

Late Cretaceous Siliceous Deep-Water Formations of the Nicoya Peninsula (Costa Rica): Age and Relationship of the Loma Chumico and Berrugate Formation and Consequences for the Terrane Stratigraphy

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Abstract

Outcrops of the Nicoya Peninsula and Gulf area represent a collage of Mesozoic oceanic terranes that became assembled during the latest Cretaceous along the western edge of the Caribbean Plate, at the boundary between the Caribbean Large Igneous Province s.s. (CLIP s.s.) to the south and the Mesquito Composite Oceanic Terrane (MCOT) to the north. In previous studies the subdivision of terranes was 3-fold: (1) the Nicoya Complex s.s., a highly deformed stack of pre-Campanian plateau-like igneous rocks that extruded and intruded into Middle Jurassic to Santonian ribbon radiolarites; (2) the Matambú Terrane, a supposedly pre-Albian oceanic basement covered by the Loma Chumico Formation considered to be of Albian age, (3) the Manzanillo Terrane, a pre-Turonian oceanic basement intruded by the Turonian Tortugal picritic suite. The Manzanillo Terrane is regarded as the westernmost outcrop of the CLIP *sensu stricto* and is covered by the Coniacian-late Campanian arc-derived Berrugate Formation cropping out in the south-eastern and eastern Nicoya Peninsula and in the Nicoya Gulf area.

Our radiolarian biostratigraphic study focused on hemipelagic, tuffitic siliceous mudstones and cherts exposed in the south-eastern and central Nicoya Peninsula. We found green, often organic-rich cherts, shales and tuffaceous siliceous mudstones to volcanic sandstones in outcrops mapped as the “Albian” Loma Chumico Formation. However, lithostratigraphy, microfacies and geochemistry indicate that these rocks are distal equivalents of the Berrugate Formation defined in the Nicoya Gulf area in somewhat more proximal facies including volcanoclastic turbidites and debris flows. The tuffitic lithologies contain well-preserved radiolarians with Turonian – Santonian assemblages. In south Nicoya the Berrugate Formation grades during the late Campanian into the overlying Piedras Blancas Formation, a pelagic, weakly tuffaceous limestone.

More recently, we sampled the type area of the Loma Chumico Formation, where, allegedly, ammonite fragments of late Albian age were found (*Neokentoceras* sp.). To our surprise, we found Turonian – Santonian radiolarian assemblages in this locality. As a consequence, the Loma Chumico organic-rich shales are coeval with the Berrugate Formation and should be considered as a facies variation, also found in south Nicoya (e.g, Punta Pochote).

We conclude that the former Matambú and Manzanillo Terranes should represent one paleogeographic forearc domain with a CLIP-like basement, for which we retain the name Manzanillo Terrane, overlain since the Turonian by pelagic/hemipelagic formations. The organic-rich lithologies (Loma Chumico facies) accumulated in the distal-most forearc area possibly under the influence of coastal upwelling and the development of an oxygen minimum zone. Depending on the proximity and activity of an intermediate volcanic arc, the black shales and cherts graded laterally and upsection into tuffaceous green debris flows, sandstones and cherts. By late Campanian time, the arc became temporarily

extinguished, which gave rise to a late Campanian-Maastrichtian pelagic limestone sequence (Piedras Blancas Fm.). The Nicoya Complex *sensu stricto* is clearly exotic with respect to the Manzanillo Terrane, since it contains Middle Jurassic to Santonian ribbon bedded radiolarites of open oceanic origin, devoid of any arc influence. We conclude that the Nicoya Complex *sensu stricto* became accreted during the late Campanian, inducing temporary cessation of arc activity in the area. Tectonic uplift and emersion is indeed documented by boulder conglomerates and the unconformably overlying shallow-water El Viejo Formation.