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 Gahagar 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 palaeoenvironmental changes. 14C ages of some of these rocks range from 1100 to 3130 Yrs B.P., suggesting their Recent to Sub Recent origin. 13C signatures of beach rocks vary largely from -1.9 to -6.7 % (PDB) and 18O 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 13C signatures (-1.9 to -6.7 %) can be attributed to changing influence of organically derived soil CO2 in the formation of these carbonates. 18O 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, Palaeoenvironment.

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 were 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 13C and 18O was better than ±0.20 %. C14 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. Micropalentological analysis shows scantly 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

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

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 of 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, δ¹³C and δ¹⁸O data and ¹⁴C ages are given in Table 1. δ¹³C signatures of beach rocks vary largely from -1.9 to -6.7 %. (PDB) and δ¹⁸O 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. ¹⁴C 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 ¹³C and ¹⁸O content in carbonates of the type viz., marine and freshwater as follows: The marine carbonates have an average δ¹³C value of +0.6 ± 1.6 %. (PDB) and δ¹⁸O value for marine carbonates of recent age vary from +28 to +30 %. Vs SMOY (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. δ¹⁸O values of fresh water carbonates of Konkan coast can be evaluated from mean δ¹⁸O 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 -+28.0±0.5 between CaCO₃ and H₂O at 25°C±5°C (O’Neil et al. 1969) the mean δ¹⁸O value of Konkan coast freshwater carbonates can be taken as +27.0±1.5 % (SMOW). The Fig.2 plots δ¹³C and δ¹⁸O 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>
<thead>
<tr>
<th>No.</th>
<th>Sample Location</th>
<th>Distance from Shoreline (m)</th>
<th>δ¹³C (% PDB)</th>
<th>δ¹⁸O (% SMOW)</th>
<th>¹⁴C Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Guhagar</td>
<td>500</td>
<td>-6.7</td>
<td>27.6</td>
<td>ND*</td>
</tr>
<tr>
<td>2</td>
<td>Velmashwar</td>
<td>300</td>
<td>-2.4</td>
<td>28.6</td>
<td>3130</td>
</tr>
<tr>
<td>3</td>
<td>Bhandarpule</td>
<td>500</td>
<td>-3.6</td>
<td>27.5</td>
<td>2970</td>
</tr>
<tr>
<td>4</td>
<td>Kalbadevi</td>
<td>500</td>
<td>-2.4</td>
<td>28.5</td>
<td>1100</td>
</tr>
<tr>
<td>5</td>
<td>Mirya</td>
<td>100</td>
<td>-2.0</td>
<td>27.6</td>
<td>1400</td>
</tr>
<tr>
<td>6</td>
<td>Deogad</td>
<td>300</td>
<td>-1.9</td>
<td>27.5</td>
<td>ND</td>
</tr>
</tbody>
</table>

* ND - Not Determined

Fig. 2 δ¹³C and δ¹⁸O plot of groups of beach rock carbonates from Konkan, Central West Coast of India (this work); Isreal (Maagaritz et al., 1979) and Red Sea and Mediterranean (Hakil and Rasheed, 1991).
show that $\delta^{13}$C and $\delta^{18}$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 $\delta^{13}$C and $\delta^{18}$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 $\delta^{13}$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 palaeotemperature of water precipitating these carbonates varied moderately.

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