

# Crustose red algae in deep time environments: Palaeoecological insights from northeastern India and Türkiye (Turkey)

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## Abstract

Crustose red calcareous algae are key organisms in benthic ecosystems worldwide with critical functions like reef-building and substrate stabilization. Coralline algae thrived as major carbonate producers, with corals and/or larger benthic foraminifera (LBF) in numerous shallow-marine Tethyan carbonate platforms from the early Palaeogene to the Neogene. The Palaeocene–Eocene limestone successions in the Jaintia and Khasi Hills, Meghalaya, northeastern India, encompass two principal community types — algal-foraminiferal and coralline algal, with no associated colonial corals, while the Oligocene–Miocene carbonates from the Sivas basin and Siirt province in Türkiye are characterized by an algal-foraminifera assemblage with bryozoans, corals, and molluscs as other noteworthy components pertinent to the carbonate platform environment. We found that the diversity and ecology of these algal communities were influenced by systematic structure of the algal assemblage, sediment input, substrate stability, water depth, and hydrodynamic energy. The algal assemblages from different epochs and varying localities diverge based on the sedimentary regime, environmental settings, and the predominant taxa. The climatic transition from the Palaeocene–Eocene greenhouse to the Oligocene–Miocene icehouse corresponded to a shift from crustose algal assemblages dominated by Sporolithales to assemblages dominated by Hapalidiales.

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## 1. Introduction

Red calcareous algae (RCA) are critical components of shallow-marine benthic habitats across numerous tropical and cold-temperate settings. They contribute significantly to the diversity of these habitats by providing substrates for the settlement of various benthic invertebrates (Daume et al., 1999; Heyward and Negri, 1999; Tebben et al., 2015; Weiss and Martindale, 2017; Duran et al.,

2018). Their fundamental ecological functions include carbonate production, both in terms of bioconstructions and loose sediment (Steneck, 1986; Adey, 1998; Nelson, 2009; Basso, 2012; Littler and Littler, 2013). Habitats dominated by RCA are economically and ecologically relevant (Coletti et al., 2017; Tuya et al., 2023) and have high sensitivity to the impacts of ocean warming and acidification (McCoy and Kamenos, 2015; Cornwall et al., 2019; Marchini et al., 2019).

Crustose RCA are commonly associated with scleractinian corals as “the glue that holds coral reefs together” (Castro and Huber, 2010), and played a major role in their successful evolution by virtue of positive biotic interactions

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