THE CAMBRIAN ALGAL FLORA

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INTRODUCTION

THE Cambrian algal flora is the oldest flora concerning which we have sufficient information to begin to develop a comprehensive picture. Fossil algae have been collected from such widely distributed places as Siberia, New York, Canada, Antartica, Australia, France and Norway. The information is very incomplete and fragmentary, yet it is sufficient to show the presence of a rich and highly varied flora with representatives of all the phyla of algae apparently present. It should be noted that in addition to the actual fossils of algae, there are several additional lines of evidence which point to the abundance and highly important algal flora. For example, in all our textbooks and discussions on historical geology and paleontology, it is pointed out that the Cambrian is the first period from whose rocks we can obtain an abundance of fossils, and almost everyone has commented on the enormous numbers and varieties of invertebrate animals which lived in the shallow, near shore, marine waters. Algae were the basic food for all these animals and it would take a very large amount of microscopic and small plants to feed them all. A second line of evidence is the abundance, thickness, and widespread distribution of algal limestones which were deposited during the Cambrian. These clearly indicate luxuriant growths of lime-depositing algae. However, our knowledge of the Cambrian algae is so incomplete and obtained from such widely scattered areas that obviously we have only a tantalizing glimpse at samples of a very rich and interesting flora. There is a great need for geologists and paleontologists to search for, collect, and study additional material.

DESCRIBED GENERA

To date the total of 59 genera have been described from the Cambrian. Of these 23 are from the Lower Cambrian flora, 21 are known to occur in the Middle Cambrian, and at least 26 have been reported from the Upper Cambrian. There is, of course, some time overlap with these genera, that is, some of the Lower Cambrian forms continue into the Middle Cambrian or even into the Upper; while some Middle Cambrian forms continue into the Upper. These genera are represented by 142 described species.

In addition to the described forms, there are many statements in the literature mentioning the fact that algae, or algae of certain types, occur in certain places without the algae themselves being named or described. All the evidence indicates that a careful search for algae in Cambrian beds should uncover vast amounts of new material. These known genera and their time distribution and number of species are shown in Table 1.

STATUS OF ALGAE AT THE BEGINNING OF THE CAMBRIAN

Algae were already very old and had a long history antedating the beginning of the Cambrian. Fossil blue-green algae have been obtained from cherts in Pre-Cambrian rocks dating back more than a billion years before the beginning of the Cambrian. Most of the evolutionary development of the algae took place before the Cambrian. At the beginning of that period, all phyla of algae appear to have been present. Actual fossils representing the blue-green, the green, the brown, and the red algae have been distinguished and described, and indirect evidence suggests that most, if not all, of the phyla of the smaller and microscopic forms probably were present. In addition to that, fossils show that structures characteristic of some of the present day families had already developed. However, the general complexion of the floras and the relative abundance of the different groups probably was appreciably different than we find today.

The actual fossil record of the Cambrian algae probably does not give a clear picture of the relative abundance of different forms any more than is the case for the fossil algae of the Tertiary. Naturally, those forms

TABLE 1 – GENERA DESCRIBED FROM THE CAMBRIAN

Genus	Stratigraphic Distribution							Number of described species
	Pre-C	Cambrian			Ordovician			
		L	M	U	L	M	U	
Actinophycus Korde				×	×			1
Amgaella Korde			×					1
Anomalophycus Fenton & Fenton				×	×			1
Angulocellularia Vologdin		×						2
Aulophycus Fenton & Fenton				×				4
Bija Vologdin				×				1
Bogutschanophycus Korde				×				1
Bosworthia Walcott			×					2
Cambroporella Korde		×						1
Caudomorpha Vologdin		×						1
Chabakovia Vologdin		×						2
Collenia Walcott	×	×	×	×	×			11
Concresceraria Vologdin		×						3
Conophyton Maslov	×	×	×					2
Corbularia Vologdin		×						1
Copperia Walcott	×			×				1
Cryptozoon Hall	?	×	×	×	×			5
Dalvia Walcott			×					2
Dasycirriphycus Vologdin		×						1
Dictophycus Korde				×				1
Digitularia Vologdin			×		×			2
Dolatophycus Fenton & Fenton				×				1
Epiphyton Bornemann		×	×	×				31
Girvanella Nicholson & Etheridge		×	×	×	×	×	×	5
Glomeophycus Vologdin		×						1
Paleoleptophycus Korde				×				1
Kostinophycus Vologdin		×						1
Mansurkella Vologdin		×						2
Marpolia Walcott			×					4
Mejerella Korde				×				1

TABLE 1 — GENERA DESCRIBED FROM THE CAMBRIAN *(Contd.)*

Genus	Stratigraphic Distribution							Number of described species
	Pre-C	Cambrian L	Cambrian M	Cambrian U	Ordovician L	Ordovician M	Ordovician U	
Monostychia Vologdin		×						1
Morania Walcott			×					8
Nemaphycus Korde				×	×			1
Nephelostroma Dangeard & Dore				×				1
Nostocites Maslov				?				1
Nubecularites Maslov			×					2
Ovoidophycus Vologdin		×						2
Palaeomicrocystis Korde			×	×				1
Palaeoporella Stolley				×	×			1
Poecilophycus Korde				×				1
Praearenaria Vologdin		×						1
Proaulopora Vologdin			×					1
Razumovskia Vologdin		×	×					4
Renalcis Vologdin		×	×					4
Sajania Vologdin			×					1
Schodachia Ruedemann				×	×			1
Seletonella Korde				×				1
Siberiella Korde			×					1
Solenopora Dybowsky			×	×	×	×	×	3
Spongophycus Korde				×				1
Stereophycus Korde				×				1
Tetonophycus Fenton & Fenton				×				1
Thaumatophycus Korde				×				1
Tubercularia Vologdin		×						1
Tunuidophyton Vologdin		×						2
Vologdinella Korde		×						1
Wahpia Walcott			×					3
Waputikia Walcott			×					1
Yuknessia Walcott			×					1

TABLE 2 – GEOGRAPHICAL DISTRIBUTION OF CAMBRIAN ALGAE

Genus \ Region	Siberia	United States	Canada	Mexico	France	Russia	Italy	Antarctica	Australia	North Africa
Actinophycus Korde	×									
Amgaella Korde						×				
Anomalophycus Fenton & Fenton		×								
Angulocellularia Vologdin	×									
Aulophycus Fenton & Fenton		×								
Bija Vologdin	×									
Bogutschanophycus Korde	×									
Bosworthia Walcott			×							
Cambroporella Korde	×									
Caudomorpha Vologdin	×									
Chabakovia Vologdin	×					×				
Collenia Walcott	×	×	×							×
Concresceraria Vologdin	×									
Conophylon Maslov	×	×								×
Corbularia Vologdin	×									
Copperia Walcott	×									
Cryptozoon Hall	×	×						×	×	
Dalyia Walcott			×							
Dasycirriphycus Vologdin	×									
Dictophycus Korde	×									
Digitularia Vologdin	×									
Dolatophycus Fenton & Fenton		×								
Epiphyton Bornemann	×	×			×		×	×	×	
Girvanella Nicholson & Etheridge	×	×	×	×	×	×		×	×	
Glomeophycus Vologdin	×									
Kostinophycus Vologdin	×									
Mansurkella Vologdin	×									
Marpolia Walcott	×		×							
Mejerella Korde	×									
Monostychia Vologdin	×									
Morania Walcott			×							

TABLE 2 — GEOGRAPHICAL DITSRIBUTION OF CAMBRIAN ALGAE (*Contd.*)

Genus \ Region	Siberia	United States	Canada	Mexico	France	Russia	Italy	Antarctica	Australia	North Africa
Nemaphycus Korde	×									
Nephelostroma Dangeard & Dore					×					
Nostocites Maslov	?									
Nubecularites Maslov	×									
Ovoidophycus Vologdin	×									
Palaeomicrocystis Korde	×									
Palaeoleptophycus Korde	×									
Palaeoporella Stolley		×								
Poecilophycus Korde	×									
Praearenaria Vologdin	×									
Proaulopora Vologdin	×									
Razumovskia Vologdin	×					×				
Renalcis Vologdin	×					×				
Sajania Vologdin	×									
Schodackia Ruedemann		×								
Seletonella Korde	×									
Siberiella Korde	×									
Solenopora Dybowsky	×							×		
Spongophycus Korde	×									
Stereophycus Korde	×									
Tetonophycus Fenton & Fenton		×								
Thaumatophycus Korde	×									
Tubercularia Vologdin	×									
Tumidophyton Vologdin	×									
Vologdinella Korde	×									
Wahpia Walcott			×							
Waputikia Walcott			×							
Yuknessia Walcott			×							
Stromatolites undescribed)	×	×	×	×	×	×	×		×	×

which had developed the calcified habit are much more likely to be preserved than those which had not. Similarly, thick bladed and large rounded forms with woody structure stand much more chance of being preserved or at least of giving indication of their presence than the very delicate lacy forms; while, of course, a large majority of the microscopic forms which have no hard parts whatever are only preserved under the most fortuitous circumstances, in other words, when they become imbedded in cherts or similar materials which, needless to say, is relatively rare.

Some of the Schizophyta or blue-green algae developed the lime-secreting habit on an extensive scale long before the beginning of the Cambrian. During the late Proterozoic and during the Cambrian they were the most important of all the limestone building organisms with the result that more than half of the genera reported belong in this group. However, calcification on a limited scale begins to appear in other groups of algae and some animals in the course of the Cambrian.

ALGAL DEVELOPMENT DURING THE CAMBRIAN

A study of the fossil algae known to date suggests several rather interesting developments during the Cambrian. It should be pointed out, however, that some of these ideas may be more apparent than real because of the fact that at present our knowledge is based on the relatively small number of collections from very widely separated places. However, the available information does permit certain tentative conclusions. Walcott's lucky find of the marvelously preserved Middle Cambrian algae near Field, British Columbia, gives clear evidence of the presence of delicate, soft-bodied plants representing widely separated types belonging to different phyla.

As the period progressed there appears to have been a fairly steady increase in the variety of the higher algae, particularly among the green and the red; also, there appears to have been a gradual increase in the development of calcification among forms other than the blue-green algae. Certain groups of green and red algae developed the habit. Thus we see the beginnings of algae of types that fit into the Solenoporaceae, the Dasycladaceae, Codiaceae, and Epiphyton. However, in most cases the calcification in these groups appears to have been rather slight with the result that the fossils obtained do not show nearly the amount of structural detail that is found among the same groups during the Ordovician when calcification had become much stronger.

Algae of the *Girvanella* type appeared in the early Cambrian and apparently developed rapidly during the Middle and Upper Cambrian when they occurred in great numbers on all continents and actually were sufficiently abundant locally to form widespread and, sometimes, quite thick limestones.

Another characteristic feature of the Cambrian was the importance and great development of the stromatolites built by blue-green algae. Their importance as rock builders will be discussed later.

In terms of evolutionary development the blue-green algae show very little if any development during Cambrian times. They were, and still are, a very conservative group One gets the impression that they had made essentially all of their development before the beginning of the Cambrian. Since Cambrian times they may have invaded and adapted themselves to a number of new environments but structurally and chemically appear to have changed very little from their Cambrian counterparts. Among the stromatolites certain types of fossils which we thought earlier to be characteristic of Cambrian time have recently been found to be developing today under certain environmental conditions as shown by the recent work of Ginsburg working in the Florida and West Indies region, and Logan working in Australia.

THE FLORAS — A SUMMARY

In summary, it may be said that the Cambrian algal floras were extensive, highly developed, and highly varied with much of the evolutionary development of the algae having already taken place. The distribution of the various genera according to age is shown in Table 1, which shows 23 genera have been recorded from the Lower Cambrian, 21 from the Middle, and 27 from the Upper. The Middle Cambrian shows by far the most varied flora, but that is largely the result of the single very lucky find by Walcott in British Columbia of a shale deposit with

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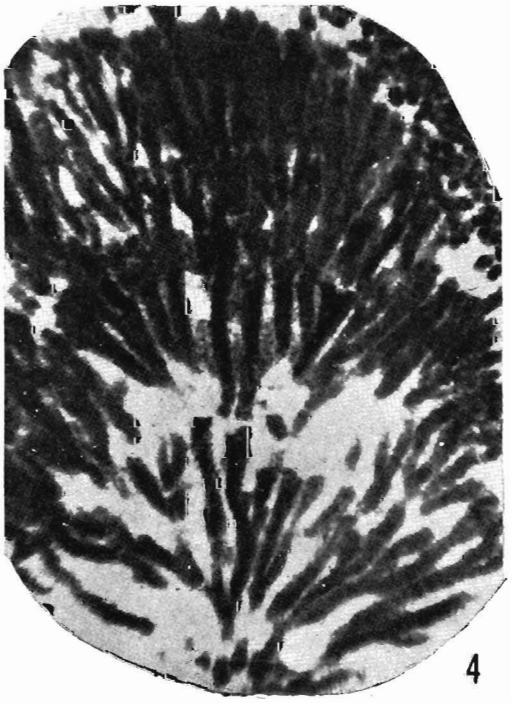

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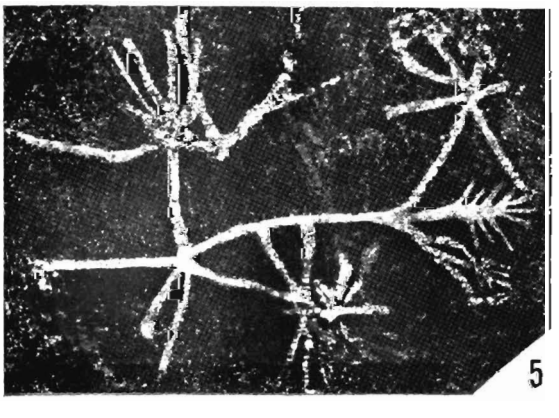

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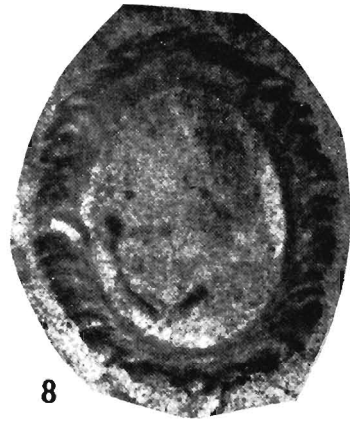
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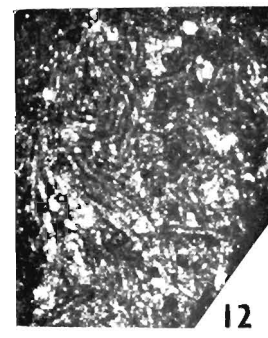
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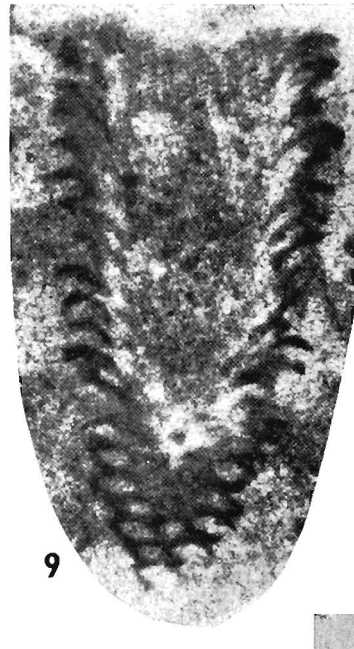
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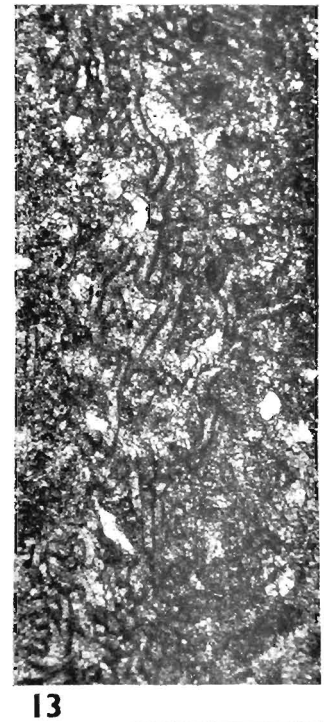
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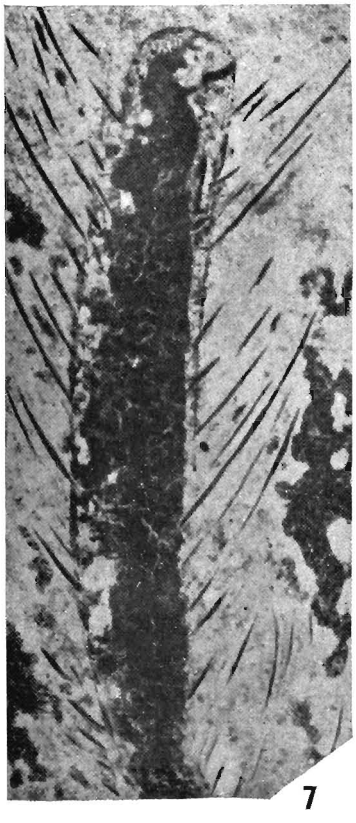
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unusually well preserved material giving an indication of the wealth of uncalcified forms which existed in the Cambrian sea. The greatest number of genera have been recorded from the Upper Cambrian, but almost all of them are stromatolites or the blue-green algae that aided in their formation.

Table 2 shows the geographical distribution of the known genera and very clearly shows the widely scattered areas from which the collections have been obtained and the very small amount of work that has been done on Cambrian algae. Practically half of the material described from the Cambrian was obtained from Siberia, and most of it from the Lena River Basin.

Table 2 also shows that stromatolites and representatives of the genus *Girvanella* are found at practically all localities that have been studied to date.

The genus *Epiphyton* was one of the most interesting and widespread genera of the Cambrian algae. It is limited entirely to that period and made its great development during the Middle Cambrian. Korde's work in the Lena River Basin and elsewhere in Siberia has shown definitely that it developed numerous species which structurally are quite distinctive and each of which appear to have had a relatively limited time distribution so that, for limited areas at least, they very definitely can be used for correlation.

ALGAL LIMESTONES

Although slightly outside of the field of the algal floras themselves, it should be pointed out that the Cambrian period was a period during which the algae were unusually important as rock builders. They were the outstanding rock builders of that period. During most of the Cambrian conditions were favorable over wide areas for the development of lime-secreting algae, permitting them to build great quantities of limestone. Also, during most of the period, they had little or no competition from limestone building animals as the first of these only appeared during the Middle Cambrian and, while they developed and increased in number and abundance in the Upper Cambrian, the quantity was still insufficient to compete radically with the limestone building algae. The limestone building activity of these algae has never been surpassed in later periods largely, however, because of the fact that the competition and active work of the limestone building animals merely took their place in the later periods and the algae were able to work only in much more restricted environments.

EXPLANATION OF PLATES

PLATE 1

1. *Cryptozoon undulatum*. Side view on a rock surface. They are about 18 inches high. Upper Cambrian, Maryland.
2, 3, 4. Examples of genus *Epiphyton* (× 30). Middle Cambrian, Lena River region, Siberia.
5. *Dalyia racemata* Walcott (× 3). Middle Cambrian, Burgess Shale, Field, British Columbia.

PLATE 2

6-9. Primitive Dasycladaceae.
6. *Amgaella amganensis* Korde (× 10). Middle Cambrian, Lena River region, Siberia.
7. *Siberiella aciculata* Korde (× 8). Middle Cambrian, Lena River region, Siberia.
8, 9. *Lenaella reticularia* Korde (× 60). Middle Cambrian, Lena River region, Siberia.
10. *Renalcis pectunculus* Korde (× 30). Upper Cambrian.
11. *Renalcis seriata* Korde (× 30) Upper Cambrian, Lena River region, Siberia.
12, 13. *Girvanella*. Upper Cambrian, Eureka, Nevada

(Figures 6-11 from Korde, 1961, 12, 13 Johnson's photographs.)