

Mineralogy of Beach & Dune Sands of Morgim-Arambol Beach on Goa Coast

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Mineralogic studies of the sand of dune and beach at Morgim-Arambol indicate that opaques, garnet, staurolite, epidote, chlorite, bluish-green hornblende, tourmaline, augite-diopside, hypersthene and zircon are the principal heavy minerals. Three mineral associations are recognized on the basis of their relative abundance and distribution on the beach: (i) garnet-epidote-staurolite rich association, (ii) garnet-epidote-staurolite-chlorite rich association, and (iii) opaque-garnet-zircon rich association. As the sediments are texturally similar throughout the beach and as there is no marked areal mineralogical sorting of the size, shape and specific gravity, this mineral distribution appears to be controlled by the variations in source rocks in the drainage basins of the rivers.

MORGIM-ARAMBOL beach on Pernem coast in Goa runs from the mouth of Chapora river in a NNW-SSE direction to a distance of about 10 km, as far as Arambol headland. To the north of the headland river Tiracol joins the sea. Along the coast, Precambrian micaceous quartzites intruded by dolerite dykes, and sub-recent laterites and beach rocks are exposed. The landward side of the beach is fringed by well developed coastal dunes which vary in height from 0.5 to 15 m.

The present study has been undertaken to determine the mineral composition and the distribution trends of the minerals of the beach and dune sands of Morgim-Arambol beach.

Methods

Eight sampling sites approximately 1 km apart on the beach were selected (Fig. 1). For the mineralogical study, two samples, one from foreshore and the other from adjacent dune were collected from each site. Three size fractions, greater than 0.25 mm, 0.125-0.25 mm and 0.063-0.125 mm, were studied for mineralogy. Tetra-bromthane (sp. gr. 2.96) was used for the separation of heavy minerals from the light minerals. At first all the minerals of the heavy suites were counted to 100 to evaluate the relative proportions of opaque and non-opaque minerals. Subsequently, 200 non-opaques grains were counted to estimate the distribution of minerals in each sample. The results are expressed in percentage on opaque-free basis (Table 1).

Results

Geological setting — Precambrian metasediments and metaigneous rocks are the principal geological formations in Goa. On the eroded surfaces of these rocks rests laterites, 5 to 30 m thick. In the deeply eroded valleys and coastal headlands, the Precambrian rocks are exposed.

Pleistocene and Recent :

Dune and beach sands and river alluvium and laterites.

Cretaceous-Eocene :

Deccan trap lava flows and associated intrusives.

Algonkian :

Pure or micaceous quartzites with basic intrusives

Precambrian :

Phyllites, quartzites with associated iron and manganese ore deposits, metagraywacks, meta-conglomerates, amphibolites, pyroxenites, granites, gneisses¹.

Mineralogy — The general characters of the heavy minerals are as follows:

Opagues: Opagues are abundant in all the

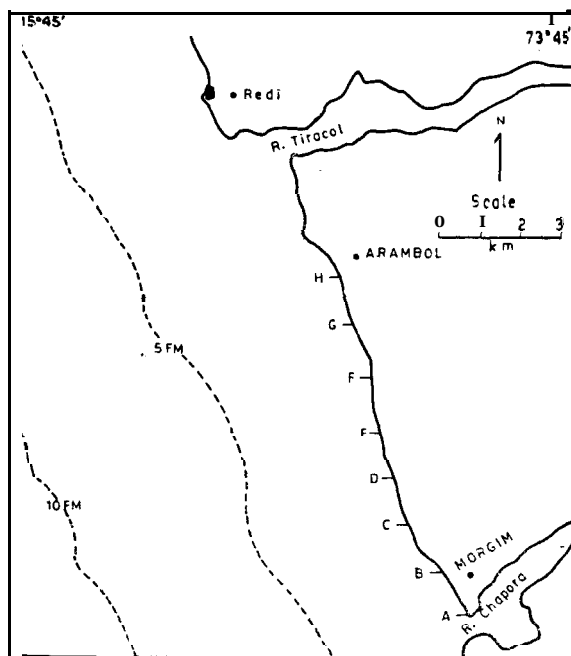


Fig. 1 -Map showing sampling sites

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samples and the grains are subrounded to rounded. The percentage of opaques is higher in dunes than in the beach.

Garnet: The mineral is common in beach and dune sands (2-31% in the beach and 2-34% in the dunes), and occurs as (i) pale brown (dominant), (ii) colourless, and (iii) pink. The grains are sub-angular to sub-rounded.

Hornblende: The mineral (1-44% in beach sands and 2-37% in dunes) occurs as bluish green (dominant), brown and a minor reddish brown. The grains are prismatic and many show diagonal fractures.

Pyroxenes: Pyroxenes (1-12% in beach and 1-14% in dunes) are represented by augite-diopside and hypersthene. Most of the augite is purplish brown (titaniferous) and a brown, non-pleochroic variety also occurs. The grains are fresh and angular to sub-angular. Hypersthene is commonly prismatic showing characteristic pink pleochroism.

Epiclote: The mineral (3-14% in beach and 1-38% in dunes) is commonly greenish yellow and also green showing characteristic ringed interference colours. The grains are sub-angular to subrounded.

Staurolite: The mineral occurs 1-16% in beach and 1-21% in dunes. The most common grains

TABLE 1 — HEAVY MINERAL PERCENTAGES OF BEACH AND DUNE SANDS

Station NO.	Size mm	Opaque/non-opaque	Garnet	Brown horn-blende	Green horn-blende	Brown tour-maline	Green tour-maline	Epidote zol-site	Augite-diopside	Tremolite actinolite	Rutile	Hypersthene	Staurolite	Zircon	Chlorite
BEACH SANDS															
A	0.250	3:1	—	—	12	40	4	—	8	4	—	4	17	—	—
	0.125	1.4:1	2	6	22	26	8	5	9	3	—	5	14	—	—
	0.063	1.4:1	14	1	22	12	8	14	10	4	1	2	7	—	—
B	0.250	3:1	13	—	20	7	24	7	—	—	—	7	—	—	—
	0.125	1.8:1	5	3	26	10	4	8	7	8	—	2	16	—	1
	0.063	1.1:1	10	4	24	13	19	7	11	—	—	4	3	1	—
C	0.250	5:1	3	3	21	3	18	3	—	—	2	5	7	—	25
	0.063	1.1:1	10	4	24	13	19	7	1:	—	—	4	3	1	—
D	0.250	0.2:1	—	—	20	12	56	—	—	—	—	—	—	—	—
	0.125	0.7:1	10	22	22	17	3	5	10	—	—	1	1	—	—
	0.063	3:1	27	—	19	12	6	7	12	3	—	3	—	1	—
E	0.250	2.2:1	11	5	34	11	25	—	2	—	—	2	—	—	—
	0.125	0.57:1	5	1	33	9	26	3	6	—	—	1	1	7	—
	0.063	1:1	24	2	13	16	12	11	10	7	—	—	—	—	—
F	0.125	2.7:1	3	5	47	9	13	3	1	—	—	9	1	—	—
	0.063	1:1	24	—	26	21	5	10	5	—	—	1	—	2	—
G	0.250	4.8:1	4	—	44	16	20	—	4	—	—	12	—	—	—
	0.125	2.2:1	6	7	36	9	23	3	1	1	—	9	—	—	—
	0.063	1.7:1	26	3	6	15	5	10	10	—	3	—	2	8	—
H	0.250	2.1:1	25	—	35	2	20	—	7	—	—	10	—	—	—
	0.125	0.51:1	14	9	24	20	16	4	1	—	—	5	2	—	—
	0.063	2.1:1	31	1	12	10	18	7	5	—	—	—	—	4	—
DUNE SANDS															
A	0.250	0.7:1	18	4	4	14	8	18	—	—	4	—	14	—	—
	0.125	0.95:1	28	2	5	2	7	37	3	—	2	—	11	—	—
	0.063	1.8:1	25	2	9	1	9	27	—	—	—	—	15	2	—
B	0.250	1.3:1	5	2	20	5	16	11	1	—	1	—	21	—	10
	0.125	2:1	2	10	15	19	9	9	2	—	—	—	6	—	9
	0.063	2.7:1	15	6	20	9	19	20	—	—	3	—	8	—	3
D	0.250	1.5:1	6	15	15	30	2	8	—	—	3	—	2	—	2
	0.125	4:1	29	9	6	14	5	5	1:	—	2	—	3	3	1
	0.063	5.5:1	19	12	9	17	5	10	9	—	4	—	3	3	—
E	0.250	1.1:3	—	4	12	20	8	—	—	—	—	—	—	—	—
	0.125	0.25:1	-6	10	20	26	12	2	8	—	—	4	2	—	—
	0.063	4:1	26	17	7	11	8	3	7	—	—	6	1	3	—
F	0.250	1.4:1	2	7	36	10	23	2	—	—	2	—	7	—	—
	0.125	3:1	7	21	21	6	—	1	6	—	—	1	—	—	2
	0.063	3:1	28	18	4	13	15	6	13	—	—	2	—	1	—
G	0.250	1.8:1	8	—	34	2	—	8	8	—	—	2	—	—	—
	0.125	1:2.2	17	23	13	19	31	2	6	—	1	1	1	—	4
	0.063	2:1	20	13	18	12	7	10	11	—	—	2	—	1	—
H	0.250	1:1	18	—	33	7	7	3	6	—	—	9	—	—	—
	0.125	10.0:1	34	3	9	18	5	9	5	—	—	1	3	10	—
	0.063	10.0:1	30	6	6	21	1	5	8	—	—	—	—	22	—

are straw yellow and brownish yellow and show characteristic pleochroism in yellows. The grains are irregular to subangular with hackly fracture and also conchoidal fracture.

Tourmaline : It is a very common mineral (3-40% in beach and 1-32% in dunes). It occurs in three varieties (i) dark green, prismatic (dominant), (ii) brown, prismatic, and (iii) rounded, colourless.

Chlorite: The grains (1-26% in beach and 1-11% in dunes) are platy, dark green and non-pleochroic. Most of them are isotropic.

Zircon: The predominant grains (1-9% in the beach and 1-23% in dunes) are colourless and some are pale brown. The grains are euhedral and zoned with high elongation index.

Tremolite-actinolite : The mineral (1-8% in beach) is commonly light green. The grains are prismatic with diagonal fractures and ragged ends.

Rutile: The mineral (1-7% in beach and 1-4% in dunes) commonly occurs as deep yellow grains, but some red grains are also seen. The grains are prismatic showing the characteristic oblique striations.

Light fraction — Quartz forms the principal mineral (70 to 75%) of the beach and dune sands with significant amounts of carbonates and minor amounts of partially altered plagioclase. Quartz grains are subangular to subrounded and contain inclusions of opaques, tourmaline and other unidentifiable inclusions.

Discussion

Mineral assemblage — The heavy mineral suites consists of opaques, garnet, staurolite, epidote, bluish green hornblende, chlorite, tourmaline, augite, hypersthene and zircon. Garnet, staurolite, epidote, bluish green hornblende, and chlorite together constitute 60-70% of the dune and beach assemblages whereas augite, hypersthene, tourmaline, zircon constitute 30-40% of the assemblages. This clearly indicates that a major contribution has been made by metamorphic rocks of low, medium and high ranks and a subordinate contribution by basic igneous rocks. Garnet, staurolite and also bluish green hornblende² are typical high rank metamorphic minerals whereas epidote, chlorite and minor amounts of actinolitic hornblende are low metamorphic minerals. Augite, hypersthene and also reddish brown hornblende³ are basic igneous minerals. Predominant green and brown tourmaline and long prismatic zircon with high elongation are indicative of major contribution from granites and granitic gneisses with associated pegmatites^{4,5}. On the basis of the relative abundance and distribution of these minerals in the area (Table 1) 3 mineral associations are recognized (i) garnet-epidote-staurolite rich-association characterizing dune and beach sediments at stations A, B and C, (ii) garnet-epidote-staurolite-chlorite rich-association characterizing the sediments at station C, and (iii) garnet-epidote-zircon rich association characterizing the sediments at stations G and H. Distribution of minerals at the intermediate stations D, E and F shows no clear pattern.

Source rocks -The ultimate source of these minerals found in dune and beach sediments in the area can be traced back to the drainage basins of Chapora and Tiracol rivers debouching on the Pernem coast. Two rivers rising in the western Ghats of Maharashtra State flow over a vast metamorphic terrain composed of dominant Algonkian Schists, bearing epidote, chlorite and staurolite with associated amphibolites and pyroxenities, Algonkian quartzites with associated iron ore and manganese ore deposits and an igneous terrain composed of granites and basalts⁶. Garnet, epidote, staurolite, bluish green hornblende and chlorite appear to have been derived mainly from the Algonkian schists and associated amphibolites traversed by the Chapora river. Tourmaline and zircon are probably derived from granites and granitic gneisses with associated pegmatites occurring in the drainage basin of the north-western tract of the Tiracol river. Augite-diposide and hypersthene have probably been contributed from the numerous basic dykes occurring along the coast and also from the basalts found in drainage basins of the rivers.

Mineral variation — The distributional trends of these minerals indicate that epidote, staurolite and chlorite are more abundant in the beach and dune sands at sample locations A, B and C which are situated near the mouth of the Chapora river, whereas opaques, garnet and zircon are present in larger amounts in the dune and beach sands at sample locations G and H near the mouth of the Tiracol river. Tourmaline and hornblende are present in uniform amounts throughout the length of the beach. Augite-clinopyroxene and hypersthene, though present in considerable amounts, show considerable areal fluctuations which are difficult to explain. As dune and beach sands are texturally similar with mean size varying between 2.75 and 3.00 ϕ and standard deviation between 0.40 and 0.50 ϕ (ref. 7) and as there appears to be no marked areal mineralogical sorting in size, shape and specific gravity, this mineral distribution is apparently related to variations of the source rocks in the drainage basins of the Chapora and Tiracol rivers.

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