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# PETROLOGY OF THE TERTIARY COASTAL SECTION AT COX'S BAZAR

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Petrographic and mineralogical studies of the coastal sections of Upper Miocene sediments at Cox's Bazar have been carried out. It is suggested that the sediments have been derived predominantly from a metamorphic source area. Further it is concluded that the sediments were laid down under shallow water condition probably in a shelf zone.

The area investigated lies $3\frac{1}{2}$ miles south of the seashore town of Cox's Bazar, a subdivisional headquarter situated 95 miles southeast of Chittagong (Fig. 1) The area is composed of hills of varying topography running along the coast of Bay of Bengal. The highest point in the area is 270 ft above sea level. These hills terminate abruptly against the seashore and expose beautiful sections of Tertiary rocks in the form of vertical cliffs trending NNE-SSW. The height of the cliffs along the beach varies within a narrow range of 115 ft–175 ft. Behind the cliffs exposures are scanty because of thick vegetation covering the hills.

## Outcrop and Lithology

The succession (Fig. 2) has been worked out mainly on the basis of study of sections along the cliff. The whole succession is composed of similar rock types. Sandstone comprises approximately three fourth of the total rock exposed. Ripple marked siltstone and shale are found to be interbedded with sandstones. The whole sequence has, therefore, been tentatively named as Cliff Sandstone.

A thin fossiliferous marine intercalation has been found in the coastal cliffs indicating an Upper Miocene age for the sediments[1] which makes the sequence equivalent of Tipam Series of the Assam.[2] Rocks considered to be equivalent of Tipam on lithologic analogy from other areas in East Pakistan have been reported.[3]

The sandstones exposed are found to be yellowish grey, semiconsolidated and highly cross-bedded at the base of the cliff with concentration of dark minerals along the false bedding. Presence of carbonized woods in the sandstone has also been noted. The features like cross-bedding and concentration of dark minerals are totally absent from the sandstones in the middle and upper parts of the section.

## Petrography

*Method of Study*.—For petrographic studies eight samples of sandstone, three from cross-bedded sandstone at the bottom, three from sandstone beds lying below the fossiliferous bands but above the cross-bedded sandstone sequence and two from sandstone beds lying above the fossiliferous bands, have been studied. Laboratory investigation has included (a) size analysis by dry sieving after necessary disaggregation using Tyler standard sieve screens of 16, 32, 60, 115 and 200 mesh, (b) heavy mineral separation from −200 sieve fraction by centrifuging, and, (c) microscopic determination of the heavy minerals and their relative abundance on the basis of grain counts.

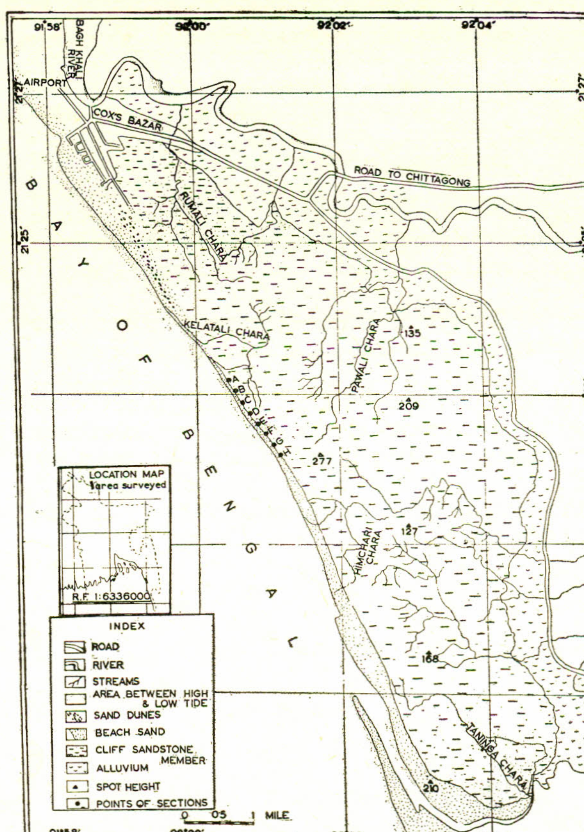


Fig. 1.—Map showing the location of sections measured at points A, B, C, D, E, F, G and H.

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In order to evaluate the statistical parameters grain size envelopes have been drawn and the, following parameters evaluated.[4]

| | | |
|---|---|---|
| (1) Central tendency | a) Phi medain dia | $Md\Phi = \Phi 50$ |
| | b) Phi mean | $M\Phi = \frac{1}{2}\ (\Phi 16 + \Phi 84)$ |
| (2) Dispersion | Phi deviation | $\sigma\Phi = \frac{1}{2}\ (\Phi 16 - \Phi 84)$ |
| (3) Symmetry | Phi skewness | $\alpha\Phi = \dfrac{M\Phi - Md\Phi}{(\Phi\sigma)}$ |

Slides were prepared from the light fractions of each of the samples. Intercept measurements corresponding to length, breadth and thickness were made on quartz grains. The values of intermediate/long axis and short/intermediate axis were computed from the intercept measurements and the shape of the grain was described in Zings' terminology.[5] The elongation coefficient (long/short axis) of quartz grains of Tertiary rocks was also computed.

## Results

*Texture.*—Grain size envelops and sand and silt-clay ratio for the sandstone from the lower, middle and upper parts of the sequence are shown in Fig. 3a and b, 4a and b, 5a, and b. The shape of the grain size envelops (Fig. 3a, 4a, 5a) are represented by smooth curves and does not suggest any mixing of sediments from two or more sources.

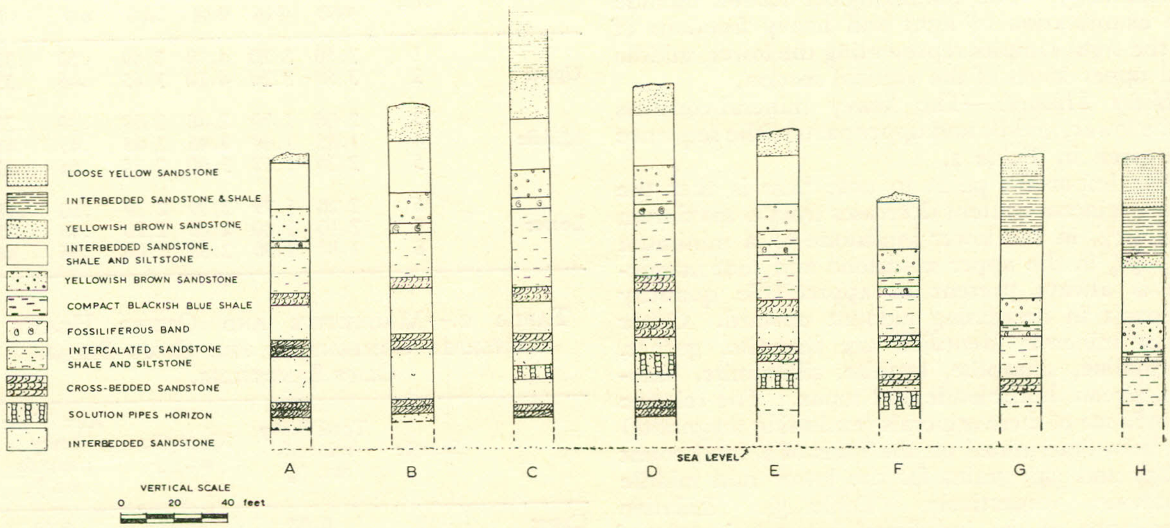


Fig. 2.—Columnar sections showing the rock types and lateral variation in lithology.

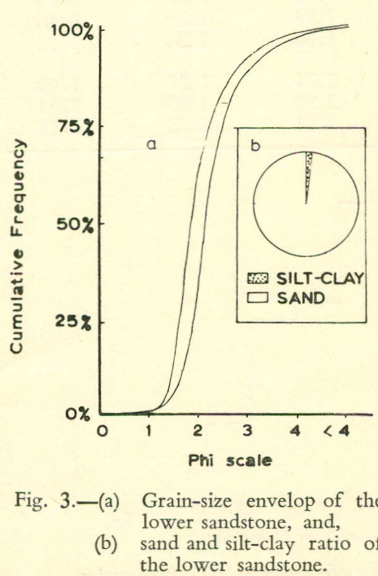


Fig. 3.—(a) Grain-size envelop of the lower sandstone, and,
(b) sand and silt-clay ratio of the lower sandstone.

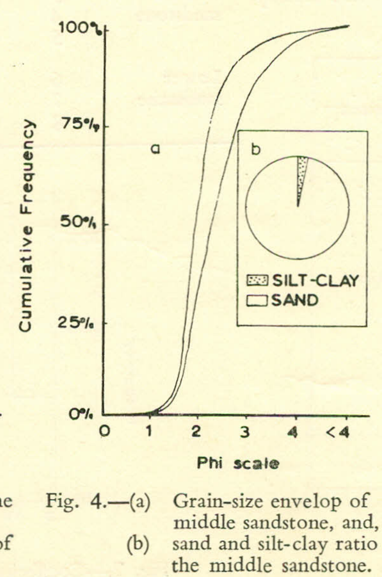


Fig. 4.—(a) Grain-size envelop of the middle sandstone, and,
(b) sand and silt-clay ratio of the middle sandstone.

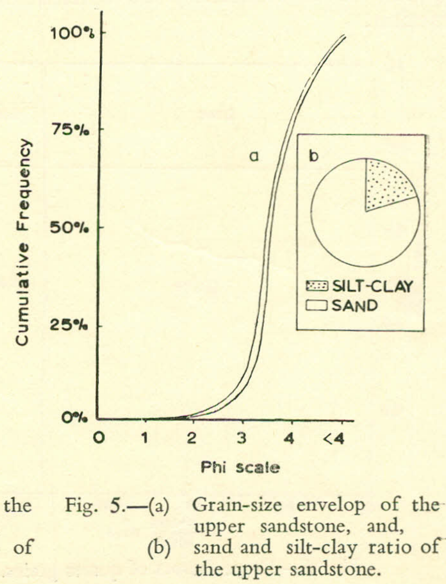


Fig. 5.—(a) Grain-size envelop of the upper sandstone, and,
(b) sand and silt-clay ratio of the upper sandstone.

The sandstone in the middle portion of the sequence is coarser than the sandstones from the lower and upper levels. Although sand fraction is the dominant component of the sandstones, the proportion of silt-clay on an average increases from 1.99% in the lower sandstone through 3.04% in the middle part to 19.99% in the upper part of the sequence (Fig. 3b, 4b and 5b). The sandstone is well-sorted with deviation ($\sigma\phi$) varying within a narrow range from .39 to .66 (Table 1). The plots of measurements on quartz grains in Zing's diagram (Fig. 6) indicate that they are largely spherical in shape with subordinate quantity of roller. In general the quartz grains have low values for the coefficient of elongation (Fig. 7).[6]

*Mineralogy.*—The mineralogical studies include the examination of light and heavy fractions of all the eight samples representing the lower, middle and upper levels of the vertical section.

*Heavy Minerals.*—The heavy mineral contents of the lower, middle and upper parts of the sequence are given in Table 2.

The important point to note here is that the heavy mineral content decreases from a maximum of 4.42% in the lower sandstone to a minimum of .04% in the upper sandstone and that magnetite is always present in appreciable quantity although in decreasing amount upward. Other heavy minerals identified are ilmenite, garnet, tourmaline, staurolite, kyanite, sillimanite, limonite, zircon, hornblende and topaz. The relative abundance of these minerals (excluding magnetite) has been determined on the basis of a total count of 857 and 340 grains for the lower and middle sandstone respectively (Table 3). Relative abundance of the individual heavy minerals of the upper sandstone has not been determined because of the extremely low content of the heavy fraction.

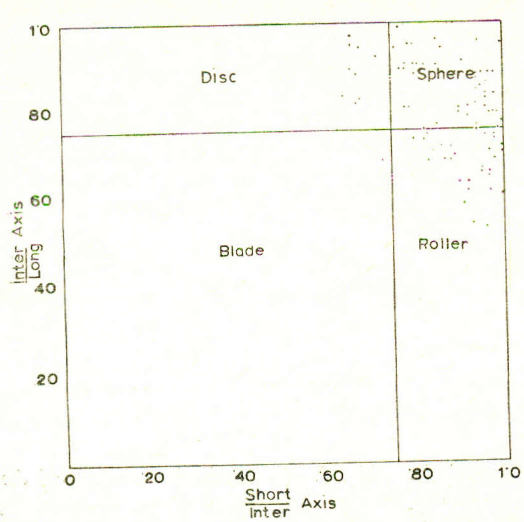


Fig. 6.—Shape factors of quartz grains.

*Light Minerals.*—Light mineral assemblage comprises predominant quartz grains and subordinate mica and feldspar. Quartz is generally found as subrounded to subangular grains many of which exhibit undulose extinction. Well-rounded quartz grains are infrequently observed. Inclusions in quartz grains are abundantly found although grains free from inclusion are also present. The inclusions may be grouped into three types; (a) irregularly distributed minute opaque grains of ore forming minerals, (b) regularly arranged

TABLE 1.—STATISTICAL PARAMETERS OF COX'S BAZAR CLIFF SANDSTONE.

| Division | Sample No. | Size distribution in Φ scale | | | | | |
|---|---|---|---|---|---|---|---|
| | | Φ50 | Φ16 | Φ84 | MΦ | σΦ | aΦ |
| Upper | 1 | 3.50 | 3.20 | 4.19 | 3.69 | .50 | .38 |
| | 2 | 3.50 | 3.20 | 4.10 | 3.65 | .45 | .33 |
| Middle | 3 | 2.00 | 1.70 | 2.48 | 2.09 | .39 | .23 |
| | 4 | 1.85 | 1.60 | 2.46 | 2.03 | .43 | .41 |
| | 5 | 2.20 | 1.68 | 3.00 | 2.34 | .66 | .21 |
| Lower | 6 | 2.20 | 1.79 | 2.79 | 2.29 | .50 | .18 |
| | 7 | 2.10 | 1.80 | 2.60 | 2.20 | .40 | .25 |
| | 8 | 1.80 | 1.50 | 2.62 | 2.06 | .56 | .46 |

TABLE 2.—MAGNETITE AND OTHER HEAVY MINERALS CONTENT OF THE COX'S BAZAR CLIFF SANDSTONE.

| | Sample | Total heavy minerals wt. % | Magnetite wt. % | Rest of the heavy minerals wt. % |
|---|---|---|---|---|
| Upper sandstone | 1 | 0.04 | 0.03 | 0.01 |
| | 2 | 0.07 | 0.05 | 0.02 |
| Middle sandstone | 3 | 1.90 | 1.37 | 0.63 |
| | 4 | 1.95 | 1.39 | 0.56 |
| | 5 | 1.36 | 1.24 | 0.12 |
| Lower sandstone | 6 | 2.74 | 1.29 | 1.45 |
| | 7 | 3.52 | 1.39 | 2.13 |
| | 8 | 4.32 | 2.23 | 2.19 |

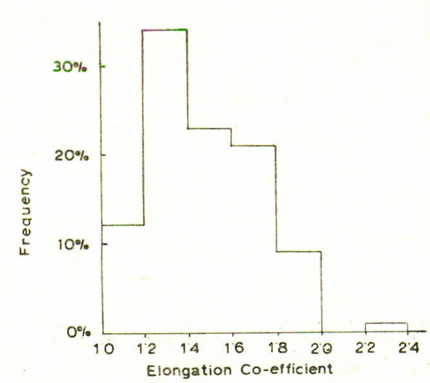


Fig. 7.—Coeffecient of elongation of quartz grains.

TABLE 3.—RELATIVE PERCENTAGE ABUNDANCE OF HEAVY MINERALS IN COX'S BAZAR CLIFF SANDSTONE.

| Minerals | Lower sandstone % by count | Middle sandstone % by count |
|---|---|---|
| Ilmenite | 34.80 | 32.40 |
| Garnet | 19.00 | 15.00 |
| Tourmaline | 19.00 | 13.20 |
| Staurolite | 6.00 | 4.40 |
| Kyanite | 1.70 | 6.20 |
| Sillimanite | 2.20 | 5.00 |
| Limonite | 5.40 | 2.06 |
| Zircon | 1.05 | 0.30 |
| Hornblende | 1.05 | 1.76 |
| Topaz | 0.23 | 3.35 |
| Unidentified | 1.15 | 17.60 |

grains of opaque minerals, and (c) inclusion of acicular habit frequently of apatite. Inclusions belonging to the first two catagories are far more abundant. Apatite, besides occuring as acicular crystals, has also been found as six sided tabular grains. Besides iron ore and apatite, zircon and sphene have also been found to occur as inclusions. Liquid inclusions are very uncommon. Among the mica, biotite is more abundant than muscovite.

Feldspars are found in greatly subordinate quantity. Of the feldspars orthoclase is more abundant and found as subrounded grains exhibiting solution pitting. Plagioclase and microcline are of minor occurrences and are found as subrounded grains.

## Discussion and Conclusion

Mechanical analysis of sandstones collected from different levels of the vertical section reveals that sorting is better in case of lower sandstone. With the proportion of silt and clay increasing upward the sorting becomes relatively poor in case of upper sandstone.

The suite of heavy minerals present include magnetite, ilmenite, garnet, tourmaline, staurolite, kyanite, sillimanite, limonite, zircon, hornblende and topaz. Apart from hornblende all the minerals are chemically stable. Hornblende is however present in notably low quantity. The assemblage of heavy minerals indicate a mixed parentage. The sillimanite–kyanite–garnet or garnet–kyanite–staurolite suite is a well-known indicator of metamorphic sources.[7] Therefore, presence of garnet, staurolite, kyanite and sillimanite alongwith strained quartz grains in abundance indicates that the source rocks for the sediments must have been metamorphic. Magnetite which is the most abundant heavy mineral may have been derived from basic and ultrabasic igneous rocks, but magnetite bearing metamorphic rocks as a source cannot be ruled out. Zircon and tourmaline, are also indicative of igneous source but zircon is found in greatly subordinate quantity. Therefore it is suggested that the sediments were largely derived from a metamorphic province.

Among the light fraction quartz is the most predominant mineral. Although quartz grains are found to be spheroidal in shape, microscopic study indicates that they have marked angularity. The elongated quartz grains which are described as roller in Zing's terminology are also angular.

From the study of such a limited coastal exposure of sediments of Upper Miocene age it is very difficult to say much about the condition of deposition of these sediments. It can however be suggested that the sediment have been derived predominantly from a metamorphic source. Marked angularity of the quartz grains may be taken as indicative of a rather short distance transportation. The Assam plateau comprising of Archaean metamorphic and igneous complex in the north may be suggested to have supplied bul of the sediments. Presence of cross-bedding, ripples marks, streaks of coal in the sediments and also the marked lateral variation in lithology suggests that the sediments were laid down under a very shallow water condition probably shelf zone. The presence of such macrofossils as *Chlamys*, *Lovenia*, *Temnopleurus*, *Balanus*, and *Ostrea* described by Ahmad[1] also supports the above conclusion.

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