Chapter 5
Coralline Algae: Mineralization, Taxonomy, and Palaeoecology

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Abstract

This critical review focusses on three areas of recent research on the crustose coralline algae:

Calcification and Diagenesis

Recent work has clarified the calcification of corallines as being a two-stage process; firstly, tangential and secondly radial calcite is deposited within the matrix of the cell walls. This internal calcification of cell walls is unique to the coralline algae and should be used to interpret early problematic red algae in which other characteristic structures are not present. Recent descriptions of subcrustal aragonite from corallines show that this form of mineralization is not restricted to the squamariaceans, as has been generally considered.

Taxonomic Revisions of Genera

New investigations on Recent coralline algae by workers in Australia and Britain is leading to important revisions of well-known Recent and fossil genera. The time is appropriate to assess the implications of this work for palaeontology. Important questions are the preservation of taxonomic characters and the relationships between fossil taxa and groups of Recent taxa. Specific determination of many fossil corallines suffers from excessive splitting on the basis of too few characters. The importance of detailed measurements and statistics is emphasized.

Ecology and Palaeoecology of Coralline Algae

The longevity of coralline genera, together with their ecological restrictions and plasticity of growth forms in relation to environmental parameters, makes the corallines a good group for palaeoenvironmental analyses. Recent work has shown the strong relationships between growth form and hydraulic energy; and the generic composition of floras and water depths. The latter has exciting potential for erecting quantitative palaeobathymetric zones for the Cenozoic.

1 Introduction

Most of the major advances in corallinology at present are being made by those studying Recent corallines, particularly in the study of calcification, generic classification and morphology. An excellent review of this recent work is to be found in the text by Woelkerling (1988). Palaeontologists, meanwhile, have made some progress in generic concepts and in palaeoecology. In this post-Harlan-Johnson era there still remain major problems in the validity of fossil
coralline species and there is little palaeontological data on which to build a phylogeny of the coralline algae.

In this review the palaeontological implications of the recent advances on present day crustose corallines and new developments in ecology and palaeoecology are discussed under the following headings:

1. Calcification and diagenesis;
2. Taxonomic revisions of coralline taxa;

2 Calcification and Diagenesis

The coralline algae are the most consistently and heavily calcified group of red algae and as such have recently been elevated to ordinal status (Corallinales: Silva and Johansen 1986). The calcification involves high magnesium calcite (and occasionally brucite, Weber and Kaufman 1965) precipitation within most cell walls (Figs. 1A-C, 2A-D). Other calcified red algae are the Solenoporaceae, the Squamariaceae (Denizot 1968) and some members of the Nemalionales (Galaxaura, Liagora and Nemalion: Dixon 1973).

Early electron microscope work showed that the calcified cell walls of coralline algae had a two-layered structure: an inner layer of acicular calcite parallel to the cell wall was succeeded by radial, inward-growing calcite crystals (Figs. 1A, 2C; Bailey and Bisalputra 1970; Alexandersson 1974, 1977; Flajs 1977a,b; Garbary 1978). Flajs (1977a,b) described two cell-wall types: the Lithothamnium-type with the two layered structure described above and a Goniolithon-type with a central noncalcified zone and outer radial crystals. The Lithothamnium-type has subsequently been described from a wide range of corallines (Mesophyllum, Lithothamnion, Lithophyllum (Fig. 2C), Phymatolithon, Porolithon, Corallina and Jania) by Cabioch and Giraud (1986) and Massieux et al. (1983) and is also seen in the extinct Solenopora (Flajs 1977b). However Flajs's (1977b) Goniolithon-type has neither been confirmed by other authors nor has it been found in other genera. More recent work in the 1980s using SEM and TEM techniques on calcified tissue has significantly advanced our knowledge of calcification (Massieux et al. 1983; Walker and Moss 1984; Cabioch and Giraud 1986). However the physiological processes involved in calcification within the cell wall remain unclear. Experimental work by Digby (1979) showed how, in the normally reducing environment of the thallus, increased alkalinity is brought about by oxidation through strong oxidase, catalase and carbonic anhydrase activity and the removal of hydrogen ions. More recently Okazaki et al. (1982) have shown that alginic acid is associated with cell wall calcification and that this acid induces calcite deposition and strongly inhibits aragonite deposition. Cabioch and Giraud (1986) have found no ultrastructural differences between calcified and uncalcified floridean cells. In an ultrastructural study of a range of temperate corallines they have shown that calcification is a two-stage process which relates to the two calcified zones.