Short Communication

**Algal microboring on ooids: An evidence of Holocene sea transgression in eastern India**

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Ooid concentrated sediments occur at about 75 and 120 m depths on the outer continental shelf off Chennai. They are associated with sediments containing predominantly of terrigenous and authigenic green clay facies. Quartz, foraminifers and green grains are present in the nucleus of the ooids. SEM studies on the surfaces of ooids revealed pits formed mechanically in high energy conditions and pits and channels tailored by endolithic algae. Ooids associated with microborings probably indicate their formation in shallow marine environment and their concentration at two specific depths indicate sea level still stands close to ooid depths. Presence of terraces and reefal barriers at depths around 60 and 110 m on this margins also support palaeo-strand lines at these depths and ooid formation in the two successive phases of Holocene transgression.

Ooids grow in agitated near-shore marine environment. These are located within the calcareous sediments in the eastern outer shelf of India. Their presence is related to sea floor geomorphology and also to Late Pleistocene-Holocene transgression. The present study is important to understand the geomorphic control of ooid formation and to evaluate environmental significance. This paper envisages detailed examination of surface microtexture of ooid grains from south of Madras to decipher the palaeostrand lines vis-a-vis marine transgression during Holocene.

About 24 sea bed samples were recovered from sample repository library of the Marine Wing, Geological Survey of India (GSI). These samples were collected using van Veen grab during the cruises of R. V. Samudramanthan (SM-4, 43, 52 and 72) conducted by the GSI in between 1984 and 1990, from different depths on the continental shelf off Madras (Fig.1). Sand fraction of the sediment, in particular grain size of 177-125 μm were separated. Ooid grains were picked from these samples and examined internal (after grinding) and external features under the scanning electron microscope (SEM, LEICA S440).

The sediments were mostly clayey sands with 20-90% skeletal components of shallow marine origin. Foraminifera, pteropod, gastropod, pelecypod, bryozoa, corals and shell fragments are present. Both planktic (species of Globigerina, Globorotalia) and benthic (species of Bolivina, Buliminia, Operculina, Triloculina, Rotalia, Borelis, Quinquiloculina) were identified. Quartz and garnet as terrigenous and authigenic green grains were also observed.

The colour of ooids varies from white through creamy yellow, light brown, orange, light grey to dark grey while their shape varies from spheroidal, oblong spheroidal to ellipsoidal. They are highly polished. Quartz, green grains and foraminifers, present in the sediments, are found in the nucleus of the ooid (Fig.2A) and a few do not exhibit nucleus (Fig.2B). The surfaces are engraved with pits and channels of different origin. Some pits occur as subcircular to subelliptical shallow depression (2-3 μ) on their surface (Fig.2C) probably formed due to abrasion—a signature of mechanical action under high energy submarine conditions. Such pits are, however, scanty.

Biogenic pits are characterised by stubby tubules, maximum 20 μ width and occasionally branched but not anastomosed. Linear to curvilinear dark and light lines are spread over almost the entire surface of ooid grains. Tubules generally formed intertwined network.
In many instances ooid grains are riddled with subcircular borings of 20-25 μ diameter. Second generation of calcium carbonate material, with or without silicates, fills most of the pits and the hollow lines (Fig. 2E). Growth of such crystals has also been observed in the sections (Fig. 2B) along some curvilinear channels. Size of such aragonite crystals are much shorter within the channels than those found within the ooid grains. Borings run parallel to, and intersect the lamellae in the outer envelope. Aragonite fillings are, however, hardly present in deeper parts of the channels (Fig. 2B).

Ooid concentrations are high in the outer shelf sediments off Tamil Nadu coast around 75 m and 120 m depths. The skeletal constituents of the sediments point to a nearshore environment favourable for reefal development. Presence of these shallow benthic forams in the nucleus of ooids confirms in-situ origin. Characters of pits on the ooid surfaces suggest that they are formed due to mechanical abrasion and collision in the nearshore surf zone. This environment signifies low strand lines of the sea in the outer shelf area.

Microorganisms belong to blue-green algae, green algae, red algae and heterotrophic fungi can cause boring structures on ooid surfaces\(^2,3\). Such microorganisms range in size from a few to 100 μ. Other surface eroding microorganisms like bryozoans and microsponges, though not usually as abundant or as widespread as endolithic algae and fungi, can cause borings. However, the size of borings varies. Fungal borings are smaller than algae. Moreover, branching of filaments is characteristic of fungi.

In the study area tubulate microborings, comparable to those present in the Carolina shelf sediments\(^4\), are represented by siphonaceous green algae\(^1\) belonging to the genus *Ostreobium*. The other filamentous microboring of anastomosing linear to curvilinear channel with terminating spherical structures are believed to have been tailored by fungal hyphae though blue-green algae *Plectonema terebrans* and *P. endolthicum* are capable of forming such structures\(^5\). The second type of microbore are fewer in number. However, superimposition of different algal and/or fungal structures cannot be ruled out. Borings occupy the entire surface of the grains suggesting considerable rolling of the ooids on the substrate.

The vertical distribution of photosynthetic organisms is controlled by light penetration in the sea and the compensation depth of algae. Photosynthetic endolithic algae, therefore, can be used as depth

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Fig. 1—Sample locations with percentage of ooid in sediments

However, microborings about 20 μ in diameter characterised by elongate perforations, nonintersecting, anastomosing and terminating in spherical structures, are found on the surface of few ooid grains. These features are likely to have been formed by fungal hyphae\(^2\) though some blue-green algae\(^1\) might also be responsible for such features. The curvilinear features are the surface expressions of algal borings parallel to, but just beneath the surface.
Fig. 2—A) Section of ooid exhibiting peripheral coatings around nucleus of a foraminifer, B) aragonite crystals along periphery but not within channels in a section of ooid; no nucleus due to intense boring and recrystallisation, C) impact and collision pits and algal microborings on an ooid surface, D) tubes forming intertwined network on ooid surface and E) secondary deposition of aragonite crystals within channels and bores.

indicators by defining fossil photic zones. Intense algal boring activity occurs at depths between 20 m and 50 m. The endolithic activity thus occurs either simultaneously or subsequent to oolitisation. As ooids are largely confined to around two depth levels (75 m and 120 m), two palaeo-strand lines in the outer shelf around 60 m and 110 m isobaths are postulated.

The radio carbon age of the ooids from outer shelf sediments of the northern Bay of Bengal is 10,800 ± 115 y BP. The ages of the algal ridges at 85 and 100 m depths off Visakhapatnam are 10,790 ± 170 y BP and 12,530 ± 170 y BP respectively. They point to their formation during Holocene transgression. The age of the coral reef from 115 m depth off Mahabalipuram is 14,500 ± 190 y BP.

Since the last glaciation (18000 yBP) the sea level rises in phases globally about 120 m. This is also
exemplified in eastern Indian coast by the presence of several successive terraces at depths 55, 60, 70, 85, 110, 115 and 130 m and the development of algal reefs off Visakhapatnam and coral reef off Mahabalipuram. Present finding of two in situ microbored ooid concentrated zones, at 120 m and 75 m depths off Chennai is consistent with the above facts and corresponds at best with 110 m and 60 m palaeostrand lines respectively. This suggests the presence of at least two transgressional phases in eastern India, particularly on the Tamil Nadu coast.

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References