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Isotopic Studies of Beach Rock Carbonates from Konkan, Central West Coast of India

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ABSTRACT

The beach rock carbonates from the 200 km long stretch from Guhagar in the north to Deogad in the south along the Konkan coast (Maharashtra) are studied for ¹⁴C dating and ¹³C : ¹²C and ¹⁸O : ¹⁶O ratio determination to understand their depositional processes and paleoenvironmental changes. ¹⁴C ages of some of these rocks range from 1100 to 3130 Yrs B.P., suggesting their Recent to Sub Recent origin. $\delta^{13}\text{C}$ signatures of beach rocks vary largely from -1.9 to -6.7 ‰ (PDB) and $\delta^{18}\text{O}$ signatures lie in a narrow range of +27.5 to +28.6 ‰ (SMOW), respectively. Isotopic data obtained in this study show that cementation of beach rock carbonates might have taken place in a shallow vadose zone. The large variations in $\delta^{13}\text{C}$ signatures (-1.9 to -6.7 ‰) can be attributed to changing influence of organically derived soil CO₂ in the formation of these carbonates. $\delta^{18}\text{O}$ signatures of beach rock carbonates indicate that the paleotemperatures of waters precipitating these carbonates varied moderately.

Key Words : Beach Rock, Carbon and Oxygen and Isotopes, Cementation, Paleoenvironment.

INTRODUCTION

Beach rocks of the central west coast of India have been described and studied by several workers (Setty and Wagle, 1972; Dikshit, 1976; Powar et al. 1978; Wagle, 1990; Badve et al. 1995; Kamble, 1997 and Soman et al. 1996), however the process of their cementation still remains unexplained. According to Wagle (1990), these beach rocks are believed to have been formed in an intertidal environment during regressive phase of the sea. However, Soman et al. (1996) have indicated that beach cement is of marine phreatic, meteoric phreatic and/or meteoric vadose origin. The present isotopic study of beach rocks has been carried out to understand their cementation processes and paleotemperature changes at the time of their formation.

METHODS

The beach rock samples containing carbonate content of more than 60 % (by weight) were selected for isotopic measurements of ¹³C: ¹²C and ¹⁸O: ¹⁶O ratios. Whole rock sample powder are allowed to react with ~89 % orthophosphoric acid at 25±1°C (McCrea, 1950) for 24 hours to liberate CO₂ gas. The CO₂ gas released was purified and isotopic ratios were measured using VG micromass 903 Mass Spectrometer. The measuring precision obtained for $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ was better than ±0.20 ‰. ¹⁴C dating of beach rock carbonates was carried out using Task Benzene Synthesiser and Paakard low level liquid scintillation system following the standard

procedure of Bhushan et al. 1994 and Krishnaswami, 1994.

GEOLOGY, FIELD FEATURES AND SAMPLE LOCATION

Geologically, the region is occupied by the formations of different ages viz., Precambrian (granite and feldspathic gneisses), Cretaceous and Eocene (Deccan trap basalts) and Tertiary and Quaternary (soils, sands, beach rocks, shells and pebbles, etc.) and lies between lat. (14°48' and 20°22') and long. (73°20' to 73°40') along the Central West Coast of India. The beach rocks are exposed all along the coast from Janjira in the north to Deogad in the south (3-4 m), more often as patches, dipping seaward at an inclination of 5 to 15° (Wagle, 1990). Beach rocks usually tend parallel to the beach. They are either directly attached to the mainland or separated from it by a zone of sandy beach or muddy / marshy area. Some beach rocks are massive and hard and others are soft and friable. Micropaleontological analysis shows scanty presence of forams. However, the occurrence of benthic foraminiferas suggest the dominance of interrestrial influence. Stratigraphically these beach rocks are inferred to belong to recent formations, developed during Later Holocene. The sample locations of beach rocks are marked in Fig.1.

The textural parameters of the beach rocks are given in Table 1.

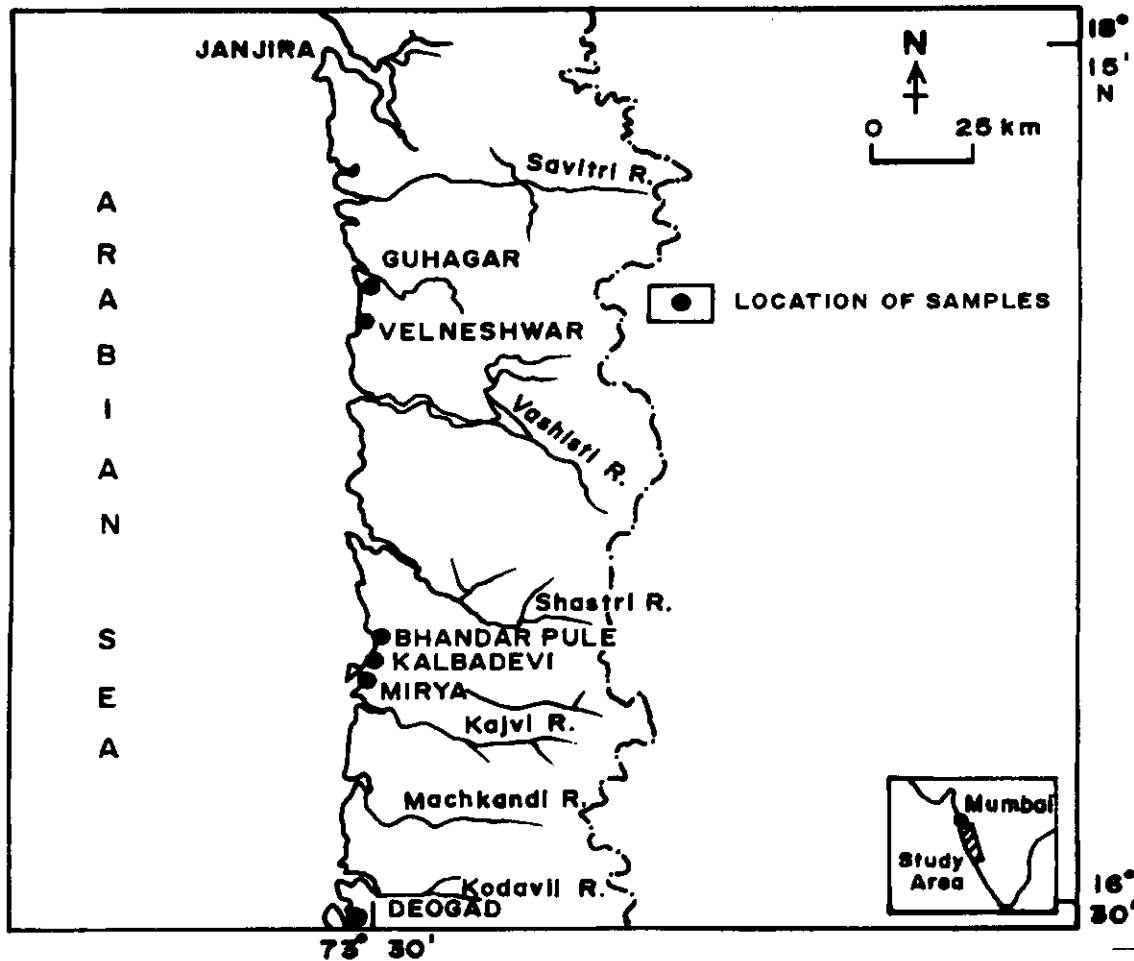


Fig.1 Map showing location of beach rock carbonates

Table 1 Textural Parameters of the Beach Rock

Station	Mean Grain Size	Standard Deviation	Skewness	Kurtosis
Guhagar	3.2	0.68	-0.56	1.30
Velneshwar	2.75	0.83	-0.11	0.75
Bhandarpule	2.16	0.74	0.29	1.00
Kalbadevi	2.44	1.35	-0.45	0.77
Mirya	1.9	0.90	0.05	0.63
Deogad	2.05	0.57	0.048	1.43

Important observations are as below :

1. Frequency curves shows unimodal distribution for Deogad and bimodal for Guhagar, Velneshwar, Kalbadevi and Bhandarpule while Mirya shows polymodal distribution.

2. Sediments of Guhagar, Velneshwar and Deogad are moderately well sorted; Mirya and Bhandarpule are moderately sorted and Kalbadevi are poorly sorted.

3. Sediments of Guhagar, Velneshwar and Kalbadevi are negatively skewed if the beach rocks are given in Table 1. suggesting strong winnowing, while Mirya, Bhandarpule and Deogad shows influence of dune sands.

4. The predicted dominant environment of deposition-after Friedman, 1961, is as below - Dune / River in Mirya, Bhandarpule and Deogad; Beach/River in Guhagar, Velneshwar and Kalbadevi.

5. Kalbadevi and Mirya sediments shows moderate energy and high mobility while other beaches show high energy and high mobility.

RESULTS AND DISCUSSION

The location and description of samples, their distance from shoreline, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ data and ^{14}C ages are given in Table 1. $\delta^{13}\text{C}$ signatures of beach rocks vary largely from -1.9 to -6.7 ‰ (PDB) and $\delta^{18}\text{O}$ signatures lie in a narrow range of +27.5 to +28.6 ‰ (SMOW), respectively. There is no correlation of isotopic data with the distance from shoreline. ^{14}C ages of some of these rocks ranges from 1100 to 3130 Yrs B.P., suggesting that these rocks are of Sub Recent origin. Badve et al. (1995) have also opined the same.

In order to discuss the carbon and oxygen isotope composition of beach rock carbonates, we establish the relationship between ^{13}C and ^{18}O content in carbonates of the type viz., marine and freshwater as follows: The marine carbonates have an average $\delta^{13}\text{C}$ value of $+0.6 \pm 1.6$ ‰ (PDB) and $\delta^{18}\text{O}$ value for marine carbonates of recent age vary from +28 to +30 ‰ Vs SMOW (Keith and Weber, 1964). Freshwater carbonates are generally lighter and show much broader variations in carbon and oxygen isotope compositions than marine carbonates. Keith and Weber (1964) reported a mean value of -4.9 ± 2.8 ‰ (PDB) for 183 selected freshwater carbonates. $\delta^{18}\text{O}$ values of fresh water carbonates of Konkan coast can be evaluated from mean $\delta^{18}\text{O}$ value (-1.5 ± 1 ‰ SMOW) of Konkan coast cold waters, obtained as a part of independent oxygen

isotope study of thermal and cold waters of the area by the first author. Considering fractionation factors of $\sim +28.0 \pm 0.5$ between CaCO_3 and H_2O at $25^\circ\text{C} \pm 5^\circ\text{C}$ (O'Neil et al. 1969) the mean $\delta^{18}\text{O}$ value of Konkan coast freshwater carbonates can be taken as $+27.0 \pm 1.5$ ‰ (SMOW). The Fig.2 plots $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ data of fresh and marine carbonates as established above and also of beach rock carbonates as given in Table 2. A close examination of isotopic data presented in Fig.2

Table 2 Isotopic Data of Beach Rock Carbonates from Central West Coast of India

S. No.	Sample Location	Distance from Shoreline (m)	$\delta^{13}\text{C}$ ‰ (PDB)	$\delta^{18}\text{O}$ ‰ (SMOW)	^{14}C Years
1.	Guhagar	500	-6.7	27.6	ND*
2.	Velneswar	300	-2.4	28.6	3130
3.	Bhandarpule	500	-3.6	27.5	2790
4.	Kalbadevi	500	-2.4	28.5	1100
5.	Mirya	100	-2.0	27.6	1400
6.	Deogad	300	-1.9	27.5	ND

* ND - Not Determined

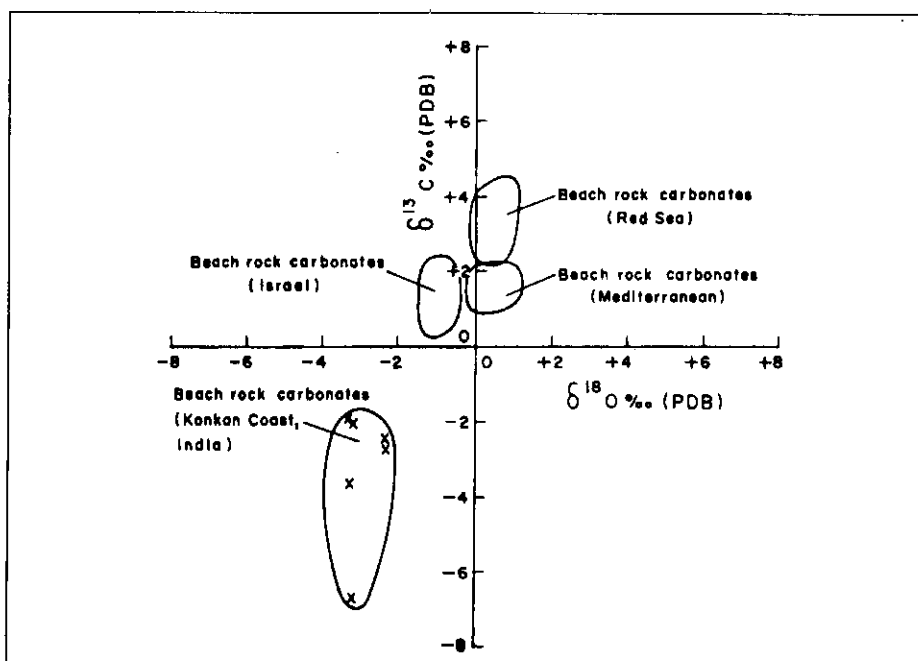


Fig.2 $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ plot of groups of beach rock carbonates from Konkan, Central West Coast of India (this work); Israel (Maagaritz et al., 1979) and Red Sea and Mediterranean (Hakil and Rasheed, 1991).

show that $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ signatures of beach rock carbonates lie in the range of fresh water carbonates, suggesting that cementation of these carbonates may have taken place in shallow vadose zone. Holail and Rasheed (1991) have studied the stable isotopic composition of beach rock carbonates from the Mediterranean and Red sea coasts of Egypt and obtained $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values ranging from +1 to +4.5 ‰ (PDB) and +30 to +31.2 ‰ (SMOW), respectively, indicating a marine origin for these carbonates.

The isotopic data of Konkan coast beach rock carbonates lie outside the range of Egyptian coast carbonates, suggesting their freshwater origin. The broader variations in $\delta^{13}\text{C}$ signatures (-1.9 to -6.7 ‰) of beach carbonates are attributed to a variable contribution of organically derived soil CO_2 to other inorganic species of carbon which form these carbonates. The oxygen isotopic composition of beach rock carbonates range from 27.5 to 28.6 ‰ (SMOW), indicating that paleotemperature of water precipitating these carbonates varied moderately.

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