have formed under oxidizing, evaporitic, low energy, protected conditions. Presently they from in (i) tidal channels, lagoon, playa lakes, and mud flats within the area of intertidal influence, and (ii) in supratidal environments. Fossils are rare and confined to some localized bands. Gypsum crystals are formed within the sediments after their deposition and are therefore postdepositional. Thin laminations of gypsum are formed in sediments of deeper parts of the playa lakes or lagoon.

On the basis of the present study it is interesting to speculate on the origin of some older deposits of Kutch. It is suggested that the unfossiliferous sections of 'Gypseous Shale' sequence (Mohan and Gupta, 1968) of the Tertiary, which closely resemble the Rann deposits, had a similar mode of origin during regressive cycles. The intercalated fossiliferous bands are perhaps thin records of short spells of marine transgressions. Similarly, the unfossiliferous yellow-grey gypseous clays of Katrol series were probably formed under much the same conditions as the Rann sediments.

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REFERENCES

GLENNIE, K. W. and EVANS, G., (1966) Reconnaissance of the Recent sediments of the Ranns of Kutch and Rajasthan Desert, India. *Research Report 1229: Shell Research N. V. Amsterdam. The Netherlands., Appendix B & D.*

MOHAN, M. and GUPTA, S. C, (1968) The microfauna and age of the 'Gypseous Shales', Western Kutch, India. *Contributions from the Cushman Foundation for Foraminiferal Research.,* v. 19, pp. 21-25.

POSNJAK, E., (1940) Deposition of calcium sulphate from sea water. *Am. Jour. Set., v. 35,* pp. 539-568.

PASCOE, E. H., (1964) *Manual of Geology of India and Burma, v. 3.* Govt, of India, Delhi, pp-1905-6.

GRAIN SIZE DISTRIBUTION AND MINERALOGY OF MIRA MAR BEACH AND ESTUARY, GOA

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Introduction: This paper presents the results of studies in the grain size and mineralogy of the sediments of Mira Mar beach and the adjoining estuary. The Mira Mar beach is an estuarine beach in Panaji, Goa, which is situated on the west coast of India. The tidal range in the estuary is about 2.2 metres. The swell waves of about 12 second period prevail during monsoon months (May-September); the heights of the waves during this season range from 60-90 cm. In the fair weather months (December-March) the waves of 6 second period prevail in the estuary. The heights of these waves vary from 15-30 cm.

Geological setting: The geological succession in the Goa region is as follows:

Pleistocene and Recent	—	Dune and beach sands and river alluvium
Tertiary to Recent	—	Laterites
Cretaceous - Eocene	—	Deccan Trap lava flows and associated intrusives
Precambrian	—	Phyllites, quartzites with associated iron and manganese ore deposits, meta-graywackes, meta-conglomerates, meta-basalts, amphibolites, pyroxenites, granite gneisses (after Oertel, 1958)

Collection of samples and laboratory methods: Six reference points, about 1 km apart, were set up on the dunes from Campal light house point through the Mira Mar beach (Fig. 1). From the reference points 1 to 6, the width of the beach increases progressively from 15 to 144 metres. About 250 samples were collected from the

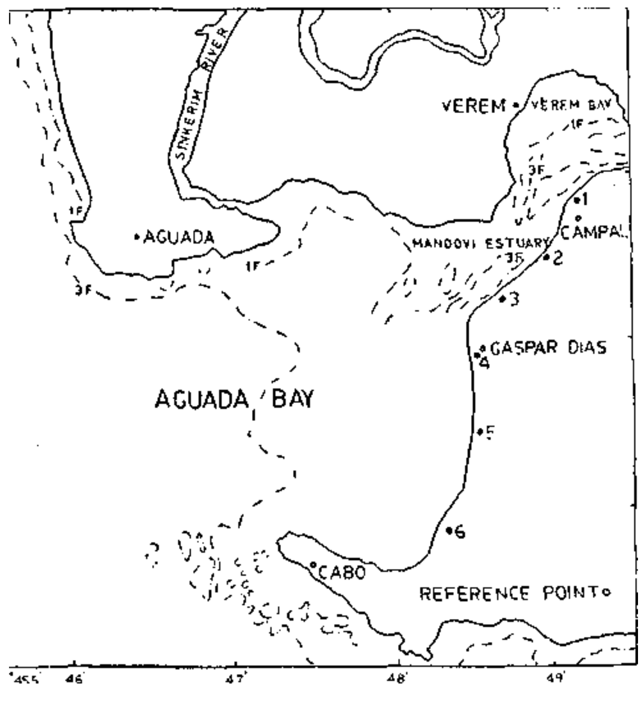

Figure 1.

period July 1967 to August 1969 and studied for their grain size analysis. A set of sieves based on Wentworth's scale was used for determining the size grades. The conventional size parameters such as median phi, skewness phi, sorting coefficient and phi kurtosis were calculated (Krumbein and Pettijohn, 1938). The mineralogy of the beach and dune samples was studied.

Grain size data: The sediment between reference points 1 to 4 consists of medium to fine sand (2.2 *4*> to 2.5 <*p)* for the months April-September and the sediments at reference points 5-6 are fine grained (md phi 2.8 0 to 3.0 <*p)*. The latter area, though being close to the sea, shows no significant variation in grain size throughout the year. At reference points 1 to 4, the sediments are invariably very fine during November, becoming coarse (1.8 <*p* to 2.0 <*p)* during the months of January-March, and October-December. A slight coarsening in this area is attributed to the very heavy admixture of the shelly material in the sediments believed to be brought about by low amplitude, long period waves that prevail in these months.

The sorting coefficient ranges from 1.25 to 1.45 and therefore the sediments are described as well sorted. The size frequency distribution of the sediments is described as normal by quartile skewness and quartile kurtosis values. Dure sands adjacent to the beach have (i) median diameter ranging from 2.8 <*p* to 3.0 <*j*>, (ii) sorting values varying from 1.20 to 1.30, indicating that the dune sands are fine grained and well sorted.

Mineralogy: Quartz is the principal mineral constituent in the light fraction; other minerals present in very minor amounts are partially altered plagioclase and orthoclase. The quartz grains are subrounded to rounded. The quartz grains are of two types—quartz grains showing straight to slightly undulose extinction and containing inclusions of tourmaline, zircon, rutile and some opaques; these grains have been designated as of plutonic and vein origin. In addition to this, there is a variety of quartz showing strong undulose to wavy extinction; these detrital quartz grains have probably been contributed by metamorphic rocks.

Table I gives the percentage of the heavy minerals. This mineral assemblage is usually the result of the disintegration of metamorphic rocks and intermediate igneous rocks. Minerals like augite, hornblende and tourmaline are present in different varieties. Augite is represented by nonpleochroic brown (dominant) and pleochoric light green varieties (aegirine augite) and by the variety diallage. Hornblende is present showing faintly pleochroic dark brown, and light green to dark green (dominant) varieties. Tourmaline is represented by dark brown and dark green (dominant) varieties.

The grains of amphiboles, pyroxenes, tourmaline and titanite being prismatic and hence having low sphericity, have been deposited selectively in the upper course of the estuary at the reference points 1 to 3, while equidimensional opaques have been rolled further down the estuary to be concentrated at reference points 4 to 5. At reference point 6, there is an increase of non-opaques again (notably tremolite-actinolite and spinel) which may be due to the mixture of river suite and local suite derived by the erosion of a number of rocks occurring in the off-shore. The mineralogy of dune sands differs from that of the beach sands in being deficient in non-opaques except zircon. This probably reflects a selective transportation of rounded and small sized opaques from the adjacent beach, and this has been observed elsewhere (Shepard and Young, 1961).

Source rock: The three tributaries of Mandovi river, Candepar, Madie, Valvota, traverse a wide variety of rocks and are the main suppliers of the sediments in this area.

Hypersthene, augite and enstatite are available in basic igneous rocks, like gabbros, hypersthene dolerite and a number of basic dykes occurring in the central tract of Goa, and also from the Deccan Trap basalts; titanite from granite gneisses, talc

TABLE I

Ref-Points	1 2			3	4	5	6	
Minerals	250-64 Microns	250-125 Microns	64 Microns	250-64 Microns	250-64 Microns	250-64 Microns	250-64 Microns	
Opaques	64.2	66.3	57.6	72.0	90.9	88.0	67.8	90.3
Hypersthene	7.0	11.3	13.0	6.5	2.0	2.2	3.4	—
Enstatite	0.7	—	1.4	0.5	—	—	—	—
Augite	2.8	2.5	4.0	—	2.0	0.43	1.7	0.52
Tremolite-Actinolite	7.1	4.0	4.8	4.0	0.66	0.85	7.7	1.0
Hornblende	7.7	3.7	1.6	2.0	0.66	1 3	2.6	2.6
Epidote	2.8	1.3	3.2	—	0 66	—	0.87	0.51
Spinel	1.4	6.3	2.4	4.0	0 66	—	6.9	—
Titanile	2.8	—	3.2	4.0	0.44	2.2	5.2	0.51
Staurolite	—	—	—	—	0.20	—	—	—
Biotite	—	—	—	—	—.	0.5	—	—
Rutile	—	—	—	—	—	0.43	0.87	—
Tourmaline	5.7	3.7	8.8	7.0	1.6	3.9	2.6	1.5
Zircon	—	—	—	—	—	0.85	—	2.1

chlorite schists and amphibolite occurring in the centra] and eastern tracts; tourmaline and zircon from granite gneisses and associated pegmatite veins; hornblende from amphiboUtes, hornblende schists, and banded gneisses found to a limited extent in central and eastern regions. Tremolite-actinolite, and epidote are probably derived from high-magnesium limestone, tremolite actinolite schists, and amphibolite forming the central tract. Opaques may have been derived from a number of rock types. The small amounts of biolite, staurolite, and rutile may have been derived from metagraywackes and reworked sediments, all found in the course of the river.

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REFERENCES

KRUMBIEN, W. C, and PETTIJOHN, F. C, (1938) *Manual of Sedimentary petrography, D.* Appleton-Century Co., Inc., New York pp. 229-238.

OERTEL, G., (1958) Mapa Geologico De Goa, *Rec. Geo!. Surv. Portugal,* v. XL.

SHEPARD, F. P. and YOUNG, R., (1961) Distinguishing between beach and dune sands, *Jour. Sed. Petrol.,* v. 31, pp. 196-214.