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(abstract)

GEISTER, Jörn: REEF FORMATION DURING EUSTATIC CYCLES - BAJOCIAN AND QUATERNARY REEFS COMPARED

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During rapid eustatic sea level fluctuations (> 1 cm/year) of great amplitude (> 50 m), appreciable reef growth is restricted to terminal transgressive ("T-reefs") and regressive phases ("R-reefs") within each eustatic cycle. Well developed "T-reefs", as defined above, are represented by the "emerged reef terraces" of the late Pleistocene and Holocene shallow-water reefs. All of these were formed towards the terminal stages of a major transgression (1, 2). By contrast, corresponding Quaternary "R-reefs" came into being only towards the ends of major glacial regressions. As a consequence, these reefs are deeply submerged today and are only imperfectly known from echo soundings, remote controlled photography, and occasional local dredging. Virtually nothing is known about their internal structure and ecology.

On the other hand, Bajocian coral reefs of the eastern Paris Basin (3) are typical "R-reefs" corresponding to the terminal regressive phases of 3 eustatic cycles. Their transgressive counterparts (Bajocian "T-reefs") may have been deposited in a high topographic position along the former Rhenish Massif. Due to prolonged subaerial exposure and erosion, subsequent to their formation, they are not preserved. The following discussion focuses on the above two reef types accessible for study. These are not only separated by a timespan of more than 170 million years, but also formed during opposite phases of the eustatic cycle.

Typical Quaternary "T-reefs" preferably settled on a hard substratum provided by an older reef and other limestone forming outer terrace margins or topographic highs on a freshly inundated sea floor. Pioneering reef-building biota are frequently represented by medium diversity associations of incrusting and massive scleractinians that lived above wave base. Initiation of reef growth on soft substratum seems to be exceptional. Prevailing growth rates of the massive corals vary from less than 10 to 25 mm/year depending on systematic affinity, depth and temperature of the water. Holocene shallow-water reefs were growing to thicknesses up to 20 m within several thousand years.

By contrast, Bajocian "R-reefs", settled on a perfectly level sea floor covered by sand or sandy mud. These are frequently underlain by ammonitic mudstone. Reefs were initiated as coral biostromes of very low diversity. Their pioneer coral fauna consisted of supposedly deep-water morphotypes of otherwise massive scleractinians (mostly Isastrea spp.) and thin disc-like Thamnasteria sp. resembling the growth habits of modern deeper-water agariciids. Growth band analyses of a number of well-preserved coral specimens from a Bajocian reef in Luxembourg indicates very low distal growth rates ranging from 3.0 mm/year in the massive, to 1.9 mm/year in the more flattened colonies (4). These observations, supplemented by sedimentological evidence, point to an onset of reef growth at water-depths well below wave base. The shallow and upmost part of the original reef bodies was probably colonized in a later stage by a more diverse coral fauna of substantially higher growth rates. But this is not preserved resulting from a considerable bioerosional lowering of the water/sediment interface during the transgressive phase of the following cycle. Growth rate was estimated for the remaining reef body, suggesting that it needed some 8000 years for the 18 m of reef rock to develop (4). Assuming a roughly sinusoidal eustatic curve, the preserved reef deposits and underlying marls may correspond only to half or a quarter of the entire cycle. The remaining time (the final stages of the regression and the following transgression) is concealed in the bored hardground, truncating the reef. Provided that this assumption is correct, a eustatic cycle with a period in the order of 20'000 to 40'000 years can be suggested which is quite comparable to Quaternary reefs.

Marked discontinuities, occurring within emerged Quaternary reef terraces, were caused by non-deposition and subaerial erosion resulting from periodic emersion and intertidal truncation of "T-reefs" during succeeding transgressions (1, 2). On the other hand, discontinuities, truncating the tops of successive Bajocian "R-reefs", resulted from both non-deposition and from bioerosive lowering of an already lithified and deeply submerged sea floor during the transgressive phases.

Disruptions of reef growth, caused by natural physical and biological disturbances, are common in the Quaternary but seemingly are absent from the Bajocian reefs examined. Erosion by boring bivalves and, even more intensely by clionid sponges is widespread in the Quaternary. But it was restricted to minor lithophagan bore holes in the Bajocian corals where clionids are completely absent. Binding calcareous algae which are well represented in Quaternary reefs were not found in Bajocian reefs. Calculated from growth band data, the gross carbonate production of one particular Bajocian "R-reef" under study was fairly low but remains within the range of its Holocene counterparts (4).

It will be difficult and costly to obtain an intimate knowledge of the ecological structure and development of Quaternary "R-reefs", which are at present submerged in 60 to 120 m water depth. However, it may prove essential for the development of a satisfactory and coherent model for the formation of "T/R-reefs". Once a valid reef model has been established for the Quaternary, it will obviously become an efficient tool in the paleoecological reconstruction of more ancient "T-reefs", which due to their low preservational potential were doomed to early subaerial destruction. Finally, a suitable model would shed additional light onto the often contended divergent development of Quaternary and Pre-Quaternary reefs.

References:

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