

Chapter 2

Geomorphological Layout of the Saraswatī Land

Land of Triple Provinces

The drainage of the two rivers that once constituted the two branches of the legendary Saraswatī River of prehistoric antiquity encompassed three radically different physiographic–geological provinces. One of the branches, the Satluj (once called Shutudri or Shatadru) arose in southern Tibet beyond the Himālaya, the other the Tons (earlier called Tamasa) emerges in the ever-snowy Himādri or Great Himālayan domain, and the third the Chautang (Drishadwati of the Rigvedic times) drained the northern foothill belt of the western Indo-Gangetic Plains (Plate 2.1, Fig. 2.1). In its middle reaches the river traversed a large swathe of alluvial plain, and then passed through the dreary landscape of sand dunes of the Thār Desert, before ending in the Rann of Kachchh, once a part of the realm of the Arabian Sea.

Mountain Province

Standing high like a colossal sentinel, the Himālaya province is divided into four terranes or subprovinces; one altogether different from the other in respect of landforms, lithological makeup, structural design and tectonic history (Fig. 3.2). These are the *Tethys Himālaya* in the north, the *Great Himālaya* or Himādri, the *Lesser Himālaya* and the *Siwālik* in the south. North of the Himālayan province, the Tibetan landmass is an undulating terrain of peneplaned plateau 3600–7500 m above the sea level (Plate 2.4, Fig. 3.2). In the Tibetan belt the eastward-running Brahmaputra and the northwestward-flowing Sindhu have carved out their valleys and built floodplains of gentle topography. These two rivers emerge from a terrain of domal upwarp capped by the many-splendoured Mount Kailās (6714 m). South

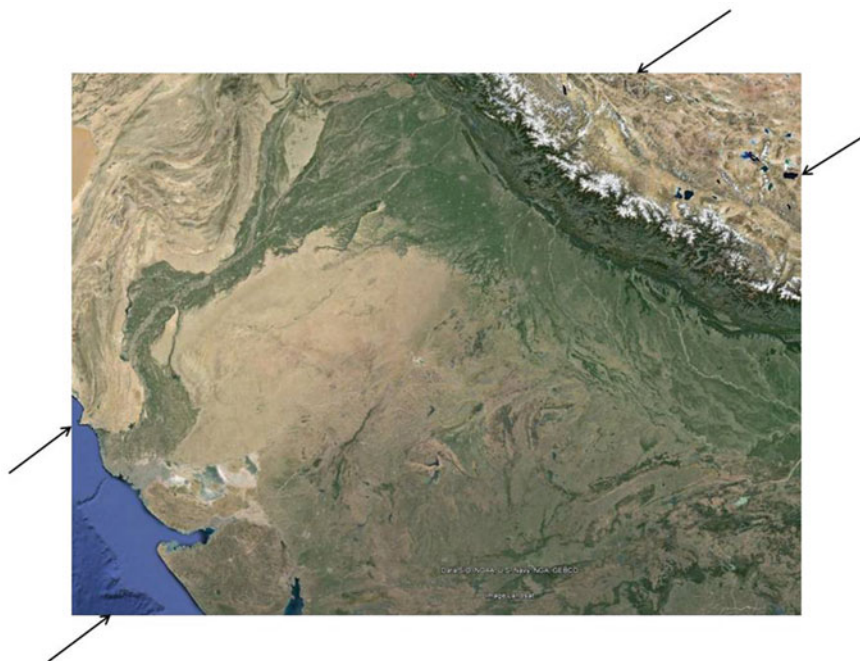


Plate 2.1 Satellite imagery shows the three geologically different and physiographically contrasted provinces—the trans-Himalayan Tibet, the geodynamically mobile Himalaya, the Indo-Gangetic Plains and the Aravali domain of the Indian Shield—through which once the legendary Saraswatī River of antiquity flowed. The *arrows* mark the domain of the Saraswatī basin (Source Google Earth)

of this topographic eminence are the twin lakes—Mānsarovar and Rākshastāl (Plates 2.1 and 2.2). It is a spot west of the Rākshastāl that is the source of the Satluj (Shatadru and still earlier Shutudri).

The Tethys Himālaya is a rugged terrain remarkable for its fantastically sculptured landforms in sedimentary rocks. Bereft of vegetation on the whole, this desolate domain is a cold desert populated extremely sparsely, that too only in isolated places in valleys where clumps of trees have found foothold. Glaciers abound, and rivers have cut deep V-shaped valleys across the ranges of sharply rising peaks. To the south of the Tethys subprovince stretches in a great sprawl the lofty Great Himālaya—also called Himādri. Perennially capped by snow and ice, the rugged ranges of the Himādri rise 3000 to more than 7500 m high. Bandarpunchh (6320 m) and Leo Pargial (6770 m) in the west are amongst the tens of high peaks of this subprovince. From one of the glaciers of this domain (the Har-ki-Dun) emerges the Tons (Plate 2.3) and from another its tributary the Yamunā. The Tons was earlier known as Tamasā. And through Shipkilā gorge and past the Leo Pargial flows the Satluj. The Himādri has extremely youthful and forbiddingly rugged

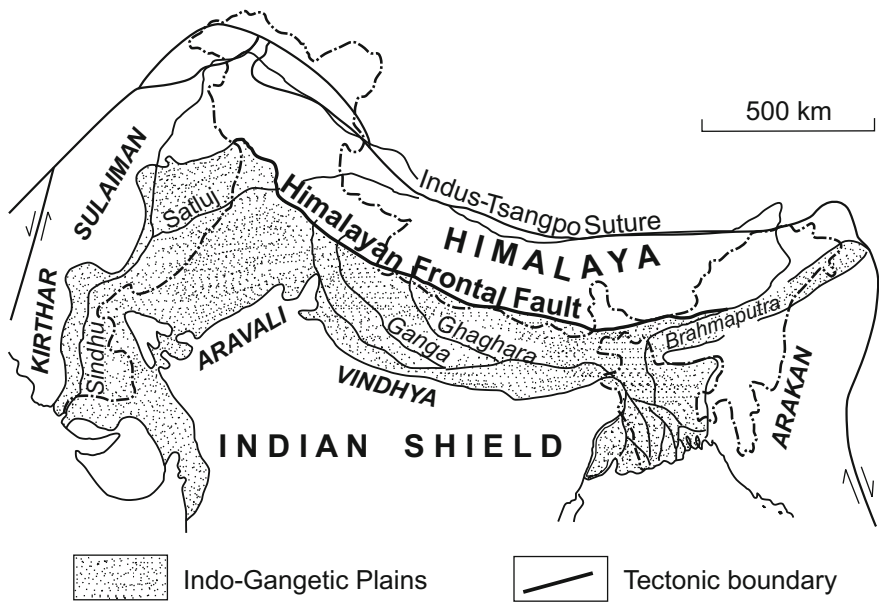


Fig. 2.1 Sketch map shows the floodplains of the Saraswatī and Sindhu rivers in the western IndoGangetic Plains



Plate 2.2 The Rākshastāl, south of Mount Kailās. Close to this lake is the source of the western branch of the Saraswatī, known as Shatadru or Satluj (Photographed by Anup Sah, Nainital)



Plate 2.3 Har-ki-Dun nestling on the southern flank of the Great Himālaya is the source of the eastern branch of the Saraswatī—the Tamasā, today known as Tons (Photographed by Shree Niraj Pant). The lower picture shows a tributary of the Tons river in very upper reaches

topography of the lithotectonic block that is made up of high-grade metamorphic rocks and gneissic granites. The southern face of the Great Himālaya is broken by high precipitous scarps. Through very deep gorges across the high ranges flow the rivers Satluj, Tons and Yamunā, churning violently through the narrow canyons.

The Great Himālaya overlooks the subprovince of the Lesser Himālaya, the elevation of which ranges from 600 to more than 2500 m (Fig. 3.2). The rocks that make up the mountains are sedimentary rocks, thrust over low-grade metamorphic and volcanic rocks. In contrast to the other subprovinces, the Lesser Himālaya is a relatively mild terrain with gently sloping mountain sides and rounded summits. Streams and rivers flow in their comparatively wide, winding valleys, which become suddenly narrow gorges on crossing faults that are very common. In such belts of crossing, the landscape is very rugged. The mountains wear carpets of rich soil that once supported dense forests but are now bereft of the sylvan cover over greater part of the land. This subprovince happens to support comparatively dense population. In the south is the Siwālik subprovince that is made up of exclusively sedimentary rocks. The Siwalik ranges rise 250 to 1600 m, forming the southern front of the Himālaya. The rugged ranges are commonly broken by south-facing scarps, while on their northern steeper slopes rush down streams through unending cascades. Then there are long flat stretches of thick gravel deposits within the synclinal valleys of the rugged Siwālik hills. These are called *dūns*, such as the



Plate 2.4 Satellite imagery shows the mountain domain (Himālaya and Tibetan plateau) of the Saraswatī. Arrows indicate the areas of the sources of Shatadru (Satluj) and the Tamasā (Tons) (Source Google Earth)

Pinjaur Dūn and the *Pāontā Dūn* through which the Yamunā–Tons flow. The Siwālik is covered with dense forests and is sparsely populated.

Foothill Belt

At the foothills of, the Siwālik the 360–240 m above sea level, the northernmost belt of the Indo-Gangetic Plains embodies a fringe of coalescing fans of gravelly deposit over a width of 20–40 km, some of which extend 7–15 km southwards from the immediate foothills. This happens to be the youngest stratigraphic unit but older than some terrace alluvium of the province of the Indo-Gangetic Plain. This unit is on the average 7–10 m thick; and known as *Bhābhar*. The gravel deposits were formed by rivers and streams coming from the mountains and dumping their heavy loads as the gradient of the ground decreased. These have been dated $>80,000 \pm 500$ yr B.P. to $<51,000 \pm 300$ yr B.P. (Shukla and Mujtaba 2015). Streams have cut rather wide and sharp channels characterized by 3700 ± 100 yr old terraces (Plate 3.1), more than 3 m above the stream beds.

Digital elevation model constructed from SRTM and ASTER satellite data, combined with fieldwork between Yamunā and Satluj rivers brought out a large, wide fan of gravelly deposits—earlier named as Terminal Fan (Mukherji 1976)—the surface of which dips southwards (gradient 20–30 cm/km) and characterized by *diverging abandoned palaeochannels of a river* (Srivastava et al. 2006). This unit shows highest drainage density anywhere in the Saraswati land. Within the tract of the frontal Siwālik range there are spectacular 30–100 m high vertical river-cut cliffs and the seasonal streams characterized by terraces (Chaudhuri 2008a). And in the immediate foothill belt there are several short and narrow incised seasonal water courses, the main one being the Sarsutī, the Mārkaṇḍa, the Dāngri, the Ghagghar and the Patiāli (Fig. 2.2).

A very remarkable feature of this belt is that the water-divide between the Gangā and the Sindhu does not coincide with the highest point of the interfluvies between the Yamunā and Satluj rivers—it is 15–93 km away to the west (Srivastava et al. 2013). It seems that the ground made up of southwestward-expanding alluvial fan and characterized by diverging drainage system is arched nearly 3 m up. The surface profiles (Srivastava et al. 2013) across this huge fan (Fig. 2.3) indicate that most of the seasonal streams have carved extraordinarily wide water courses, within which the active streams occupy narrow incised channels (Plate 3.1).

West of Ghagghar (Fig. 2.2), five wide dry channels, known as Patiāli, Wah, eastern Naiwāl, central Naiwāl and western Naiwāl, emerge from the point at Ropar—the point where the southward flowing Satluj River abruptly swerves west. And west of the Satluj in the area of the Beās–Rāvi interfluvies, 0.5–5 m thick layers of aeolian sands are intercalated with more than 150 m thick multicyclic sediments of the unit known as *Bhangar* in Indo-Gangetic Plains (Rubi and Punj 1997). The presence of aeolian sands in northern part of the western Indo-Gangetic Plains

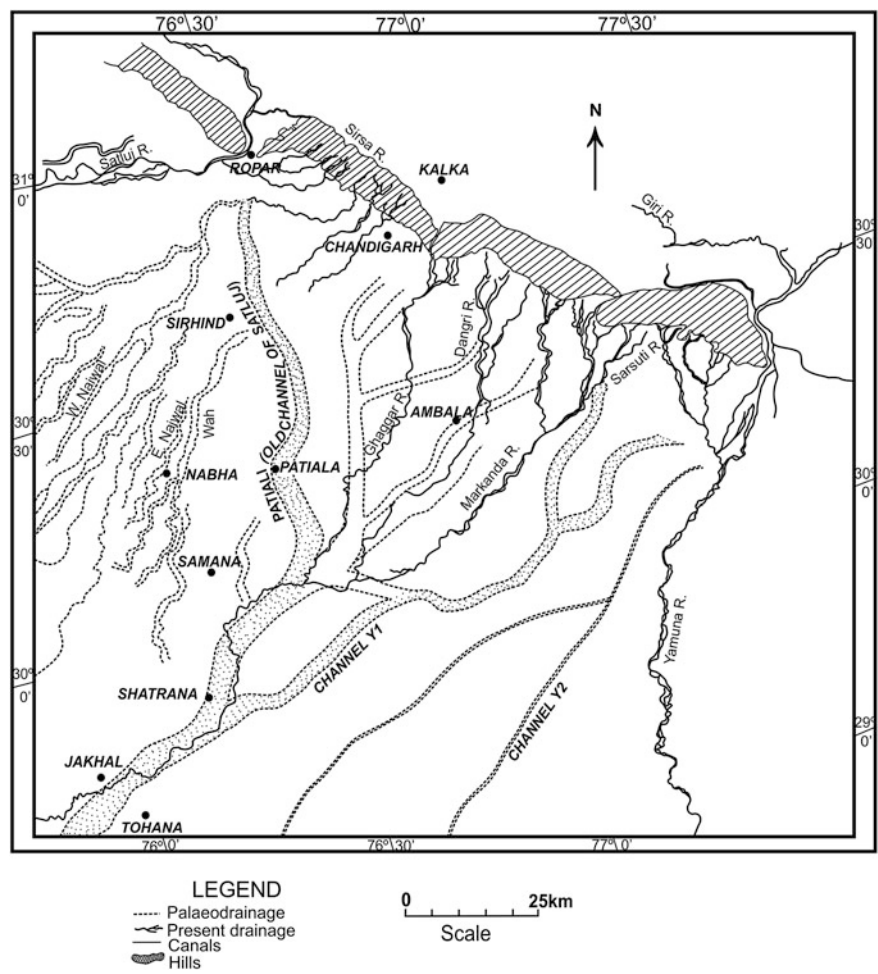


Fig. 2.2 Siwalik-born rivers and streams south of the Siwalik ranges. Most of these are ephemeral streams and associated with palaeochannels (After Yashpal et al. 1980)

implies the great sway of the dust storms that rise from the Thār Desert situated far to the southwest.

Floodplain in Middle Reaches

The floodplain (240–120 m above the sea level), through which the Ghaghara and its tributaries flow, gently slopes first southwards then westwards and finally southwestwards. In the Ambālā–Ludhiānā tract, the elevation is 240 m and then

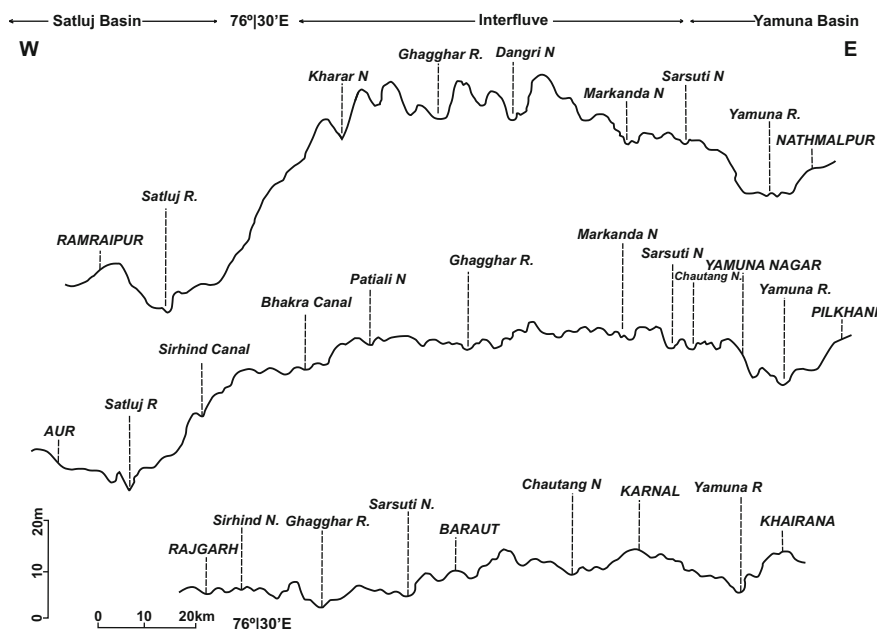


Fig. 2.3 Profiles across the large alluvial fan south of the Siwālik foothills show the wide water courses of seasonal streams and the narrow channels of active streams (vertical scale very much exaggerated) (After Srivastava et al. 2013)

progressively decreases to just a few metres above the sea level in the low-lying stretch of the Great Rann of Kachchh where the Nārā reach of the river ends (Plate 2.1, Fig. 2.1).

East of the Ghagghar basin is the NE–SW trending Arāvali front, the western foot belt of which is covered by discontinuous mantle of sediments derived from the hill ranges. In the Sirsā area there is a depressed tract—seven metres lower than the general elevation of the floodplain. The bluffs at Razābād and Bajika is indeed steep cliff that drops 7–8 m within a span of just 30 m. Not only the depressed ground, the Ghagghar channel in the Hisār–Sirsā tract is characterized by two paired fluvial terraces, respectively 10 and 3.5 m above the present river-bed (Singh et al. 1988). The higher terrace is more conspicuous. The terraces imply uplift of the ground through which the river flowed.

Downstream of Sirsā the river channel is 4–6 km wide. The northern limit of the floodplain is defined by a sharp palaeolake and the southern limit is buried under the aeolian deposit. Between Tohana and Ellenābād, there is a 2–10 km wide palaeochannel to the south of the Ghagghar (Saini et al. 2009).

Lower Reaches: Desert Terrain

West of the flat alluvial expanse, the land is covered by wind-blown sand heaped up as ridges and dunes. Varying in height from less than a metre to as much as 10 m, and in length a few metres to more than 5 km, the dunes are mostly of linear and parabolic shapes (Kar 1993, 2014a) forming long ridges as well as crescent-shaped mounds (Plate 2.5; Figs. 2.4 and 2.5). In addition to the dunes there are sand sheets of more than 5 m in thickness. The dunes and the sand sheets form the undulating landscape of the Thār Desert.

The sands of the desert represent sediments initially deposited by rivers, later churned and blown off by storms and swept away and heaped elsewhere (Fig. 2.5a). According to Dhir and Singhvi (2012) much of the Quaternary period in the Thār being arid, the oldest aeolian sand date nearly 200,000 yr B.P. Before the Last Glacial Maximum, the major emplacement of desert sands took place in four major

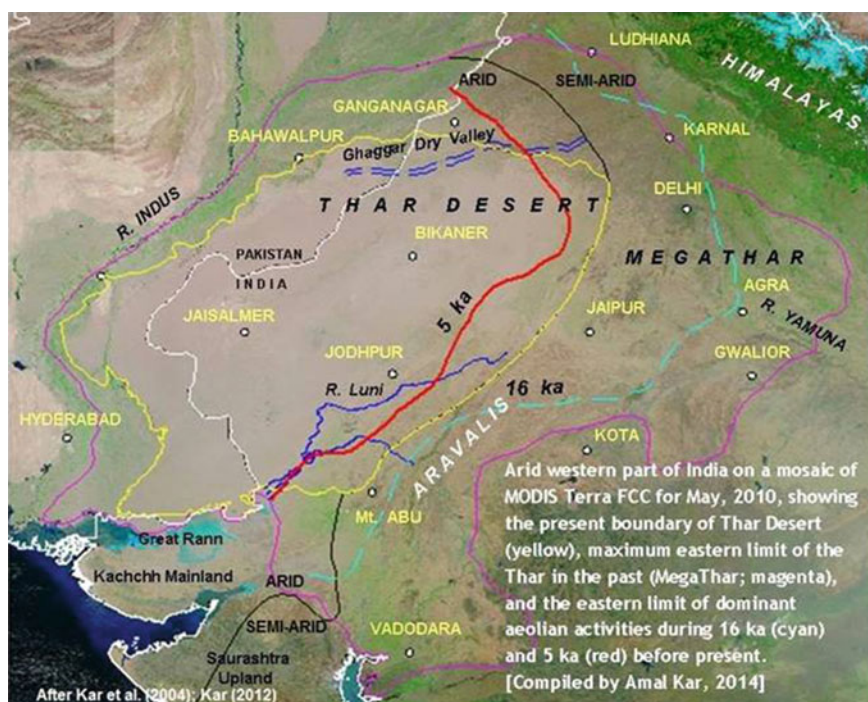


Plate 2.5 MODIS-Terra FCC of western part of the Indian subcontinent draped with the present Thār Desert (yellow boundary). The maximum eastern limit of the Thār in the past is shown by magenta line. The eastern limit of the dominant aeolian activities 16,000 years ago (red line) and of semi-arid region 5000 years ago (black line) (After Kar et al. 2004; Kar 2012)

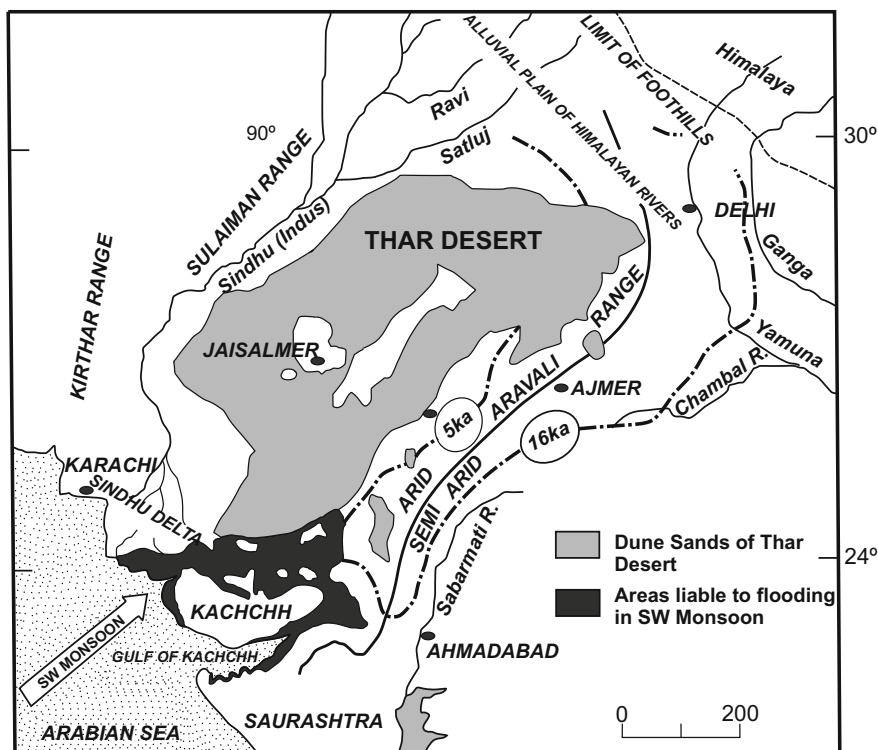


Fig. 2.4 Extent of the Thār Desert of sand-covered rocky terrain and sand dunes (From Dhir and Singhvi 2012)

phases—during 115,000–100,000 yr B.P., ~75,000 yr B.P., ~55,000 yr B.P., and between 33,000 and 2500 yr B.P. (Singhvi and Kar 2004). The Last Glacial Maximum (24,500–18,000 yr B.P.) was a period of feeble SW monsoon wind. The SW monsoon wind peaked up after the dune-building increased, especially between the intervals 16,000–10,000 yr B.P. and 14,000–10,000 yr B.P., Thār (Plate 2.5, Fig. 2.4) then expanded beyond its present limit. A period of higher monsoon rainfall followed, reaching the maximum during 7000–6000 yr B.P.; and after that aeolian activity was confined within the desert; particularly during 5000–3500 yr B.P. and 2000–8000 yr B.P. (Kar et al. 2004).

The huge mass of aeolian sands extends almost up to nearly the coast. In such a dreary land as this, the intermittent courses of the Ghagghar, the Hākrā, the Nārā become increasingly unclear. However, one can see the trace of the river where the dunes are less numerous (Flam 1993). The Hākrā course from Fort Abbās to Fort Derāwal is marked by a depression partially filled with sediments. Southeast of Fort Derāwal the Hākrā course is lost. A river that originated in the Great Himālaya (Himādri) and flowed with full force through the Ghagghar course all the way up to

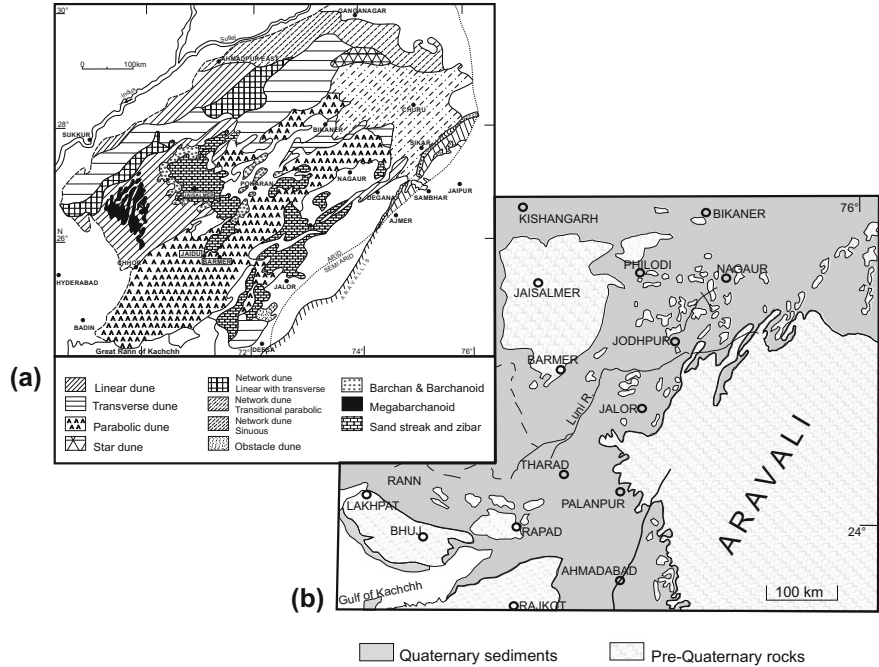


Fig. 2.5 **a** Types of sand dunes in the Thār Desert (After Kar 1996). **b** Lower reaches of the Saraswatī encompass inliers amidst sand of wind-worn Pre-Quaternary rock. *Broken lines* shows international boundary (After Bakliwal and Wadhawan 2003)

Cholistān (Pākistān) would not have abruptly ended (dried up) without flowing further downstream. There is no denying that the downstream reach is largely hidden under the pile of desert sands. However, the graphic descriptions given by explorers, engineers, geographers and archaeologists (Makeson 1844; Raverty 1892; Stein 1942; Mughal 1995; Panwar 1986) who worked extensively in that swathe of land (Cholistān and Sindh) provide credible account of the channel of the great river.

Analysis of aerial photographs and satellite imagery reveals existence of much older dysfunctional and disorganized drainage system in the Bīkāner–Jaisalmer region (Kar and Ghose 1984; Kar 1988; Ramasamy et al. 1991; Sahai 1997; Rajawat et al. 1999). By dysfunctional drainage it is meant that there are palaeochannels without flowing water and they form a network of complex drainage.

In western Rājasthān, there are inliers of worn out older rocks (including Precambrian) jutting out above the sandy waste of the *Marusthali* (desert) (Fig. 2.5b). East of the Thar Desert—in the rocky terrain between the foot of the

Arāvali and the Bikāner–Jaisalmer belt—there are numerous salt lakes and playas. The playas and salt-encrusted clay deposits represent the lakes that have dried up. These playas and salt lakes occur in a riverine domain, implying their origin to blockages in the courses of the once flowing river (Ghose 1964; Kar 1988, 1990).

Coastal Belt

The terminal point of the Ghagghar–Hākrā–Nārā (Saraswatī) is the flat expanse of the salt-impregnated, salt-encrusted, marshy land that is inundated by sea water during rainy season (Plate 2.6; Fig. 2.6). Known as the Great Rann of Kachchh, it is a sunken tract encroached upon by sea water, as evidenced by thick tidal sediments. It is believed that the floor of the Rann sank a number of times, the last time sometimes around 2500 yr B.P. when an earthquake happened in this region (Merh 2011). The sinking and rise of water level in the Rann of Kachchh is attributed also to sea level changes (Gaur et al. 2013; Mathur 2002). It seems that there was interesting interplay of land–sea relationship as transgression followed regression (Hashimi et al. 1995) and concomitant intermittent uplift of the landmass of Kachchh and sinking in the Rann region.



Plate 2.6 Satellite picture of the region where the Saraswati ends into the part of the sea today represented by the Great Rann of Kachchh. The Rann is flanked in the south by the island of Kachchh (Source Google Earth)

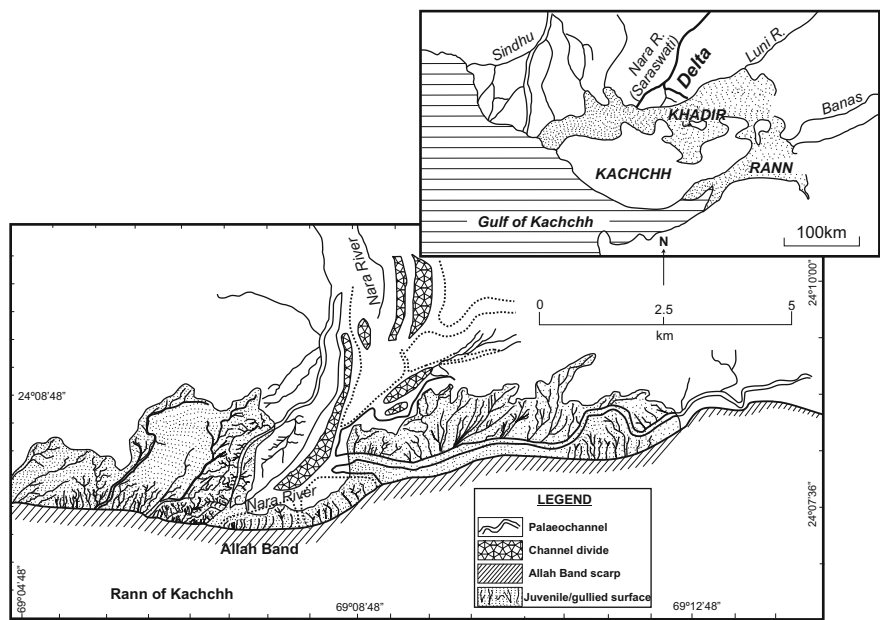


Fig. 2.6 Delta of the Nārā River—the terminal reach of the ancient Saraswatī—against the Allāhband high in the Great Rann of Kachchh (After Tyagi et al. 2012). *Inset* Deltas of three rivers that emptied into the Rann Sagār—the Rann that was once under sea water (from Ngangom et al. 2012)

The northern part of the Rann comprises three large deltas—the western one attributed to the Sindhu that then flowed into the depression (Flam 1993), the middle delta built by the Nārā (i.e., Hākrā, i.e., Ghagghar), and the eastern one by the Luni River (Fig. 2.6 inset and Plate 2.6), the Luni draining the southwestern flank of the Arāvali (Sharma and Bhadra 2012). It may be mentioned that quite many workers have concluded that the Rann of Kachchh is an extension of the Gulf of Kachchh—or an inlet of the Arabian Sea (Siveright 1907; Flam 1993).

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