Proc. Indian natn. Sci. Acad., **55**, A, No. 3, 1989, pp. 578-583.

FINE SAND MINERALOGY OF SOILS ON DIFFERENT LAND FORMS OF ARID RAJASTHAN

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(*Received 14 June 1988*; *Accepted 29 July 1988*)

Fine sand fraction of soils on sand dune, interdunal plain, alluvial plains of varying texture, and peni-plain of arid region of Rajasthan was studied for the mineralogy and to know the sources of these sediments. Quartz was a predominant mineral followed by orthoclase, plagioclase and microcline in light mineral fraction. The heavy mineral fraction comprised chlorite, monazite, zircon, garnet, tourmaline, mica, kyanite and iron ore minerals. The order of dominance of minerals remained similar in light fraction, whereas the order was different for heavy fraction of different land forms. Minerals profile suggests that sediments are not from igneous and metamorphic rocks existing in the region but of pre-exisiting alluvium of these rocks and are of more than one cycle of transformation and deposition.

Key Words : Land Forms; Arid Region; Soils Mineralogy; Source

INTRODUCTION

AGGRADED alluvial plains and dune field are the dominant land forms in arid region of Rajasthan. The alluvial plains were formed in past humid period of quaternary by well integrated drainage system[1] whereas dunes, sandy plains and inland basins were created by intense aeolian activity during the prolonged arid phase of the pre-Holocene period.[2] Pareek[3] considered that desert sands are : (*a*) brought from a distant source not resembling the rock formation around, (*b*) from weathered outcrops, transported by winds to different places and (*c*) from weathering zone of underlying *in situ* rocks. Wadia[4] observed that the sands of the dunes have been transported from the Rann of Kutch whereas Gupta,[5] based on mineralogy of sands, hypothesized that these were derived from the vast depositional basin within the area. Singh[6] considered their origin from the weathering of local rocks, whereas Dhir *et al.*[7] attributed it to the breakdown of light-textured materials. The present study was, therefore, undertaken to find out the mineralogy of fine sand fraction of the soils on different landforms of arid Rajasthan to establish the source of these sediments.

MATERIALS AND METHODS

The study area, which is a pleistocene alluvial plain, lies between 27 °N and 25° 45 °N latitude and between 72° and 73°55 'E longitude, covering part of Jodhpur, Nagour and Pali districts of Rajasthan. The major part of the plain was transformed by the wind action of late quaternary to duny complex. This picture is interrupted by the outcrops of upper vindhyan sandstone and limestone, Pre-cambarian granites and rhyolites and Aravallis slates and quartzite. The dunes, interdunal plains, alluvial plains, piedmont plain, hills and plateaux are the dominant land forms which are covered by variety of soils.

Profile pit on each of the dominant land form (Table I) was excavated and samples from different depths were collected. Sand fraction was separated out after removing $CaCO_3$, oxides and organic matter.[8] Dry sands were sieved and 0.10 to 0.25mm size fraction, which was dominant, was taken for the mineralogical studies.

TABLE I

Sites and associated characteristics

Major landform	Lithology of rock exposures	Landform unit	Parent material	Soil name
A. Dune field	Manlani Ryolites	(*A*) Coalerled Parabolic dune	Aeolian	Dune
		(*B*) Interdune	Aeolian	Shergarh
B. Alluvial plain (*i*) Coarse textured	Vindhyan sandstone	(*A*) Hummocky plain	Older alluvium partially reworked by wind	Chirai-hummocky
		(*B*) Flat plain	Distant old alluvium	Chirai
(*ii*) Medium textured	(*a*) Limestone	Accumulative upland	Local alluvium	Gajsinghpura
	(*b*) Jalore-Granite	Flat plain	Local alluvium	Pipar
(*iii*) Fine textured	Phyllite of slate	Flat plain	Local alluvium overslate	Pali
C. Peniplain	Vindhyon fine grained sandstone	Denudational surface	Weathering sandstone	Palaripichkia

Ten gram dried sand was suspended in 'Bromoform' (sp. gravity 2.86) in a conical shaped separator funnel in order to obtain light and heavy minerals. Both the fractions were washed with acetone and then dried and weighed.

Slides were prepared with Canada balsam and grains were studied under both ordinary and polarized transmitted light. The frequency distribution of minerals was obtained by counting them from a mechanical counter fitted on the microscope stage.

RESULTS AND DISCUSSION

Morphology of the Minerals

Microscopic study reveals that quartz occur in two forms, i.e., as weathered subrounded to rounded and fresh grains which are polygonal and angular. The surfaces of quartz grains are devoid of dissolution features. Orthoclase is subrounded to rounded, few grains were fragmented and weathered and exhibited pitted appearance, whereas plagioclase is mostly fractured and weathered. Mica grains are elongated and serrated, whereas biotite grains show reddish brown to dark reddish brown colour and are highly pleochroic. Chlorite particles are tiny, flat flakes with characteristic chlorophyll green colour. Granets are pink to reddish brown with subconchoidal fractures. Monazite is typically rounded, spherical and greenish yellow in colour, whereas zircon is thin, needle-like elongated crystals. Tourmaline occurs as elongated with greyish brown crystals whereas kyanite appears splintery and angular.

Mineralogical Composition

Soils of the dune and interdunal plains are highly sandy (88 to 97 per cent sand), comprising (76 to 92 per cent fine sand). The sorting coefficients (1.10 to 1.38) indicate moderately well-sorted nature of the sediments. Light mineral fraction (95 per cent in dune and 98 per cent) in interduned of fine and is predominated by quartz, followed by *ortho*-clase, plagioclase and microcline minerals (Table II). The heavy fraction, which is 5 per cent in dune and only 2 per cent

TABLE II

Mineralogiacl composition of fine sand fraction (light minerals)

Land form	Depth (cm)	LM (%)	Quartz	Orthoclase	Plagioclase	Microcline
Dune	0-50	94	52	43	5	1
	100-150	95	52	44	4	1
	200-250	95	52	44	5	1
Interdunal	0-30	98	57	39	4	1
	66-120	98	57	39	4	1
	120-150	98	57	39	4	1
Hummocky plain	0-10	94	61	32	5	1
	10-35	94	58	35	5	1
	35-68	95	50	37	7	1
	95-135	96	54	36	7	3
Coarse textured plain	0-15	92	52	32	6	1
	40-70	96	50	37	6	1
	370-440	95	51	38	8	3
Medium textured (Limestone)	0-20	99	67	29	3	1
	30-46	99	74	22	1	3
	78-110	99	67	30	3	—
Medium textured (Granite)	0-12	97	65	32	3	—
	28-48	98	64	31	5	1
	65-105	98	65	27	6	1
Fine textured (Slate region)	0-10	96	61	31	5	2
	10-20	98	63	31	4	2
	20-35	98	63	32	4	1
	35-60	98	64	31	3	2
Peniplain (Sandstone)	0-10	99	68	26	2	3
	10-30	98	65	29	3	3
	30-50	99	63	30	4	3
	60-80	99	53	31	9	6

interdunal sands, comprises chlorite, zircon, opaque, garnet, monazite, kyanite and mica minerals in order of dominance (Table III). The mineral assemblage shows that the soils of dune land form of Rajasthan are different from those of Punjab and Haryana,[9] where fine sand contains tourmaline and kyanite as predominant minerals.

TABLE III

Mineralogical composition of heavy fraction of fine sand

Land form	Depth (cm)	HM %	Mica	Chlorite	Garnet	Monazite	Tourmaline	Zircon	Kyanite	Opaque
Dune	0–50	6	4	35	9	5	2	31	3	15
	100–150	5	4	34	9	5	1	30	3	15
	200–250	5	4	35	9	5	2	31	2	15
Interdunal	0–30	2	4	31	6	6	—	37	5	11
	66–120	3	4	31	6	6	—	38	5	12
	120–150	2	4	30	5	7	—	37	5	12
Hummocky plain	0–10	6	9	24	12	20	2	19	4	10
	10–35	6	9	24	13	22	4	19	3	8
	35–68	5	8	24	14	20	4	18	3	8
	95–135	4	4	30	12	20	2	22	3	4
Coarse textured	0–15	8	9	24	12	20	2	28	3	8
	30–46	4	8	30	15	21	3	35	3	9
	370–440	5	2	28	9	9	—	28	3	20
Medium textured (Limestone)	0–20	1	4	25	11	23	2	29	4	3
	30–46	1	2	34	11	22	2	26	2	4
	78–110	1	5	34	6	24	1	24	1	5
Medium textured (Granite)	0–12	3	—	33	12	11	—	37	3	4
	28–48	2	—	29	14	12	—	32	6	8
	65–105	2	—	27	11	8	—	33	5	15
Fine textured (Slate)	0–10	4	4	27	9	6	—	35	3	16
	10–20	2	3	30	8	6	—	35	3	15
	20–35	2	1	33	8	4	—	34	4	17
	35–60	2	1	32	8	5	—	36	4	16
Peniplain (Sandstone)	0–10	2	1	33	9	15	2	38	1	1
	10–30	2	1	32	8	16	2	39	2	2
	30–50	1	1	32	6	16	1	39	3	1
	60–80	1	0	26	7	10	1	25	—	31

Fine sand fraction of coarse-textured alluvial plain constitutes 55 to 67 per cent of the total sand. The sorting coefficients (1.32 to 1.50) show that the sediments are moderately sorted. The light mineral fraction (92 to 97 per cent) comprises quartz, feldspars and microcline (Table II), whereas heavies show different assemblages in the plain. Zircon, chlorite, opaque, mica, garnet, monazite and kyanite minerals are present in fine sands of alluvial plain, whereas hummocky plain sands consists of chlorite, zircon, monazite, garnet, opaque, mica, kyanite and tourmaline minerals (Table III).

Medium to fine textured soils of the plains contain 50 to 60 per cent sand but sediments are poorly sorted, as shown by high sorting coefficients (2 to 2.85). Light fraction (95 to 99 per cent), comprises minerals similar to dune field or to coarse-textured plains but the content of quartz shows an increase with depth and that of feldspars a decrease. This indicates weathering of feldspar minerals after deposition. Chlorite, zircon, monazite, garnet, opaque, mica, kyanite and tourmaline are present in sands of limestone region soils whereas zircon, chlorite, garnet, monazite, opaque, kyanite and mica are present in granite region sands.

Soils of phyllite and slate regions (Table I), although fine in texture, contain 18 to 32 per cent sand and are dominated by the fine sand fraction. The sediments are poorly sorted as evidenced by high coefficients (2.3 to 3.19). Zircon, chlorite, opaque, garnet, monazite, kyanite and mica are present in heavy fraction of the sands.

Soils on denuded sandstone plateau, although dominated by sands (68 to 87 per cent comprises 0.5 to 0.25 mm size particles. The sediments seen to be moderately sorted (sorting coefficients 1.3 to 1.8). Light fraction of the fine sand is silimar to others but the heavy minerals show the presence of tourmaline, besides zircon, chlorite, monazite, garnet, opaque, kyanite and mica.

Parent Source of Sediments

Each land form unit shows a specific mineral assemblage, although not differing widely in composition. Further, 80–90 per cent of heavy mineral fraction is found to be composed of resistant minerals which are dull in appearence and are subrounded to rounded. However, few fractured, angular and grains with silica overgrowth are also observed. These features suggest that sediments, which are the parent material of the soils, are weathered and has undergone more than one cycle of transportation and deposition. Presence of chlorite, which is considered to be a weatherable mafic mineral[10] in the weathered sediments raises doubts about their nature. This may possibly be a resistant type of chlorite, formed during metamorphism of the parent rock.[11] The mineral assembelage and associated features thus suggest that sediments on these land forms are from already weathered sediments of metamorphic and igneous rocks remnants of which exist in the area, and are deposited during pluvial period of Early Quaternary. Brownlow's[12] data show that biotite, chlorite, muscovite and quartz are dominant minerals in phylite and slate whereas garnet, staurolite and plagioclase are dominant minerals in schist rocks.

Source of Sands

Source of sand for dune field soils seems to be similar as evidenced by similar mineralogical composition, out differers from that of alluvial plain soils. This could be seen from higher proportion of zircon (45 per cent) in dune field than in coarse-textured plain, where it constitutes 19 per cent only. Similar is the content of monazite, garnet and kyanite, which are less than 50 per cent of that in sediments of coarse-textured plain. This shows that source of sands for dunes is other than coarse-textured plains, as proposed by Dhir *et al.*[7]. Presence of interlayered smectite and amorphous material in higher proportions in dune field soils clay[13] also suggests that sands are from weathering surfaces which are under wetting and drying cycles. The wetting and drying cyclic conditions are favourable for the formation of the interlayered and amorphous material.[14,15] It is, therefore, quite probable that dune sands are transported from the weathering surfaces and stream bed, and not transported from the Rann of Kutch as envisaged by Wadia[4] or from vast depositional basin.[5]

ACKNOWLEDGEMENTS

Thans are due to Dr RP Dhir and to Dr Vasudeva Rao, Head of the Basic Resources Studies Division, CAZRI and Senior Scientist, IARI, New Delhi respectively for suggestions and help in microscopic examination of the minerals.

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