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How differential biogenic sediment production impact the stratigraphic architecture of carbonate systems: a stratigraphic forward modelling study of Miocene Llucmajor platform

Timothy O. Tella
University of Potsdam

Gerd Winterleitner
University of Potsdam

Maria Mutti
University of Potsdam

Understanding the roles played by biota in the evolution of carbonate architecture requires integrating interdisciplinary datasets due to the complex interplay of biological, oceanographic, mineralogical and ecological factors that create stratigraphic and sedimentological changes in carbonate systems through geologic time. Stratigraphic forward modelling enables this approach by using mathematical equations, algorithms and empirical assumptions to numerically reproduce the processes and factors that acted over geologic time. One of the many factors that strongly influence stratigraphic heterogeneity and architectural evolution of carbonate systems is biogenic carbonate production, whose impact still requires detailed investigation. Hence, in this study we attempted to investigate, using stratigraphic forward modelling, the role of different biogenic sediments in the evolution of carbonate systems geometries using the Llucmajor platform as a reference case study.

We developed several forward models of the coral-dominated Llucmajor platform based on parameters from published outcrop and well data, as well as modern analogues. These models were validated through comparison with published outcrop and well data, leading to the reference model on which several sensitivity analyses were carried out. Carbonate production was modelled by creating five model sediment classes (massive corals, dish corals, reworked grains, and muds, and rhodalgal sediments) to reflect the biotic associations that have been interpreted from outcrops of the platform. These model sediments classes interacted with environmental parameters such as wave agitation, sea level fluctuation and bathymetric modification to produce four lithofacies comparable with the Llucmajor lithofacies: backreef lagoon, reef core, forereef slope and open shelf lithofacies.

By studying, through numerous sensitivity tests, the complex interplay between carbonate production and environmental changes, our results show that: 1) progradation of carbonate systems is strongly influenced by the interaction between the bathymetric profile of the basin and variation of carbonate production alongside accommodation; 2) increased production rate of rhodalgal sediments results in increased progradation of the platform, whereas reduced rhodalgal production rate results in the opposite response; and 3) platform geometry and internal architecture varies significantly according to the interaction of the predominant carbonate producing biotas, such as the production of rhodalgal sediments versus coral sediments.