Geochronology of Miliolite Rocks of Kutch, Western India

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Abstract

Preliminary geochemical, mineralogical and geochronological studies using ²³⁰Th/²³⁴U method, of nine miliolite rocks from Kutch are reported. The Kutch miliolites are characterised by lower CaCO₃ and higher quartz contents compared to their Saurashtra counterparts. The range of ages for the Kutch and Saurashtra miliolites are same and both can be accommodated in the 50-70, 75-115 and >140 K. yr age groups proposed by Baskaran (1985).

The origin of the Kutch miliolites, like those of Saurashtra, appears to be marine. Theories to explain their occurrence in Kutch have to await more detailed studies of this type along with ichnological and petrographic observations.

INTRODUCTION

In recent years, considerable geological, geomorphological and geochronological studies have been carried out on the ‘miliolite rocks/deposits’ of the Saurashtra Peninsula, Gujarat State. Over 50 miliolite ages obtained using the ²³⁰Th/²³⁴U method ranged from about 30 Kyr, to about 300 Kyr (Baskaran, 1985; Bruckner et al. 1987; Baskaran et al. 1988) indicating that the miliolites are early Late Pleistocene. Occurrence of lower Paleolithic tools below the miliolite bed dated to a minimum age of 144 Kyr BP also supports the view that the miliolites in Saurashtra belong to early Late Pleistocene (Baskaran et al. 1986).

In Kutch too, miliolites occur (Fig. 1). Carter (1849) and Wynne (1872) were the first to report Carbonate Sandstones of recent ages in the interior parts. Later, Glennie (1970), and Biswas (1971) studied these ‘Carbonate Sandstones’ and showed similarity in biological and lithological composition with the miliolites of Saurashtra and ascribed an aeolian origin to these rocks on the basis of field and petrographic data. Many of these observations have recently been confirmed by Allahabadi and Patel (1986) and Patel and Allahabadi (1988). In none of these studies, however, the geochronological aspects have been looked into. For a discussion on problems associated with the miliolite deposits, reference can be made to Merh (1980). We carried out a short field work in parts of inland Kutch and collected about a dozen miliolite samples from seven locations given in Figure 1. Dating was attempted on these samples and their ages compared with those of the Saurashtra miliolites. These
are briefly discussed in this short communication. An account of the radioisotope methods for dating Quaternary deposits lying on continents is given by Somayajulu (1988).

FIELD AND LABORATORY OBSERVATIONS

Our sample locations indicated in Figure 1 show that the miliolites are confined to the inland rocky part of Kutch and range in elevations from 45 m to about 180 m above mean sea level (AMSL). These rocks/deposits vary in thickness from 2 m to 15 m and mainly occur as isolated outcrops either in the headwater regions of southerly-flowing ephemeral streams or in the foot-slope zones of rocky hills consisting of shale, sandstone and limestone of Late Mesozoic age and basalts of Early Tertiary age. The miliolite rocks are finely laminated and, at places, are rich in locally derived rock fragments. Our sampling sites are briefly described in Table I. Roughly, all the miliolites in the sampled locations are distributed in a WSW-ENE direction.

![Geological map of Kutch giving the sample location.](Image)

Sample numbers are given in the insert. See Table I for other details.

METHODOLOGY

At least one to two kg of miliolite rock, uncontaminated with the local alluvium and rock debris was collected from each location. Samples from thick miliolite deposits, but not stray pieces lying around, were collected.

In the laboratory, 1/2 kg size samples, after chipping of the surficial-layering, were powdered and oven-dried over night at 110°C. The CaCO₃ quartz, Sr and Mg contents were measured according to the method described by Baskaran (1985), and
Table 1: Location, lithology and stratigraphy of Kutch miliolites.

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Sample Code</th>
<th>Location</th>
<th>Lithological characters</th>
<th>Local stratigraphy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>70-1</td>
<td>8 km SE of Bhuj; 60 m AMSL</td>
<td>Gently bedded, almost devoid of colluvial components</td>
<td>Valley fill miliolite rests unconformably on Mesozoic sediments</td>
</tr>
<tr>
<td>2.</td>
<td>70-2</td>
<td>- do -</td>
<td>- do -</td>
<td>- do - 4 m below 70-1</td>
</tr>
<tr>
<td>3.</td>
<td>71</td>
<td>12 km SW of Bhuj; 103 m AMSL</td>
<td>Finely laminated, friable and rich in sand stone fragments of local origin</td>
<td>Rests unconformably on Mesozoic sediments</td>
</tr>
<tr>
<td>4.</td>
<td>73</td>
<td>15 km SE of Bhuj; 153 m AMSL</td>
<td>Arnaceous miliolite</td>
<td>Rests unconformably on shales and sandstones</td>
</tr>
<tr>
<td>5.</td>
<td>76-1</td>
<td>20 km South of Bhuj; 180 m AMSL</td>
<td>Gently bedded 10 m thick with interlayers of colluvial basaltic blocks</td>
<td>Sheet like miliolite rests unconformably on Deccan Traps.</td>
</tr>
<tr>
<td>6.</td>
<td>76-2</td>
<td>- do -</td>
<td>- do -</td>
<td>- do - 7 m above 76-1</td>
</tr>
<tr>
<td>7.</td>
<td>79</td>
<td>26 km SE of Bhuj; 138 m AMSL</td>
<td>Subhorizontal, thin (&lt; 2 m), without colluvial components</td>
<td>Isolated out crop resting unconformably on Mesozoic sediments</td>
</tr>
<tr>
<td>8.</td>
<td>80</td>
<td>20 km SE of Bhuj; 43 m AMSL</td>
<td>Finely laminated, pure and friable</td>
<td>Rests unconformably on foot slope of a hill of Mesozoic rock</td>
</tr>
<tr>
<td>9.</td>
<td>81</td>
<td>- do -</td>
<td>- do -</td>
<td>- do - miliolite capped by rubble</td>
</tr>
<tr>
<td>10.</td>
<td>82</td>
<td>8 km SE of Bhuj; 60 m AMSL</td>
<td>Gently bedded, almost devoid of colluvial components</td>
<td>Valley-fill miliolite, rests unconformably on Mesozoic sediments</td>
</tr>
</tbody>
</table>

* Upper part of the miliolite rock generally consists of hard duric rnut while the lower part is relatively soft.

AMSL: Above Mean Sea Level.

Table 2: CaCO₃, quartz, Sr, Mg, U, Th and ²³⁰⁹Th/²³⁴U ages of Kutch miliolites.

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>CaCO₃ (%)</th>
<th>Quartz (%)</th>
<th>Sr (ppm)</th>
<th>Mg (ppm)</th>
<th>²³⁰⁹U (ppm)</th>
<th>²³⁴⁹U (ppm)</th>
<th>²³⁴⁹U/²³⁴⁹U</th>
<th>²³⁰⁹Th (ppm)</th>
<th>²³⁴⁹Th (ppm)</th>
<th>AGE (x10⁶ yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-1</td>
<td>65.0</td>
<td>4.6</td>
<td>2190</td>
<td>4557</td>
<td>1.63±0.04</td>
<td>0.93±0.03</td>
<td>0.52±0.02</td>
<td>7.3±0.4</td>
<td>104±8</td>
<td>78.3±1.9</td>
</tr>
<tr>
<td>70-2</td>
<td>63.1</td>
<td>4.1</td>
<td>2563</td>
<td>5025</td>
<td>1.57±0.04</td>
<td>1.02±0.03</td>
<td>0.62±0.03</td>
<td>108±10</td>
<td>104±8</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>49.8</td>
<td>8.2</td>
<td>511</td>
<td>3455</td>
<td>0.58±0.01</td>
<td>0.69±0.02</td>
<td>0.70±0.03</td>
<td>104±8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>53.0</td>
<td>4.7</td>
<td>NM</td>
<td>NM</td>
<td>0.53±0.01</td>
<td>0.52±0.02</td>
<td>1.2±0.02</td>
<td>104±8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>76-2</td>
<td>42.1</td>
<td>4.5</td>
<td>1703</td>
<td>5349</td>
<td>1.03±0.03</td>
<td>0.66±0.02</td>
<td>1.0±0.02</td>
<td>104±8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>57.2</td>
<td>3.8</td>
<td>571</td>
<td>5217</td>
<td>0.57±0.01</td>
<td>0.54±0.02</td>
<td>1.0±0.02</td>
<td>104±8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>57.0</td>
<td>6.3</td>
<td>NM</td>
<td>NM</td>
<td>0.65±0.02</td>
<td>0.61±0.02</td>
<td>1.0±0.02</td>
<td>104±8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81</td>
<td>63.0</td>
<td>2.8</td>
<td>1007</td>
<td>3620</td>
<td>0.64±0.02</td>
<td>0.55±0.02</td>
<td>1.0±0.02</td>
<td>104±8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>63.7</td>
<td>4.6</td>
<td>2360</td>
<td>3346</td>
<td>0.79±0.02</td>
<td>0.52±0.02</td>
<td>1.0±0.02</td>
<td>104±8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Samples 76-1, 76-2, 79 and 82 have 3.5, 15.3, 3.7 and 17.1% aragonite in their CaCO₃, rest contain only Calcite.
Errors quoted for U, Th isotopes are due to propagated one sigma counting statistics only, for others see text.
NM: Not Measured  C: Corrected for detrital ²³⁰⁹Th contribution (see Baskaran et al., 1988)
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Baskaran and Somayajulu (1986). The 5% acetic acid (HAc) method was used to dissolve the CaCO₃ in the samples for dating (Baskaran, 1985). The U, Th isotope analyses were carried out using the procedures described by Baskaran (1985) and Baskaran et al. (1988). Detailed procedure for ascertaining the corrected ²³⁰Th/²³⁴U and ²³⁴U/²³⁸U activity ratios and for the calculation of the ²³⁰Th/²³⁴U ages are also given in Baskaran (1985) and Baskaran et al. (1988). For a complete account of the ²³⁰Th/²³⁴U dating method and its applications, reference be made to Ivanovich and Harmon (1982).

RESULTS AND DISCUSSIONS

The CaCO₃, Sr, Mg, quartz contents together with the U, Th concentrations, ²³⁴U/²³⁸U and ²³⁰Th/²³⁴U activity ratios and ages are given in Table II.

CaCO₃ and Mineralogy

The CaCO₃ content of the sampled Kutch miliolites ranges from 42.3% to 65% averaging 57.1%, compared to the average CaCO₃ content of 86.8% reported for the Saurashtra miliolites. The quartz content ranges from 2.8 to 8.2% averaging 4.8% which is higher than the mean value of 2.7% obtained for the Saurashtra miliolites. Only few of the nine samples studied have 3.5 to 1.17% aragonite in the CaCO₃—a situation similar to that found in Saurashtra (Baskaran and Somayajulu, 1986). It is thus seen that the Kutch miliolites are relatively more impure and contain more quartz compared to their Saurashtra counterparts.

Th and U Isotope Systematics

The U and Th contents of the Kutch miliolites are in the range of 0.53 ± 0.01 to 1.63 ± 0.04 and 0.52 ± 0.02 to 1.02 ± 0.03 ppm respectively. Both these ranges are in good agreement with those found for miliolites of Saurashtra. Since 5% HAc was used for dissolution, correction for the detrital Th was only applied to calculate the ²³⁰Th/²³⁴ U activity ratios. Applying standard assumptions including the U/Ca and Sr/Ca plotting (Baskaran et al. 1988), the ²³⁰Th/²³⁴ U ages could be calculated for nine of the eleven samples. These ages range from 42.4 Kyr. to 167 Kyr. (Table II).

The ²³⁴U/²³⁸U activity ratios range from 1.04 ± 0.01 to 1.12 ± 0.02 and these when corrected for their respective sample ages range from 1.05 to 1.17 yielding a mean value of 1.11 ± 0.02 which within errors is equal to the seawater value of 1.14 ± 0.02 (Koide and Goldberg, 1965; Krishnaswami et al. 1970). This indicates that bulk of the miliolite material was formed in a coastal marine environment—a case identical to the miliolite formation in Saurashtra (Baskaran, 1985). We plan to carry out stable isotope measurements of ¹³C and ¹⁸O on Kutch samples as in the case of Saurashtra miliolites (Baskaran et al. 1985).

²³⁰Th/²³⁴U Ages

The ages of the nine Kutch miliolites fall into the groups, M I, (50–70 Kyr), M II (75–115 Kyr) and M III (> 140 Kyr) suggested by Baskaran (1985). Baskaran et al. (1988) treated M III as more of a scatter than a group. It is reasonable to
conclude that miliolite formation took place around the same time both in Saurashtra and Kutch.

Though the sample number is small, it is interesting to note that older miliolite rocks occur at lower elevations (Sample nos. 80, 81 and 82—Tables I, II) and the younger ones occur at higher elevations (samples 76–2 and 79). In Saurashtra also, the oldest miliolites (M III) occur in lower elevations and that too close to the sea coast only (Baskaran et al. 1988). Unlike the miliolite rocks in Saurashtra which are almost continuous from coast to inland, those from Kutch are confined to the rocky inland situations several kilometers away from the present coast line.

SUMMARY AND CONCLUSIONS

The miliolite rocks of Kutch have formed between late Middle Pleistocene (170 Kyr BP) and Early Late Pleistocene (45 Kyr BP) and are contemporaneous with those of Saurashtra. The miliolites from Kutch are relatively more impure with higher quartz contents compared to their Saurashtra counterparts. Also the older ones are at lower elevations and bulk of the miliolite formation has taken place in a coastal marine environment in Kutch, similar to what happened in Saurashtra. More samples from different regions of Kutch have to be studied for geochemistry, petrography, ichnology (Chakrabarti and Baskaran, 1988) and geochronology. Only then can one explain the occurrence of these interesting deposits at different locations in Kutch.

ACKNOWLEDGEMENTS

We are grateful to Prof. S. S. Merh for providing the geological map of Kutch (Fig 1). We thank the authorities of the Physical Research Laboratory, Deccan College and of the Oil and Natural Gas Commission for providing facilities and encouragement.

References


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(Received: Dec. 9, 1988)