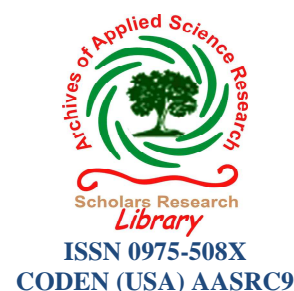




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Geomorphological and textural characteristics of sediments of St. Marys Island Western continental shelf, India

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ABSTRACT

The geodynamics of Cocount Island of St.Marys Island group of Karnataka state has been studied. The present study attempts to delineate the geomorphic and textural characteristics of the sediments of the St.Marys Island in the western continental shelf of India. The poorly sorted, mesokurtic to very leptokurtic sediments nature of the beach sediments suggest both erosional and depositional environments successively. Geomorphically identified repeated swales and beach ridges towards the Inland suggest Coconut Island is currently emerging vertically up.

Keywords: St.Marys Island, Karnataka state, depositional environments, beach ridges, swales.

INTRODUCTION

Many plate reconstructions propose a close link between Madagascar and Greater India from late Precambrian to Cretaceous times, and the separation is estimated to have started during or shortly after a period of Late Cretaceous basic and felsic magmatism that is well-known from Madagascar [13]. During this late Cretaceous break-up event, the western margin of India presumably rifted off the eastern margin of Madagascar; however equivalent Cretaceous volcanism is not well documented from western India. Possible exceptions include mafic dykes in mainland south-west India [8, 9] and the acid volcanic rocks of the St.Marys Islands. There are four large islands in the St.Marys Islands group, namely Coconut Island, North Island, Darya Bahadurgari Island and South Island. Out of the four Islands the one from St.Marys Islands the northern most Island has a basaltic rock formation in a hexagonal form, the only one of its type in India [11,12]. The rocks have very well developed columnar joints and hence the island has been gifted by the Karnataka state Government to the Geological Survey of India which has declared the rocks as a national Geological Monument. The Island covers an area which is about 500m (1640.4ft) in length with a width of 100m (328.1 ft).Coconut Island, which is the farthest

from the shore is about 2.5 km west from the mainland. The two northern Islands viz., Coconut Island and Northern Island have nearly equal area (0.14km^2 and 0.13km^2 respectively) and larger compared to the other two islands. Topography rises above the transient sea level to about 11.38 m in Coconut Island, 16.6 m in North Island and 11.5 m in Darya Bahadurgari Island. The present study carried out in Island Geomorphological features of Coconut Island and the various techniques employed in grain size determination include direct measurement, dry and wet sieving and sedimentation studies. The Standard methods for grain-size analysis are based on sedimentation rates for the fine fractions and sieving for the coarse fractions. These methods have some important disadvantages they are time-consuming, very dependent on laboratory technique and operator error and a large amount at least 10g of material is needed. Most of the geomorphic and sedimentologic studies that have been carried out in the past were on the sediment deposition along Island coasts. In this regard, the sedimentology of beach sediments plays a vital role in documenting the depositional history of a region. A common method currently used to characterize grain size distribution of clastic materials is based upon the assumption that following a transformation to the log of the base the entire sample has an approximately Gaussian distribution [1,2]. Percentile measures based on the entire population are commonly used to calculate the parameters of Mean, Standard deviation, Skewness and Kurtosis [3].

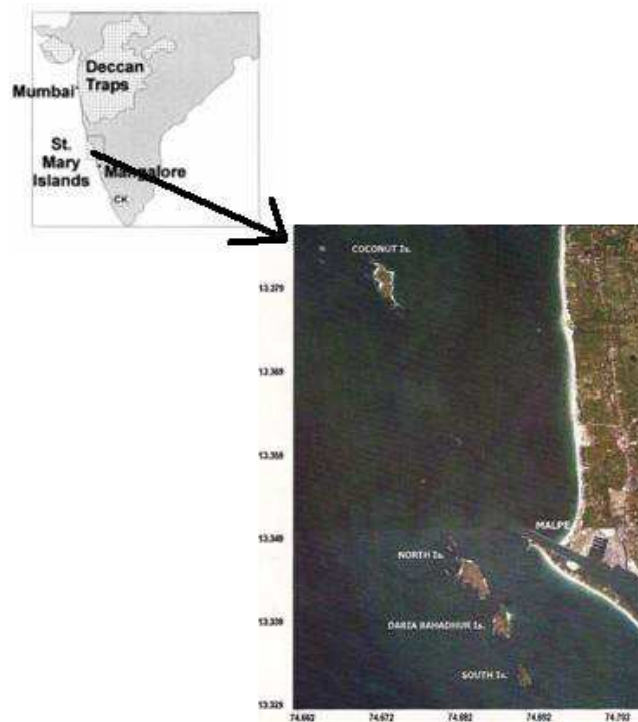


Fig.1 Location map of the Study area

Location of the study area:

St.Marys Island is located at about 6 Km NNW of the port of Maple in South Kanara district, Karnataka and about 670 Km South of Bombay. The St.Marys Islands group of Islands of Udupi has a latitude of $13^{\circ}28'$ that are oriented nearly parallel to the coastline. The Island covers an area which is about 500m (1640.7 Feet).The North South aligned Islands are in a noncontinuous

chain. The St.Marys Islands form a chain of small islands trending NW-SE over a distance of about 6 km off the western coast of central India, near the coastal village of Maple. The islands consist entirely of flat-lying, undeformed felsic volcanic rocks, including dacites and rayodacites [6,10,14] some with spectacularly developed columnar jointing.

MATERIALS AND METHODS

Sediment samples were collected during January 2009 through trenching at intervals of 5m from the top collected sediment samples. The Islands geomorphic features were studied by a field survey and satellite map. Standard sediment size analysis was carried out and statistical parameters were calculated [3] to delineate the depositional environment. Samples were also taken from the different morphological units of the beach (low, mid, and high- tidal zones, berms and dunes). Thin section studies are also carried out to know the mineralogy.

Grain size analysis:

There is a variety of methods to determine the size analysis of the sediment particles but the methods are based on one of the three fundamental principles such as settling velocity, sieving and thin section techniques. The mechanism of sieve analysis is performed to determine the distribution of the coarser, larger-sized particles and the hydrometer method is used to determine the distribution of the fine particles.

The samples are collected in the polythene bags. After ensuring a complete dryness, the samples are splitted. Then the samples are sieved the ASTM sieves are arranged in a manner as 8, 12, 16, 22, 30, 44, 66, 85, 120,170 and 240. Then the sieves are shacked in Ro-Tap mechanical shaker for about 15min. Then all the sieved fractions are collected and weighed accurately. The parameters mean, standard deviation, skewness and kurtosis are estimated using the formulae of [3,4,5] (Table-1

Table 1. Formulae used for computing various size parameters).

Parameters	Formulae of Friedman (1962)	Formulae of Folk & Ward (1957)
Mean	$\hat{\mu} = \frac{1}{100} \sum f(m_{\phi})$	$M_z = (\phi_{16} + \phi_{50} + \phi_{84})/3$
Standard deviation	$\bar{\sigma} = (\sum f(m_{\phi} - \bar{x})^2/100)^{1/2}$	$\sigma_l = \frac{(\phi_{84} - \phi_{16})}{4} + \frac{(\phi_{95} - \phi_5)}{6.6}$
Skewness	$\bar{\alpha}_3 = \frac{1}{100} \hat{\sigma}^3 \sum f(m_{\phi} - \bar{x})^3$	$Sk_1 = (\phi_{16} + \phi_{84} - 2\phi_{50})/2(\phi_{84} - \phi_{16}) + (\phi_5 + \phi_{95} - 2\phi_{50})/2(\phi_{95} - \phi_5)$
Kurtosis	$\hat{\kappa} = \frac{1}{100} \hat{\sigma}^4 \sum f(m_{\phi} - \bar{x})^4$	$K_G = \frac{(\phi_{95} - \phi_5)}{2.44(\phi_{75} - \phi_{25})}$

RESULTS AND DISCUSSION

Geomorphology:

The St. Mary's islands was sub aerial in nature as that of in Madagascar was still attached to India. Rifting of Madagascar from India took place around 88 M.Y (11,12). The land forms in the study area are primarily of depositional nature. The volcanic activity which gave rise to the St.Marys Islands was sub aerial in nature as that of in Madagascar

was still attached to India. The topography of the island is highly irregular and rugged and the islands, except the coconut islands are mainly rocky. The Coconut Island has the maximum elevation of 10m above mean sea level compared to the other Islands, which is greater.



Fig:2 Marine terrace at about 4m above waterlevel-Cocount Island

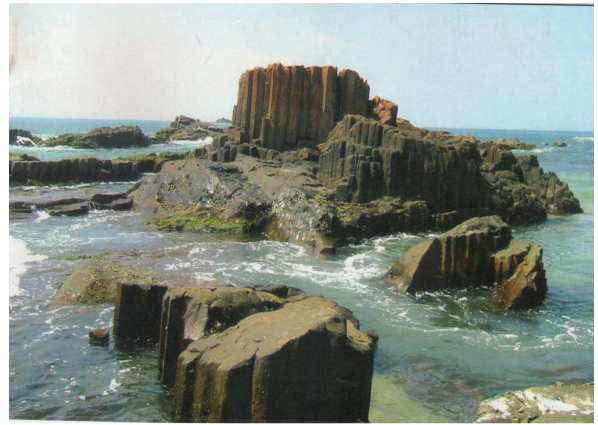


Fig:3 Marine wave cut platform -Cocount Island



Fig:4 Pebbles-bearing zones a close up view



Fig:5 A view of Columnar basalt (Height 7m)



Fig: 6 A closeup view of the Columnar basalt



Fig:7 A view of the elevated beach

The Coconut Island has a patchy layer of wave-worn rhyodacite pebbles and cobbles covering the +3m surface. To the west of the pebble bed is the shell deposit, of nearly at 2.5m in observed. Most parts of the Coconut Island most have an elevation of about 6m which represents a dissected marine terrace. St.Marys has just a few coconuts tree for vegetation. There are several morphology identified in the field i.e. columnar basalt (Fig-5), Wave-worn pebbles, Rhyolite pebbles, Shell carbonates, Wave cut platform (Fig-3) and Coconut tree (Fig-2).

Sediment characteristics:

Frequency Curves:

The fraction of 100g sample retained on each sieve is presented by bar diagram i.e. histogram as proposed by McBride. The comparative study of the histogram i.e. weight percentage frequency curves of all the samples broadly show higher concentration of medium sand-size fragments. Samples from southern margin and lake have comparatively more coarse sediments. The weight percentage data is cumulated and plotted in cumulative weight percentage verses phi (Φ) values ranging from -1.25 to 4.25. The comparative study of the cumulative curves show poor sorting of grains as the curves show a general tendency of horizontal closeness (fig.8).

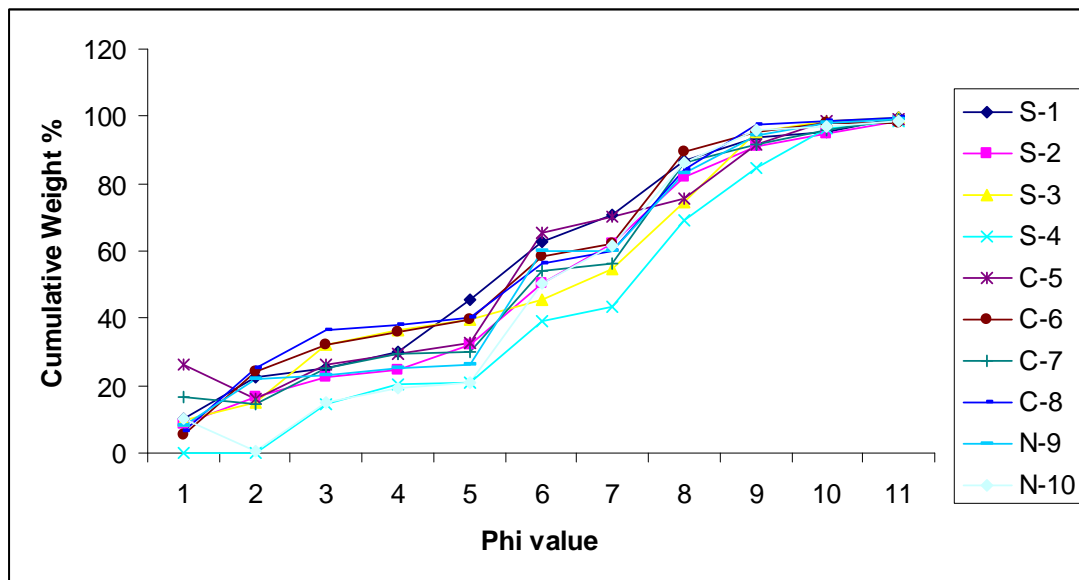


Fig 8. Cumulative curves showing trend of the samples collected from Coconut Island

Graphic Measures:

After sieving and weighing, sediments are subjected to graphic measures for measuring the grain size such as graphic mean (M_Z), graphic standard deviation (σ_1), graphic skewness (S_K) and graphic kurtosis (K_G).

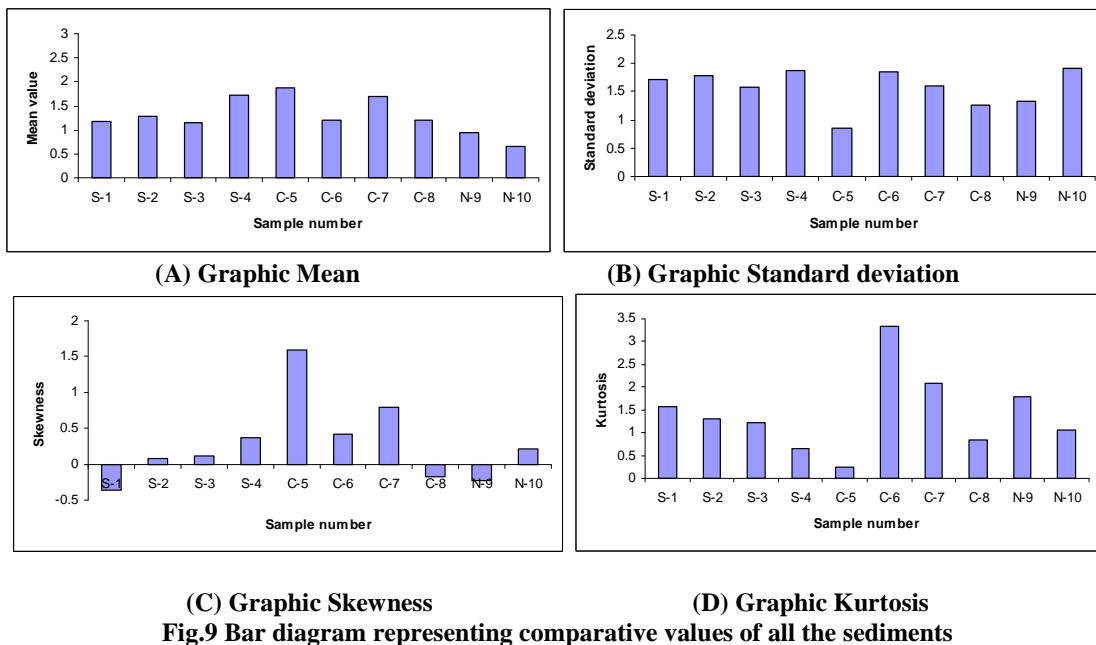
The moment mean values are identical to the graphic mean data of the analyzed samples, [3]. The values obtained for graphic mean range from 0.93 to 1.87 Φ , with an average value of 1.29 Φ (i.e. S-2, C-6, C-8). The average value shows the dominance of medium to fine sand sediments, especially in the northern study area. Similarly a few individual values i.e. N-9 and N-10 showing low values, because of almost equal percentage of coarse to fine sediments (fig 9A).

Table 2. Graphic measures from the grain size analysis of the sediment samples from different area Graphic mean size (M_z):

Stat.Paramet./ Sample No.	Φ 95	Φ 84	Φ 75	Φ 50	Φ 25	Φ 16	Φ 5	Φ 1	(M_z)	(σ 1)	(S_k)	(K_G)
S-1	4.36	2.65	2.56	1.56	0.52	-0.65	-1.52	36.2	1.18	1.71	-0.37	1.58
S-2	4.44	2.98	2.22	1.23	0.12	-0.32	-1.86	45.2	1.29	1.77	0.07	1.3
S-3	4.23	2.42	2.45	1.52	1.20	-0.52	-1.32	39.2	1.14	1.57	0.12	1.23
S-4	4.13	3.56	3.12	1.94	-0.32	-0.32	-1.87	16.2	1.72	1.87	0.37	0.65
C-5	3.12	3.15	3.10	1.23	-0.52	1.25	0.54	44.8	1.87	0.86	1.6	0.25
C-6	3.95	2.45	2.89	1.95	1.02	-0.75	-2.96	44.2	1.21	1.84	0.41	3.33
C-7	3.06	3.21	2.45	2.10	0.75	-0.23	-1.78	15.0	1.69	1.59	0.79	2.08
C-8	3.21	2.52	2.56	1.32	0.32	-0.19	-0.68	32.8	1.21	1.26	-0.17	0.83
N-09	4.21	2.12	2.21	1.52	0.65	-0.83	0.21	45.0	0.93	1.34	-0.22	1.8
N-10	4.65	2.30	2.65	1.02	0.06	-1.35	-1.98	19.5	0.65	1.91	0.22	1.07

Inclusive graphic standard deviation:

Inclusive graphic standard deviation evaluates sorting of the sediment which in turn helps to reconstruct sedimentation history of the detrital sediments. A verbal classification of inclusive graphic standard deviation values ranging from a positive decimal fraction to over four was suggested by [3]. Inclusive graphic standard deviation values ranging from 0.86 to 1.87 Φ , denotes an admixture of moderately sorted to poorly sorted sediments. However, most of the values range between 1 to 1.57 Φ , which is poorly sorted category (Fig 9B). Only one sample is moderately sorted out category i.e.C-5 from southern margin belongs to clean sandy beaches having less quantity of clastic from surrounding area.



Inclusive graphic skewness:

Skewness refers to the symmetry of the distribution and indicates whether the sediments have a tail of fine or that of coarse fraction. Symmetrical distribution has 0.00 Φ skewness value. Any deviations from this to the positive or negative value indicates fine skewed or coarse skewed nature of the curve respectively. Inclusive graphic skewed values have been classified into five verbal classes by Folk 1961. The inclusive graphic skewness values of the sediment samples vary from -0.22 to 1.6 Φ . The bar diagram (Fig 9C) clearly indicates that the entire area is dominated by coarse skewed-near symmetrical (8 Samples). Two samples viz. S-1 and N-9 have comparatively very coarse skewness in the study area.

Graphic kurtosis:

Kurtosis reflects the peak of a frequency curve and measure the ratio between sorting in the tail of the distribution and that in the central portion. [3] Suggested that normal distribution has kurtosis values. Any deviation from the normal was grouped by him in the six classes. The inclusive kurtosis (Table-2) value ranges from 0.25 to 3.33 Φ with an average value of 1.59 Φ (Fig 9D). The entire areas is dominated by mesokurtic to very leptokurtic sediments.

CONCLUSION

A total of ten sediments admixtures from St. Marys Islands have been analyzed for grain size and geomorphology are also studied. The main conclusions drawn are as follows:

The present field of investigation noted that different geomorphology feature in entire study area. The St. Marys Island and its geomorphic features like wave cut terraces, elevated beach deposition suggest that there is an ongoing process of uplift. The St. Marys Island consists entirely of acid composition and includes Dacites, Rhyodacities, Rhyolites and Granophyres and carries basic patches. These rock types are present in all the large islands of the St. Marys Islands group and of well developed columnar joint is seen on Coconut Island. At Coconut Island sediments varying from coarse to fine grain and dominated by medium sand size fraction with an average value of 1.12 Φ . The characteristics feature of Island sediments i.e. very poorly sorted of grains is well exhibited by most of the samples, falling range of 0.86 to 1.87 Φ standard deviation. The dominance of Coarse Skewed-near Symmetrical nature of sediments (S_K 0.22 to 1.6 Φ) shows more percentage of Coarse grained material in the island shore line. The Kurtosis values exhibit a variable situation ranging from mesokurtic nature of sediments (K_G 1.59 Φ). It has been noticed that the sediments from entire area show almost the same characteristic though collected from northern and southern margin of the St. Mary Island and show both erosional and depositional environments. The poorly sorted similar observed sedimentary textural, admixtures nature of coastal sediments and the series of beach ridges and swales from the present coastline to the inland palaeocoast of St. Marys Island lead to the conclusion that the land is emerging vertically up.

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