

Acknowledgement

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**Environmental Distribution of Calcareous Algae
in Upper Devonian Reef Complexes**

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With 2 figures and 1 table

Zusammenfassung

Kalkalgen sind wichtige Bestandteile in Riffkomplexen der Frasnstufe und Famennstufe im Canning Bassin in West-Australien, und auch in Riffentwicklungen und Bankentwicklungen der Frasnstufe in West-Kanada. Mindestens 17 Gattungen von Kalkalgenskeletten treten in den oberdevonischen Karbonatfazies dieser beiden Regionen auf. Viele Algen sind quantitativ bedeutsame Bestandteile in verschiedenen Fazies, und einige Formen waren Gerüstbildner in Riffen.

Die Algen in Riff-Fazies-Rückseiten umfassen *Girvanella*-Knötchen und -Krusten, Dasycladaceen-(*Vermiporella*-)Segmente, radiosphaeritische Calcisphaeren und Rotalgen (*Parachaetetes* und *Solenopora*). Riff-Fazies sind durch inkrustierende Formen, wie *Renalcis* (eine problematische Alge), *Sphaerocodium* (= *Rothpletzella*) (eine grüne oder blaugrüne Alge) und *Keega* (eine „altertümliche coralline“ Rotalge) charakterisiert.

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Renalcis und *Sphaerocodium* sind wichtige Gerüstbildner in Riffkomplexen in West-Australien, aber in den meisten Riffkomplexen West-Kanadas den Stromatoporen untergeordnet. Vorriff-Fazies enthalten Spezies von *Sphaerocodium* und *Parachaetetes* aus größerer Wassertiefe.

Eine ähnliche Verteilung der oberdevonischen Kalkalgenskelette ist aus der Sowjetunion berichtet worden. Wahrscheinlich ist die gleiche Verteilung in Karbonatkomplexen dieses Alters in anderen Regionen der Welt, wo diagenetische Prozesse die Fossilreste nicht zerstört haben, zu finden.

Abstract

Calcareous algae are important constituents in reef complexes of Frasnian and Famennian ages in the Canning Basin of Western Australia and in reef and bank developments of Frasnian age in western Canada. At least 17 genera of skeletal calcareous algae occur in Upper Devonian carbonate facies in these two regions. Many algae are quantitatively significant constituents in various facies and some forms functioned as framebuilders in reef facies.

Algae in back-reef facies include *Girvanella* nodules and crusts, dasycladacean (*Vermiporella*) segments, radiosphaerid calcispheres, and solenoporacean red algae (*Parachaetetes* and *Solenopora*). Reef facies are characterized by encrusting forms, such as *Renalcis* (a problematic alga), *Sphaerocodium* (= *Rothpletzella*) (a green or blue-green alga), and *Keega* (an "ancestral coralline" red alga). *Renalcis* and *Sphaerocodium* are principal framebuilders in Western Australia reef complexes, but are subordinate to stromatoporoids in most western Canada occurrences. Fore-reef facies contain deeper-water species of *Sphaerocodium* and *Parachaetetes*.

A similar distribution of Upper Devonian skeletal calcareous algae has been reported from the USSR; this same pattern probably occurs in carbonate complexes of this age in other regions of the world where diagenetic processes have not destroyed the fossil evidence.

Résumé

Les algues calcaires sont des éléments importants pour les complexes de récifs datant des époques Frasnienne et Famennienne dans le Bassin Canning de l'Australie Occidentale, et pour les développements de récifs et de batteries de l'époque Frasnienne dans le Canada de l'ouest. Il y a dans ces deux régions au moins 17 espèces d'algues calcaires squelettiques dans des faciès carbonates de l'époque du haut Dévonien. Dans divers faciès, beaucoup d'algues sont des constituants d'une importance quantitative et certaines formes ont servi de cadre à des faciès de récif.

Dans des faciès de récif postérieurs nous trouvons parmi les algues des nodules et des croûtes *Girvanella*, des cerces dasycladacéan (*Vermiporella*), des calcisphères radiosphaerids, et des algues rouges solénoporacéans (*Parachaetetes* et *Solenopora*). Les faciès de récif sont caractérisés par des formes encroûtées, tels que *Renalcis* (une algue problématique), *Sphaerocodium* (= *Rothpletzella*) (une algue verte ou bleu-vert), et *Keega* (une algue rouge « coralligène ancestrale »). *Renalcis* et *Sphaerocodium* sont des cadres principaux des complexes de récif de l'Australie Occidentale, mais sont subordonnés aux stromatoporoids dans la plupart des endroits du Canada de l'ouest où se produit le même phénomène. Les faciès de récif frontaux contiennent des espèces de *Sphaerocodium* et de *Parachaetetes* dans des eaux plus profondes.

Un rapport de l'URSS indique qu'il y a une distribution semblable des algues calcaires squelettiques de l'époque du haut Dévonien; cette même structure se retrouve probablement dans des complexes carbonates de cette époque pour d'autres régions du monde où des procédés diagenétiques n'ont pas détruit des fossiles.

Краткое содержание

Известковые водоросли являются важной составной частью рифовых образований в ярусах Frasnе и Famenne бассейна Canning, Западная Австралия, а также при развитии рифов и банок яруса Frasnе в Западной Канаде. В обеих областях найдено, по крайней мере, 17 различных видов водорослических скелетов в верхне-девонских известковых отложениях. В различных фациях многие водоросли являются важным компонентом, а некоторые формы их даже образуют постройки рифов. — Водоросли тыла рифовых фаций представлены клубнями и корками *Girvanella*, сегментами Dasycladaceae (*Vermiporella*), радиосферическими *Calcisphaerae*, и красными водорослями Rhodophyta (*Parachaetetes* и *Solenopora*). Рифовый фаций характеризуется инкрустирующими видами *Renalcis* — некая проблематическая водоросль, *Sphaerocodium*, или *Rothpletzella*, некая зеленая, или синезеленая водоросль, и *Keega*, некая древняя Corallinacea. В Австралии *Renalcis* и *Sphaerocodium* являются ведущими при образовании рифовых построек, но в рифах Западной Канады они уступают свое место строматопорам. До-рифовые фации содержат виды *Sphaerocodium* и *Parachaetetes*, растущих на больших глубинах. — Такие же отложения найдены и в верхнем девоне СССР. Можно ожидать, что подобные отложения будут найдены и в других частях мира.

Introduction

Much of our knowledge of Upper Devonian calcareous algae has developed only within the past few years and has come about mainly through studies of carbonate reef and bank complexes in Western Australia (PLAYFORD & LOWRY, 1966; PLAYFORD, 1967; and WRAY, 1967 a, 1967 b), Alberta (PLAYFORD, 1969; TOOMEY, MOUNTJOY & MACKENZIE, 1970; and WRAY & PLAYFORD, 1970), and the Ural region of the USSR (МИКЛУКНО-МАКЛАЙ, 1961; and CHUVASHOV, 1965, etc.). As a result of these investigations, it is now generally recognized that Upper Devonian calcareous algae constitute a diversified floral assemblage with some forms occurring locally in great abundance. Further, it has been shown that several encrusting calcareous algae were important in the construction of reef frameworks (e. g., WRAY & PLAYFORD, 1970).

The purpose of this brief account is to summarize our present understanding of the environmental distribution of the principal kinds of Upper Devonian skeletal calcareous algae, particularly those that have been observed in reef complexes of Frasnian and Famennian ages in the Canning Basin of Western Australia and in reef and bank developments of Frasnian age in western Canada. As such, this paper contains neither detailed paleontological nor sedimentological discussions of the algae, which are included in some of the references cited above. Algal stromatolites occur in a variety of facies in the Canning Basin reef complexes (PLAYFORD & СОСКВАЙН, 1969), but the environmental significance of these kinds of calcareous algae is not considered in this discussion.

Characteristics of Upper Devonian Calcareous Algae

Assemblages of skeletal calcareous algae in Upper Devonian carbonate facies are characterized by four distinct groups: 1) solenoporacean red algae, 2) so-called "ancestral coralline" red algae, 3) codiacean and dasycladacean green algae, and 4) a large number of encrusting forms assigned to the blue-green or green algae and to problematical algae of uncertain affinities (fig. 1). All genera presently

known from Alberta and Western Australia belonging to these groups are listed in Table 1. Similar assemblages have been described from the USSR (CHUVASHOV, 1965, 1967); however, the list of genera is different because the nomenclature is complicated by synonymies and other taxonomic problems.

The most conspicuous elements of the overall algal flora are encrusting forms included here in the fourth group (fig. 1). Many are quantitatively significant constituents in various facies and some forms functioned as framebuilders in reef facies. Unfortunately, the biologic affinities of most of the genera in this group are poorly understood. The tubular encrusting algae *Girvanella* and *Sphaerocodium* have morphologic characteristics common to both the blue-green and green algae, but classification is difficult because these genera are extinct and lack modern calcareous descendants. *Renalcis*, one of the most commonly occurring forms assigned to this group, has been classified previously as blue-green algae (see WRAY & PLAYFORD, 1970), but in most respects it is unlike living blue-green algae. It seems more correct to consider this and other related forms as problematical algae of uncertain affinities.

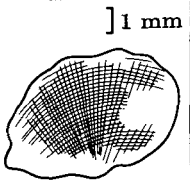
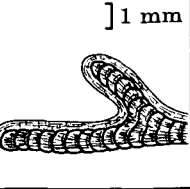
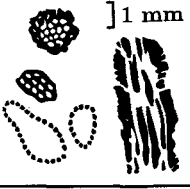
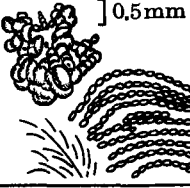
PRINCIPAL GROUPS		GENERA	HABITS
SOLENOPORES		<i>Solenopora</i> <i>Parachaetetes</i>	ATTACHED
'ANCESTRAL CORALLINE'		<i>Keega</i>	ENCRUSTING BINDING
CODIACEAE and DASYCLADS		<i>Litanaia</i> <i>Vermiporella</i> <i>Calcispheres</i>	FRAGMENTS SEGMENTS
BLUE-GREENS or GREENS and/ UNCERTAIN		<i>Girvanella</i> <i>Sphaerocodium</i> <i>Renalcis</i>	ENCRUSTING BINDING

Fig. 1. Principal groups of Upper Devonian skeletal calcareous algae. Diagrammatic section of representative kinds, common genera, and habits of typical skeletal remains.

Table 1. Upper Devonian calcareous algae known from Alberta and Western Australia.

		WESTERN AUSTRALIA	ALBERTA
Red	SOLENOPORACEAE	<i>Parachaetetes</i> <i>Solenopora</i>	<i>Parachaetetes</i>
	"Ancestral corallines"	<i>Keega</i> <i>Stenophycus</i> <i>Tharama</i>	<i>Katavella</i> ¹⁾ <i>Keega</i>
Green	CODIACEAE	<i>Litanaia</i> <i>Ortonella</i>	<i>Kamaena</i> ¹⁾
	DASYCLADACEAE	<i>Vermiporella</i> Calcispheres ²⁾	<i>Vermiporella</i> Calcispheres ²⁾
Blue-green or green		<i>Girvanella</i> <i>Sphaerocodium</i>	<i>Girvanella</i> <i>Sphaerocodium</i>
Uncertain affinities		<i>Chabakovia</i> ¹⁾ <i>Frutexites</i> ¹⁾ <i>Paraepiphyton</i> <i>Pleurocapsites</i> ¹⁾ <i>Renalcis</i>	<i>Paraepiphyton</i> ¹⁾ <i>Renalcis</i>

¹⁾ Undescribed.

²⁾ Radiosphaerid calcispheres have been generally classified as algae of uncertain affinities, but are similar to the reproductive bodies (gametangia) of some modern dasycladaceans.

Calcareous red algae include representatives of the Solenoporaceae and forms called "ancestral corallines" which have internal cellular tissue similar to Cenozoic coralline red algae. The solenoporids generally developed as attached nodular growth forms and include the genera *Solenopora* and *Parachaetetes*. The "ancestral corallines" comprise both encrusting (*Keega*) and articulated-segmented (*Katavella*) growth forms. These algae represent the earliest appearance of forms resembling modern Corallinaceae.

Skeletal remains of the codiacean and dasycladacean green algae occur mainly as fragments and segments of the originally attached plant. Radiosphaerid calcispheres, believed to be reproductive bodies of unknown dasycladacean algae, and *Vermiporella* segments are the most common representatives of the green algae.

Environmental Distribution

Calcareous algae occur widely distributed in most of the major facies of the Upper Devonian carbonate complexes of Western Australia and Alberta, and from a sedimentological point of view they are important in three ways. First, many forms are quantitatively significant sediment contributors. Second, some encrusting forms have had a role in reef-building by erecting self-supporting skeletal frameworks and in binding sedimentary particles. Third, individual taxa are restricted to specific depositional facies and therefore are useful in the interpretation of paleoenvironments.

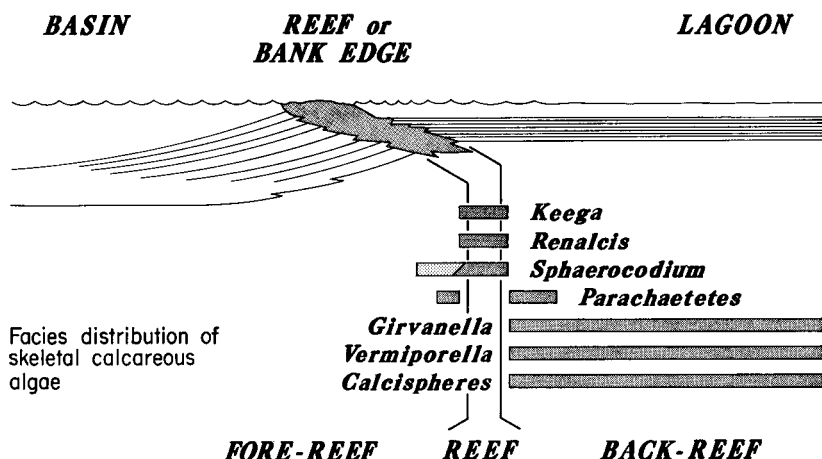


Fig. 2. Environmental distribution of principal taxa of skeletal calcareous algae in Upper Devonian reef and bank complexes.

The environmental distribution of the principal kinds of skeletal calcareous algae in Upper Devonian reef and bank complexes is illustrated schematically in Fig. 2.

Back-reef facies are characterized by three principal elements, radiosphaerid calcispheres, *Vermiporella* segments, and *Girvanella*. *Girvanella* occurs as nodules and laminated crusts on other constituents. *Parachaetetes* is found in some localities in back-reef facies immediately behind the reef.

Renalcis and *Sphaerocodium* are abundant in reef facies and these two genera are principal framebuilders in the Canning Basin reef complexes; however, these algae are subordinate to stromatoporoids in most Alberta occurrences. *Renalcis* seems to be an unusually good indicator of reef and bank-edge developments because of its common occurrence and its close restriction to these facies.

The indigenous calcareous algal flora in fore-reef environments consists of occasional solenoporids (*Parachaetetes*) and deep-water species of *Sphaerocodium*. Fore-reef facies may contain storm-transported algal constituents normally indigenous to reef and lagoonal environments, as well as allochthonous debris deposits of lithified algal limestone derived from reef and bank margins.

Remains of skeletal calcareous algae are sufficiently abundant and widespread in various facies in Upper Devonian carbonate complexes to provide a useful index of paleoenvironments which can complement interpretations based on other biota and depositional textures. Major elements of the algal flora are cosmopolitan, occurring in Australia, Canada and the USSR, although a few forms may be provincial and unique to Western Australia.

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Pennsylvanian Stratigraphic Reefs in Kansas, Some Modern Comparisons and Implications

By PHILIP H. HECKEL, Iowa City *)

With 5 figures

Zusammenfassung

Die ausgedehnten plattformartigen Strukturen im Stanton-Kalk des südöstlichen Kansas bestehen hauptsächlich aus Kalkschlamm und phylloiden Algen, am Rand jedoch aus Kalkareniten, die weitgehend aus Echinodermen- und Algendetritus zusammengesetzt sind. An die Strukturen grenzen breite Vertiefungen (1 × 30 km), die von Kalkareniten gesäumt oder gefüllt sind, und ein größeres Becken mit mergeligem skeletalem Kalklutit.

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