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A Biogeochemical Comparison of Fossil (Carboniferous) and Modern Crustose Red Algae.

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ABSTRACT

The nature of the contribution of various types of algae to sedimentary organic matter continues to be a topic of research interest. Crustose red algae have not received as much attention as other types. The fossil calcareous red algae (Phymatolithon) examined in this study are from the lower part of the Ste. Genevieve Formation (Carboniferous) in Union County, Illinois, USA. They were observed in the patch reef phase of a small carbonate mound-patch reef. The three modern specimens (collected and identified by T. Collar) are the crustose algae Lithothamnion, Clathromorphum and Phymatolithon. From a rocky intertidal area near Cape May, Massachusetts, USA.

The pyrolyses of the three (unlabeled) modern algal specimens exhibited similar properties, including a predominance of alkylbenzenes, phenols and nitriles (peaks 3, 8, 9, 16, 20, 32, 33) (Fig. 1a). Phenols have not been observed in the pyrolyses of several types of algae, including a red macroalgae (Von Herzen et al., 1996). Polychaetates pyrrole products [4, 5, 12, 27] are also important, and would be expected. The minor dipropargyls [44, 45, 47, 57] detected indicate the presence of proteins. A variety of simpler nitrogen compounds, including pyrrole [6, 11] and benzonitriles [14, 33] may be derived from proteins or from more resistant macromolecular structures. The long-chain alkylamines [63] is also noteworthy. The fossil specimens of Parachaetetes (pyrolyzed at 610°C after HCl digestion to remove carbonates and thermodesorption at 310°C for 20 sec. to remove bitumen) yielded relatively abundant monomeric hydrocarbons (3, 8, 13, 15, 26) and phenols [16, 20, 24, 31, 34] (Fig. 1b). These distributions are different, the importance of monoaromatic and phenolic compounds in both the Carboniferous and modern specimens demonstrates a significant similarity. The fossil specimen's pyrrole also contains a variety of minor nitrogen compounds [1, 2, 6, 11, 13, 14, 33], some of which are also found in the modern samples and all of which are unusual in the pyrolyses of such ancient (ca. 340 Ma) organic matter. The C18 alkylbenzenes [55] are relatively unimportant, but normal hydrocarbons are not, except for the C15 and C17 n-alkanes (Fig. 1b). Coincident with the absence of MK fatty acids is the dominance of the C2 alkylbenzene (Fig. 1a). In this study we have found significant chemical similarities between the pyrolyses of specimens of modern and fossil crustose red algae. The entanglement of the organic matter of Parachaetetes by calcite greatly enhanced its preservation, in spite of the specimens' great geological age.

Thin-section Photomicrographs

Transmitted White Light

Organic matter appears light

Longitudinal (vertical) thin section in plane-polarized light showing moderately well preserved cellular structure and distinctly banded growth layers in a Parachaetetes thallus. Bar Scale is 0.1mm long.

Transverse thin section in plane-polarized light of the same Parachaetetes thallus. Note the well preserved polygonal cell walls. Organic matter appears at light-colored cell filling. Bar scale is 0.1mm long.

Sample 1

Sample 2

Sample 3

Pyrroles of both modern and Carboniferous red algae have relatively abundant alkylbenzenes and (alkyl)phospholipids.

* The organic matter of the Carboniferous samples appears generally well preserved, with relatively abundant nitrogen compounds in their pyrolyzates.

Van Herzen, R., Putnam, B. and de Leeuw, J.W., 1996, Novel algal polyphenolic biomacromolecules as precursors of humic substances: Identification of a compound family and their function in the preservation of ancient algal thallus. Clathromorphum (pyrolyzed at 610°C after HCl digestion to remove carbonates and thermodesorption at 310°C for 20 sec. to remove bitumen) yielded relatively abundant monomeric hydrocarbons (3, 8, 13, 15, 26) and phenols [16, 20, 24, 31, 34] (Fig. 1b). These distributions are different, the importance of monoaromatic and phenolic compounds in both the Carboniferous and modern specimens demonstrates a significant similarity. The fossil specimen's pyrrole also contains a variety of minor nitrogen compounds [1, 2, 6, 11, 13, 14, 33], some of which are also found in the modern samples and all of which are unusual in the pyrolyses of such ancient (ca. 340 Ma) organic matter. The C18 alkylbenzenes [55] are relatively unimportant, but normal hydrocarbons are not, except for the C15 and C17 n-alkanes (Fig. 1b). Coincident with the absence of MK fatty acids is the dominance of the C2 alkylbenzene (Fig. 1a). In this study we have found significant chemical similarities between the pyrolyses of specimens of modern and fossil crustose red algae. The entanglement of the organic matter of Parachaetetes by calcite greatly enhanced its preservation, in spite of the specimens' great geological age.

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