as Ornach-Nal fault, whereas, eastern boundary is presumed to extend northward from the eastern end of Bhuj fold-and-thrust belt. They proposed that a few mm/y of motion relative to India along its southern boundary, causing N-S compression would yield the observed zone of seismicity and active faulting. Considering proximity of Kachchh region with plate boundary they argued that seismicity in the region may not be related to intraplate seismicity.

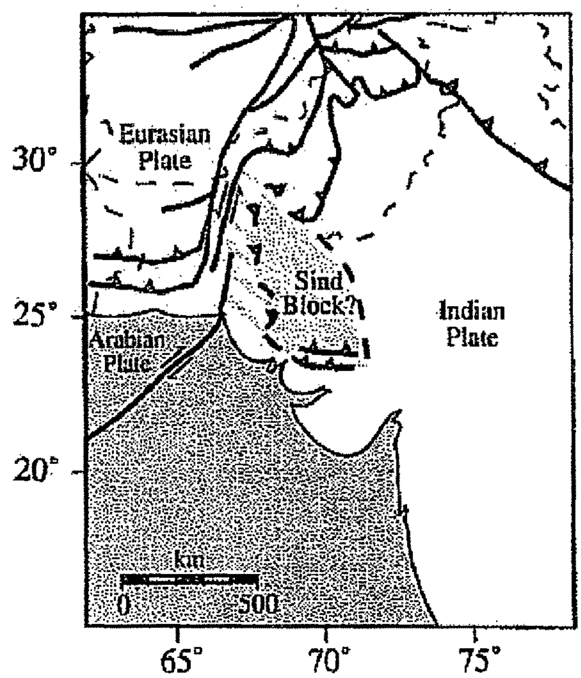

Fig. 3.1: Sind Block as proposed by Stein et al. 2002.

According to Biswas and Khattri (2002) and Biswas (2005) the rift is bound on the north by the Nagar Parkar Fault (NPF) and the North Kathiawar Fault (NKF) marks the southern boundary. The basin framework consists of an embayment closed by Radhanpur-Barmer Arch in the east, a sloping platform featured by parallel east-west fault-ridges and a Median High across them (Biswas, 1981 and 1987). The Median High is believed to be first order basement ridge and is manifested as geomorphic high across the Banni half-graben and Kachchh Mainland Uplift. Morphology of the basin is governed by roughly E-W trending regional faults from north to south named as (1) Nagar Parkar Fault (NPF), (2) Allah Bund Fault (ABF), (3) Island Belt Fault (IBF), (4) South Wagad Fault (SWF), (5) Gedi Fault (GF), (6) Kachchh Mainland Fault (KMF) and (7) Katrol Hill Fault (KHF) (Fig. 1.2).

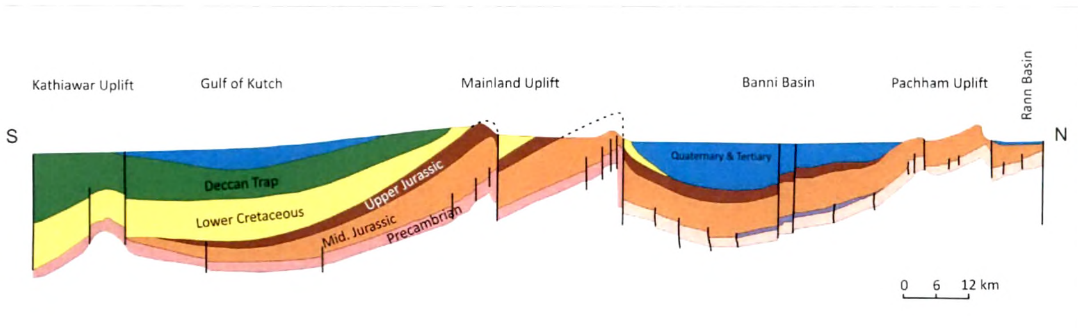

Fig. 3.2: Geological cross section across Kachchh basin (after Biswas 1987).

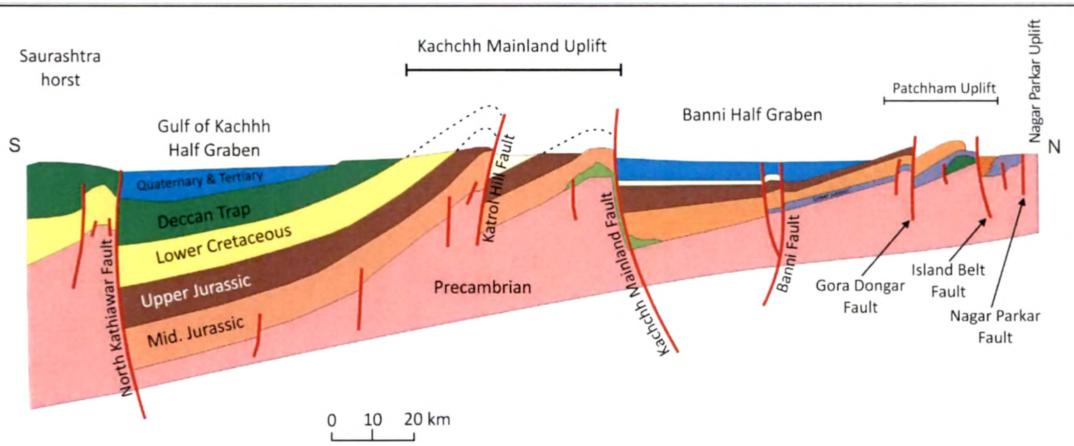

Fig. 3.3: Geological cross section across Kachchh basin (after Biswas 2005).

According to Biswas (1987 and 2005) footwall uplifts along these intra-basin strike faults have resulted in block tilting which has given rise to four sub-parallel linear ridges and half-grabens (Fig. 3.2 and Fig. 3.3). The uplifts are the outcropping areas known from north to south as, Nagar Parkar Uplift (NPU), Island Belt Uplift (IBF), Kachchh Mainland Uplift (KMU) & Kathiawar Uplift (KU) and the grabens/half-grabens form extensive plains covered by Quaternary sediments known as Great and Little Rann of Kachchh. The graben/half-grabens are different depositional domains for rift-fill sedimentation. The Nagar Parkar Uplift (NPU) and the Kathiawar Uplift (KU) are considered north and south rift shoulders respectively. The Island Belt Uplift is broken into four individual uplifts namely Patchham Island, Khadir Island, Bela Island and Chorar Hill from West to East. Biswas presumed unexposed transverse wrench faults for segmented appearance of Island Belt Uplift. Standing amidst the plains, these uplifts appear as a chain of islands and hence are collectively called Island Belt. Several small fault-related uplifts occur in line with the bigger ones, e.g. Kuar Bet to the north-west of Patchham Uplift and Kakindia, Karabir, Gorabir and Gangta Bets, which occur between Khadir Uplift and Wagad Uplift. According to Biswas (2005) the comparatively thin sediment cover is drape-folded over tilted basement blocks producing linear monoclonal flexures along the faulted margins of these uplifts. The positive Bouguer anomalies coinciding with these ridges are interpreted as evidence for involvement of basement in their origin. The marginal/master faults are exposed wherever the flexures are eroded.

Contrary to the above, Karanth (2003), Mathew et al. (2006) and Karanth and Gadhavi (2007) attributed the major uplifts to compression resulted from northerly movement of the Indian plate, producing fault-propagation folds.

STRATIGRAPHY

Kachchh peninsula lies between Thar Desert comprising of a thick blanket of sand as well as Indus alluvium in the north and Saurashtra covered with Deccan Traps together with some patches of Cretaceous-Tertiary sedimentary rocks in the south. The vast Gujarat alluvium is located to the east and the Arabian Sea is situated in the west. Sediments are found younging southward as well as westward. Except for some brief spells of hiatus, the stratigraphy of Kachchh is represented by nearly unbroken sequence of sediments ranging from Late Triassic to Holocene (Biswas, 1987). A period of non-deposition, followed by diastrophism, erosion and volcanism, during the close of the Upper Cretaceous time separates the Mesozoic and Cainozoic rocks of Kachchh. Volcanism is represented by the Deccan Trap lava flows. Mesozoic system of Kachchh includes sediments ranging in age from Bathonian to Santonian. Tertiary period includes Palaeocene to Pliocene sediments and the Quaternary consists of Pleistocene and Holocene sediments. Mesozoic rocks consist of marine sediments from Bathonian to Portlandian and non-marine sediments in Cretaceous. The Deccan Trap lavas occupy the time gap between Lower Cretaceous and Palaeocene sedimentations. Tertiary sediments are mainly marine throughout with the exception of Palaeocene rocks which are continental volcano-clastic deposits. Quaternary sedimentation is of varying origin aeolian, marine and fluvial.

The rocks are exposed along fault related uplifts and domes. Consequent folding has affected the Mesozoic strata and they are surrounded by strips of gently dipping Tertiary strata forming peripheral plains, which wrap around the Mesozoic structures. The depressions between uplifts comprise the Cainozoic sub-basins.

A considerable part of Kachchh is covered by young Quaternary sediments distributed in recently emerged land from the basin (Banni grassland) and as described earlier by 'neither a land nor a sea-like region' (Lyell, 1855, p 346); the Great Rann and Little Rann.

Mesozoic rocks

Mesozoic rocks of Kachchh cover a significant part of the Mainland and other highlands. The major uplift zones namely (1) Kachchh Mainland, (2) Wagad, (3) Pachham Island, (4) Khadir Island, (5) Bela Island, and (6) Chorar Hills constitute scattered outcrops of Mesozoic rocks (Fig. 3.4). These outcrops are separated by Great & Little Rann of Kachchh and Banni Plains. The total thickness of Mesozoic sequence is about 3000 m (Biswas, 1987). Exposed Mesozoic sedimentary sequence belongs to Middle Jurassic (Bathonian) to Middle Cretaceous (Albian) (Table 3.1). Borehole data from the Banni region reveals the presence of Upper Triassic [Rhaetian to Lias] in the subsurface (Koshal, 1975; Biswas, 1987 and 2002).

Wynne (1872) was first to provide detailed account of Mesozoic rocks of Kachchh along with a quarter inch map, which has been the basis and reference for all subsequent work. He divided the Jurassic rocks into a lower marine and an upper non-marine unit. He termed them respectively as Lower and Upper Jurassic, however, terms did not mean Lower and Upper Jurassic age. His 'Upper Series' comprised plant-bearing rocks and 'Lower Series' characterised by marine fossils.

Stoliczka (1872) investigated the stratigraphical relations of the rocks in field and suggested fourfold classification which includes Pachham, Chari, Katrol and Umia groups. Waagen (1875) adopted it and defined the units by 'ammonite assemblage zones' which were correlated with the European zones to fix their ages. In this classification mainly lithological and paleontological characters were taken into consideration.

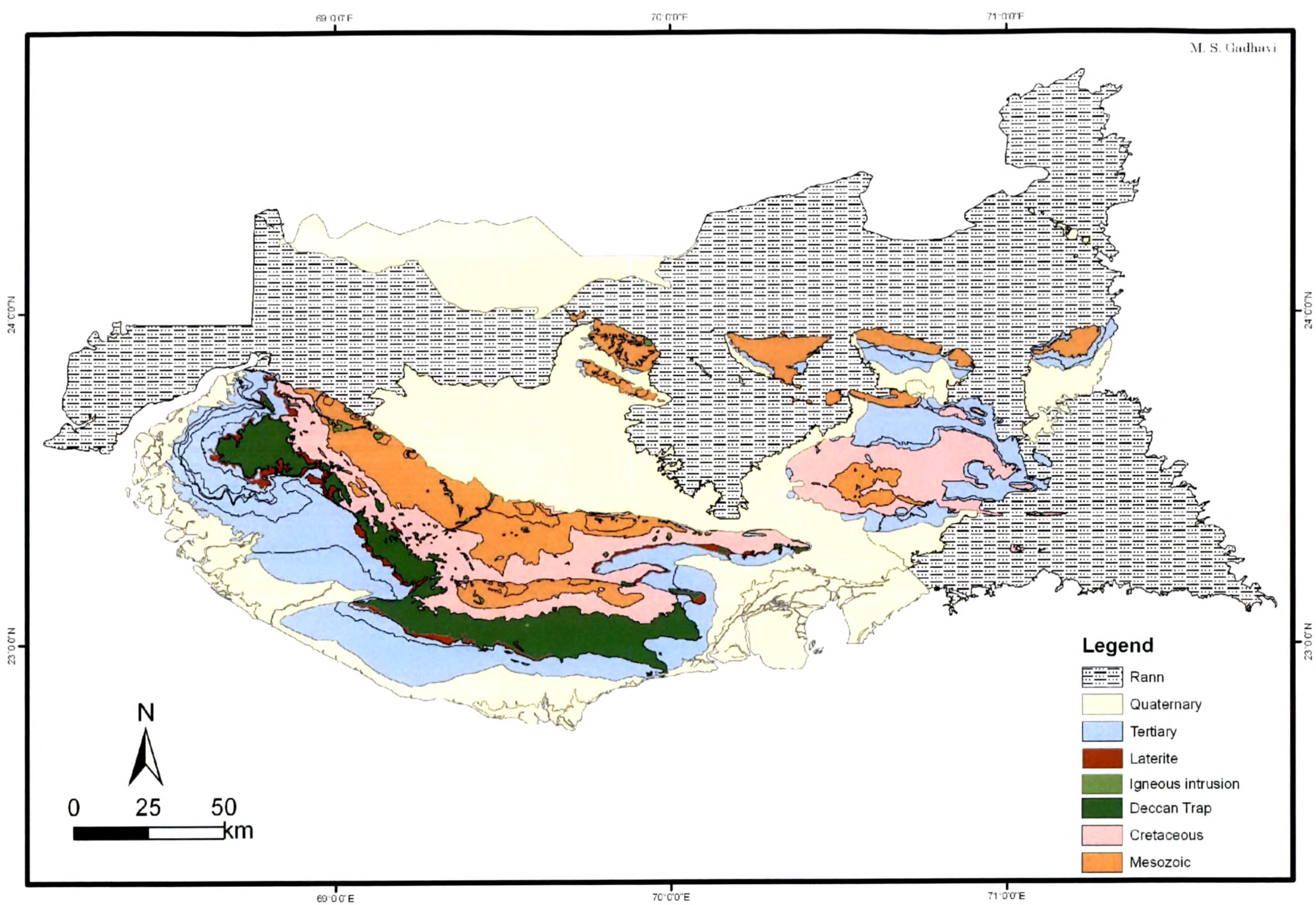

Fig. 3.4: Simplified geological map of Kachchh Region. (modified after Karanth and Gadhavi 2007).

Table 3.1: MESOZOIC ROCKS OF VARIOUS PARTS OF KACHCHH

					Rajnath (1932) Bio-stratigraphy		Biswas (1977) Litho-stratigraphy		
				Age	Entire Kutch		Mainland Kutch	Pachham	E. Kutch
Period	Epoch	Stage		Ma	**Series**	Stages/Beds	**Formation**	**Formation**	**Formation**
Cretaceous	Senonian	Maastrichtian		66.0	Deccan Traps				
				74.0					
		Campanian		83.0					
		Santonian		86.6					
		Coniacian		83.5					
	Gallic	Turonian		90.4					
		Cenomanian		97.0			Unconformity		
		Albian		112.0	Umia 1000 m	Bhuj beds	Bhuj (850 m) Sandstone (+Shale) (Fluvio-deltaic)		Unconformity
		Aptian		124.5		Ukara beds			
		Barremian		131.8					Wagad Sandstone (365 m)
	Neocomian	Hauterivian		135.0		Umia beds			Sandstone (+ferruginous bands), shale inter-beds (Delta front)
		Valanginian		140.7		Trigonia beds			
		Berriasian		145.6			Disconformity		
Jurassic	Malm	Tithonian	*Upper*			Umia ammonite bed	**Jhuran** (760 m) Sandstone (+Calc. Band), shale (Delta front to *pro-delta)*		
			Middle	152.1	Katrol 300 m	Upl Katrol shales			
						Gajansar Beds			
			Lower			Upper Katrol			
		Kimmeridgian	*Upper*						
			Middle			Middle Katrol			
						Lower Katrol			**Washtawa** (207 m) Shale + Sandstone *(Lagoonal)*
			Lower	154.7					
			Upper			Kantkot sandstone			

		Oxfordian	*Middle*	157.1			Local disconformity	Unconformity	
			Lower		**Chari 360 m**	Dhosa oolite	Jumara **(275 m)** Shale (+limestone/ oolite) (Shallow marine)		**Khadir** (650 m) *Upper* - Shale (Shallow marine) *Middle* - Shale = Sandstone (Deltaic) *Lower*- Cherty limestone, Shale + siltstone (Shallow marine/ tidal flat) Basal part conglomerate & arkose (Piedmont fan)
	Dogger	Callovian	*Upper*			Athleta beds			
			Middle			Anceps beds			
						Rehmanni beds		**Goradongar** (154 m) *Upper*- Shale/sandstone *Middle*-cherty limestone *Lower*.-flaggy L. St/ oolite *(Shallow marine)*	
			Lower	161.3		Macrocephalus beds			
					Pachham 300 m	Pachham coral Bed	Jhurio **(290 m)** **Shale, limestone/ golden oolite** (Shallow marine)		
		Bathonian	*Upper*						
			Middle			Pachham shell limestone			
			Lower	166.1		Pachham basal beds (Kuar Bet beds) Base not exposed	Base not exposed	**Kaladongar** (470 m) Sandstone (+shale) (Marine foreshore) Base not exposed	
Rhaetian (*Upper* Triassic) to ? Lias to ?				? 209.5 Ma			Not exposed	Not exposed	?
Precambrian							? Basement	? Basement	Basement- Granite/ syenite

This classification was modified and revised by later workers mainly on the basis of paleontological findings. Spath (1924) was pioneer among them, who revised the work of Waagen on ammonites and further subdivided the units by ammonite zones. A significant contribution was made by Rajnath (1932), who on the basis of study of ammonoids, lamellibranches and plant fossils established a succession moderately different from the previous ones. He restricted term Umia only to lower Umia of Waagen; the upper Umia made of non-marine beds with plants fossils was termed as Bhuj Series of Middle cretaceous (Table 3.1). After detailed investigation in Jumara dome section he described 26 beds from chari and Patcham Series. He also suggested three stages of Katrol Series-Lower, Middle and Upper Katrol Stages.

Biswas (1977) proposed a new litho-stratigraphic classification, for the Jurassic rocks of Kachchh. He attempted to bring out stratigraphic relationship between disconnected outcrops. The variation in lithofacies from one part of the basin to the other and the detached fault-bounded outcrop areas separated by covered plains prevented him from the use of a uniform rock unit sequence throughout the basin. Taking into consideration lithological variations he proposed three main lithological provinces, namely Kutch (Kachchh) Mainland, Pachham (Patchham) Island and Eastern Kachchh (including Wagad, Khadir and Bela Islands and Chorar Hills). He divided stratigraphic sequence of Mainland into four formations namely Jhurio, Jumara, Jhuran and Bhuj formations in ascending order. The Bhuj formation is disconformably overlain by the basin lava flows of Deccan Volcanism on the south while base of Jhurio formation is unexposed in the north. He divided the Mesozoic rocks exposed in Pachham Island into two rock-units a lower Kaladongar Formation and upper Goradongar Formation. The scattered Mesozoic outcrops of Wagad, Khadir, Bela and Chorar are grouped under one stratigraphic province by Biswas namely Eastern Kutch

(Kachchh). Among them, he recognised three mappable rock units and named them as the Khadir Formation, Washtawa Formation and Wagad Sandstone (Table 3.1).

Predominant arenaceous nature of Mesozoic rocks of Eastern Kachchh in comparison to Kachchh Mainland is attributed by Biswas to proximity of province to eastern basin margin. The lithostratigraphic successions of three provinces represent the vertical profiles of environments respectively at the depocentre, and at northern and eastern margins of the basin. Superposing environmental tracts of successive periods of sedimentation, correlating environments across time planes and taking cognizance of sedimentary processes, Biswas (1981) proposed history of sedimentation and the basin framework. Three major transgression-regression cycles during the Mesozoic sedimentation near the depocentre (Kachchh Mainland) are identified.

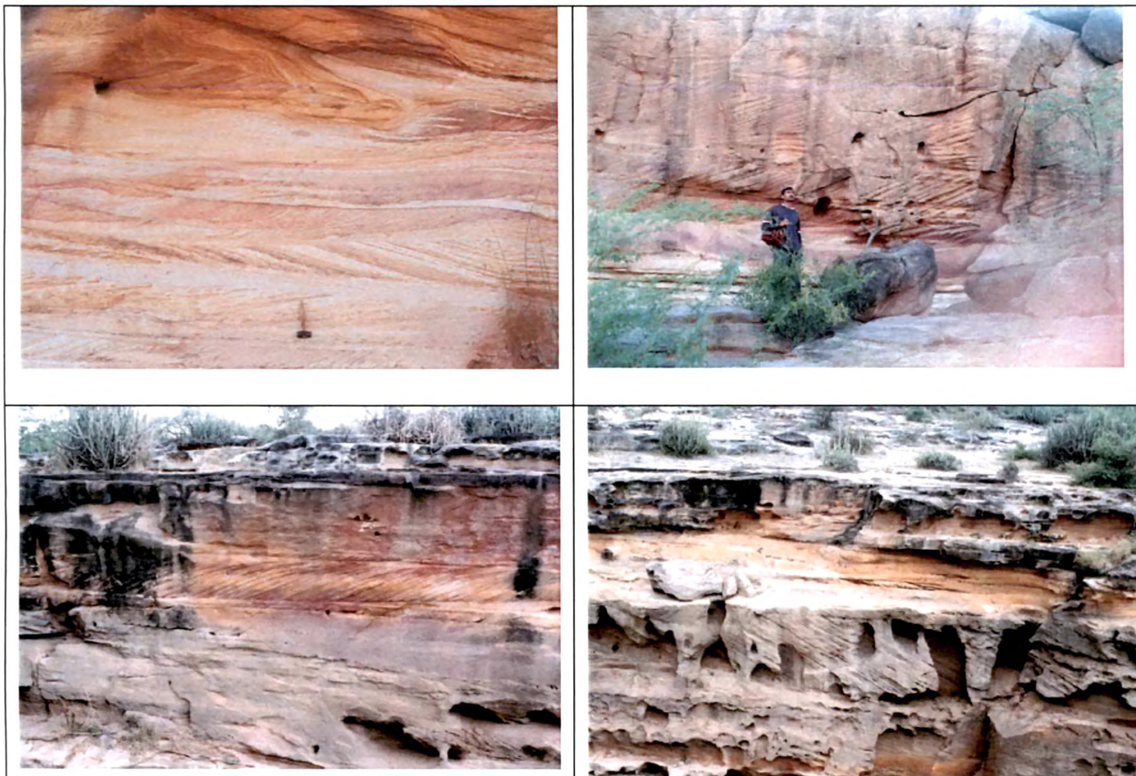

Fig. 3.5: Field photos of current bedded Bhuj Sandstone.

By and large the Mesozoic sedimentary rocks comprise sandstones and shales with some cherty/ oolitic/ flaggy limestone. Dark ferruginous bands are often encountered in sandstones. These sedimentary rocks are deposited in fluvio-deltaic/ deltaic to shallow marine environment. Bhuj sandstones laid in this environment abundantly exhibit current bedding (Fig. 3.5).

From the comparison of shale-sandstone percentage curves, Biswas (1981) proposed that the supply of detritus material was stable and rates of uplifts, erosion and sedimentation were balanced; i.e. the basin received supply from a constant source area; which eventually led him to conclude that the basin pattern remained unchanged under uniform tectonic environment throughout sedimentation.

The basin is traversed by a nearly N-S trending Median High. On the eastern part of Median High existed a shallow marine environment condition and to its west the basin was deeper with thicker sediments and facies (Biswas, 1993 and 2005).

Deccan Trap

Extent of Deccan Traps is not as immense in Kachchh region as in other parts of Western India, its presence is significant as the region is characterised not only by some flows of Deccan Trap basalts but also by several post-Trappean basic and alkaline igneous intrusive bodies intruding into the Mesozoic formations.

Outcrops of lava flows are restricted only to the Kachchh Mainland extending from Lakhpat in the west to Anjar in the east, primarily to the south of Katrol Hill Range. Lava flows are dominantly tholeiitic basalts that overlie unconformably over the Cretaceous sandstone. The rocks form more or less linear outcrop extending across the mainland with a maximum width of about 10 km in the east near the town of Anjar and gradually tapering westward.

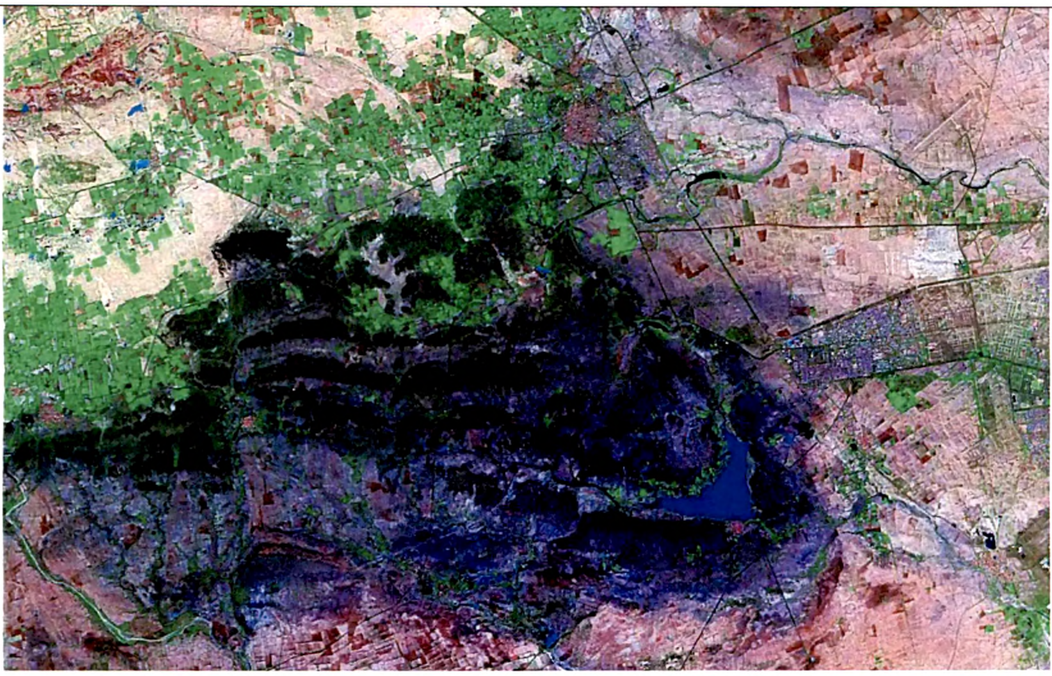

Fig. 3.6: Satellite image of folded Lava flows south of Anjar.

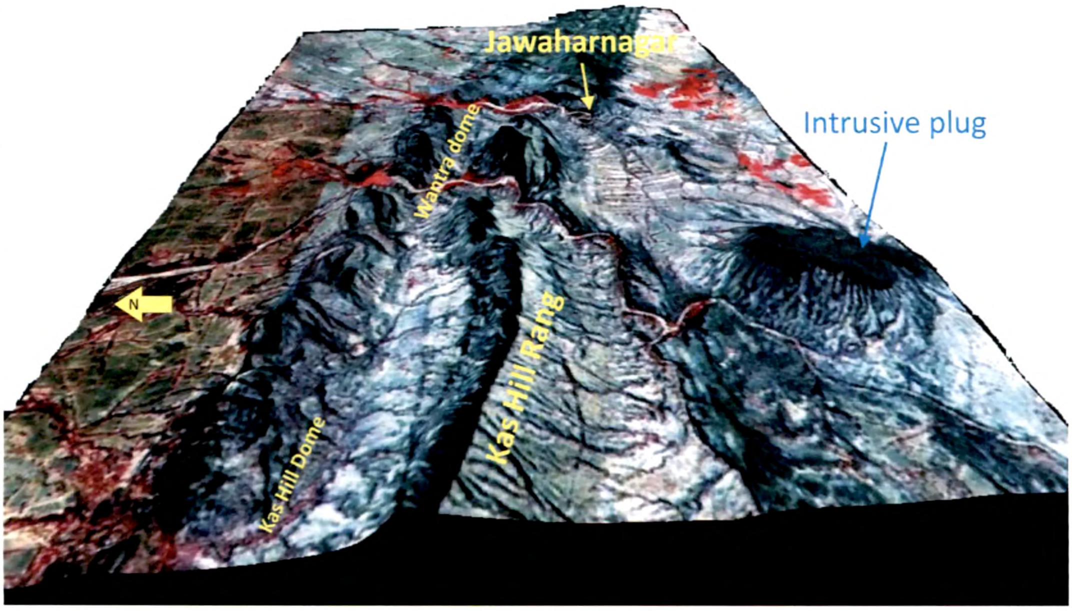

Fig. 3.7: Intrusive plug south of Kas Hill Range as seen on LISS-PAN merged satellite data draped over SRTM elevation data.

In the western part it forms an inlier within the Tertiary ricks (Merh, 1995). The traps flows are seen complying with the strike and dip observed in Mesozoic strata, rising gradually with southerly dip and in some places forming anticlines that follow outcrop pattern similar to that of Mesozoic strata (Fig. 3.6). Alternations of softer and harder flows help pronounce these forms (Wynne 1872). Six major flows have been reported at the eastern extremity near Anjar where, they show alternations of columnar and amygdaloidal basalts, occasionally separated by inter-trappean beds.

The columnar flows form prominent ridges and hills while the amygdaloidal ones being softer are eroded to low-lying plains. A maximum thickness of about 500 m is recorded in the eastern part while it decreases to almost 150 m in the northwest where only a couple of older flows are preserved. The distribution and extent of trap flows in Kachchh appears to have been controlled by the pre-trappean topography. The central part of Kachchh Mainland was already elevated and exposed to weathering before Deccan Trap volcanic activity.

Igneous Intrusions

Igneous intrusions are represented by number of plugs and dykes. The plugs have given rise to many isolated hill (Fig. 3.7), whereas dykes have produced minor ranges which traverse the country for considerable distances. The dykes are generally of basaltic nature, while, plugs, loccaliths and sills are of alkaline basalt, which are usually confined to the structural domes in the Mesozoic rocks.

These intrusives, however, are not traceable in the Cainozoic formations. The intrusive rocks are of the composition of alkali basalts (De, 1981; Biswas, 1993; Das and Guha, 2000). Das and Guha (2000) have identified numerous intrusive plugs and stocks in

Kachchh Mainland and in the Island Belt. Two bodies (stocks) of melanocratic gabbro (Fig. 3.4 and Fig. 3.8) are seen conspicuously at the NE (Kuran) and NW (Nir Wandh) parts of Pachchham Island

The Banjado Hill (Fig. 3.9) located NW of Khadir Island is also similar to intrusive found in Pachham Island. Occasionally leucocratic syenitic differentiates have also been noticed. Large basic sills are encountered in Mundhan-Jara region in the Mainland and near Juna in Pachham Island. Basic dykes are recorded at several places particularly in parts of Pachham and Bela islands.

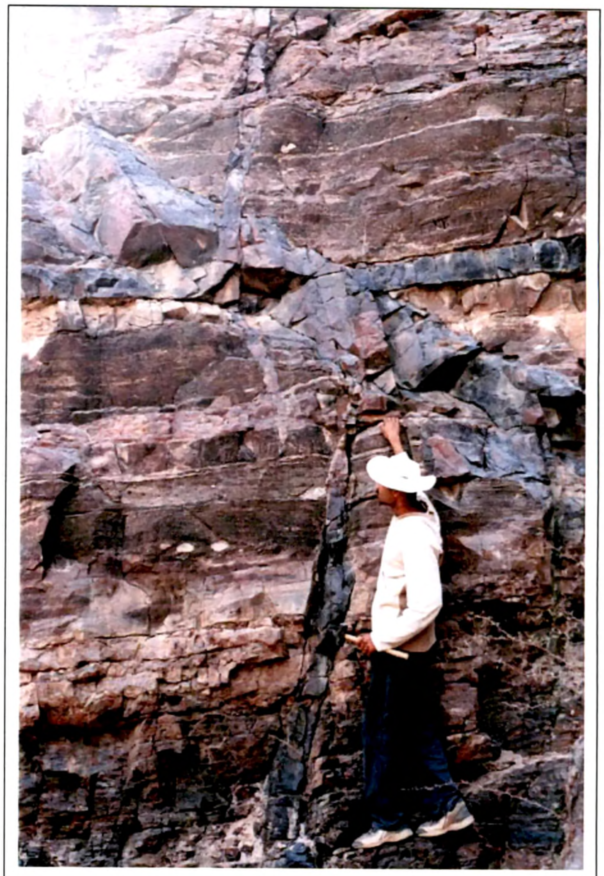

Fig. 3.8: Dykes and sills intruded in Lower Jurassic rocks of Pachham Island (Nir Wandh).

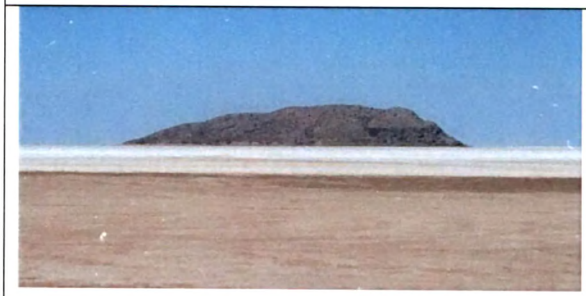

Fig. 3.9: Bhanjda Hill igneous intrusion; west of Khadir Island.

Tertiary rocks

A more or less complete sequence of Tertiary rocks from Palaeocene to Pliocene in exposed in Kachchh as narrow strip fringing the Mesozoic outcrops of the highlands. The sequence is best developed in the coastal strips of the southern and western parts of Kachchh Mainland. The maximum development is seen in the south-western part of the Mainland (Fig. 3.3). Existence of Tertiary rocks in the

Banni, the Great and Little Rann, beneath the Recent sediments, is indicated by the patchy outcrops in the marginal areas of the highlands adjacent to the basins and also from shallow holes drilled (Biswas 1993). The rock beds in the marginal strips around Mesozoic rocks dip away from the highlands and towards basins. The Lower Tertiary rocks overlie the Deccan Trap flows in southern and Western Kachchh Mainland while in other areas they are seen directly over the Mesozoic rocks. The sequence starts with the trap wash deposits known as Madh series and lateritic horizons (Table 3.2). The limit of Tertiary sea is marked by the invariable occurrence of lateritic and volcano-clastic rocks at the base. From this fact it is evident that present day highlands stood out as islands in the Cenozoic sea and they never submerged completely; only their peripheries were inundated. There is a general eastward onlap of beds indicating west to east transgression of the Tertiary sea (Biswas 1993).

Wynne and Fedden (1872) were first to study Tertiary rocks of Kachchh. In their classification they considered lithological and paleontological characters and compared them with that of Sind-Baluchistan. Biswas subsequently remapped the Tertiary rocks of Kachchh and found the earlier classification to be a mix up of litho-stratigraphic and bio-stratigraphic nomenclature. He therefore proposed a revised stratigraphy and taking into account various factors, suggested a time-stratigraphic classification (Table 3.2). According to Biswas during Palaeogene, deposition was restricted to the western part of the Kachchh Mainland, the thickest parts being exposed in the south western coastal plains which was the deepest part of the basin. During the middle of Miocene, the sea transgressed and crossed over to the Radhanpur eastward joining with the Cambay Basin.

Table 3.2: CAINOZOIC ROCKS OF KACHCH

					Biswas (2002)			Biswas & Raju (1971)	
					Litho-stratigraphic units			Time stratigraphic units	
Period		**Epoch**		**Stage**	Formation	*Lithology*	**Environment**	*Series*	**Stage**
Quaternary		Holocene							
		Pleistocene			Sandhan	Sandstone, minor limestone and shale. Upper part calcareous concretionary	*Littoral /fore shore*		
Tertiary	Neogene	1.64 Ma Pliocene 5.2 Ma	Late	Piacenzian				***Kankawati***	
			Early	Zanclian					
		Miocene 23.3 Ma	Late	Messinian	Unconformity				Unconformity
				Tortonian					
			Middle	Serravallian	**Chhasra**	Upper: Silty shale Lower: Shale/limestone, highly fossilliferous	*Marine inner shelf*		
				Langhian				***Khari***	Vinjhan
			Early	Burdigalian	**Khari Nadi** Unconformity	Variegated siltstone and sandstone	*Marine foreshore*		
				Aquitanian					Aida
	Palaeogene	Oligocene 35.4 Ma	Late	Chattian	**Manyara Fort**	Upper: Foraminiferal limestone/shale, Middle: Limestone with coral bioherms, Lower: lumpy clay stone	*Marine shelf*	***Bermoti***	Waior
			Early	Rupelian					Raamania
					Unconformity				
		Eocene 56.5 Ma	Late	Priabonian					Unconformity
					Fulra Limestone	Dense foraminiferal limestone	*Open marine carbonate platform*		
			Middle	Bartonian				***Berwali***	Babia
				Lutetian	**Harudi** Unconformity	Clay stone/ limestone, coquina, fossilliferous	*Lagoonal to near shore*		
			Early	Ypresian	**Naredi**	Upper: ferruginous	*Lagoonal*		Kakdi

		Palaeocene 66.0 Ma	Late	Thanetian	Unconformity	claystone, Middle: Assilina limestone, Lower: glauconitic gypseous shale		***Madh***	
			Early	Danian	**Mata-no-Madh** Unconformity	Volcanoclastics: tuffaceous shales & sandstones, bentonitic claystone	*Terrestrial*		
					Deccan Traps	Basalt	*Terrestrial lava flows*	***Decca Traps***	

While the Mesozoic sediments are well consolidated, Tertiary rocks are rather friable. They readily form bad-land topography. Clay-stones, siltstones, foraminiferal limestone (Fig. 3.10), silty shales and calcareous sandstones are the Tertiary rock types.

Fig. 3.10: Tertiary limestone exposure in western Kachchh.

Quaternary

Quaternary deposits of Kachchh primarily comprise of unconsolidated sediments of aeolian, marine and fluvial origin. A considerable part is occupied by marine deposits; they occur most extensively in Banni grasslands & in the Ranns of Kachchh and along the coastal plains, surrounding all the highlands. On the other hand, aeolian deposits are mainly seen as obstacle dunes.

Following table shows sequential Quaternary stratigraphy of Kachchh (after Merh 1995).

Table 3.3: Quaternary stratigraphy of Kachchh (after Merh 1995).

Sediments of the Great and Little Ranns; Raised mud-flats along the coast	Holocene
Dunal Accumulations of miliolite	Upper to Middle Pleistocene
Conglomerate and grit of the upper part of Kankawati Series	(?) Lower Pleistocene

The miliolite deposits occurring as outliers within the rocky mainland are only undoubted Pleistocene rock type occurring in Kachchh. It occurs as obstacle dunes as well as sheet deposits and occupies low grounds at the base of the hills. It is formed by cementing (calcareous) of windblown sands of mainly shell fragments and sand (mostly quartz) grains. Miliolite is seen in isolated patches deposited within the depressions of hills even at considerable elevations (Fig. 3.11). Miliolite of fluvio-aeolian origin are often seen along the valleys within the hill-ranges.

Fig. 3.11: Inclined miliolite layers atop Habo hill, Northern Hill Range.

Rann of Kachchh

The Great and Little Rann (also spelled Run, Runn, Ran or Rin) of Kachchh forms unique tract of land which is characterised by flat unbroken surface of dark silt, baked by sun and blistered by saline incrustations and is varied during dry season only by mirage & great tracts of dazzlingly white salt or during monsoon extensive but shallow pool of concentrated brine; its intense silent desolation is oppressive. The effect of mirage is so severely deceptive that the smallest shrubs at a distance assume the appearance of forest, a gazelle appears a camel. In dry season the whole surrounding space of Rann resembles a vast expanse of water when sun shines. With the commencement of summer the blustery wind becomes so harsh that even still wet layer of silt on Rann gets lacerated like a frazzled carpet (Fig. 3.12).

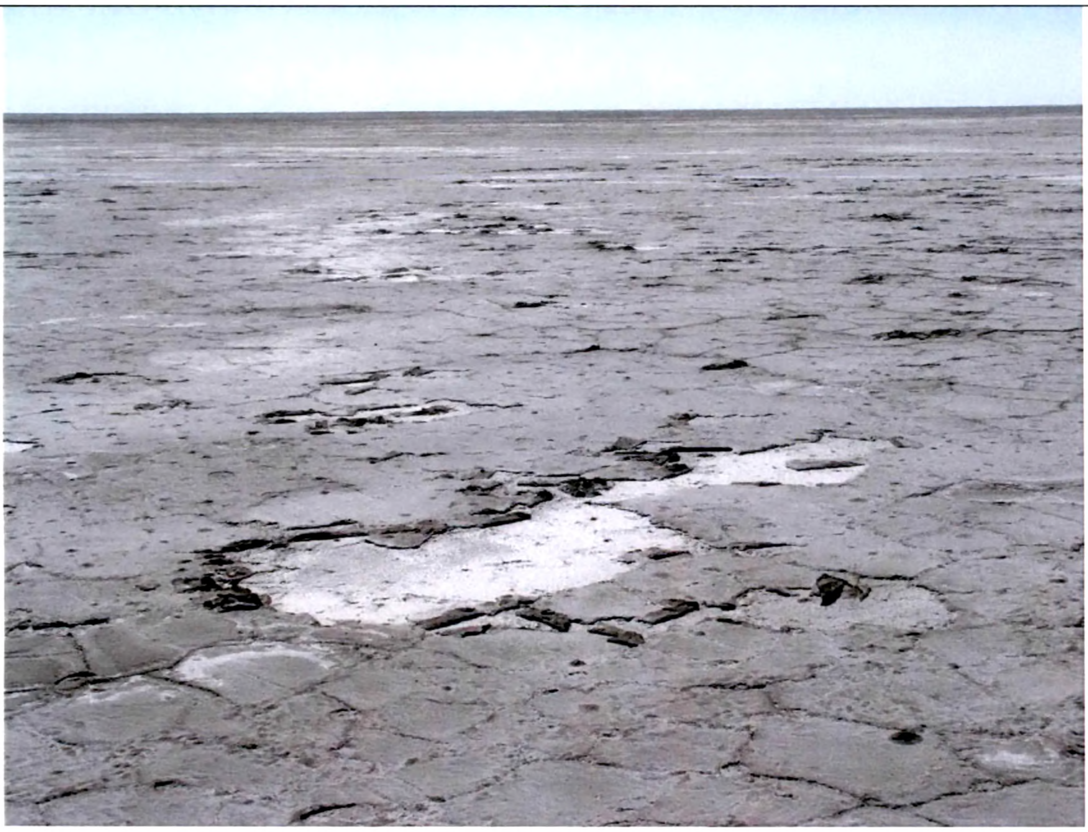

Fig. 3.12: Rann surface torn by blistering wind.

Nothing remains perceivable at a distance of a few tens of feet when the deposits of Rann, dried by several months' sun get air lifted along with the blowing wind. Due to such visionary illusions and complete absence of any landmark, it is not uncommon to lose direction in Rann without a compass.

The evolution of Rann has always remained the matter of speculation for the researchers. Attempts have been made previously to define the Rann with available terms of physical geography. Burnes (1834) portrayed it as vast expanse of flat, hardened, sand encrusted with salt beautifully crystallized in large lumps. Grant (1837) considered it to be elevated bed of sea whose level surface is result of yearly repeated flooding by sea which has gradually omitted all of its inequalities to form such a level surface. Lyell (1850) depicted it as dried-up bed of inland sea. According to Wynne (1872) the Rann must have been hillier than present planar appearance and islands rising from the Rann are modified summits of older surface. On the other hand Sivewright (1907) described it as delta of the Hakra, the lost river of Sind. It is believed that when Alexander departed on his return march to Europe in 325 B.C., Rann was part of Arabian Sea (Major Raverty as cited by Sivewright 1907).

From the historical accounts of Arab historians Sivewright (1907) came on to conclusion that even after 712 A.D. Rann formed shallow sea allowing navigation up to the historical town Pari Nagar situated near present day Virawah (Lat: 24.5270 N Long: 70.7666 E) (Fig. 3.15). Alternatively, findings of archaeological sites within Rann such as Luna (Lat: 23.7087 N Long: 69.2480 E) and Vigo Kot (Lat: 24.2327 N Long: 69.2107 E) propose that once upon a time Rann was congenial for human settlement (Fig. 3.16).

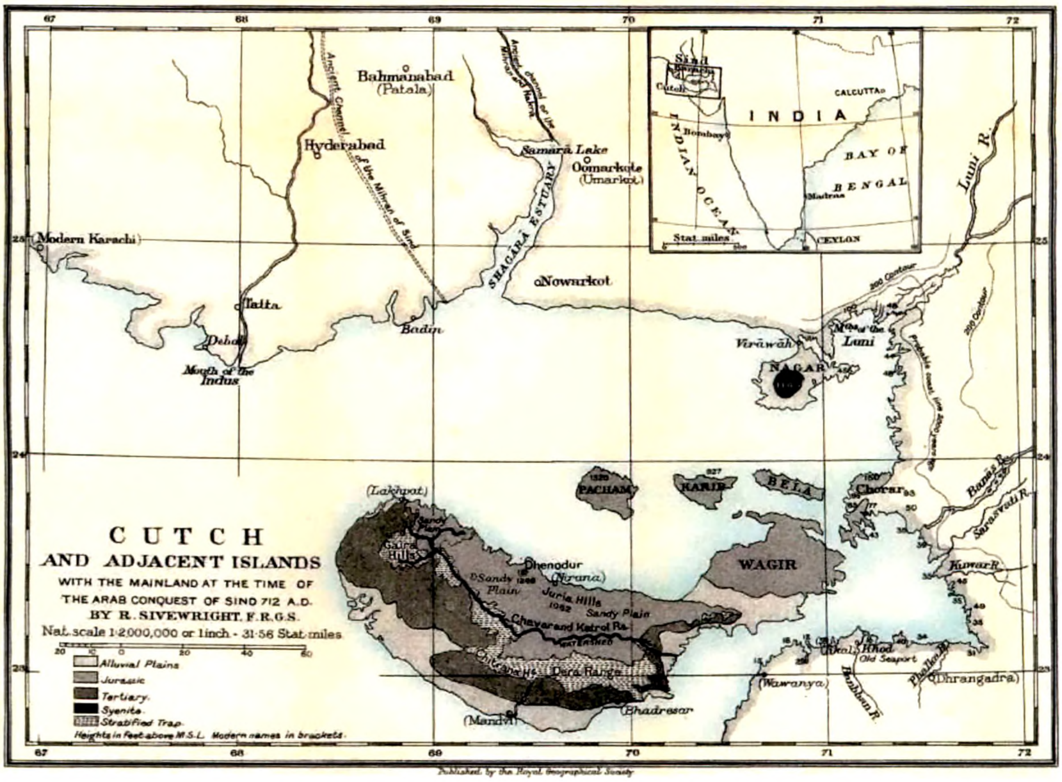

Fig. 3.13: Kachchh region during A.D. 712 as postulated by Sivewright (1907) based on account of Arab historians.

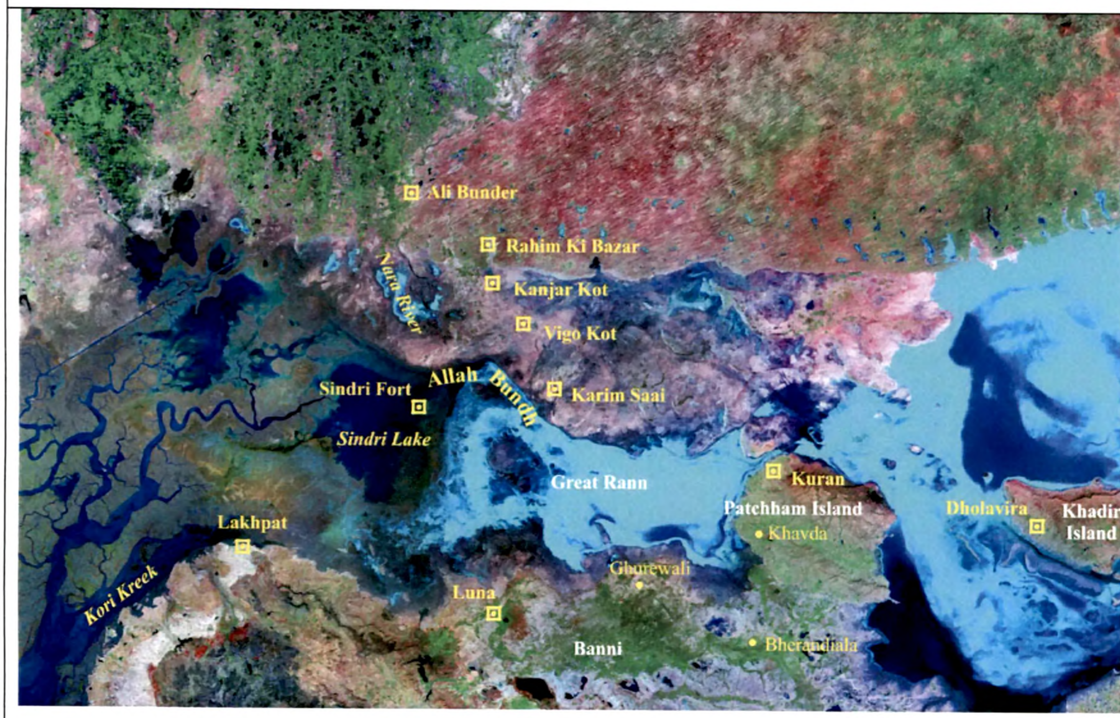

Fig. 3.14: Archaeological sites within and around Great Rann of Kachchh.

The sediments of Rann consist of fine laminated clay deposits intercalated by thin layers of silt and fine sand. Sequence of clay-silt deposits is often underlained by thick layer of medium sand. The Great and Little Rann of Kachchh and Banni plains furnish suitable conditions for occurrence and preservation of seismically induced soft sediment deformation and liquefaction features.