
The Thar or the Great Indian Sand Desert

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Abstract

Located along the eastern margin of the vast Indo-Saharan hot arid belt the monsoon-driven Thar Desert has a dominantly sandy landscape, where a range of other landforms sculpted by the fluvial and aeolian processes are also found. Several fluctuations in climate between drier and wetter phases during the Quaternary period and periodic earth movements have decided about the type and intensity of geomorphic processes. Most of the landform assemblages are, therefore, polygenetic in nature and have interesting evolutionary history. Parabolic dunes cover the largest area in the Thar, while numerous ranns (playas) act as some major receptors of water and sediments. Presently the human activities are becoming a major driver of geomorphic process acceleration, resulting in significant modifications in the landforms and consequent implications for environment and livelihood both within and outside the desert.

Keywords

Landforms • Fluvial • Aeolian • Lacustrine • Quaternary • Climate change • Sand dunes • Tectonism • Human pressure

1 Introduction

The Thar Desert, or the Great Indian Sand Desert ($\sim 285,000 \text{ km}^2$), is situated in the arid western part of Rajasthan state in India and includes the adjoining sandy terrain of Pakistan till the Indus River. It forms a distinctive, but integral part of the arid lands of western India that runs through the states of Punjab, Haryana, Rajasthan and Gujarat (Fig. 1). The eastern limit of Thar Desert is defined by the moisture availability index (I_m , defined by India Meteorological Department as: $((P-PET)*100)/PET$, where P is precipitation and PET is potential evapo-transpiration) of -66.6 , which divides the arid from the semi-arid tract.

This boundary roughly passes through the foothills of the degraded Aravalli Hill Ranges through Rajasthan, which has the distinction of being one of the world's oldest mountains ($\sim 2500 \text{ Ma}$). In the west, the desert extends up to the fertile alluvial plains of the Indus River in Pakistan, beyond which the arid lands continue across West Asia and North Africa up to the Atlantic coast. In the south, the Thar boundary lies along the Great Rann of Kachchh and the sandy plain and fossil dune system of north Gujarat. The fossil dunes and other old dissected aeolian bedforms in the semi-arid tracts beyond the Thar mark its previous extension (i.e., Megathar; Fig. 2).

2 Landforms

Broadly, the basement for Quaternary sedimentation and landform development in Thar Desert was a vast pediplaned surface, composed largely of the Precambrian meta-sediments and igneous rocks in the east and gradually thickening

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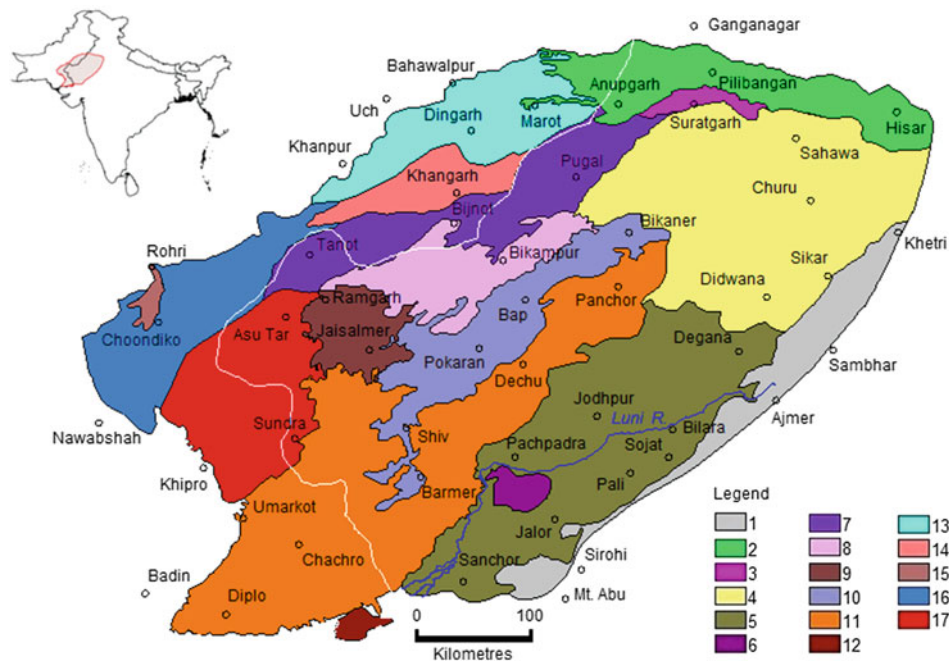


Fig. 1 Major geomorphic provinces in Thar Desert, with an emphasis on dune landscape. 1 Aravalli Hills with/without obstacle dunes, 2 Alluvial plain of N, 3 Star dune field of N, 4 Transitional parabolic dune field of NE, 5 Luni alluvial plain in S with isolated hills and colluvial plains, 6 Siwana Hills with obstacle dunes, 7 Transverse dune field of NW, 8 Parabolic dune field of NW, 9 Hamada landscape of

Jaisalmer with sand streaks and zibars, 10 Gravel pavements with isolated sand dunes and sand streaks, 11 Parabolic dune field of S, 12 Nagarparkar upland, 13 Saline alluvial plain of NW, 14 Transitional parabolic dune field of NW, 15 Rohri upland, 16 Network dune field of W, 17 Linear dune field with megabarchan fields in W. The white line across the map shows the boundary between India and Pakistan

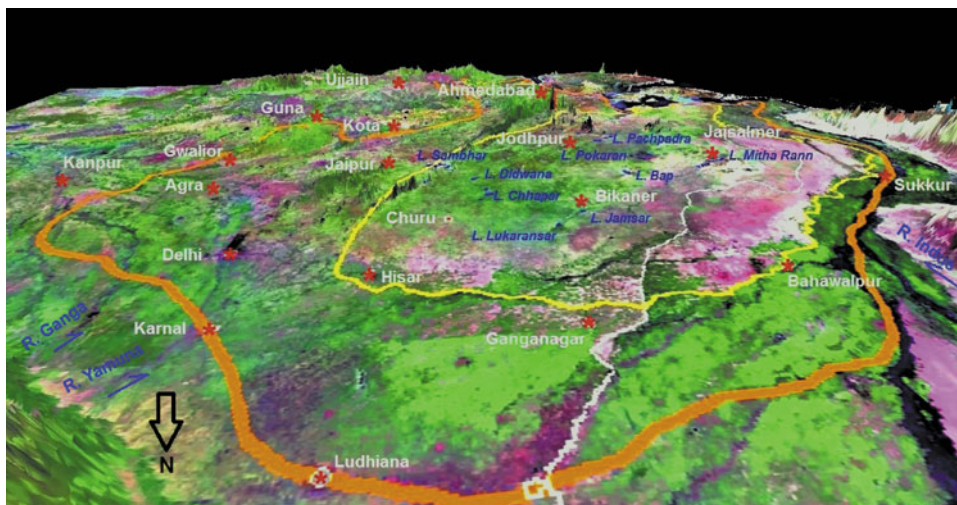


Fig. 2 Looking south into the Thar—Megathar Region. Thin yellow line demarcates Thar Desert. Thick saffron line demarcates Megathar. L (in blue) stands for major ranns (saline lakes). This 3D image is generated from Landsat TM and ETM + FCC mosaic of the region

(freely available from Global Land Cover Facility, University of Maryland, USA), draped over the SRTM DEMs (sourced from Global Land Cover Facility)

deposits of Mesozoic and Tertiary periods westward. Although most landform units have experienced interplay of different processes over time, it is possible to classify them according to the processes that dominated for a fairly long

period as fluvial, lacustrine and aeolian. The major geomorphic provinces are shown in Fig. 1, whereas the broad physiography of the region and location of some major saline lakes is provided in Fig. 2.

Fig. 3 A sandstone mesa with gravel-strewn pediment near Osian, north of Jodhpur



Fig. 4 Exfoliation dome of granite near Mt. Abu



2.1 Hills and Pediments

The major landform sequence is hills and uplands—rocky/gravelly pediments (and pavements)—buried pediments (colluvial plains)—flat older alluvial plains—younger alluvial plains—river beds. The hillslopes usually have a general paucity of debris. Concave and straight segments dominate over the convex segment. Lithological and structural variations are faithfully replicated in the slope configurations, as noticed in the cuestas and mesas (Fig. 3). The limestone hills (e.g. between Bilara and Sojat to the south of Jodhpur) have a much subdued topography with convexo-concave slope. Most granite hills (mostly in the southeast) have a convex outline due to exfoliation (Fig. 4). The rhyolite hills (mainly in the central part), on the other hand, have a craggy outline. Cavernous weathering that produces tafoni and alveolar relief along joints is dominant along many granite hills and some ferruginous sandstone hills. The Siwana Hills in south-central part, with circular arrangement of an outer rim of rhyolite peaks and inner bosses of granites and porphyries, are the remnants of a major Proterozoic volcanic cone (735–505 Ma) that collapsed due to cauldron subsidence after the ejection of magma, leaving a saucer-shaped caldera interspersed with granitic bosses (Kar 1995).

The pediments at the base of hills usually have a slope of $<4^\circ$, where the debris character is highly influenced by local lithology. Usually the pediment slope is concave, but joint-controlled weathering and erosion along the granite pediments produce a multi-convex profile. The piedmont angle is more pronounced on sandstone and granite, and the least on rhyolite. Some pediments in western part are formed over very old lithic calcretes (e.g., in Shiv-Barmer-Chohtan area). The long history of pediplanation in south-eastern Thar has left the remnants of many pediments on granite-gneiss as broadly convex and dissected gravelly surfaces without any trace of an adjacent hill (Kar 1995). A bevelled edge along many pediments with fringing gully networks suggests a phase of pediment regradation upon stream rejuvenation.

2.2 Desert Pavements and Hamadas

The desert pavements with a broadly convex outline occur mainly between Bikaner, Bap, Pokaran and Fatehgarh, where the surface is characterised by closely packed gravels and pebbles ($\sim 2\text{--}30$ cm size) in a matrix of fine sand and silt-sized particles. Large boulders are few. At many places the gravels have a gradational contact with a conglomerate bed of Lathi Sandstone (Jurassic), from which the loose

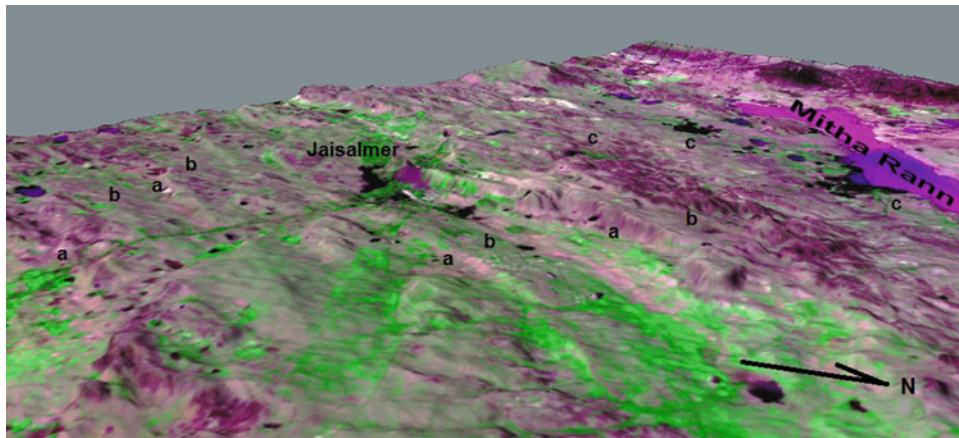


Fig. 5 Landsat ETM + FCC dated 19 September 2006, draped over SRTM data, to show the Hamada landscape around Jaisalmer. The major distinctive features are a series of steep SE-facing escarpments (*a*), each followed northwards by a gentle slope that faithfully follows the dip of the rock, and ends at the foot of another escarpment (*b*), thus forming a cuesta landform. A number of shallow ephemeral channels originating along the dip slope translocate rainwater and sediments towards the foot of the next escarpment. Traditional practice of the farmers is to regulate the flow along valleys through a series of anicut-

like structures, and also to prevent it from meeting the saline Rann (*c*). After the rains, as water percolates through soil, the conserved moisture is used for winter cropping of wheat, mustard, etc. This is called 'Khadin' cultivation. Greenery in the image is largely due to rejuvenation of range vegetation (*lighter tone*) and invasion of the aggressive mesquites, *Prosopis juliflora* (*dark tone*), but occasionally due to crops (*pearl millet*) also. *Black parallel strips* in far right are due to the skipping of pixels by ETM + sensor

gravels are derived, but at others (e.g. near Bap, Jayal and Kathoti, yielding a rich hoard of Palaeolithic artefacts) no such association is noticed.

In the non-sandy areas of the very dry western part the Tertiary and pre-Tertiary beds of sandstone, limestone and shale in Jaisalmer area with typical near-horizontal or gently north-westward-dipping disposition, have been sculpted into high level structural plains (or hamadas) and cuestas, bounded by steep southeast-facing escarpments. Usually, behind the escarpment a cuesta or a hogback is followed by a narrow gravel plain where ephemeral channels from the cuesta converge. Then a broadly convex and north-westward dipping rocky surface follows, the continuation of which is broken by another escarpment (Fig. 5). The hamadas on the Eocene Khuiyala and Bandah Limestone beds have some palaeo-karstic features like shallow dolines and sink holes (e.g., near Khinya; Kar 1995). A narrow arcuate belt of dissected ferricrete in the area (with subsequent calcretization at places) possibly demarcates the boundary of a Miocene coast under a warm and humid tropical climate, followed by post-Tertiary drier climates. The pavements and hamadas are replete with desert varnish, case hardening and box weathering features, as well as cleaved gravels and ventifacts that are often etched and grooved by aeolian sand blasting on limestone (Fig. 6). The shifting of coarse sand by wind across the rocky surface often creates numerous waves of closely-spaced 1–2 m high sandy bedforms that are called zibars.



Fig. 6 Etched and grooved limestone formed due to aeolian sand blasting on a hamada surface near Jaisalmer

2.3 Colluvial and Alluvial Plains

Down the slope from pediments and pavements, the buried pediments/colluvial plains are composed of heterogeneous sediments. The thickness is more than a few meters near the Aravalli Hills, but decreases gradually westward where it varies from 30 to 100 cm. The flat older alluvial plains occur downslope of the colluvial plains, and are usually characterized by zones of illuviated soft nodular kankar, or

gypsum at 30–300 cm depth within the sand and alluvium. Often these are followed down the profile by alternate sequences of aeolian and fluvial sediments, and sometimes lacustrine beds, which are followed further down by hard and compact carbonates/fluvial gravels resting on basement rocks. These plains are widely distributed in the south-east, but also form the base of dune landscape in most parts of the desert. The alluvial stratigraphy provides clues to interesting history of the early drainage systems from the Himalaya and the Aravalli Hills, as well as the changing depositional environment with time (Kar and Ghose 1984). The younger alluvial plains occur downslope of the older alluvial plains, especially as narrow stripes along the major ephemeral channels, including the Luni and its tributaries in the southern Thar and the Ghaggar in northern Thar. The sandy alluvium of the unit gets periodically replenished by floods, making them the most fertile areas for cultivation.

2.4 Ranns (Playas)

A number of inland ranns (ephemeral playa lakes), with a flat salt-encrusted surface that get inundated during monsoon rains, are found within the desert. The largest among these is the Sambhar Lake ($\sim 293 \text{ km}^2$; 32 km E–W; 17 km N–S) along the eastern fringe, followed by Bap ($\sim 51 \text{ km}^2$) in the western part, whereas other notable ones with approx. sizes of 21–30 km^2 are at Pachpadra, Thob, Chhappar, Sanwarla, Mitha Rann, Kanodwala Rann, and those below 20 km^2 size at Didwana, Sujangarh, Parihara, Lunkaransar, Jamsar, Rakhi, Bassi, Kandara, Pokaran, Lawan, Redana, etc. Some of these are associated with an ephemeral stream network (e.g., Pachpadra, Thob), but several have been formed in the lee of high hills through deflation and capturing of an ephemeral stream into the resultant depressions by the hill-margin dunes (e.g., at Didwana and Chhappar in E; Redana in W), or through a long period of etching and grooving of the softer rocks (e.g., Mitha Rann and Kanodwala Rann in Jaisalmer area). Some of the ranns have a distinct neotectonic connection (e.g., Sambhar Lake; Rakhi, Bassi and Kandara along an E–W lineament in S) (Kar 1990, 1995). Most of the ranns are used for commercial salts or gypsum production.

2.5 Aeolian Bedforms

The dominant landforms in the Thar Desert are the aeolian bedforms, especially sand dunes and interdune plains, and the low sandy hummocks and sand sheets on the vast plains. Presently the strong pre-monsoon summer winds from the southwest and the west are mostly responsible for dune-building. Over the millennia enormous quantity of medium

to fine sand and silt has been brought into the region and its western fringes through the Indus and the Satluj River systems, with the Himalayan provenances, and enough has also been produced locally through sub-aerial processes and contributions from the Aravalli provenances, which get recycled several times to construct the aeolian landforms.

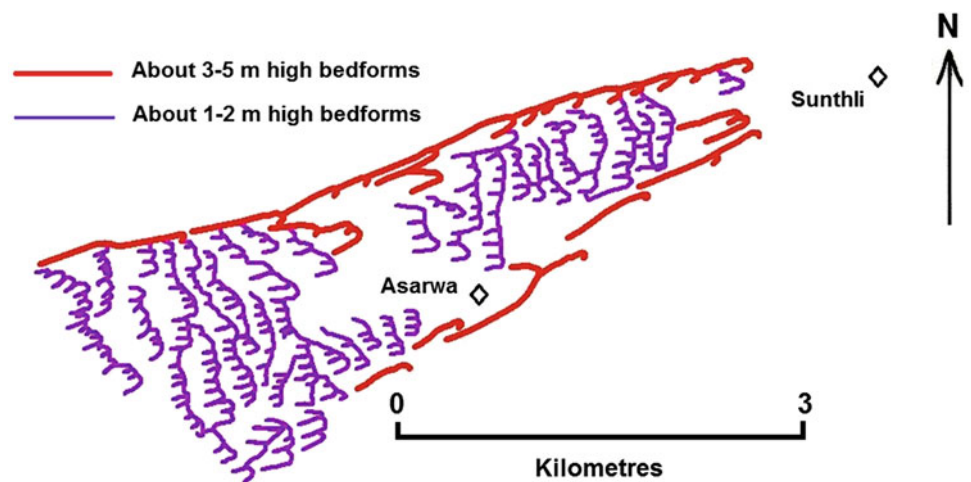
The sand dunes could be broadly classified as ‘old’ and the ‘new’ dunes, where the old ones with an average height of 15–30 m are mostly the partly stabilized and vegetated parabolic, linear, transverse, star, network and major obstacle dunes. Most of these old dunes occur in coalescing chains. Parabolic dunes cover the largest area, and their shape reflects the changing wind strength from southwest to northeast. In the southwest, where the wind strength is high, the dune chains usually occur in hair-pin and chevron patterns with 3–5 km long arms that join together at sharp angles. As the wind strength gradually declines in the central and the northern parts, the arms become shorter (~ 0.5 – 1.0 km in the northeast), and the sharp junction is replaced by a curved nose (Fig. 7). Further downwind, as the wind strength becomes feeble along the fringe of the desert the parabolics transit into two major kinds of network dunes: (a) compound hooked dunes with linear and transverse forms to the right-hand side of the main dune arm (when looking downwind; Fig. 8), and (b) a wide, long-arm parabolic form with small network pattern within it (Fig. 9; Kar 1993). The linear dunes occur mainly in the western part of the Thar, especially in Jaisalmer-Tharparkar region, and are broadly oriented SW–NE, i.e., in the direction of wind (Fig. 10). The dunes were earlier thought to have originated from parabolic dunes, but studies since then traced their origins from streams of barchans in the high wind energy zone in the west (Fig. 11), and from lee vortices behind major obstructions, or along major stream valleys through funnelling effect (Kar 1987). The dunes are characterised by a broadly convex summit. The length varies from more than 10 km in the extreme west of the field to 1–2 km in the east. The high transverse dunes occur mainly in the NW part and were formed astride the path of sand-laden wind (Fig. 12). Linked star dunes of 15–35 m height occur in a narrow strip along the northern margin of the Thar (Fig. 13). Simple and compound obstacle dunes have been formed on the windward and leeward sides of the hills. The dunes are highly dissected by rills and gullies, especially along the eastern margin of the desert (Fig. 14).

Apart from the old dunes, numerous fields of new dunes also exist within the desert, especially in the high wind energy regime of the west, where fields of 1–8 m high barchans and 20–40 m high compound megabarchans form under natural settings (Fig. 15). Elsewhere within the desert high human pressure on the semi-stabilized old dunes and sandy plains are accelerating the aeolian process, leading to

Fig. 7 Google Earth image of a typical parabolic dune cluster near Bafrau in the central part of Thar Desert, showing *a* semi-stabilized/reactivated arms of old dunes; *b* deflation hollows in the wake of the dunes; and *c* formation of new aeolian bedforms downwind

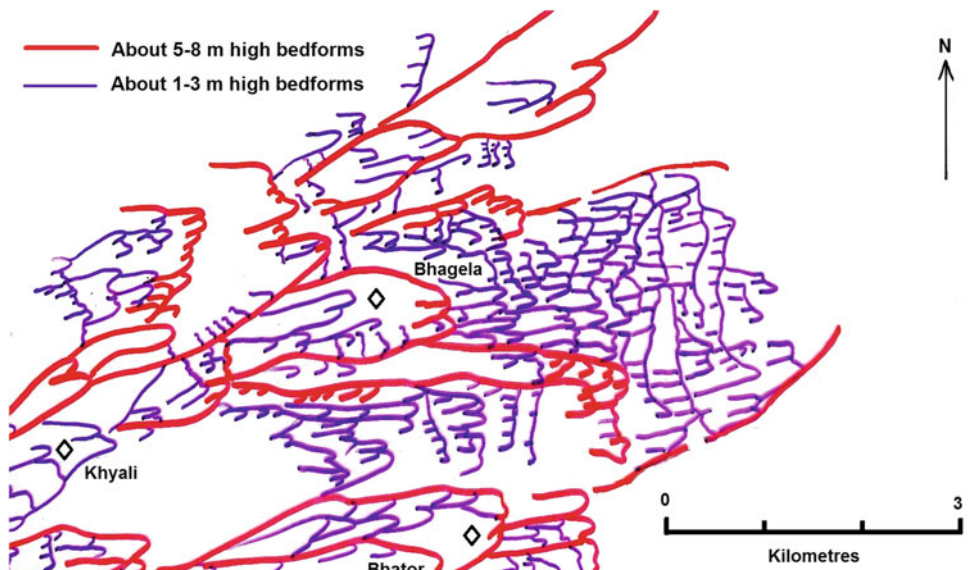


Fig. 8 Outline of compound hooked dunes with low transverse bedforms to the right-hand side near Didwana. Dominant wind is from SW during summer months



Based on visual interpretation of Landsat TM FCC of 147-040, dated 18 January, 1986

Fig. 9 Outline of the wide, long-arm parabolic bedforms with small network dunes within them near Churu



Based on visual interpretation of Landsat TM FCC of 147-040, dated 18 January, 1986

Fig. 10 Google Earth image of 6–10 m high linear dunes near Bersiyala (SW of Jaisalmer), with *a* Y-junctions, and *b* small feathers on left flank. When reactivated, the dunes crests are infested by a chain of crescentic bedforms (*c*). Dominant wind is from SSW during summer months

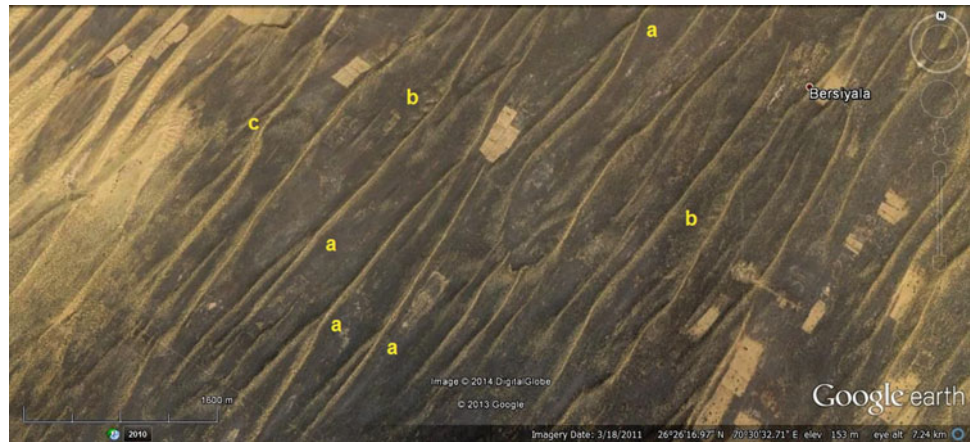
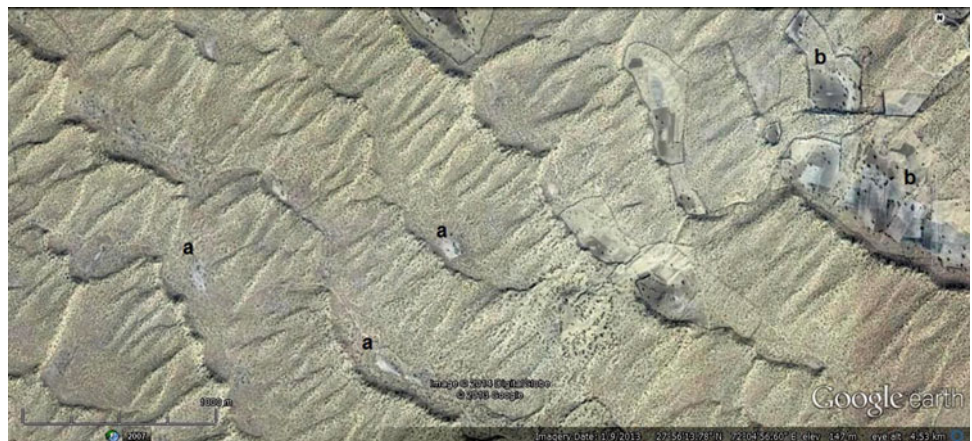


Fig. 11 Google Earth image of 1–2 m high new linearly-arranged bedforms (*a*), being formed to the NW of Bersiyala through chains of barchans downwind of the older, semi-stabilized linear dunes



Fig. 12 Google Earth image of 18–25 m high transverse dune chains to the west of Bikaner, with narrow interdune plains where strong deflation has exposed the subsurface gypsum layer (*a*). Some of the interdunes are now irrigated (*b*) by the Indira Gandhi Canal network



either advancement of the arms of old dunes or formation of new bedforms as barchans, sand streaks or nebkhas (Fig. 16), which ultimately evolve into the dominant bedform type that triggers their origin and growth. Examples of such sand reactivation abound near the settlements and in areas of deep ploughing.

3 Evolutionary History

Antiquity of Thar Desert is enigmatic, but stratigraphic records bear testimony of fluctuating arid to humid climate from as early as late Jurassic (as carbonaceous, near-shore

Fig. 13 Google Earth image of 12–20 m high linked star dunes to the SE of Suratgarh. The peaks occur at major nodes of the dune arms (*a*)



Fig. 14 Stabilized old obstacle dunes (*background*) and thick sandy plains (*foreground*) dissected by gullies along the margin of the Thar Desert near Jaipur. The sand profile often shows a faint hint of palaeosol formation nearer the surface, and yields medium to large calcified plant roots below, suggesting antiquity of the edifices



Fig. 15 A field of 20–30 m high megabarchans with tiers of smaller barchans to the SW of Asu Tar during winter when the sharp NE-facing slip face is replaced by a much-rounded crest due to wind blowing from NE direction



aeolian sand beds of Bhadasar Sandstone, impregnated with case-hardened and ferricreted nodules), to the early Quaternary (as ferruginous sandstone of Shumar formation, duricrusted calcrete pediments of Barmer area, widespread gypsum/halite beds, etc.) as the Indian landmass drifted northwards and monsoon climate evolved. Discovery of the wide, dry bed of the Ghaggar River in the northern fringe of the Thar as that of the legendary Saraswati River from the Himalaya, and establishment of the contribution of a major Himalayan river, the Satluj, in its survival (Oldham 1893),

provided the initial clues to the role of climate change and tectonism in the desert landscape evolution. Studies since then have established the role of some large, now-extinct stream networks in construction of the thick sandy alluvial plains. Notable among these was the Saraswati-Drishadvati River system, which used to be nourished by the snowfed Satluj and the Yamuna Rivers at different periods of time between 10 and 60 ka BP or beyond, especially during the vigorous monsoon phases (Ghose et al. 1979; Kar and Ghose 1984; Clift et al. 2012). The ephemeral Luni River system



Fig. 16 A typical shrub-coppice dune, or Nebkha, associated with a clump of 3 m high *Capparis decidua* plants near Pokaran. Usually these dunes attain a height to length ratio of 1:7 to 1:10 during the period of strong summer wind from SW. The ratio gradually decreases

after the monsoon (July–September) as the SW wind is gradually replaced by the weaker NE wind, and by winter the Nebkhas are reduced to small humps around the bushes

from the Aravalli Hills is now the only surviving system in the south-east where several of its tributaries are becoming defunct and partially buried under aeolian sand (e.g., the Lik, the Jojri), but periodic floods sometimes revive them (e.g., floods during 1979, 1991 and 2006).

Observation of several Quaternary sequences suggests widespread occurrence of alternate fluvial and aeolian activities across the desert, the lacustrine and fluvio-lacustrine deposits being noticed in some favoured locations only. Radiocarbon and luminescence dating of some sequences provided a chronology of events within the limits of those methods (typically ~ 0.5 –150 ka) for late Quaternary period (Singh et al. 1974; Singhvi and Kar 2004). Electron Spin Resonance (ESR) dating of calcretes provided dates of ~ 100 ka, but the process of calcretization homogenises a range of previous depositional environments, often making it difficult to filter the original environments out of the mass. Since the dated sequences are few and landscape variability large, the history of dominantly fluvial, aeolian and lacustrine events summarized below is provided with a caution that the dates and the deduced environments may be considered as a broad first-level framework, and not as definitive region-wide phenomena.

3.1 Fluvial Sequences

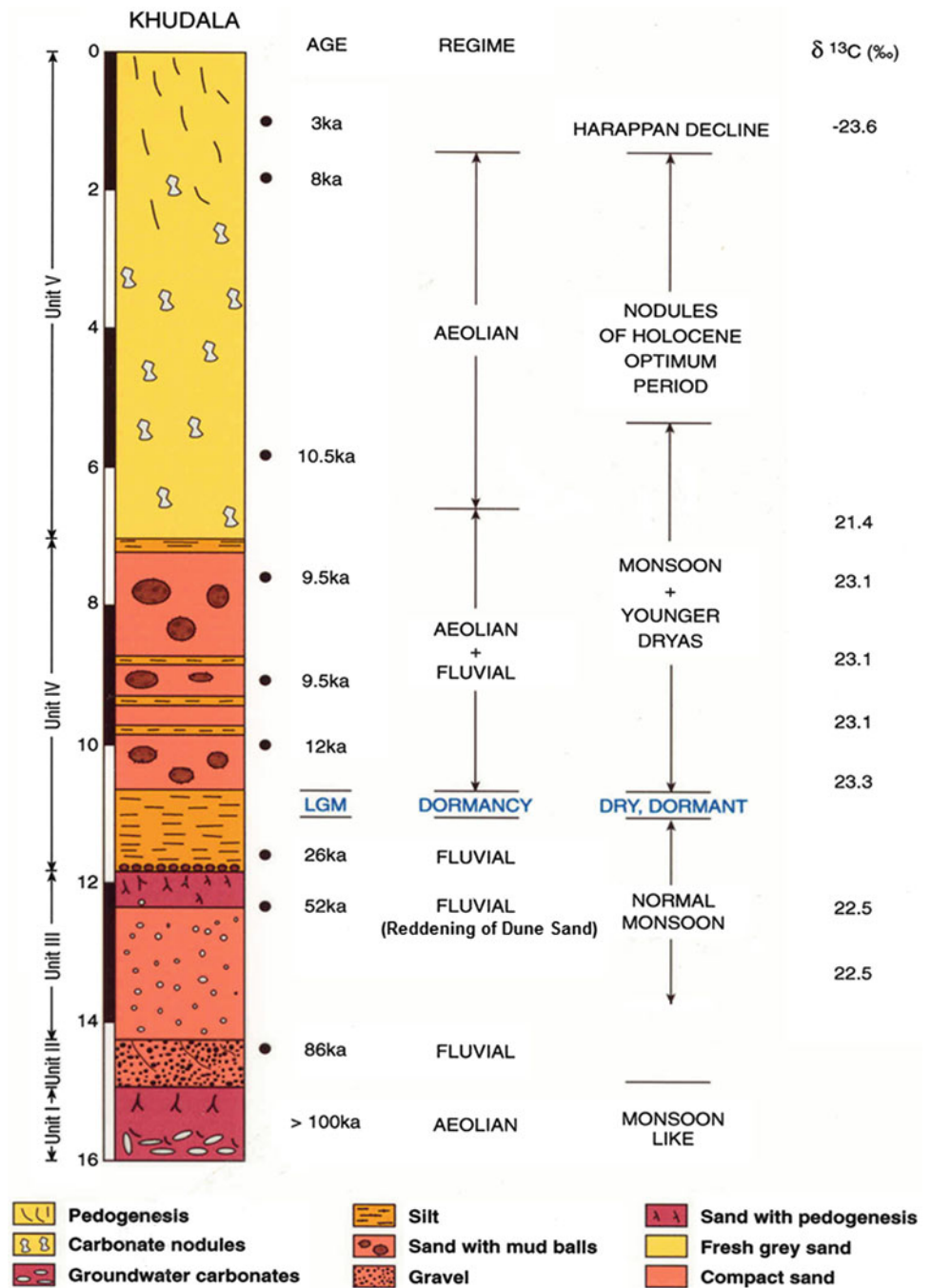
Stratigraphic records suggest that the beginning of the Quaternary period in the desert might have been marked by a wetter climate with high-intensity rainfall that was responsible for basal gravels and conglomerates. Pre-Quaternary aeolian deposits, if any, were either washed away by repeated floods and/or were admixed with fluvial deposits and became calcretized. A somewhat consistent chronology of fluvial deposition could be framed for the lower part of the Luni River only, between Tilwara and Khudala, where the major pluvial periods were: ~ 80 –90 ka, ~ 55 ka,

~ 30 ka and 7–6 ka (Kar et al. 2001; Bajpai 2004; Jain et al. 2005), possibly yielding more frequent monsoon season flows along the ephemeral sand-bed stream networks. The pluvial peaks were followed along their rising and falling arms by significant aeolian activities as wind strength responsible for the vigorous monsoon continued beyond the peak phases. The Last Glacial Maximum (LGM; 24–18 ka) perhaps witnessed the driest phase during the last 100 ka as monsoon circulation receded. A tectonic event intervened at ~ 10 ka when a post-LGM, semi-viscous, fluvio-lacustrine deposit of sand-silt at Khudala (Fig. 17) was shaken vigorously to form oblong mud balls and tilted. Older fluvial records from the region are beyond the conventional dating range, but suggest a high-energy braided stream system in a subsiding basin under a strong monsoon regime during Pliocene (Jain et al. 2005). Analysis of several slack-water flood deposits along a tributary junction with the Luni in its gorge section near Tilwara revealed many monsoon-driven high magnitude floods during 0.5–1.0 ka period (i.e., Medieval Warming), which became less frequent during 0.4–0.2 ka, the Little Ice Age (Kale et al. 2000).

3.2 Aeolian Sequences

Dating of sediments from a number of dune sections across the Thar and its eastern margin suggests that the aeolian history is at least 160 ka old (Singhvi and Kar 2004; Dhir et al. 2010). The major periods of enhanced sand mobilization were 100–115 ka, ~ 75 ka, ~ 50 ka, 30–25 ka and 14–7 ka, when aeolian deposition took place even beyond the present Thar boundary (i.e., into the Megathar). Each of these episodes was followed by a period of relative landscape stability. The stability after the ~ 75 ka flux was perhaps associated with a period of sustained monsoon rainfall and strong seasonality, as attested by reddening of sediments (Kar et al. 2001; Singhvi and Kar 1992; 2004). The main driving force

Fig. 17 Generalized late Quaternary sedimentary sequence at Khudala (25° 21' 55'' N, 71° 48' 38'' E), Luni River, with approximate age and interpreted environment (modified after Kar et al. 2001)



for aeolian activities all through was the SW monsoon. Contrary to popular view, the LGM was not a period of high aeolian activities because the SW monsoon was weak. Also, no significant aeolian activities were noticed in the Megathar region after the post-LGM aeolian peak of 14–7 ka. After this, significant aeolian activities were recorded only from within the desert at 5.0–3.5 ka, and 2.0–0.6 ka. The latest phase of sand mobility in the desert started around 0.3 ka, when the rates of dune mobility and sand accretion began to surpass the geological rates due to increasing human pressure (Kar et al. 1998).

3.3 Lacustrine Sequences

Analysis of sediments from several ranns within the desert suggested a hyper-saline condition in most of them during the LGM, and till ~13 ka, when the summer monsoon got re-established and the freshwater conditions started dominating over the dry and hyper-saline conditions, especially in the ranns in the east and the north-west. The Climatic Optimum helped most lakes to receive a sustained and higher freshwater inflow by 7.5–6.0 ka, but a decreasing trend was noticed from about 5 ka (Singh et al. 1974). The ranns to the

west of the present 200 mm isohyet appeared to have been much less affected by such shifts in the monsoon behaviour, as the rainfall pattern did not change appreciably. The present ephemeral condition of the ranns under a shifting climate between wet and dry phases was established from 3 ka in the east, and from 6 ka in the west (Singhvi and Kale 2009).

4 Human Impact

Thar Desert is one of the world's most thickly populated arid regions with a density of human population of $\sim 110 \text{ km}^{-2}$, and livestock population of $\sim 120 \text{ km}^{-2}$. While the livestock population has doubled over the last five decades, human population has registered a four-fold increase. To cater to the needs of these increasing populations, especially for cropping, wood collection and grazing, significant land use decisions have been taken by the stakeholders with environmental consequences. This includes deep tractor-ploughing of the sandy plains across the desert, as well as of the sand dunes and sandy hummocks that earlier used to function as either rangelands or as long fallows, replacement of the traditional agro-forestry-cum-land fallow system that used to provide food and fodder especially during droughts, with cropping alone with/without irrigation, and un-regulated use of the pastures for fuelwood collection and grazing. Since the landforms are in a very fragile state due to climatic and terrain constraints, such activities are increasing the erosion risk, sediment mobility and degradation of land quality. Many of the semi-stabilized old dunes have become highly reactivated and are advancing to newer areas, while new barchans are forming in parts of the sandy plains where none existed earlier. Gully erosion is increasing in the groundwater-irrigated old sandy plains and obstacle dune slopes along the eastern margin of the desert, while water-logging and salinization is spreading in the palaeochannel-dominated canal-command areas. Falling groundwater level and higher input cost of irrigated agriculture along the eastern margin of the Thar is compelling many farmers to switch back to rainfed farming, but the semi-stabilized sandy landscape that was levelled previously for irrigated farming and was denuded of natural vegetation, is becoming more prone to sand reactivation. The net result is a gradual increase in the dust load in the atmosphere, which when viewed in the context of global warming, may get enhanced further and significantly modify the monsoon behaviour over Indian subcontinent (Bollasina et al. 2011). Indeed, the scale at which the changes are taking place, the landscape of the region is perhaps transiting gradually from the Holocene to Anthropocene! It is, therefore, necessary that land use decisions and land management in the region are based on proper understanding of the land forming processes and their vulnerability to induced pressures.

5 Conclusions

Landforms in the Thar Desert have evolved through a fairly long period of interplay between fluvial and aeolian processes, especially during the Quaternary period, but periodic tectonic activities have also played a crucial role. Broadly, the base mosaic of hill/upland—pediment—coluvial plain—alluvial plain—river sequence has been acted upon by the contemporary processes under a dominantly dry but fluctuating climate such that the aeolian processes and a variety of aeolian bedforms are now most dominant, modifying or burying many fluvial landforms, but also aiding the formation of some playas. The stability of most landforms in the current era of Anthropocene depends largely on their resource use potentials and robustness in the face of ill-managed human exploitation. As human pressure is accelerating the geomorphic processes, the fertile and otherwise usable agricultural lands, both within the desert and along its wetter margins, are becoming more threatened. Unless appropriate policy interventions are made early towards the use of land the consequences may prove disastrous under a warmer climate.

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