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DATASET ON MAPPING AND MORPHOMETRY OF SAND DUNES IN NUBRA AND SHYOK VALLEYS, LADAKH HIMALAYA, INDIA

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ABSTRACT

Ladakh Himalaya is a cold desert having an average height of more than 3000 m above mean sea level. The Nubra and Shyok are the two prominent valleys located in the Ladakh Himalaya, India. During the course of field traverses clusters of many sand dunes have been observed along the courses of Nubra and Shyok Rivers. However, sand dune occurrences are restricted to certain parts along the courses of both the rivers. For example, sand dunes tend to occur in and around the granitic suite of rocks. XRD of sediments suggests that these granites are the provenance of these sand dunes. Results of mapping and morphometric studies suggest that the formation of sand dunes in the Nubra and Shyok Valleys are mainly controlled by surrounding rocks coupled with various geomorphic processes, viz., fluvial, glacial and aeolian. Among these geomorphic processes, aeolian agent appeared to have played major role in formation of sand dunes. This study deals with mapping and morphometry of these sand dunes located in both the valleys.

KEYWORDS: Sanddunes, Sand Dunes in India, Nubra and Shyok Valleys, Cold Desert, Ladakh, India

Various geomorphic processes such as aeolian, fluvial and glacial has significant role in modifying landscapes and shaping the surface of the earth on local to regional scales (Derbyshire and Owen, 2017). Further, the interaction among aeolian, fluvial and glacial processes can significantly modified earth surface morphology. Globally, various researchers have also identified the importance of fluvial and aeolian interactions, but there is limited work to understand these interactions and the associated evolution of landscapes (Liu, 2015, 2005) (Bullard, 2002, 2003).

The Quaternary basin of Ladakh Himalaya is composed predominantly of sediments having lacustrine, fluvial and glacial origins. Tectonics and prevailing climatic conditions are known to have played an important role in the formation of these basins (Bagati and Thakur, 1993).

The dominance of aeolian process over other processes is apparent in these areas, which is revealed by occurrences of several patches of sand dunes in the Nubra Valley and Shyok Valley during field traverses. Sand dunes occur in clusters along the courses of Nubra and Shyok Rivers. Their occurrences are restricted to selected parts along the course of both the rivers. These dunes have variable shapes and sizes. The results of mapping and morphometric studies on sand dunes are presented in this article involving extensive field work and use of google earth images.

LOCATION OF STUDY AREA

Nubra and Shyok Valleys are located in Ladakh Himalaya. The area is located in tectonically active zone. The Nubra Valley is a tri-armed valley located to the north east of Diskit town (Figure 1). The River Nubra forming the

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Nubra valley is a tributary of the Shyok River, which drains the Nubra region of Leh and finally joins Indus River in the east of Skardu in Pakistan. The Nubra River joins Shyok River which bifurcates into a large valley that distinguishes the Karakoram ranges from Leh. The Shyok River, a tributary of the Indus River, originates from the Rimo Glacier, one of the tongues of Siachen Glacier.

Figure 1: Location of Nubra and Shyok sand dunes on satellite image (Google Earth)

In fact, the Nubra and Shyok valleys represent high altitude cold desert regions with rare records of precipitation and scanty vegetation, except at some sporadic places which supports green cover along river beds.

MATERIALS AND METHODS

Mapping and Morphometry of Sand Dunes

Detailed morphological mapping of sand dunes (SD) of both the valleys were done using global positioning system (GPS) and by taking critical field traverses along and across the sand dune bodies during two consecutive years, i.e., 2016 & 2017. For marking locations of SD, GPS was used, whereas for detailed mapping of SD, Google earth image and its tools were used. The various parameters of SD, namely, length, breath, height and perimeter, were worked outseparately for both the Nubra and Shyok valleys. The identification and morphometric studies of SD carried out at various locations along the Nubra and Shyok Valleys are shown in Figure 1, and their details are given in Table 1. The patches where SD were studied are named as N1, N2, S1, S2, S3 and S4 (Table 1). The classification of SD was done by following the guidelines given by Lancaster (2001) and Hatano and Hatano (2001).

Bulk Mineralogy

X-ray diffraction (XRD) technique was used to study the mineralogy of sand dunes for deciphering the probable source rock. For this purpose, sands from sand dunes were collected by removing the upper surface from the depth of half feet.

Table 1: Locations of patches of sand dunes along Nubra and Shyok valleys

Patch	Latitude	Longitude	Place/River
N1	34°36'20.62"N	77°36'26.79"E	Along Nubra River, Nubra Valley
N2	34°34'40.89"N	77°37'11.56"E	Along Nubra River, Nubra Valley
S1	34°34'41.43"N	77°30'6.24"E	Along Shyok River
S2	34°33'53.65"N	77°30'0.51"E	Along Shyok River
S3	34°41'48.01"N	77°17'22.71"E	Along Shyok River
S4	34°42'11.65"N	77°15'21.15"E	Along Shyok River

RESULTS AND DISCUSSION

Sand Dunes Along the Nubra River

The SD were observed at two places, i.e., N1 and N2 (Figure 2). The morphometric parameters of sand dunes, measured by Google Image, are given in Table 2 and Table 3. The length of sand dunes at N1, where they occur in clusters, ranges from 8.54 to 49.44 m and breath from 17.55 to 367.47 m, while their height ranges from 0.33 to 29 m (Table 2). At N2, only one longitudinal sand dune was observed having 388.69 m length, 1245.77 m width and 32.8 m height (Table 3).

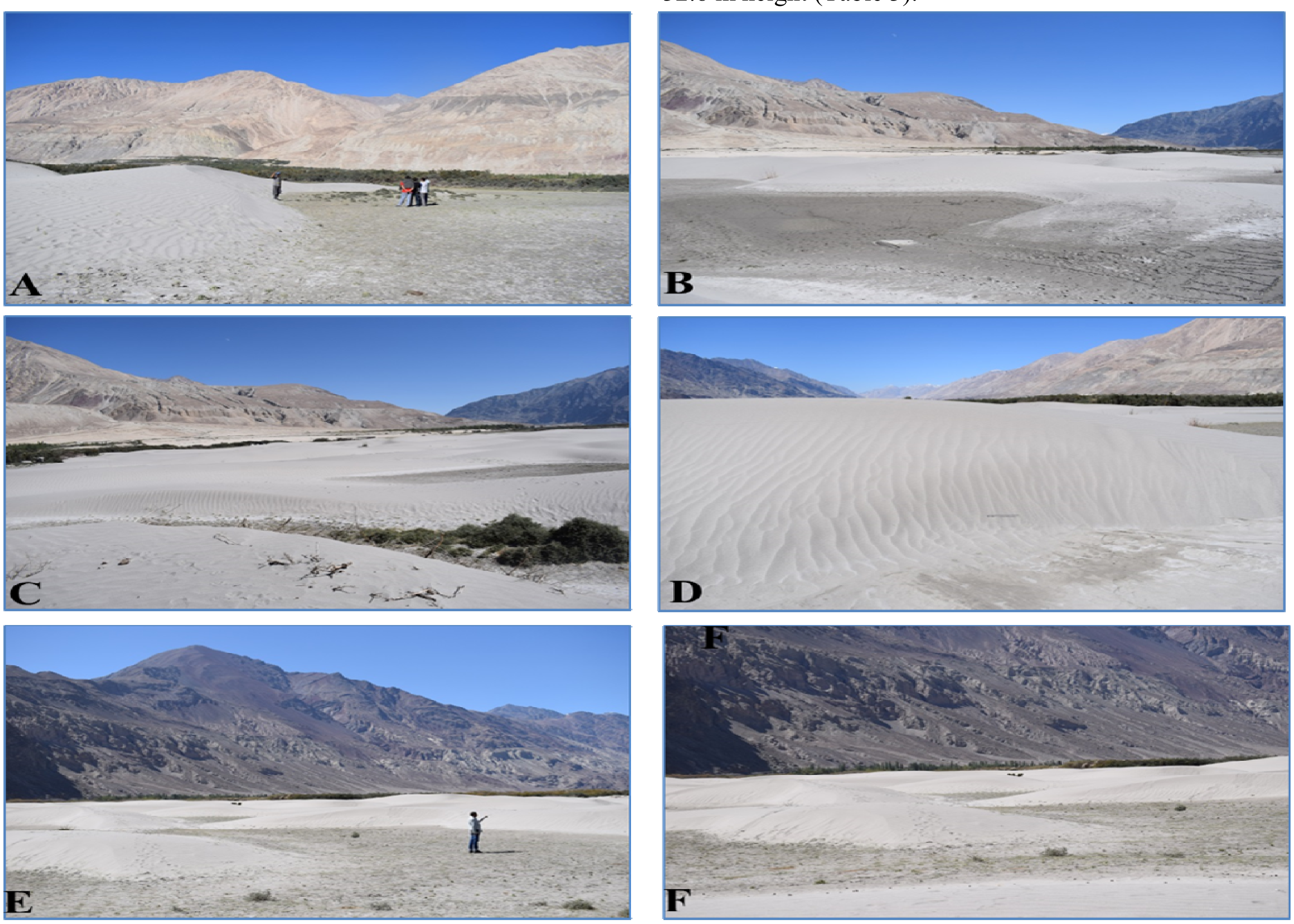

Figure 2: Sand Dunes along Nubra River (A) Morphologically crescent shape. with well defined leeward direction (B) Barchanoid Sand Dunes (C) Barchnoid Sand Dunes (D) Wind Ripple Marks on Sand Dunes (E) Sand Carpating in foot hills (F) Various Barchanoid Sand Dunes

Table 2: Morphometric data of sand dunes observed along Nubra Valley at N1

Sl. No.	Length (m)	Wridth (m)	Height (m)	Area (Sq m)	Perimeter (m)	Type
1	14.8	20.64	0.33	191	57	Disturbed Barchan due to River
2	12.2	21.72	1.33	211	60	Disturbed Barchan due to River
3	8.99	21.24	3.67	168	50	Disturbed Barchan due to River
4	11.04	37.63	2.00	386	91	Barchan
5	9.75	25.74	1.00	218	66	Barchan
6	12.05	66.98	10.67	725	173	Barchanoid
7	24.82	69.94	10.00	920	175	Barchanoid
8	11.62	17.55	0.67	164	48	Disturbed Barchan due to River
9	8.54	18.1	0.67	135	46	Disturbed Barchan due to River
10	20.73	65.92	4.00	837	153	Disturbed Barchan due to River and Man Activities
11	12.52	101.01	16.33	1209	224	Barchanoid
12	13.69	57.59	3.67	677	130	Barchanoid
13	11.03	51.69	2.67	557	132	Barchanoid
14	20.65	198.65	22.67	2,757	455	Barchanoid
15	15.42	83.68	13.33	1229	205	Barchanoid
16	11.51	58.87	4.67	589	148	Barchanoid
17	49.44	60.33	19.67	2,082	255	Barchanoid
18	15.77	173.71	23.00	2,276	395	Barchanoid
19	12.17	48.73	23.00	649	131	Barchanoid
20	23.04	257.34	23.00	3,812	584	Barchanoid
21	17.06	180.88	23.67	3,296	444	Barchanoid
22	21.27	70.51	20.00	994	168	Barchanoid
23	16.62	65.15	8.67	793	157	Barchanoid
24	45.69	50.62	16.33	1333	205	Barchanoid
25	17.46	51.12	11.67	606	135	Barchanoid
26	13.03	61.64	17.67	849	156	Barchanoid
27	26.71	258.57	24.67	4,161	600	Barchanoid
28	20.91	220.74	25.00	4,050	504	Barchanoid
29	14.18	81.35	21.33	974	197	Barchanoid
30	34	286.98	29.00	4,573	702	Barchanoid
31	15.25	62.26	23.67	691	149	Barchanoid
32	26.88	367.47	25.00	5,567	859	Barchanoid affected by Vegetation Cover
33	33.91	242.8	28.00	4,349	597	Barchanoid
34	25.12	202.17	22.00	3,781	492	Barchanoid
35	13.82	51.65	21.33	647	128	Barchanoid
36	15.32	121.18	20.67	1,548	266	Barchanoid
37	20.03	343.36	17.33	6,429	799	Barchanoid
38	19.7	118.64	15.00	1,303	254	Barchanoid
39	29.47	141.92	10.67	2,122	333	Barchanoid

Table 3: N2, Second Sand Dunes Patch along Nubra River

Sr. No.	Length (m)	Wridth (m)	Height (m)	Area (Sq m)	Perimeter (m)	Type
1	388.69	1245.77	32.80	347,885	2,761	LINEAR/DISTURBED

Table 4: S1 Sand dunes Patch along Shyok River

Sr. No.	Length (m)	Wridth in (m)	Height (m)	Area (Sq m)	Perimeter (m)	Type
1	231.05	279.72	9.00	27,403	924	Barchanoid Type
2	199.18	362.2	15.67	34,508	1,058	Barchanoid Type
3	222.37	438.02	16.00	36,718	1,294	Barchanoid Type
4	64.1	459.56	39.33	32,412	1,183	Barchanoid Type
5	112.91	393.52	51.33	28,142	1,008	Barchanoid Type
6	127.03	404.15	34.00	39,322	1,132	Barchanoid Type
7	79.17	449.77	34.00	37,145	1,197	Barchanoid Type
8	85.7	180.17	6.67	12,035	484	Barchanoid Type
9	94.06	466.96	5.33	30,704	1,208	Barchanoid Type
10	68.32	157.51	6.00	7,733	422	Barchanoid Type
11	70.52	215.64	13.00	11,367	554	Barchanoid Type
12	165.57	391.87	11.33	32,157	1130	Barchanoid Type
13	177.68	898.89	11.00	69,913	2194	Barchanoid Type
14	235.12	409.58	7.00	91,409	1,555	Barchanoid Type
15	199.84	1910.27	15.67	247,239	4,512	Barchanoid Type
16	91.83	1424.09	11.00	128,692	3,543	Barchanoid Type
17	121.02	369.39	7.67	28,142	930	Barchanoid Type
18	95.35	443.23	8.67	28,846	1,116	Barchanoid Type
19	106.93	875.99	11.33	53,947	2,191	Barchanoid Type
20	86.62	679.93	9.33	46,497	1,657	Barchanoid Type
21	68.12	128.43	6.00	5,312	375	Barchanoid Type
22	83.09	142.37	7.00	5,417	410	Barchanoid Type
23	60.24	464.27	20.05	36,852	1,396	Barchanoid Type
24	108.99	400.14	9.33	35,559	1,136	Barchanoid Type
25	58.25	217.45	12.00	11,302	604	Barchanoid Type
26	77.62	215.57	13.67	15,547	643	Barchanoid Type
27	72.74	158.35	11.00	12,532	522	Barchanoid Type
28	121.52	816.05	14.67	77,847	2,071	Barchanoid Type
29	72.51	482.41	15.67	31,676	1,153	Barchanoid Type
30	31.34	235.8	10.67	6,755	551	Barchanoid Type
31	71.98	389.74	17.67	19,664	889	Barchanoid Type

Sand Dunes along the Shyok River in Hunder

The SD were studied in four patches, named S1, S2, S3 and S4, in Hunder area along the Shyok River. The length of SD in Hunder area ranges from 14.44 m to 232.12 m, breadth 46.28 to 1910.27 m and height 1.33 to 51.33m. In another place along the Shyok River, SD are located in three patches and all are barchanoid type (Table 4, 5, 6 & 7).

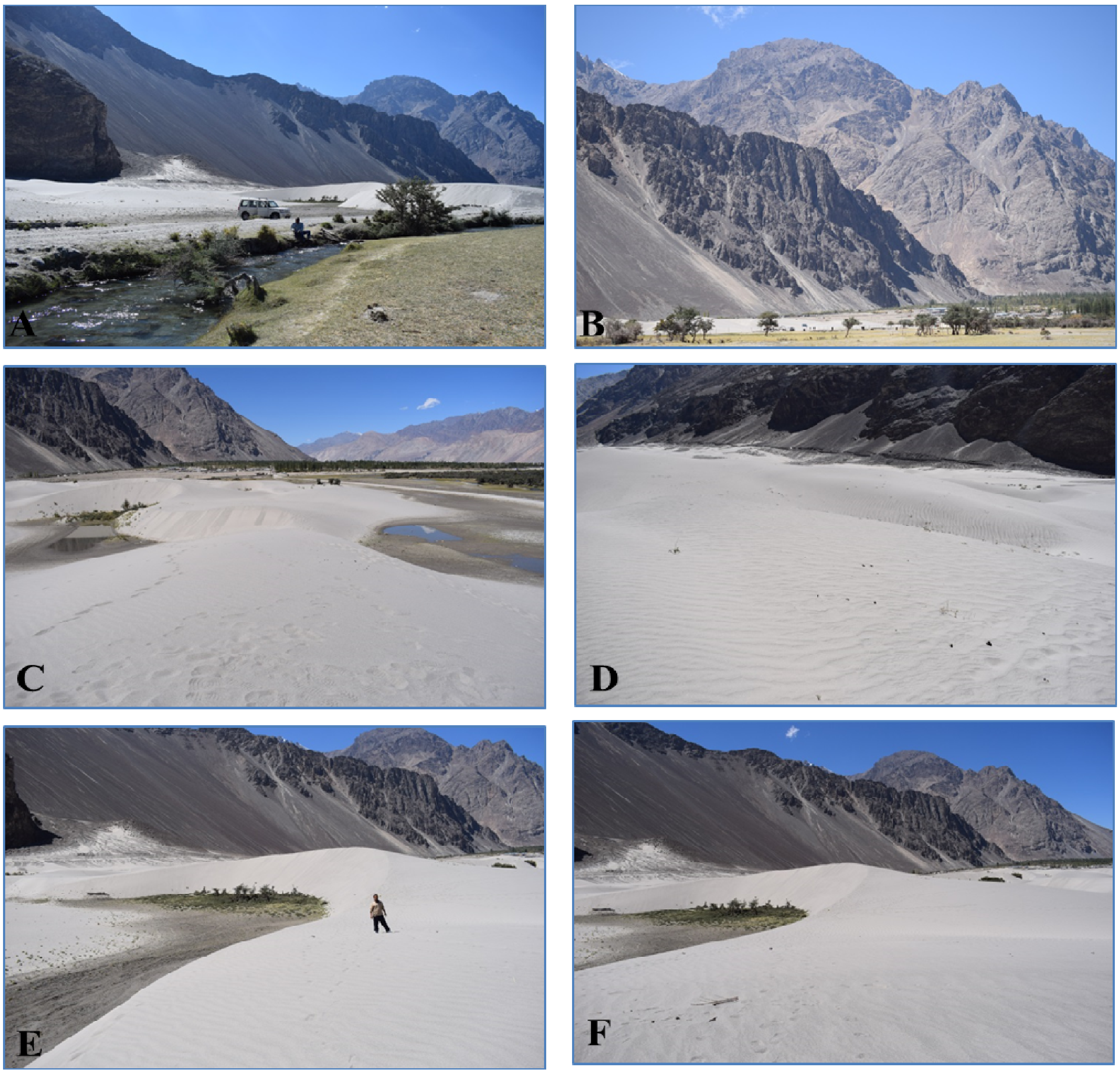

Figure 3: Sand Dunes in Hunder Area (A) Sand dune carpeting bounded by hill slope and stream course. (B) Sand Dunes covered with Vegetation (C) Sand Dunes with inter sandunal lakes (D) Sand dunes showing ripple marks. (E) Typical barchanoid type sand dunes (F) Sharp edges though margin blunt in Barchanoid

Table 5: S2 Sand Dunes patch along Shyok River

Sr. No.	Length (m)	Wridth (m)	Height (m)	Area (Sq m)	Perimeter (m)	Type
1	115.38	247.97	10.90	23,043	666	Barchanoid Type
2	81.19	326.64	10.50	21,714	812	Barchanoid Type
3	70.71	438.28	19.50	31,944	1,060	Barchanoid Type
4	62	148.17	25.77	6,454	361	Barchanoid Type
5	84.42	433.8	23.60	31,193	1,087	Barchanoid Type
6	79.26	486.08	25.79	32,503	1247	Barchanoid Type
7	72.09	227.57	18.20	15,541	657	Barchanoid Type
8	44.81	217.2	14.37	9,191	530	Barchanoid Type
9	42.69	412.4	13.70	29,107	1,076	Barchanoid Type
10	56.28	409.55	42.00	26,373	1,082	Barchanoid Type
11	145.63	459.91	24.20	48,591	1,382	Barchanoid Type
12	29.89	185.44	13.07	4,949	429	Barchanoid Type
13	50.71	97.71	5.67	3,033	235	Barchanoid Type
14	90.68	194.94	24.67	11,785	578	Barchanoid Type
15	65.36	376.72	29.00	26,199	1,020	Barchanoid Type
16	77.49	503.48	11.33	40,899	1,444	Barchanoid Type
17	68.72	1055.72	5.00	75,259	2,501	Barchanoid Type
18	77.22	371.77	17.33	23,487	949	Barchanoid Type
19	42.49	81.98	1.49	2,859	236	Barchanoid Type
20	34.59	139.77	6.33	5,400	378	Barchanoid Type
21	34.52	144.75	9.33	3,469	346	Barchanoid Type
22	41.37	146.49	23.00	4,881	453	Barchanoid Type
23	32.92	110.46	20.20	3,236	292	Barchanoid Type
24	81.33	218.14	14.00	16,279	660	Barchanoid Type
25	24.15	239.16	19.00	7,195	551	Barchanoid Type
26	121.09	679.73	28.70	53,929	1,604	Barchanoid Type
27	94.46	569.45	34.33	42,759	1,414	Barchanoid Type
28	68.47	170.91	32.00	8,577	414	Barchanoid Type
29	58.69	233.11	40.00	9,133	541	Barchanoid Type
30	19.84	64.46	47.33	842	146	Barchanoid Type
31	21.54	46.28	30.87	666	116	Barchanoid Type
32	26.33	64.41	43.33	1,124	153	Barchanoid Type
33	31.67	75.58	20.67	1,704	185	Barchanoid Type
34	34.65	177.95	7.13	2,743	398	Barchanoid Type
35	35	187.19	45.00	7,495	480	Barchanoid Type
36	28.54	117.11	36.33	2,893	289	Barchanoid Type
37	14.44	110.79	23.17	1,990	280	Barchanoid Type
38	30.74	88.53	20.37	2,061	229	Barchanoid Type

Table 6: S3 Sand Dunes Patch along Shyok River

Sr. No.	Length (m)	Wridth in (m)	Height (ft)	Area (Sq m)	Perimeter (m)	Type
1	47.93	52.34	1.33	2,898	224	Barchan Type
2	40.79	61.9	8.00	1,835	189	Barchan Type
3	48.31	53.32	6.00	2141	193	Barchan Type
4	72.24	101.35	6.67	3,238	273	Barchan Type

Table 7: S4 Sand Dunes Patch along Shyok River. The dunes presented in Table 7 are highly disturbed but we classified them in brachanoid type

Sr. No.	Length (m)	Wridth in (m)	Height (ft)	Area (Sq m)	Perimeter (m)	Type
1	132.55	127.94	3.33	7,402	459	Barchan Type
2	104	105	8.33	6,911	388	Barchan Type
3	187.28	200.34	5.00	17342	661	Barchand Type
4	113.51	98.69	3.00	7,016	349	Barchan Type

Three geomorphic processes, viz. glacial, fluvial and aeolian, appears to have played key role in formation of SD in river beds of the Ladakh area. However, abundance of wind-generated ripple marks reveals dominance of aeolian action in genesis of SD. In fact, the presence of Barchans type of SD suggests that wind was mostly unidirectional during formation of barchans dunes in the area (Hatano and Hatano, 2001) (Figure 2 and 3). Barchans type of SD are formed where there is a limited supply of sand, having flat ground, in which wind blows in one direction (Pidwirny, 2015). As merging of two or more barchans were commonly seen, barchans of the area have been categorized as barchanoid type of sand dunes (Tables 2 and 4). Wherever their morphology has been obliterated by river actions their shape is disturbed. Longitudinal dunes are rarely observed in the area. However, morphology of longitudinal dunes suggests that their formation may be related to multidirectional wind regime.

The carpeting of sand in the hill slope may be linked with funneling of winds towards lower section of hill ranges, swiping sand along with them and dropping with subsidence when they hit hill leading to sand carpeting of the varying thickness in hill slopes. It was also observed that the majority of dunes are present in the vicinity of granitic terrain, which may be due to supply of sands from such rocks. This is further supported by mineralogy through XRD studies. The XRD of sediments suggests quartz is the dominant phase followed by feldspar, biotite and chlorite, with occasional hornblende and heavy mineral assemblage of zircon, rutile, sphene and ilmenite. This mineral assemblage is more akin to granitic suite of rocks. Therefore lithology of sand dunes appears to be controlled by litho units of the region, especially granitic rocks. Thus, in a nutshell, results of this study suggest that the formation of sand dunes in the Ladakh area is controlled by lithology and geomorphic agents, with dominance of aeolian processes relative to fluvial and glacial processes.

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