

## Carbonate Lumps in the Lawson's Bay Area, Visakhapatnam, East Coast of India

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Modern carbonate lumps are found in the Lawson's Bay area. The carbonate lumps are inferred to have been deposited by biochemical process in the littoral zone. Abundant high Mg-calcite with subordinate aragonite and dolomite are the minerals in the carbonates. Aragonite and dolomite are considered to have been formed by the diagenetic alteration of high Mg-calcite. *Amphiroa fragilissima* and *Chaetomorpha* sp. are the dominant algal forms present in the carbonates. No direct evidence on the age of carbonates in the bay could be obtained.

**P**LEISTOCENE carbonate-rich sediments, deposited at the time of lowered sea level, constituting mainly shell fragments, foraminiferal tests and oolites formed by inorganic precipitation of  $\text{CaCO}_3$  as aragonite, have been reported from the outer continental shelf off the Visakhapatnam coast<sup>1,2</sup>. However, no such carbonate-rich deposits are noticed so far on the present-day beaches or in the littoral zone of Visakhapatnam coast. During a field trip to the Lawson's Bay, a small, shallow open bay, irregular carbonate lumps (Fig. 1) have been found in the beach and intertidal zone. In addition, creamy, thin to very dense carbonate coatings on pebbles and boulders (Fig. 2) have been noticed. Some of the lumps show pseudo-oolitic and pisolitic forms with irregularly grown sub-spherical bodies (Fig. 3).

The beach sediments are mostly unconsolidated quartz sands and overlie the bed rock consisting of Pre-Cambrian khondalite gneiss. The khondalite rocks outcrop here and there and some of these are submerged during high tide. The bay where the carbonate lumps are occurring lies within 30°N of the equator and falls under the area of pure carbonate depositional environments of the world<sup>3</sup>. In this paper an attempt is made to evaluate the mode of deposition of the carbonate lumps and to compare these with the calcareous deposits on the outer continental shelf off the Visakhapatnam coast.

Hydrographical studies in the Lawson's Bay have been carried out earlier<sup>4,5</sup>. The bay and the adjacent coastal area are under warm humid climate. Water temperature shows a double oscillation with one maximum during April (27°C) and another during October (29°C). Salinity of the surface waters ranges from 17.4 to 34.96‰, the minimum being in October and maximum during April.

### Materials and Methods

Four carbonate lump samples and adjacent beach sand samples were collected in the Lawson's Bay area (Fig. 4). Samples were examined under

binocular microscope and the algal species were identified. Carbonate contents of the lumps and the adjacent beach samples were determined<sup>6</sup>. Sand particles, incorporated in the lumps during their formation, in the insoluble residue of the carbonates were separated. These entrapped sands and the beach sands underlying and surrounding the lumps were compared under a binocular microscope. Chemical analysis of the carbonates was carried out<sup>7</sup>. Mineralogical composition is determined with X-ray powder diffractometry using Ni filter and Cu/K radiation.

### Results

*Amphiroa fragilissima* and *Chaetomorpha* sp. are the dominant algal forms present in the carbonates. The beach sands are significantly poorer in the carbonate content than the carbonate lumps and contain very few shell fragments. Texturally the entrapped sands in lumps are relatively finer than beach sands. Results of X-ray diffraction analysis of carbonate sample 2 show that high Mg-calcite (conc. of  $\text{MgCO}_3$  23 mole %<sup>8</sup>) with a sharp peak at 29.8° 2 $\theta$  is the dominant mineral in the carbonate sample with subordinate aragonite (36.5° 2 $\theta$ ) and traces of dolomite (31.8° 2 $\theta$ ). Data of chemical analysis of the carbonates and carbonate contents of the beach sands are given in Table 1.

### Discussion

Organic and inorganic processes have been suggested for the precipitation of carbonates in the marine environment. In the Lawson's Bay, however, carbonate lumps are considered to have been formed by the biochemical process. The inference is mainly based on the distinct algal framework and the presence of lime-secreting algae *Amphiroa fragilissima* and *Chaetomorpha* sp. in the carbonates. Besides, the clastic nature of the bay sediments indicates that physico-chemical precipitation of carbonate does not take place in the Lawson's Bay at present. Earlier investigations on carbonate sediments<sup>9</sup> have shown that coralline algae, *Amphiroa* is more efficient producer of calcium

carbonate than the green alga *Chaetomorpha* sp.<sup>10</sup>. *Amphiroa fragilissima* and *Chaetomorpha* sp. grow as extensive mats in the Lawson's Bay area<sup>5</sup>. The existence of a regular seasonal succession in the regeneration, maximum growth and decline of algal forms along the Visakhapatnam coast has also

been noticed. Degeneration of these algal forms during January-April might have added considerable carbonate to the bottom sediments of the Lawson's Bay. Algal fragments might have been concentrated to form the lumps entrapping some sands in the adjacent area. The creamy crust on the pebbles and boulders is inferred to have been formed by lime precipitation in the micro-environment created by the algae. It also may be considered to have been formed by the micritization of algal fragments resulting in an apparently cell-less, creamy carbonate coatings. Absence of carbonate lumps and lime coatings on pebbles in other parts of Visakhapatnam coast may be attributed to the restricted occurrence of abundant lime-secreting algal forms in the Lawson's Bay area<sup>5</sup>.

It is doubtful whether the carbonate lumps are initially formed in their places of occurrence, because the beach is subject to varying current action. However, the difference in the size of entrapped sands and beach sands surrounding carbonate lumps and the gradual seaward decrease in the grain size of sands in the Lawson's Bay suggest that carbonates were deposited seaward to the present position of their occurrence. Further, the significantly high carbonate content of the lumps (66-87%) compared to the beach sands (2.0-3.5%) surrounding the lumps rules out the possible *in situ* concentration of the carbonates. Therefore, the carbonate lumps are considered to have been formed in the littoral zone and transported to the beach.

Mineralogically, carbonates of the Lawson's Bay are predominantly high Mg-calcite with subordinate aragonite and dolomite. Coralline algae in tropical

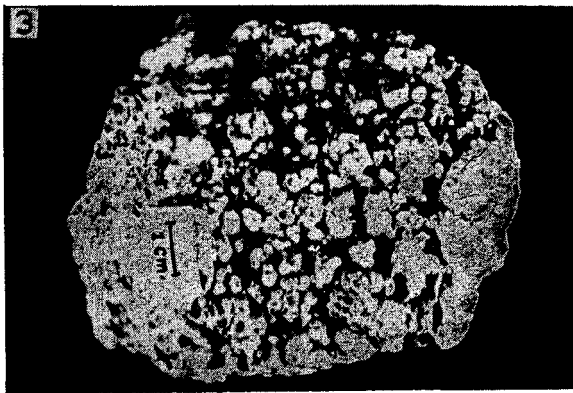
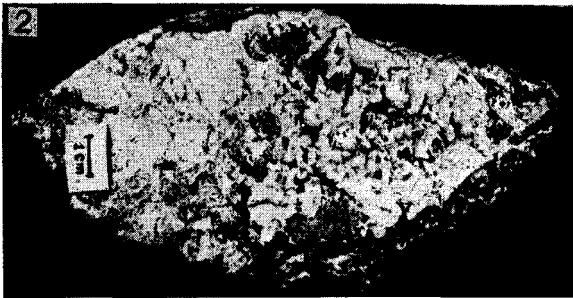
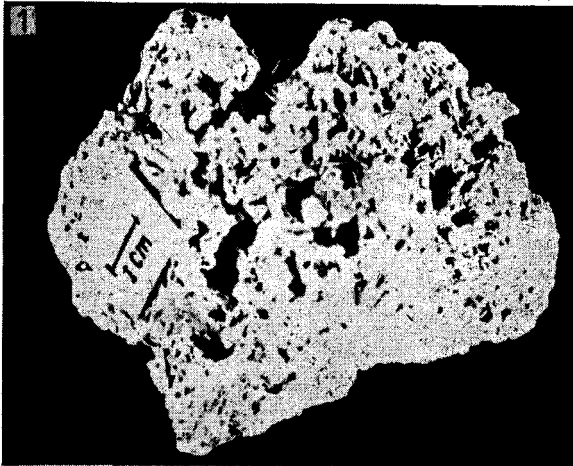


Fig. 1 — Carbonate lump in the Lawson's Bay area

Fig. 2 — Carbonate encrustation on the Khondalite rock

Fig. 3 — Pseudo-oolitic nature of carbonates

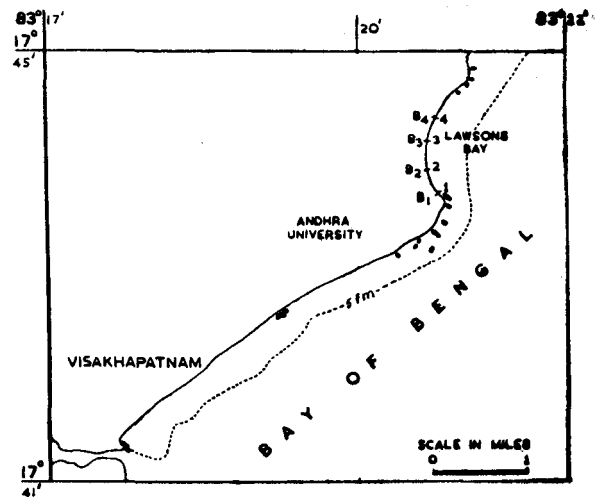


Fig. 4 — Locations from where carbonate samples in the Lawson's Bay area are collected

TABLE 1 — PER CENT CHEMICAL COMPOSITION OF THE CARBONATES AND THE ADJACENT BEACH SANDS

Sample No.	Al	Fe	Ca	Mg	Carbonate	Beach sands	Carbonate
1	1.35	1.78	31.6	3.75	74	B <sub>1</sub>	3.5
2	1.18	0.5	40.1	6.33	87	B <sub>2</sub>	2.5
3	1.51	2.3	30.3	4.15	76	B <sub>3</sub>	4.25
4	1.9	2.1	29.7	3.05	66	B <sub>4</sub>	2

and sub-tropical seas are made up of high Mg-calcite<sup>11,12</sup>. Aragonite and dolomite in carbonates are inferred to have been formed chiefly by the alteration of metastable high Mg-calcite. The general stability sequence for calcium carbonate minerals constituting carbonate sediments under natural conditions<sup>13-16</sup> strongly supports the possible alteration of high Mg-calcite to aragonite in the Lawson's Bay. However, Siesser<sup>16</sup> states that green algae contribute aragonite while coralline algae contribute high Mg-calcite to the sediments and the high Mg-calcite is the least stable carbonate mineral and should be the first to show diagenesis. During diagenesis Mg is liberated to interstitial waters and subsequently might have been precipitated as dolomite. In addition, the blue-green algae are capable of concentrating Mg and thus offer an additional source of Mg for dolomitization<sup>17</sup>. Chemical composition of carbonates (Table 1) of the Lawson's Bay shows a good correlation to chemical composition of the algal sp.<sup>18</sup>. However, the relatively higher Fe content (0.5-2.3%) in these carbonates may be attributed to the high Fe content in the lateritic soils that contribute sediments to the Lawson's Bay.

No direct evidence on the age of carbonates in the Lawson's Bay could be obtained. However, the original organic framework, the mineralogical composition and a comparison with algal carbonates in other areas<sup>18</sup> suggest that the carbonates are modern in age. It has been observed<sup>19</sup> that modern marine carbonates are composed predominantly of the metastable phases, high Mg-calcite and aragonite, whereas ancient rocks are chiefly low Mg-calcite and dolomite.

Carbonate sediments in the outer continental shelf off the Visakhapatnam coast show no correlation regarding modes of deposition and mineralogy to the modern carbonates of the Lawson's

Bay. However, the two carbonates represent a shallow marine environment of deposition.

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