

## CARBONATE MINERALOGY AND FAUNAL RELATIONSHIP IN TROPICAL SHALLOW WATER MARINE SEDIMENTS: CAPE COMORIN, INDIA

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### ABSTRACT

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The carbonate mineralogy of Recent sediments from the western and eastern continental shelves around Cape Comorin off the southern tip of India was determined by X-ray diffraction analyses. The results show that in the sediments where benthic foraminifera are the most abundant component, as on the extreme western side and on a narrow strip between the depths of 40 and 50 m, on the eastern side (Gulf of Manaar), the carbonate mineralogy is dominated by high magnesium calcite. In sediments where molluscs exceed other components, as on the eastern shelf between 10 and 40 m, the most abundant mineral is aragonite. Low-magnesium calcite does not appear to be related to depth or carbonate components.

### INTRODUCTION

Carbonate sediments are the product of the marine environment and therefore, reflect its characteristics and have diagnostic value. Faunal assemblages and their state of preservation, and the mineralogy of carbonate sediments have been studied extensively and these results are reviewed, e.g. by Milliman (1974) and Bathurst (1975). However, such studies on low latitude shelves are comparatively few and shelves around the Indian Ocean have been the least studied. An exception to this is the western continental shelf of India where considerable work on carbonate sedimentology has been carried out (Hashimi and Nair, 1976; Hashimi et al., 1978; Gupta, 1979; Nair and Hashimi, 1981). The present investigation deals with the relationship of carbonate mineralogy to the nature and abundance of the skeletal components on the continental shelf around Cape Comorin at the southern tip of peninsular India.

## SEDIMENTARY FACIES

Detailed sedimentological studies of the eastern and western shelves around Cape Comorin have been carried out by Hashimi et al. (1981). The following is summarised from the latter paper. The sediments are fine to medium sands from Quilon to Tuticorin (Fig. 1) with exception of two patches off East Cape which are clayey silt and silty sand. This presence of sandy sediments between 10 and 50 m is in sharp contrast to the region north of Quilon where silts and clays are found at these depths. The marked difference in the texture is attributed to the presence of large estuaries north of Quilon which trap coarse-grained sediments, resulting in the accumulation on the inner shelf of only silts and clays. Between Cape Comorin and Tuticorin the sediment texture is coarse sand. Periodic bed forms (ripples/waves) were also observed in this region, however, the direction of sediment transport is not very clear. The inner shelf (10–50 m) from Quilon to Tuticorin is composed of carbonate sediments with 0.5 to 94% calcium carbonate in the sand-size fraction. Carbonate sediments range from very high (average 71.5%) between Cape Comorin and Tuticorin to 37.5% (average) between Quilon to Cape Comorin. This is in contrast to the northern part of the western continental shelf of India where the carbonate sediments dominate only beyond 50 m water depth (Hashimi and Nair, 1976; Nair et al., 1979).

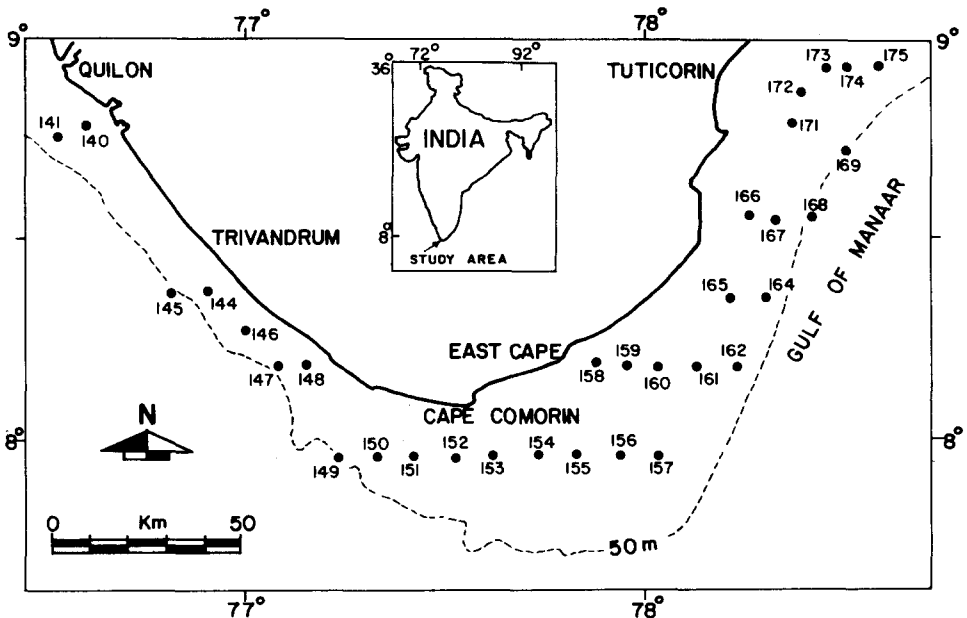


Fig. 1. Sample location map.

## MATERIAL AND METHODS

The thirty-two samples (Fig. 1) used in the present study were collected in 1977 during the 17th cruise of RV "Gaveshani". The carbonate components were hand picked from the coarse fractions. The separated carbonate grains were spread over a gridded tray for point counting of more than 300 grains for each sample. The samples after counting were hand ground and analysed by X-ray diffraction to determine their carbonate mineralogy (Table I) following the earlier described peak height method (Nair and Hashimi, 1981).

TABLE I

Carbonate mineralogy of the sediments (sand size)

Sample No.	Depth (m)	Aragonite (%)	Low Mg-calcite (%)	High Mg-calcite (%)	Mol. percentage MgCO <sub>3</sub> in high Mg-calcite
140	29	59.3	21.9	18.7	14.5
141	44	93.0	7.0	—	—
144	47	68.1	6.7	25.2	14.5
145	60	48.4	30.9	20.7	16.0
146	55	47.2	15.7	37.1	14.5
147	49	50.8	21.8	27.4	14.5
148	40	33.3	35.4	31.3	15.5
149	50	45.0	12.7	42.3	16.0
150	52	59.9	22.2	17.9	16.0
151	44	42.6	16.5	40.9	15.5
152	38	67.2	12.8	20.1	15.0
153	30	49.4	26.6	23.9	16.0
154	32	66.7	13.6	19.7	16.0
155	33	73.8	11.0	15.1	15.5
156	37	49.4	23.9	26.6	15.0
157	41	38.0	15.5	46.5	14.5
158	18	80.8	13.1	6.1	14.5
159	25	85.2	6.4	8.4	14.5
160	25	80.0	7.0	13.0	15.5
161	27	60.1	14.1	25.8	15.5
162	33	48.7	14.5	36.7	15.5
164	30	24.9	34.4	40.7	15.5
165	22	77.8	10.6	11.6	14.5
166	20	71.6	15.7	12.6	15.5
167	24	54.2	15.3	30.5	14.5
168	61	42.7	25.1	32.2	15.5
169	50	34.4	14.0	51.6	15.5
171	20	54.7	34.9	10.4	15.5
172	18	83.4	6.3	10.3	15.5
173	17	68.0	22.7	9.3	15.5
174	21	95.1	2.9	1.9	14.5
175	41	62.6	19.8	17.7	14.5

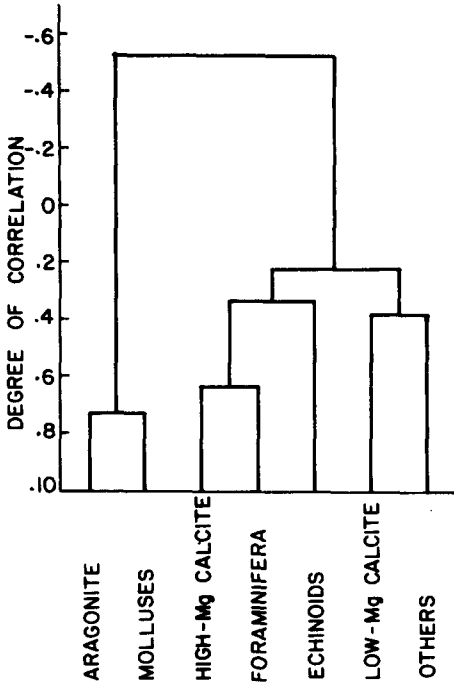


Fig. 2. Dendrogram showing the results of cluster analysis.

In order to find out the relation among the components and the minerals we first calculated the correlation coefficient ( $r$ ) based on the percentage of components and the percentage of the minerals. After comparison in such a way we obtained a matrix of  $7 \times 7$  composed of 42 correlation coefficients (excluding those of main diagonals which are all equal to 1.0). Then clustering was done upon the matrix using "the weighed pair group method with simple arithmetic averages" (Sokal and Sneath, 1963) and a dendrogram was drawn as shown in Fig. 2.

## RESULTS AND DISCUSSION

### *Carbonate assemblage*

The shelf sediments contain calcium carbonate dominantly in the form of skeletal material. Two major constituents are: (1) molluscs; and (2) foraminifera jointly ranging from 83 to 98%. The next most common constituents are echinoid. Ostracods, bryozoans, sponge spicules, serpulids and algal, coral and rock fragments are rare and have been grouped together under "others".

## Molluscs

This group is the most abundant and ranges from 20–92%. The shells are brownish to dirty white and white in colour, broken, dull lusted, sometimes rounded, worn and covered with secondary calcium carbonate coatings. The area between Cape Comorin and Tuticorin has the highest percentage (63–91%) of molluscs (Fig. 3A).

## Foraminifera

This group, next in abundance to molluscs, is dominated by the benthic foraminifera (Fig. 3B). It is most abundant (33–69%) on the western side of Cape Comorin along with few patches of high percentages (34–54%) on the eastern side beyond 40 m water depth. The shells of foraminifera are generally whole with occasional indications of wear and tear. Secondary coatings of calcium carbonate are also common. The colour varies from brownish to dirty white and white. The benthic foraminifera consist mostly of *Amphistegina* sp., *Miliolid* sp., *Operculina* sp., *Ammonia* sp. and *Elphidium* sp.

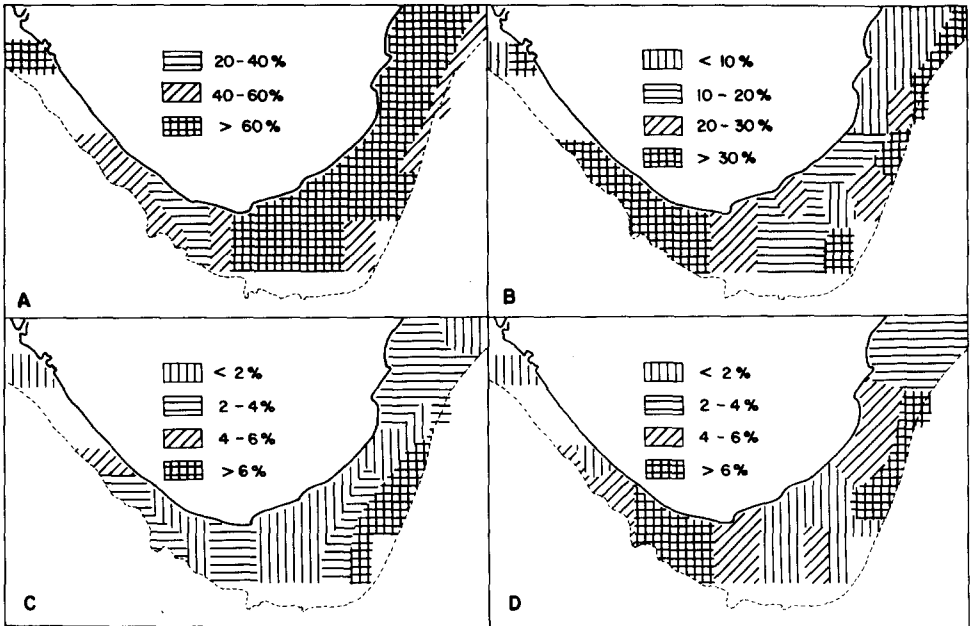


Fig. 3. A. Distribution of molluscs in sand fraction. B. Distribution of foraminifera in sand fraction. C. Distribution of echinoderms in sand fraction. D. Distribution of others in sand fraction.

### *Echinoderms*

This group is quantitatively least abundant (1–11%). Echinoderms occur in the form of fragments and spines. The fragments are yellowish white and spines are yellowish to violet. Their distribution does not show any particular pattern (Fig. 3C).

### *Others*

This group includes ostracods, bryozoans, sponge spicules, serpulids and algal, coral and rock fragments. Except for ostracods, which occur as complete shells, others occur as fragments with colour variation similar to that of the molluscan shells. The bryozoans are found as encrustations on various grains. These components do not have any particular trend of distribution. However, two zones of higher percentages (6–16%) are encountered. One is west of Cape Comorin and the other is south of Tuticorin beyond 30 m water depth (Fig. 3D).

## CARBONATE MINERALOGY

The aragonite contents (Fig. 4, Table I) in the samples range from 33% (sample no. 148) to 95% (sample no. 174). Sediments with the lowest aragonite (25–49%) contents are present on the eastern side (Gulf of Manaar) beyond 35 m water depth, whereas at depths less than 35 m the range of aragonite is 55–95%. On this shelf the percentages of molluscs are correspondingly low (38–51%) and high (70–91%) respectively. The western shelf shows a moderate abundance (48–68%) of aragonite along with a corresponding lesser distribution of molluscs (20–55%). A statistical relationship between aragonite and molluscs is also observed in the cluster analysis (Fig. 2). A correlation factor of 0.734 between the two indicates that the aragonite is predominantly contributed by molluscs. Foraminifera show an inverse relationship with the aragonite, while echinoderms and others show no correlation with the aragonite distribution (Fig. 4). Our findings are in agreement with those of Milliman (1974) who reported that the most common class in molluscs is the pelecypoda which are probably the major benthic contributors to the skeletal assemblages of modern marine sediments. This may be one of the reasons why aragonite is the most abundant carbonate mineral and can explain the direct relationship between the distribution of molluscs and the aragonite.

Both forms of calcite, low-magnesium and high-magnesium, are present (Table I). Low-magnesium calcite has a range of 6–35%. With the exception of the group "others", low-magnesium calcite does not show any correlation with other carbonate components. The correlation factor with the "others" is small (0.380).

The distribution of high-magnesium calcite varies from 2–52% from

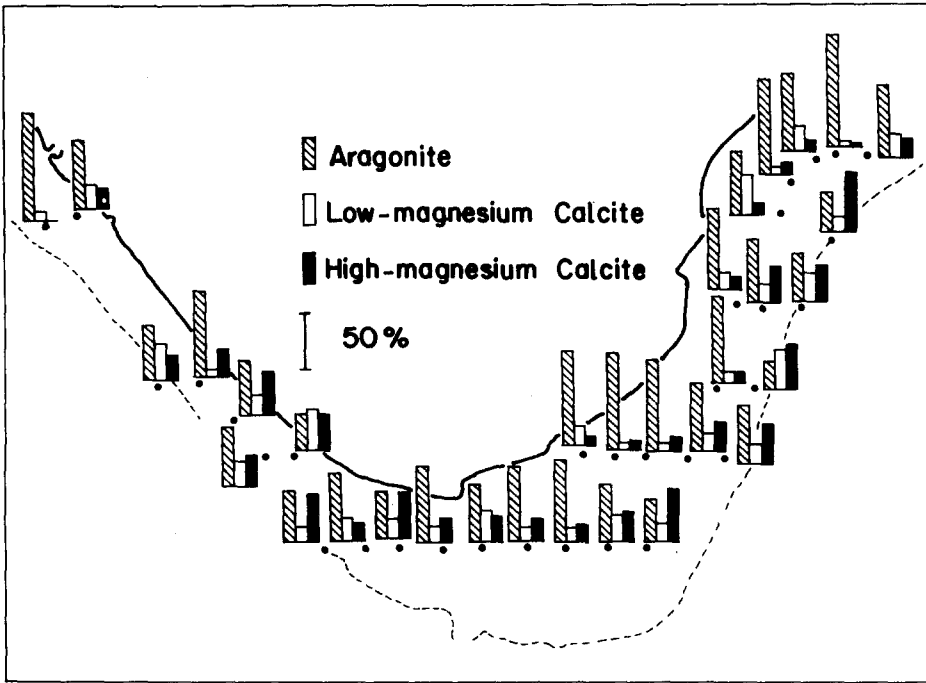


Fig. 4. Bar diagram showing the relative proportions of aragonite, low- and high-magnesium calcites.

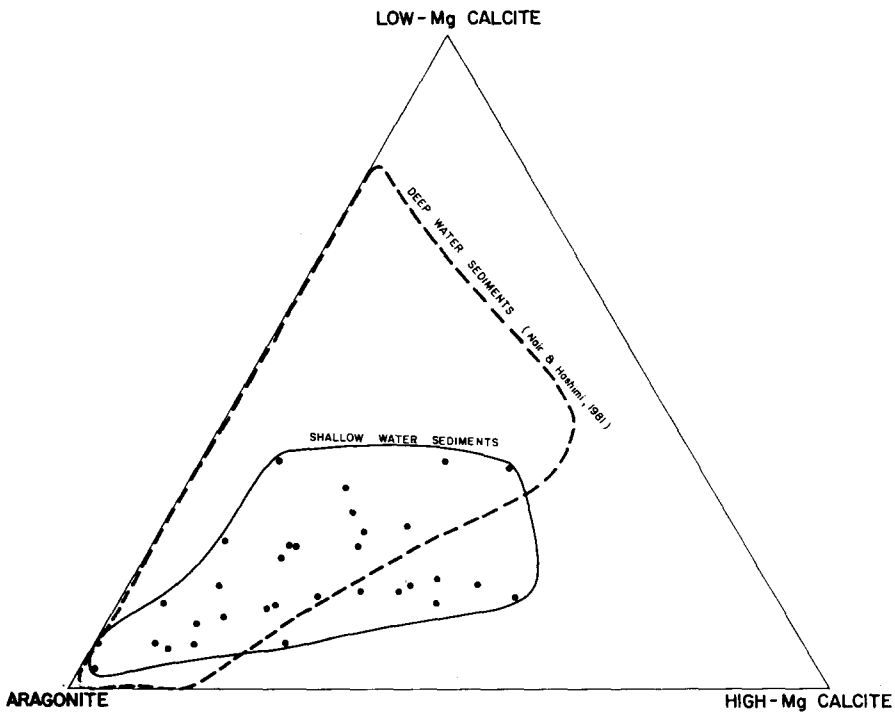


Fig. 5. Ternary diagram showing the difference in carbonate mineralogy between shallow and deep-water sediments of the continental shelf.

Quilon to Tuticorin (Fig. 4). The western side shows comparatively higher values (21–42%) than the eastern side (2–52%). High-magnesium calcite shows a correlation factor of 0.626 (Fig. 2) with foraminifera. This may be the reason for high concentrations of high-magnesium calcite on the western and eastern shelves where the percentages of foraminifera are high.

The mole percentage of  $\text{MgCO}_3$  shows relatively narrow variation 14.5–16% (Table I) compared to the values 0–16% in the carbonate sediments of the northern part of the western continental shelf of India (Nair and Hashimi, 1981). This range is similar to the values for Florida and the Bahamas (Stehli and Hower, 1961) and Bermuda (Friedman, 1964). Comparison of the bulk mineralogy of the study area with the rest of the western continental shelf (depth range 30–220 m) indicates distinct differences between the two (Fig. 5). The main one is the decrease in the amount of low-magnesium calcite in the study area. This difference is attributed to the relatively narrow spectrum of carbonate assemblage present in these shallow-water sediments and to the decrease in the abundance of the pelagic low-magnesium calcite foraminifera.

Many of the shells are covered with one or more coatings or carbonate. The coatings appear to be related to carbonate precipitation occurring during the late Pleistocene, because coated grains like relict ooids ranging in age from 9960 to 11,330 yrs (Nair and Hashimi, 1980) are present on the north

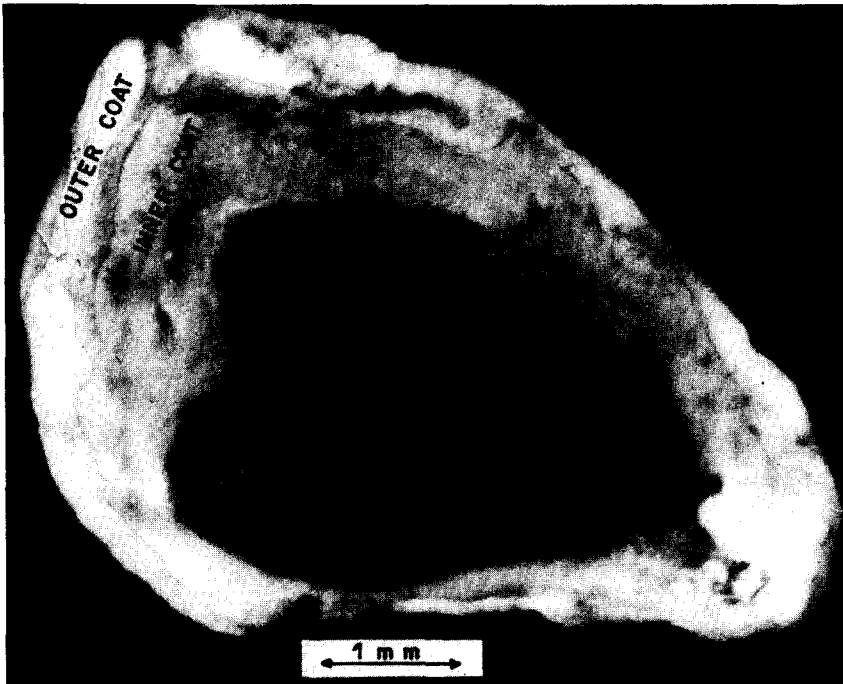


Fig. 6. Two cycles of secondary  $\text{CaCO}_3$  coatings on an algal grain.



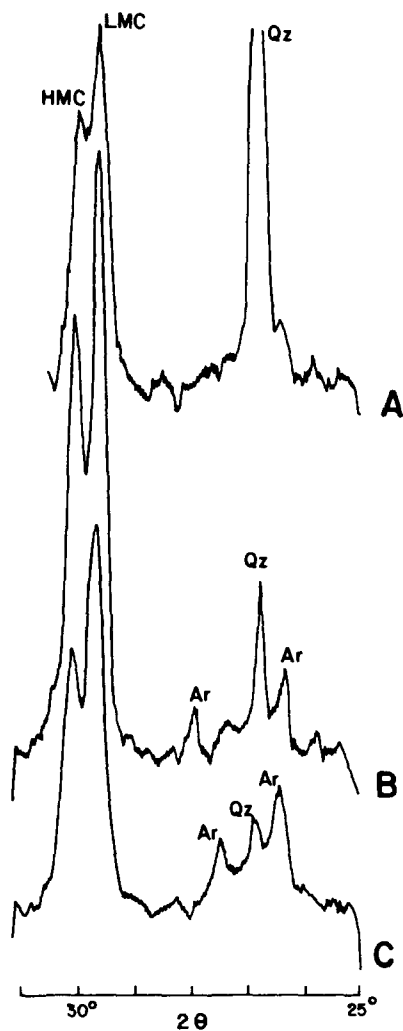


Fig. 7. Trace of diffractograms showing the mineralogy of: (A) core; (B) core and inner coat; and (C) whole sample. Qz = Quartz; Ar = Aragonite; LMC = Low-magnesium calcite; HMC = High-magnesium calcite.

western part of the Indian shelf. In order to decipher the mineralogy of the secondary coatings, a thickly coated piece with two generations of coating (Fig. 6) was taken and divided into three parts for X-ray analyses. The core of the fragment is dark brown in colour and appears to be a micritised piece of calcareous algae. The inner surface abutting the core (skeletal/non-skeletal) is irregular and commonly shows vitreous lustre, while the outer surface of the inner coat is smooth. In the first case, the whole sample was analysed, in the second case the outer coat was removed by 10% acetic acid treatment and analysed, while in third case only the core was analysed, after

removal of both coatings. The mineralogy of the core was dominantly calcitic, containing both low- and high-magnesium calcites (Fig. 7A), while in the inner and outer coats the presence of aragonite was also noticed (Fig. 7B, C).

## CONCLUSIONS

In conclusion, the results show that in the sediments where benthic foraminifera are the most abundant component, as on the extreme western side and on a narrow strip between depths 40 and 50 m on the eastern side (Gulf of Manaar), the carbonate mineralogy is dominated by high-magnesium calcite. In sediments where molluscs exceed other components, as on the eastern shelf between 10 and 40 m, the most abundant mineral is aragonite. Low-magnesium calcite does not appear to be related to depth or carbonate components. Minor modification in these relationships can result from coatings of aragonite.

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