
CHAPTER VII

DRAINAGE AND PLAYAS

DRAINAGE AND PLAYAS

INTRODUCTION

The Thar Desert has been considered until recently as an area of dryness and aeolian activity, devoid of any fluvial features. The existing drainage system viz. the Luni, Kantli and Ghaggar-Hakra rivers, is indeed a blessing to this desertic terrain. Similarly, the pluvial lakes and playas are the characteristic features of the arid terrain, which have been amply witnessed in the study area. Studies carried out by various workers on the drainage characteristics of the Thar have revealed that in addition to the present day ephemeral streams, there exists an array of palaeochannels of former streams traversing the dunal country, indicating the prevalence of a major river system in the area. References about the earlier mighty rivers viz. the Saraswati, Dhrishdavati and several other tributary streams flowing through the region, have been made in the ancient Sanskrit literatures such as Rig Veda, Bhagavata Purana, Mahabharata, etc.

Recent workers have provided different views on the origin, existence and migration of these palaeo-river systems. They include Oldham (1874), Dey (1927), Wadia (1938), Krishnan (1960), Ghose (1964), Pandya (1967), Wilhelmy (1969), Sharma (1974), Ghosh (1977), Allchin *et al.* (1978), Ghose *et al.* (1979), Bakliwal and Sharma (1980), Yashpal *et al.* (1980), Kar and Ghose

(1984), Bakliwal and Grover (1988), Raghav and Grover (1991), Ramasamy *et al.* (1991), etc.

THE PRESENT DAY DRAINAGE

The detailed studies on the drainage of the study area carried out with the help of satellite imageries and subsurface geological data, point to an interesting history of its evolution (Plate VII.1). The study area is drained by two ephemeral rivers, the Luni and the Kantli. In addition to these there are numerous smaller streams and rivulets, forming either tributaries to these major channels or separate internal drainage systems. Except Kantli and its sister streams, overall drainage in the study area is southwesterly flowing (Fig. 7.1.).

LUNI RIVER

The Luni is the most important river system in the Indian desert. It has the only integrated drainage network within the Thar. This river has quite a flashy seasonal flow and its waters turn saline downstream.

Originating as two tributaries, viz. the Saraswati and Sagarmati, the ephemeral Luni has its source in the Pushkar hills of the Aravalli Mountain Range, located about 11 km NE of Ajmer (Plate VII.2). After the Saraswati-Sagarmati confluence at Govindgarh, the Luni flows in a south westerly direction through Ajmer, Nagaur, Pali, Jodhpur, Barmer and Jalore districts and then ultimately gets lost in the Great Rann of Kachchh. The tributaries of the Luni include Mithri or Jojri in Jodhpur district (on the right bank of Luni), Guhiya, Raipur Luni, Lilri, Reria, Sukri, Khari, Bandi, Mithri, Jawai in Pali district, Khari Bandi, Sagi in Jalore district and Krishnavati in Sirohi district (all on the left bank of Luni). In the study area, the Lilri river originates as Sukri Nadi from the Aravalli hills and joins the Luni river near Nimbol village. The Jojri Nadi or Mithri joins the Luni on the right bank at Khejarli Khurd.

The total length of the Luni is about 525 km and it drains a total area of about 35,000 km². The greatest peculiarity of this river is that it tends to increase its width rather than deepen its bed. The present study area includes a length of about 250 km of the Luni channel. The total

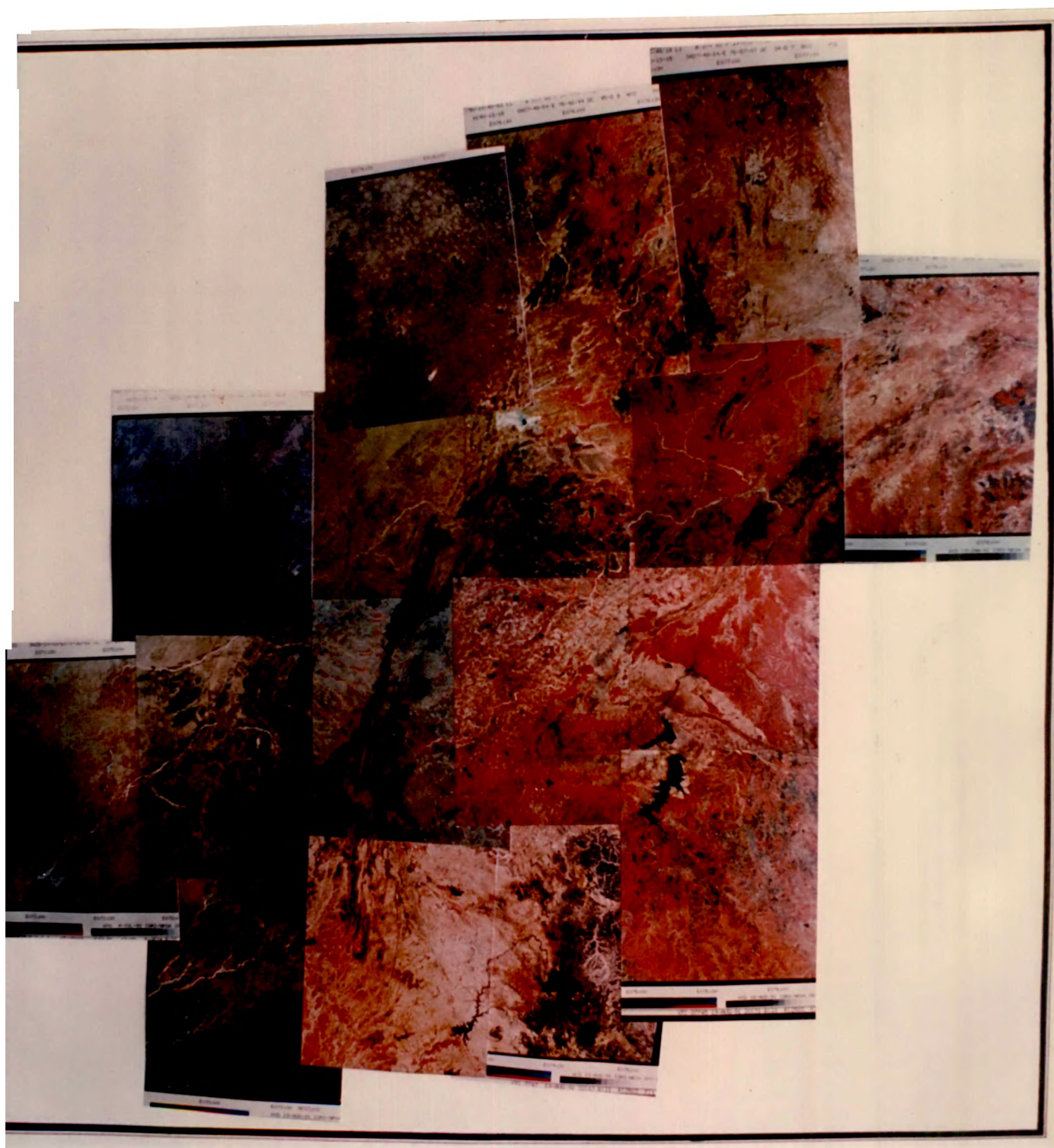
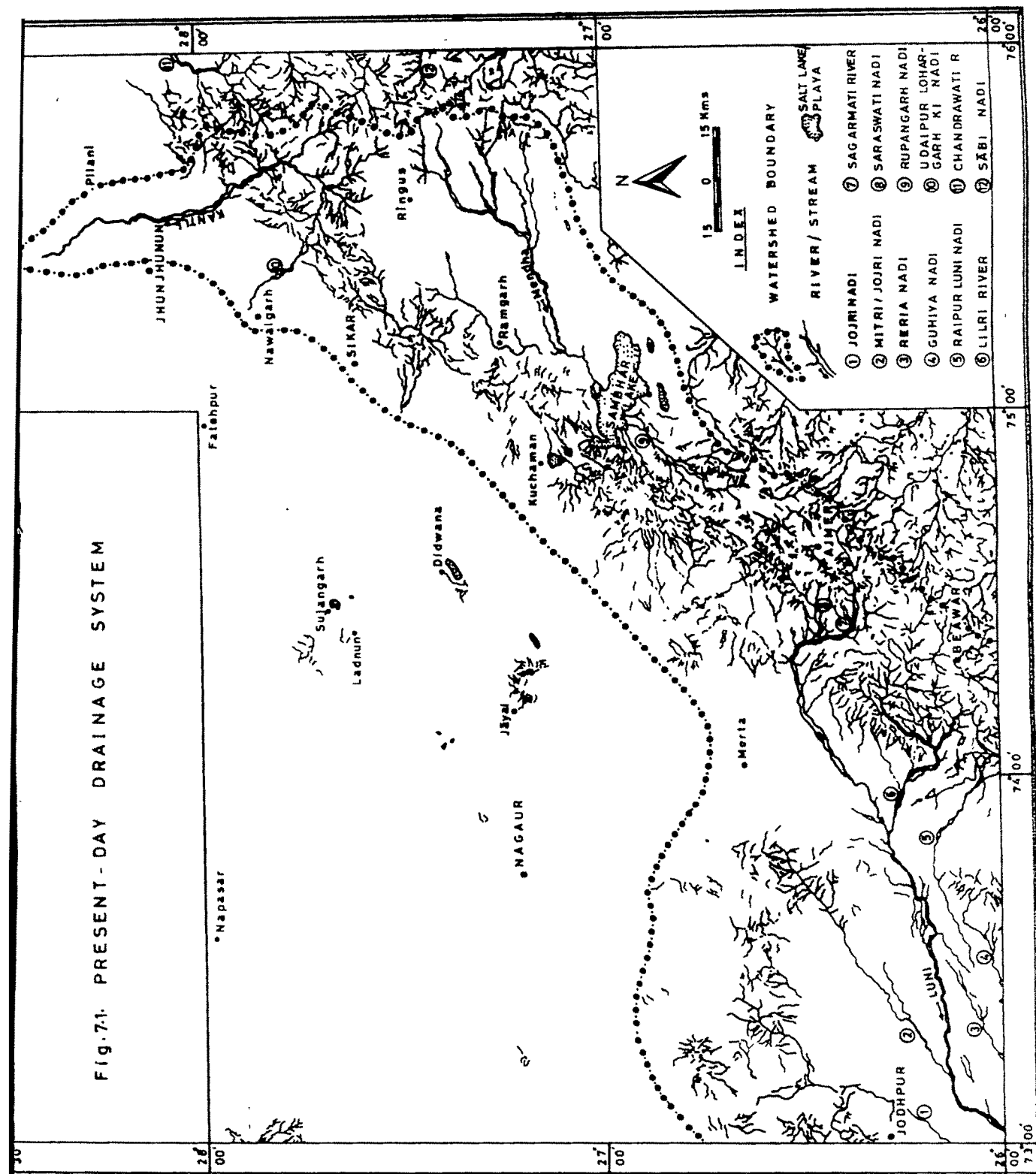


Plate VII.1 IRS (LISS - I) satellite imagery mosaic of the Trans-Aravalli Pediplains showing the major drainage systems, tectonic elements and related physiographic features.



Plate VII.2 A panoramic view of the Luni watershed at source region i.e. Pushkar hills, and extensive linear pediplains.

Fig. 7-1. PRESENT-DAY DRAINAGE SYSTEM



watershed area covered within the present studies is about 31,700 km². The average width of the channel is about 500 m, maximum widths of about 1 to 1.5 km occurring near Badayali, Kekindra, Surpura, Kharchiya, Anandpur Kalu, etc. The Luni channel tends to decrease in width towards southwest of the study area. Channel braidations are seen at Surajgarh, south of Rian, Kekindra, Kharchiya, Kaneo, Lamba, etc.

The outline of the shape of the Luni river valley from the source to Luni junction (Chawan) in the study area is shown in the longitudinal profile (Fig. 7.2a). This profile shows the presence of number of knick-points attributed to the structural/tectonic elements. The knick-points are manifested in the form of marked change in gradient in the river profile. The Saraswati river upto the confluence with Sagarmati river near Govindgarh shows three marked gradients, one between Amba (source) and Bhanwata (steep gradient of 1:25), the second between Bhanwata and Pisangan (1: 342) and the third between Pisangan and Gusayan ki Dhani (1:650). These gradient changes occur within the hilly terrain comprising Alwar quartzites of Delhi Supergroup. The fault FF between Gusayan ki Dhani and Alniyawas played a major role in shaping the river profile gradient.

After the Saraswati-Sagarmati confluence, the Luni channel shows three marked breaks in gradient, viz.,

- (i) Between Gusayan ki Dhani and Devanya, the gradient averages about 1:486, the dominant lithology in this part constituted by the Ajabgarh schists. The fault FF between Devanya and Maliyon ki Dhani significantly contributed to the change in gradient.
- (ii) Between Devanya and Jhak, the gradient decreases considerably to about 1:1333, which is attributed to the horizontally disposed Marwar Supergroup of rocks comprising Jodhpur sandstones, within the Trans-Aravalli Zone.
- (iii) Between Jhak and Luni (Chawan), the river bed gradient increases to about 1:873, the litho-tectonic features contributing to this change are constituted by the Bilara limestone and Jodhpur sandstone in the Rajasthan Shelf Zone, the Ajabgarh schists further WSW, the fault FF between the schistose rocks and the Malani rhyolites in the extreme southwestern parts towards Chawan.

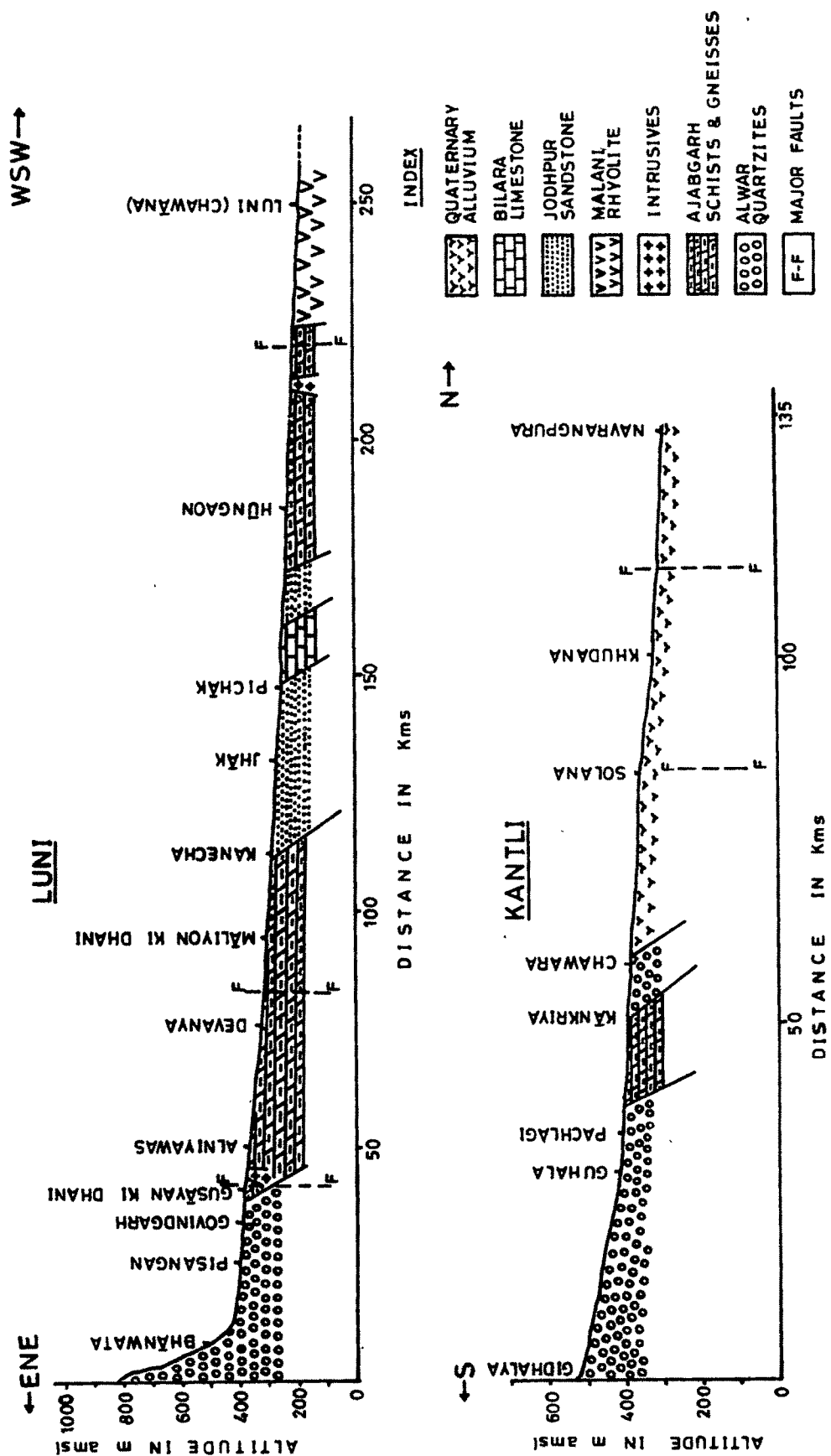


Fig.7.2. LONGITUDINAL PROFILES OF LUNI AND KANTLI RIVERS AND THEIR LITHOTECTONIC SIGNIFICANCE

General characteristics of the different segments of the Luni channel are given in Table 7.1. Compared to the western parts, the eastern part of the study area is relatively better drained. Notable watersheds in this part are Kantli, Mendha, Rupangarh, Dohan, Dongar, Sahibi (Sabi), Chandrawati, Udaipur-Lohargarh ki Nadi, Madhobini Nadi, Sota Nadi, Dhudhala Nadi, Bandi Nadi, Sukh Nadi (Singhana Nadi) and Khariya Nadi.

KANTLI RIVER

The Kantli is a northerly flowing ephemeral river originating from the hills near Gidhalya village in Sikar district (Plate VII.3). Few small tributaries join the Kantli mainly in the upper reaches. The river finally gets dried up and disappears in the dunal tracts near Navrangpura of Rajgarh village in Churu district. Draining a total length of about 135 km the Kantli flows through the hilly terrain in the upper reaches, cutting across the Aravalli ranges for about 52 km upto Mainpura in Jhunjhunu district and then flows through the vast aeolian dune field in the north. The total catchment area of the Kantli is about 1746 km².

Minor shifts in the flow of the Kantli channel are observed along its course. The outline of the longitudinal profile of the Kantli river shows five marked breaks in its gradient (Fig. 7.2b). These are attributed to the litho-tectonic features, viz., the Aravalli uplift and the stepped faults.

- (i) Between the source at Gidhalya and Guhala the gradient is about 1:250; the Aravalli uplift may have played a major role in this steep gradient.
- (ii) Between Guhala and Pachlagi, the gradient decreases to about 1:500, the tectonic features within the Aravalli Mountain Range may be the causative factor.
- (iii) Between Pachlagi and Solana the gradient further decreases to about 1:980, the litho-tectonics in this part predominated by the step faults within the basement Ajabgarh schists and Alwar quartzites.
- (iv) Between Solana and Khudana, the gradient shows marked increase to 1:433.
- (v) Between Khudana and Navrangpura, the gradient once again decreases considerably to 1:966.

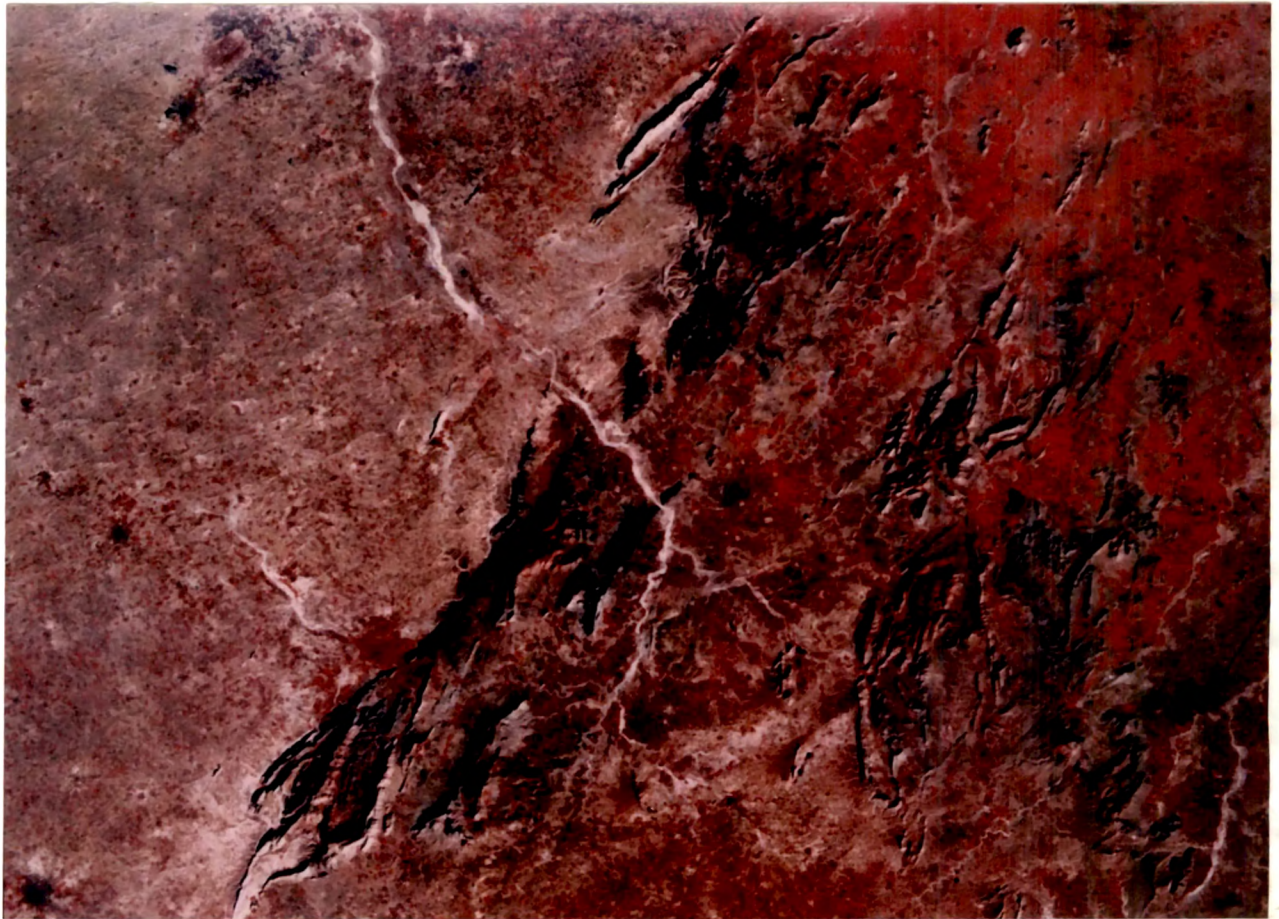


Plate VII.3 Satellite imagery photograph of the Kantli river basin depicting numerous geomorphic features.

Relevant channel characteristics of the Kantli river are summarised in Table 7.2 and the general characteristics of other smaller streams of the study area are summarised in the Table 7.3.

The overall drainage pattern in the study area is dendritic to sub-trellis type. Dendritic to sub-dendritic patterns are seen mostly in the upper reaches of the Luni, Kantli and other minor streams. The central parts of the study area are characterised by the internal drainage pattern. The playas and saline depressions viz., Sambhar, Didwana, Kuchaman, Sujangarh, Tal Chhapar, Gonarda, etc. are the manifestations of such internal drainage systems derived from local tectonic features or physiographic changes.

THE PALAEODRAINAGE SYSTEM

Evidences on the existence of well-knitted perennial drainage system in the Thar during the recent past have been inscribed in the Vedic literatures and the Mahabharata, where the Saraswati has been described as a mighty Himalayan river. This has lured a vast geoscientific community to examine and unfold the hidden facts about the lost and defunct drainage systems in the Thar.

LITERATURE REVIEW

Some important contributions on the aspect of palaeodrainage studies have come from Oldham (1874, 1893), Dey (1927), Wadia (1938), Krishnan (1960), Ghose (1964), Pandya (1967), Wilhelmy (1969), Allchin *et al.* (1978), Ghose *et al.* (1979), Yashpal *et al.* (1980), Kar and Ghose (1984), Bakliwal and Grover (1988), Ramasamy *et al.* (1991), etc. Most of these workers have described the Himalayan source of the Saraswati between the present sources of the Sutlej and Yamuna rivers, and which flowed through Ganganagar, Bhawalpur and Sind.

Ghose (1964) had reconstructed the buried stream courses in the Luni-Jawai plains. Pandya (1967), based on the inscriptions of Rig Veda, had attempted to establish the ancient course of the Saraswati. According to him, the present day Yamuna (the ancient Dhrishdavati) at one time, i.e. about 200,000 years B.P. was flowing in the Thar area and he considered it to be a major

Table 7.1 Luni river channel characteristics in the study area

Channel Segment	Flow Direction	Channel Type	Channel Length	Gradient
Sagarmati River Kharekhari-Govindgarh	WNW	Sinuuous with right angled bend at Mahjitya	36 km	1:25 1:342 1:650
Saraswati River Bassi-Govindgarh	SW	Sinuuous after leaving the hill ranges at Nand	45 km	
Govindgarh-Alniyawas	NW	Slightly sinuous, braided at Gusayan ki Dhani and Alniyawas	08 km	1:486
Alniyawas-Rohisa ki Dhani	WSW	Slightly sinuous with higher frequency of braidations	17 km	
Rohisa ki Dhani-Maliyan ki Dhani	SW	Straight to slightly sinuous with fewer braidations	21 km	1:1333
Maliyan ki Dhani-Nimbol	SW	Sinuuous	23 km	
Nimbol-Jaswant Sagar	SW	Slightly sinuous	17 km	1:873
Jaswant Sagar-Dhingana	WSW	Slightly rectilinear to sinuous	66 km	
Dhingana-Luni (Chawan)	SW	Sinuuous with local meanders, few braidations	18 km	

Table 7.2 Kantli river channel characteristics in the study area

Channel Segment	Flow Direction	Channel Type	Channel Length	Gradient
Gidhalya-Thikriya	NNW	Rectilinear to sinuous with local rectangular to angulate bends at Thikriya, Kanwat, etc.	17 km	1:250
Thikriya-Chaukri	NW	Rectilinear to sinuous	05 km	
Chaukri-Guhala	N	Rectilinear to sinuous	05 km	
Guhala-Sunari	NE	Sinuuous to straight with local meandering at Pachlagi and Papra	12 km	1:500
Sunari-Sanwal ka Bas	NW	Rectilinear to sinuous, rectangular at Mainpura, braided at Chawara, Kair and Sanwal ka Bas	30 km	
Sanwal ka Bas-Islampur	N	Sinuuous to rectilinear, braided	22 km	1:980
Islampur-Lamba Gothra	N	Rectilinear to rectangular	13 km	
Lamba Gothra-Tigiwas	NW	Sinuuous, bend with local meanders at Dhatarwala, Dhandharia, Ranjitpura. Straight channel at few places	20 km	1:433 1:966
Tigiwas-Naurangpura	N	Rectilinear	04 km	

Table 7.3 General parameters of minor rivers/streams of the study area

River/Stream	Origin/Source	Total length in study area	Flow direction
Mendha	~ 2 km NE of Aspura Bara (Sikar Dist.)	100 km	SW
Rupangarh	Aravalli hills south of Kishangarh around Naulacha-Muhami	70 km	Initially N, then NE
Udaipur-Lohargarh Ki Nadi	Raghunathgarh hills near Salaramataji	55 km	Initially NE, then NW
Sota Nadi	Garhtaknet (Sikar Dist.)	35 km	NE
Sabi Nadi	Saiwar hills-preserved forests in Sikar and Jaipur Dists.	20 km	ESE
Khariya Nadi	Surana hills (Jaipur Dist.)	10 km	SW
Madhobini Nadi	Amarsar (Jaipur Dist.)	25 km	SE
Dhudala Nadi	Confluence of Khariya and Madhobini Nadis	10 km	SE
Dohan Nadi	Mankri (Sikar Dist.)	17 km	NE
Dongar Nadi	Babai (Jhunjhunun Dist.)	13 km	NE
Chandrawati River	Confluence of Dohan and Dongar Nadis	25 km	NE

tributary stream of the Saraswati (present day Ghaggar). The earthquake activity has diverted the flow of Dhrishdavati to the east which ultimately became a tributary of the river Ganga. The Saraswati channel also fragmented into innumerable water pools and the subsequent dessication was responsible for creation of desertic environment.

Allchin *et al.* (1978) opined that the palaeo-river known by the name Saraswati in its upper course, either joined the lower course of the Indus in Sind or flowed independently into the Arabian sea through the Rann of Kachchh. Many researchers have identified this river with the present day dry bed of the Ghaggar in Haryana and Rajasthan and with the Raini, the Wahinda and Hakra (Nara) in Pakistan.

According to Yashpal *et al.* (1980), the present day Ghaggar river from Shatrana onwards represents in part, the dry bed of the Saraswati river. Ghose *et al.* (1979) viewed this river as flowing through a more easterly course between Nagaur and Bikaner through Luni river and later shifting further west. Kar and Ghose (1984) described the several courses of the Dhrishdavati, which according to them was an important tributary of the Saraswati river, that flowed in a southwesterly direction and met the Luni river. Buried courses of these were found in the Churu-Nagaur tract.

Bakliwal and Grover (1988) have worked out the signatures and north westward migration of the Saraswati river through six successive stages. Ramasamy *et al.* (1991) had attempted to exhibit the palaeochannel network of the rivers of Western India using remote sensing techniques and integrated them with the lineament fabric so as to understand the Quaternary tectonics of the region.

Wilhelmy (1969) had suggested that the Yamuna river formerly flowed through the present Hansi-Hissar branch of the western Yamuna and was known as the Dhrishdavati. The Yamuna was later captured by the Ganga system during the RigVedic times. Bakliwal and Sharma (1980) have traced out the history of migration of the Yamuna towards the east. Grover and Bakliwal (1984) have studied the migration of the Yamuna and its palaeochannels especially in its upper reaches. Sharma (1993) carried out archaeological investigations around Delhi and its

surroundings and in the Haryana alluvial plains. He reconstructed six successive stages of the easterly shift of the Yamuna based on archaeological findings and opined that the earliest courses of the Yamuna showed an apparent link with the drying traces of the Sahibi (Sabi) and the Banganga rivers, indicative of their once being the tributaries of the Yamuna.

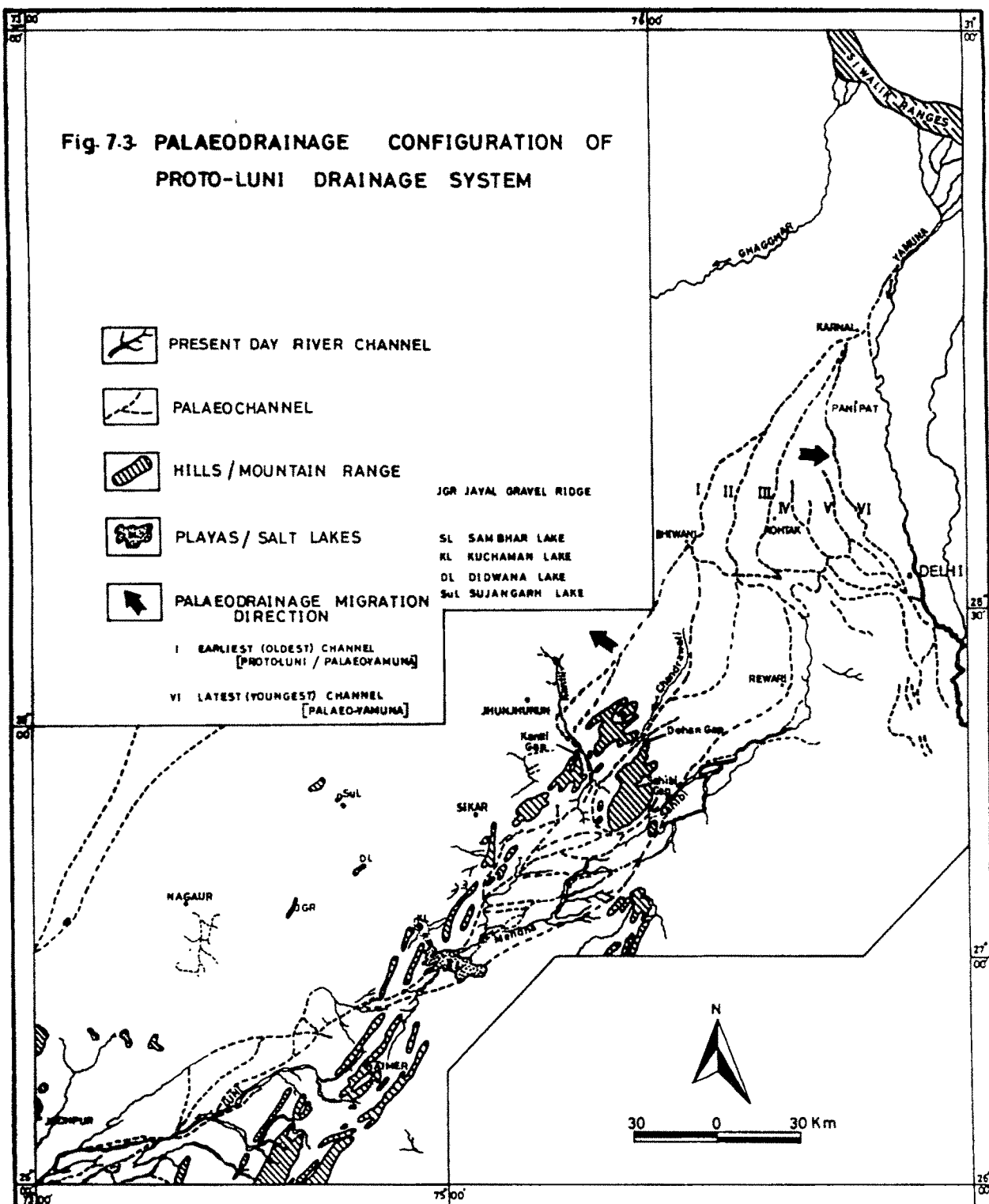
THE PRESENT STUDIES

From the foregoing account on the past drainage system of the Thar desert it is clearly established that the present day Thar has witnessed a well-knitted drainage in the past. However, the critical appraisal of available literature has led to the conclusion that the scientists have failed to provide any concrete mechanism on river migration and causes of drainage disruption. Several opinions exist regarding the former courses of the Saraswati and the Dhrishdavati rivers and the palaeo-drainage system in the Thar desert in general. The author's endeavour of reconstructing the palaeocourses of the eastern Thar rivers is a fresh look at the problem

Study of topographic maps, satellite imageries, lineament fabric and sub-surface geology through bore hole records have revealed the existence of a number of palaeochannels. These palaeochannels are depicting different geometries and orientations, and illustrate the migratory patterns of the past drainage system. In the field these palaeochannel courses are observed as gentle linear depressions characterised by potential aquifer yield zones and thick vegetation cover. Based on the above mentioned mode of studies a palaeodrainage map of the Upper Luni-Kantli basins and the northeastward extension up to the Siwalik ranges has been prepared (Fig. 7.3).

The present day Luni river which is originating from the western flanks of the Aravalli Mountain Range near Pushkar, was in fact, sprawling over an extensive area further to the northeast. Perhaps the present day Luni channel is a mere remnant of the earliest mega fluvial system that prevailed in the past, i.e. the Proto-Luni.

**Fig. 7.3 PALAEODRAINAGE CONFIGURATION OF
PROTO-LUNI DRAINAGE SYSTEM**



Proto-Luni Drainage System

The study of satellite imageries, topographic maps, bore hole records and the author's field observations have established the vastness of the Proto-Luni drainage system that extended almost upto the Siwalik pediplains, which exhibit complex network of defunct and active drainage systems (Plate VII.4). The glacier fed mighty Yamuna river descending from the Siwalik range ultimately debouched into the Gangetic plains near Tajwala. From here the river flows through a wide linear channel in a southwesterly course. From Kalanaur, which is located on the right bank of Yamuna and further downstream, the river shows a deceptive anastomosing drainage pattern, characterised by number of defunct channels, meander loops, ox-bow lakes, etc. These channels, with their westerly concavity have been delineated as palaeochannels of Yamuna (Bakliwal and Sharma, 1980; Grover and Bakliwal, 1984; Ramasamy *et al.*, 1991 and Sharma, 1993).

The identified palaeodrainage signatures of Proto-Luni river also coincide with one of such drainage systems represented by the earliest course (western most) of present day Yamuna (Fig. 7.3). This westernmost defunct channel, which has been designated as the first channel of palaeo-Yamuna, segregates from the present day course of Yamuna at Kalanaur and follows south-southwesterly course along Karnal-Bhiwani branch of western Yamuna canal. Here the satellite imagery shows distinct signatures of two courses, bifurcating near Gharaunda. These two courses are:

- (i) the western channel, which, after crossing Bhiwani follows a southwesterly course through Bhondwa, Surajgarh, Chirawa and ultimately enters into the Delhi Mountain Range via present day Kantli gap. A number of southwesterly flowing palaeo-stream courses meeting the Kantli around Pilani-Chirawa substantiate the existence of Proto-Luni channel in this area (Sharma, 1993). The present day Kantli, which flows in a northerly direction and ultimately getting lost in the alluvial tracts south of Rajgarh, is occupying more than 2 km wide channel. Looking to its small catchment and broad channel, the Kantli represents a case of 'an underfit river', whose course must have been carved out by none other than the Proto-Luni or Proto-Yamuna.

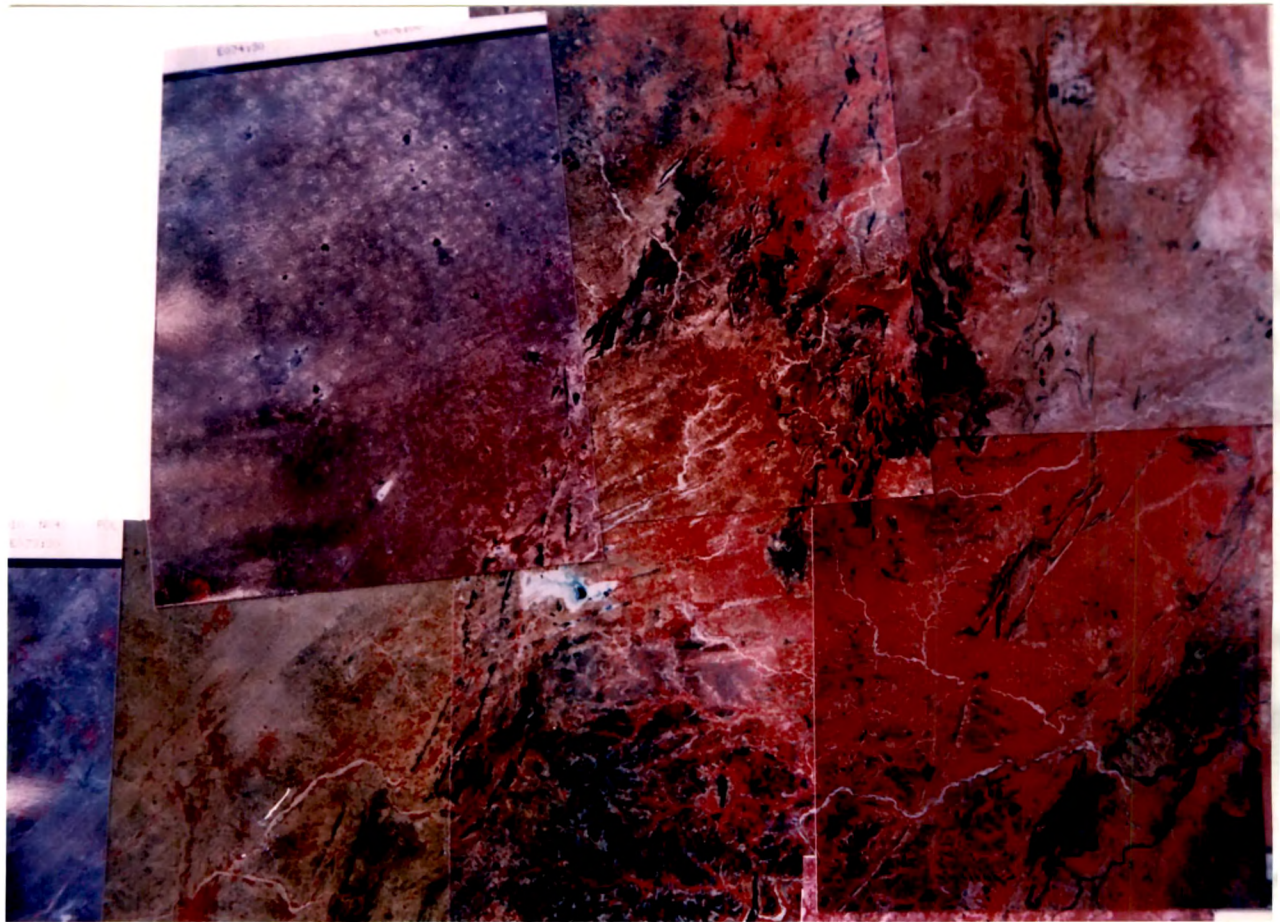


Plate VII.4 IRS (LISS - I) satellite imagery mosaic of the study area and its surroundings showing the signatures of palaeodrainage course of Proto-Luni.

- (ii) the eastern channel with south-southwesterly course passes through Rohtak, Beri and Jhajjar. From Jhajjar this channel further braids into two streams, of which the western channel flows via Mahendragarh, Narnaul and enters into the Delhi Mountain Range through Dohan gap i.e., present day Dohan (Chandrawati) river. Thick accumulation of fluvial sands, three generations of well defined terraces (Raghav and Grover, 1991) aligned in a NE-SW direction, etc. point to earlier powerful drainage system in the area. The eastern channel further southeast of Jhajjar, meets the present day channels of Sahibi (Sabi) and Sota rivers and finally enters into the Delhi Mountain Range through Sahibi gap. Here also, the presence of more than 2 km wide channel with relatively small catchment points to 'an underfit drainage system'. In addition to this, the presence of more than 80 m thick pile of sandy stratum and well rounded agate-quartz pebbles, as reported in the bore hole records of this area suggest the existence of a mighty drainage system in the past.

All these palaeochannels entering into the rugged mountain terrain through Kantli, Chandrawati and Sahibi gaps ultimately debouched into a large intermontane depression i.e., Ringus-Sambhar depression at Guhala, Nim ka Thana and Sri Madhopur respectively. Innumerable signatures seen on the satellite imageries viz. palaeochannels (buried and defunct), linear depressions within the alluvial pediplains, ultimately converge at the Sambhar lake (Plate VII.4). The present day Mendha river which originates within the pediplain areas of Aspura Bara in Sikar district, displays remarkably broad channels of about 2 km width. The existence of wide trunk stream north of Khatu, without any younger order streams in its upper reaches, presence of well defined two to three generations of terraces, etc. further substantiate the existence of a once powerful drainage system that prevailed in the past. The present day drainage, occupying the remnants of earlier stream courses, can be placed in the category of 'underfit streams'.

Downstream of Sambhar, of course, due to considerable aeolian cover, the palaeochannel signatures are not very distinct. However, based on the geomorphic expressions, viz. internal drainage system in Rupangarh river, extensive development of ravines, presence of linear depressions of significant breadth along the western flanks of Delhi Mountain Range, etc., it has been conjectured that, across the mountain range, the Proto-Luni from Sambhar must have flowed through the intermontane valleys. These doubtful palaeocourses possibly pass through:

- (i) Sachor-Amarapura-Banser-Karel-Tilora-Nand and the floodplains of Saraswati Nadi.
- (ii) Sachor-Jhalra-Bajwas-Kaldehera-Nimbola-Gudha-Alniyawas and the Luni channel.

Downstream of Alniyawas, the palaeochannel signatures of Proto-Luni are very distinct. Wide flood plains, extensive levee of more than 20 km length on the right bank between Rian and Kekind, depict the vastness of earlier mega fluvial system. The bore hole data at Badauli shows more than 80 m thick fluvial sandy gravels, ultimately developed into thick aquifers of copious water supply.

From downstream of Pichak the Proto-Luni courses are seen along the present day Reria Nadi, following straight southwesterly course through the present day Bandi river near Bhaton ki Dhani and then with the Sukri river. The detailed study of the lower Luni valley palaeodrainage courses by Tiwari and Ramakrishnan (1995) have established this as the earliest course of the Proto-Luni.

Later changes in the Proto-Luni courses, seen in the northwestern parts of the study area have been delineated by number of workers. These courses denoting the palaeo-Dhrishdavati (Kar and Ghose, 1984), palaeo-Saraswati (Yashpal *et al.*, 1980 and Bakliwal and Grover, 1988) point to north westward shift of the Proto-Luni. The author's study on the palaeodrainage aspect of this part is more or less in conformation with these workers. However, the author does not agree on the Dhrishdavati course (Kar and Ghose, 1984) along Ladnun-Jayal-Chhajoli, as the recent findings have established that the gravelly ridges of Jayal represent beach shingle bars, deposited on the eastern fringe of Palaeozoic sea i.e. the Khichan Conglomerates of Cambrian age (Gangadhar and Tiwari, 1995), and not the Quaternary gravel deposits of any past super fluvial system. The likely palaeochannel course of Dhrishdavati is seen occurring further west of Jayal.

The evolutionary history of drainage and mechanism of drainage disruption/migration is discussed as under:

DRAINAGE EVOLUTION AND MECHANISM

In the geological studies of Thar desert the aspects of evolutionary history of drainage, its migration, causes of disruption and its mechanism are full of intricacies and considered to be grey areas. This is also evident from the review of vast available literature. Till recent past the aspect of palaeo-drainage system of Thar has been dealt in conjunction with the river valley civilization. The archaeologists' opinion of past climatic changes and desertification have also been considered to be the major causative factor for drainage disruption. However, the work on Thar during last decade has brought into light innumerable signatures of tectonism, controlling the present day drainage and also the remnants of palaeochannels. This has necessitated to have a fresh look on this problem.

From the foregoing account on the palaeo-drainage configuration of the Thar desert in general and the study area in particular, it can be conjectured that (i) the overall palaeo-drainage system show a northwesterly migratory pattern; (ii) the oldest channel, the Proto-Luni flowing, abutting the western flanks of Aravalli Mountain Range and the youngest, the Saraswati (present day Ghaggar) on the northern margins of Thar desert.

The study area also displays strong element of tectonism 'the Neotectonism', whose signatures are ubiquitously recorded on satellite data, bore hole records etc. The evolutionary history of drainage migration and causes of disruption, in all probability is related to one single factor, the tectonism. The records of intensive tectonic movements and drastic topographic modifications during Neogene-Quaternary interface are well established. Waning of Tertiary sea, emergence of Siwalik ranges and episodic uplifts of Himalayan mountain range are the most illustrious examples attributed to this tectonism.

The Aravalli Mountain Range and its environs have also been affected by the Himalayan orogenic uplifts. In the study area the signatures of Himalayan uplifts have been observed in the development of regional fracture lineaments, reactivation of pre-existing basement fractures, differential uplift of Aravalli mountain range and landscape and drainage modifications.

It has already been eluded in the preceding chapter on Neotectonism that the study area and its neighbourhood is traversed by a series of major lineament fracture systems viz., Luni-Sukri lineaments (NE-SW), Dausa-Didwana fault, Tonk-Raisinghnagar lineament, Ajmer-Sandiya lineament (NW-SE) and Sardarshaher fault (N-S). Other lineaments which are occurring in the neighbouring areas are; Indo-Gangetic western margin fault (NW-SE), Great Boundary Fault (ENE-WSW), Cambay basin faults (NNW-SSE).

Neotectonism played a major role in the Proto-Luni drainage disruption and subsequent formation of the present day Luni, Kantli, Sabi, Mendha and Chandrawati drainages and the playas of Sambhar, Didwana, Kuchaman, etc. Reactivation of earlier Percambrian fault systems took place along with the development of new fault systems like the Luni-Sukri fault, the Kasganj-Didwana-Dausa fault, etc. Neotectonic analysis of the Mendha river basin has revealed the occurrence of numerous linear shears and cross linears that were responsible for creation of horst and graben configuration in the region (Ghosh *et al.*, 1991) and these neotectonic features had a causal relationship with the pre-existing strike slip faults. The master strike slip faults, the Riedel shears and Antithetic Riedel shears were responsible for producing pull-apart basins (grabens) as well as push-up swells. The differential movement of the various tectonic blocks in the Sambhar lake and adjacent regions caused large scale regional disruption of the prior drainage system, the 'Proto-Luni', resulting in tilting and creation of 'sag-ponds' across their trends. Drainage reversal was a later phenomenon, wherein the internal drainage systems (centripetal type) comprising the Mendha, Rupangarh, Khariya, etc. were formed. The details on the neotectonic features that were responsible for drainage disruption are discussed in the chapter on 'Neotectonism'.

The continued upliftment of the Aravalli Mountains was accompanied by a northwesterly rotational tilt of the entire block. In the northeastern parts the Aravallis plunged into the Indo-Gangetic alluvium and the continuous upheaval in this region caused the disconnection of the Yamuna from the Proto-Luni and its shifting towards the east, thus forming the separate Yamuna drainage system.

The braided tributary of the Proto-Luni also was disconnected and due to northwesterly tilting of the Rajasthan block, it started shifting towards the west and formed the present day Kantli river having its source in the Aravalli hills. The remnants of this palaeo-river system in the area are manifested as the Dohan and Dongar Nadis, Sukh Nadi and the Chandrawati river.

Further southwest, the present day Luni drainage system evolved with a catchment in the Pushkar hills and flowing in a southwesterly direction. The northwesterly tilting of the Rajasthan block caused the northerly shifting of the drainage system, thus forming the Dhrishdavati and Saraswati rivers and their later migratory stages.

The effect of these neotectonic activities and the Aravalli uprise was also marked in the eastern side of the mountain range, where the Chambal river (Chittaurgarh-Machilpur lineament) started shifting towards southeast. In the extreme southwestern part of the Aravalli ranges, the Sabarmati which previously debouched into the Gulf of Kachchh, shifted further southeast and finally drained into the Gulf of Cambay. The palaeochannels and river migration in northwestern India, based on the present hypothesis is shown in Fig. 7.4.

In addition to the tectonic factors, the climatic variations in the form of alternating aridity and humidity were responsible for the later minor as well as major shifting of the drainage systems. The dune-building activities blocked the lower reaches of the Kantli, thereby choking it and causing it to shift periodically right and left in the desertic terrain of Rajgarh village in Churu district.

PLAYAS

These are the saline depressions, locally known as 'Ranns', which constitute characteristic landform features in the arid-semi arid terrain of Rajasthan. Apart from being important sources of salt, these saline depressions are significant from the point of view of palaeo-climatic studies. The playas are characterised by flat surfaces with gentle slopes on the margins and the central part occupied by the saline depression. In addition to a few freshwater lakes viz., Pushkar, Budha Pushkar etc., the study area harbours number of major and minor playas as mentioned

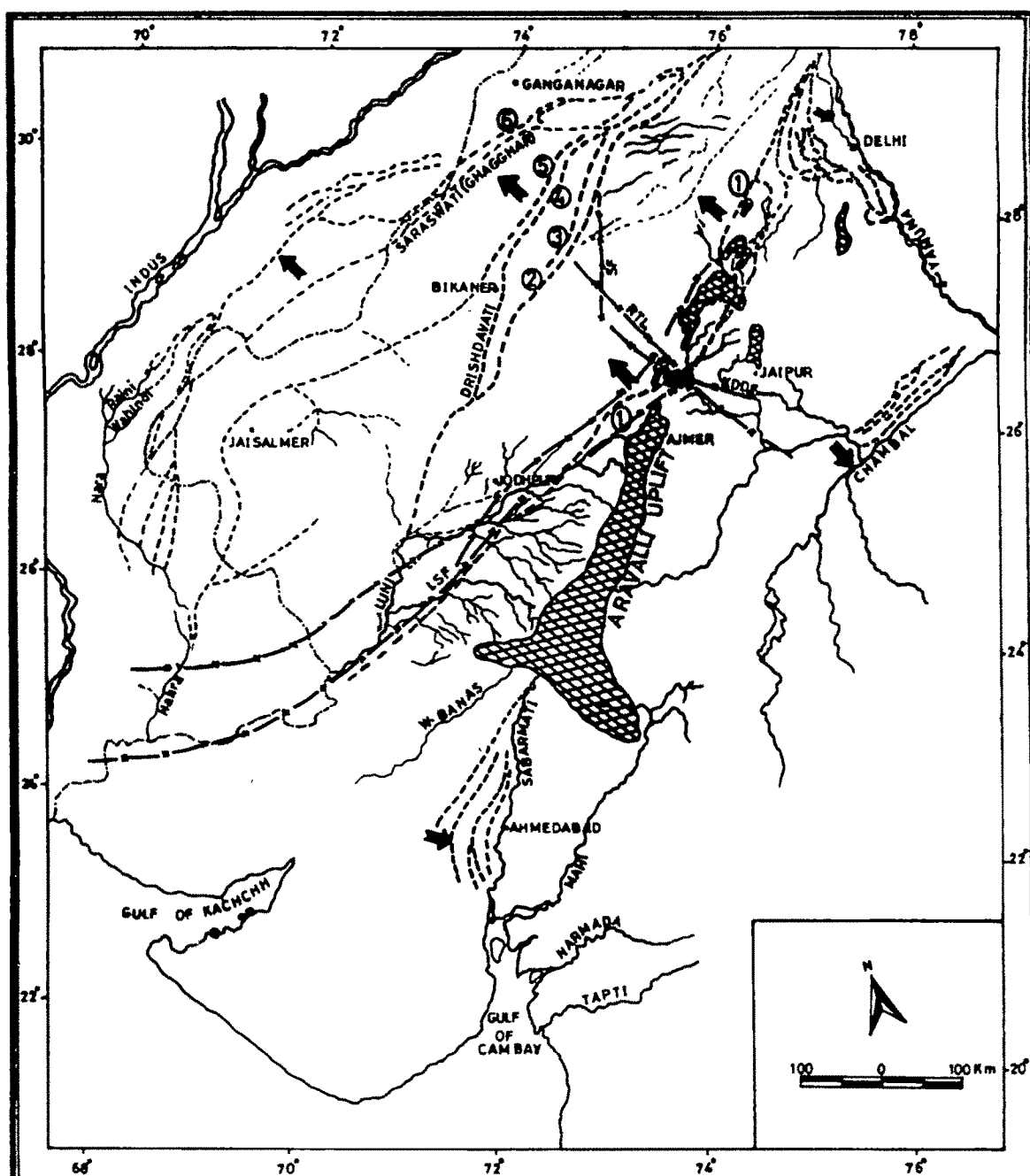








Fig. 74. REGIONAL PALEO-DRAINAGE CONFIGURATION OF NORTH WESTERN INDIA

- ① EARLIEST CHANNEL OF PROTO-LUNI LSF - LUNI-SUKRI FAULT SYSTEM SF - SARDARSHAHAR FAULT
1-2-3-4-5-6 STAGES OF RIVER MIGRATION
- | | | | | | |
|---|----------------------|---|-------------------------|--|-----------------------------------|
|  | PRESENT DAY DRAINAGE |  | ARAVALLI MOUNTAIN RANGE |  | PALEODRAINAGE MIGRATION DIRECTION |
|  | PALEODRAINAGE |  | SAMBHAR LAKE |  | TECTONIC LINEAMENTS |
- KDDF - KASGANI DAUSA DIDWANA FAULT. RTL - RAISINGHNAGAR TONK LINEAMENT

in earlier chapters. Noteworthy among these are Sambhar, Didwana, Kuchaman, Chhapar, Khatu, Sujargarh, Gonarda (Punlaota) etc. Majority of these salt lakes are of typical continental inland lake type with internal drainage. A brief account on the major saline lakes of the study area is discussed as under:

SAMBHAR LAKE

This is the most important and extensive of the saline lakes in the Thar Desert and is located within an intermontane depression. It covers an area of over 220 km², with a maximum area of 230 km² after the rains. The depth is generally less than 0.5 m except in the central parts, where it is upto 1 m deep, the maximum being 2 m (east of Mata Pahar). The lake is fed by four main ephemeral streams, viz. Rupangarh, Mendha, Kharian and Khandel. The lake has a length of about 35 km along its NW-SE axis, with a width varying between 3 and 8 km.

DIDWANA LAKE

The Didwana lake covering an area of about 10-15 km² is 5.5 km long and 2.5 km wide, with a depth of about 1 m. Lying about 100 km to the NW of Sambhar lake, this lake also has a centripetal type of drainage system with ephemeral streams draining into it from the southwest and northeast.

The Didwana and Sambhar lakes are in general surrounded by aeolian sand dunes except in the west where hillocks comprising Precambrian schists and gneisses are present. Geologically, both these lakes form a depressed zone amongst sand deposits overlying a basement of Precambrian rocks.

KUCHAMAN LAKE

Located between the Sambhar and Didwana lakes, the Kuchaman lake is a comparatively smaller playa covering an area of about 8.5 km². The Delhi Supergroup of rocks constitute the basement of this saline lake and the Palara river is the major river which supplies sediments and water to this lake.

SUJANGARH LAKE

This lake lies about 3.5 km north of Ladnu in the northern dunefields of the study area, and covers an area of about 7.5 km².

Apart from these major saline lakes, smaller saline depressions occur at Kasumbi and Dholiya in between the Sujangarh and Didwana lakes. The **Tal Chhapar** lake lies NNW of the Sujangarh lake. The salt lake at **Khatu** lies SW of the Didwana lake. The **Gonarda lake**, covering an area of about 8 km² is located near Punlaota, south of Degana in the aeolian terrain adjacent to the Aravalli Mountain Range. It is interesting to note that the lakes of Chhapar, Sujangarh, Didwana, Khatu and Gonarda are oriented roughly in NE-SW direction.

GEOMORPHIC EVOLUTION OF SALT PLAYAS

Various theories had been put forward by geoscientists to explain the origin and reasons for salinity of the saline basins in Rajasthan desert.

Holland and Christie (1909) postulated a theory of long-distance aeolian transportation of salt particles from the Rann of Kachchh and their deposition in the inland depressions of the desertic terrain. These salts were dissolved during the rains, then got accumulated and concentrated in such inland basins.

Godbole (1952) thought that the lakes are the remnants of a former sea in the region, which had receded towards the Rann of Kachchh leaving behind pockets of salt basins.

Aggarwal (1957) first emphasized a riverine connection to the salt lakes at Pachpadra and Didwana, and indicated that the courses of the streams through these lakes were blocked by sand dunes, the salinity of these lakes being enriched by the continuous subsurface flow.

Ghose (1964, 1965), in his riverine hypothesis viewed that the salt lakes were developed at the confluences of former streams. This hypothesis was modified later to accommodate the view of aeolian segmentation of former stream valleys during a drier climate (Ghose *et al.*, 1977a & b).

Saxena and Seshadri (1956) had advocated a different theory, attributing the salinity of these lakes to subsoil percolation of salts from locations of higher elevations in the northwestern parts of the Indo-Gangetic plains.

Pandey and Chatterji (1970) accounted the tectonic processes for the genesis of Mitha, Kharia and Kanodwala Ranns of the Jaisalmer area.

Khandelwal (1975) attributed the salinity of Didwana and all other Rajasthan lakes to the occurrence of halite beds.

Sinha (1977) discussed the earlier theories on marine origin, aeolian transportation of marine salts and insufficient flushing of salts from the catchments.

Mathur *et al.* (1982) have propagated the theory of Quaternary glacio-eustasy in relation to the origin of salt lakes and ascribed the salt lakes to the remnants of a Quaternary sea that extended from the north of Rann of Kachchh into the interior of Rajasthan.

Kar (1990 b) envisaged a stream-trap hypothesis for the evolution of some saline lakes in the Indian desert. He viewed that the origin of most saline lakes in the Indian desert is linked with the aeolian segmentation of former streams and salt deposition at their confluences. According to him, many lakes in the eastern parts of the desert lie at the wind shadow zone of an associated hill with flanking longitudinal dunes which were created along the hills by the lee vortices of the prevailing southwest wind. Downwind, the courses of former streams flowing away from the lakes, but sending dune guided distributaries to the lakes indicate the possibilities of former streams being trapped by advancing dune arms and then forced towards the base of the hills.

Rai and Sinha (1990) worked out the sedimentation history and geological evolution of the Kuchaman saline lake giving importance to the palaeo-climatic conditions.

Kar (1991) also opined that the origin of all the saline lakes of Thar desert is not similar and that few lakes in the Jaisalmer-Mohangarh areas viz., Mitha Rann, Khara Rann, Kanodwala Rann

and Kharariwal Rann are located amidst a rocky terrain, their origin and present outline the resultant of a long period of aeolian erosion. A number of saline and non-saline lakes in the Luni-Jawai plains are associated with lineament controlled blocks and aligned along former channel courses, thus suggesting the important role played by neotectonism (Kar, 1988 b & c; 1991).

Present Views

A general study on the origin of the major inland playas has been undertaken because these saline basins form one of the characteristic landform features of the study area. The genesis of these salt playas has been attributed to neotectonism, palaeoclimate, aeolian segmentation and inland flushing of salts.

As discussed earlier, the eastern part of the Thar desert was formerly drained by the mighty river, viz. the Proto-Luni originating from the Siwalik ranges. Interpretations have been made after careful study of the satellite imageries and the bore hole records of the region. This has revealed that the palaeochannels of the major river system of Proto-Luni pass through the present day Sambhar lake area. The reactivation of major Precambrian basement faults during the Quaternary period and creation of new fault/fracture systems, especially the Kasganj- Didwana-Dausa fault, the Luni-Sukri fault system and numerous other NW-SE, NE-SW and N-S trending minor faults, produced horst and graben configuration in the Sambhar lake region. This resulted in the disruption of the Proto-Luni drainage system and creation of elongated sag-ponds or pull-apart basins, the Proto-Sambhar forming a major basin of this type in this region. The palaeo-lake boundary signatures of Sambhar lake suggests that it probably had a much larger aerial extent in the past. This NW-SE trending basinal depression of the Proto-Sambhar formerly enclosed fresh water that got entrapped due to the Proto-Luni disruption.

An arid phase set at later stage accentuated the dune building activity. The southwesterly winds swept huge quantities of sands from the south western parts of the Thar towards central and northeastern parts. The isolated hills played a major role in the deposition of these sands mainly in the form of longitudinal dunes. The Proto-Sambhar got choked up and cut off into smaller

basins due to the intense aeolian activity, thus segmenting into the present day Sambhar, Kuchaman and Didwana lakes. The earlier streams found it difficult to cut through the dunes and flow along their original course. They started flowing through the internal corridors and the general slope towards the playa depressions caused them to drain into these lakes. Huge loads of sediments and salts were brought down from the country rocks and the dunal sands into these lakes. Subsequent monsoon rains enhanced this process and further engraved the courses of these ephemeral streams, viz. Mendha, Rupangarh, Khariya and Palara. These streams thus formed internal drainage systems, having no outlet to the sea except to the lakes of the region. In due course of time, the continuous internal flushing and accumulation of salts caused an increase in the salinity of these lakes.

The dry phase was followed by a wetter phase as evidenced by the lacustrine palyno-stratigraphy (Singh *et al.*, 1972, 1974; Ghose *et al.*, 1977b; Wasson *et al.*, 1983). During this period, the lakes received more freshwater causing a decrease in the salinity level. Minor shifting in the stream courses occurred during this period.

The arid-semi arid conditions which followed later and is continuing to the present day, led to the present day configuration of the saline lakes, with the dunal sands, especially the longitudinal dunes separating them from each other. The fluctuating aridity and humidity caused the waxing and waning of the lake boundary (Swain *et al.*, 1983). The increased concentration of salts have made these playas or saline depressions into areas of major salt deposits in the area.