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No. 5.—MIDDLE CAMBRIAN ALGAE

(With Plates 43 to 59)

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INTRODUCTION

The presence of an algal flora in connection with a large invertebrate fauna of Middle Cambrian age in the Burgess shale has been known to me for several years, but I delayed studying it in order to obtain all the material possible from the Burgess Pass quarry of British Columbia.

Through the kindness of Dr. Charles A. Davis of the United States Bureau of Mines in 1913 a number of thin sections were made of the algal remains in which occur what appear to be chains of cells of blue-green algae (Cyanophyceae) (see pl. 43), and later a series of slides were cut through the courtesy of Director George Otis Smith by Mr. Frank S. Reed of the petrological laboratory of the United States Geological Survey.

All of the type and study series of specimens are deposited in the United States National Museum where they may be examined by students.

Habitat.—The study of the shales and the invertebrate remains of the Middle Cambrian Burgess shale in which the algae are found leads to the following conclusions in regard to their habitat:

The compact, smooth, exceedingly fine-grained siliceous Burgess shale was deposited from relatively quiet, muddy water. At intervals this condition must have been continuous for some time as layers of the shale several inches in thickness have the crustaceans distributed irregularly through them. Where the shale is in thin layers with distinct lamination and bedding surfaces the fossils are more abundant but less perfectly preserved.

The presence of carbonic acid gas has been mentioned as follows:[1] That carbonic acid gas was present in the mud and immediately adjoining water is suggested by the very perfect state of preservation of the numerous and varied forms of life. These certainly would have been destroyed by worms and predatory crustaceans that were associated with them if the algal plant life and animals that dropped to the bottom on the mud or that crawled or were drifted onto it were not at once killed and preserved with little or no decomposition or mechanical destruction. This conclusion applies to nearly all parts of a limited deposit about six feet in thickness, and especially to the lower two feet of it.

Owing to faulting and alteration of most of the shales by shearing the area available for collecting is limited to about 120 feet (36.6 m.) of outcrop on a steep slope of the mountain. This condition limits our information as to the original extent of this remarkable deposit. It was probably laid down in a small bay or lagoon in close connection with the shallow Middle Cambrian sea.

It is evident that the algae, sponges, annelids, crustaceans, etc., now found in the shale lived in quiet, relatively shallow waters swarming with life and readily accessible to the waters of the open sea. In the preliminary study of the fauna I have distinguished 94 genera in collections from a block of shale not over 15 (4.5 m.) by 100 feet (29.7 m.) in area and 7 feet (2.13 m.) in thickness. Individuals of several species of crustaceans occur in large numbers at three horizons, notably *Marrella splendens* and *Hymenocaris perfecta*. Trilobites, with the exception of the genera *Agnostus* and *Pagetia,* are not abundant, although their tests almost make up massive beds of calcareous shales a few feet below the base of the Burgess shale.

Mode of growth of the Algae.—The absence of evidence of the existence of a point of attachment on any of the forms referred to

[1] Smithsonian Misc. Coll., Vol. 57, 1912, p. 42.

Morania (pls. 44, 45) except as the colonies were held together in a mucous or gelatinous matrix leads to the conclusion that they floated freely in the water and sank to the bottom along with the crustaceans, annelids, etc., that lived among and fed more or less on them. Small shells (*Lingulella*), ostracods (*Aluta*), and trilobites are found attached to membranous expansions of the plant mass as though the shells had been lying on the bottom and the algae settled down over them, and in other examples the algae were on the bottom and the shells or trilobites became attached to the upper surface of the algae (pl. 58, fig. 4). Where the algal remains form a layer of appreciable thickness in the shale numerous small annelids (*Canadia setigera* Walcott[1]) are almost always present, but it is rarely that the larger annelids and crustaceans are associated with them; this indicates that the algae covered sufficiently large areas on or near the surface of the water to afford a favorable habitat for *Canadia setigera* and other small invertebrates. The species of algae forming small colonies floated in the water free from those forming large masses and they were frequently associated with them.

When we conclude that many of the forms of algae now found in the Burgess shale grew as free colonies it must be remembered that most, if not all, of the algal material was carried into the area by currents and deposited on the muddy bottom of the pool, lagoon or bay, and that probably none of it grew *in situ*. The floating species (*Morania confluens*, etc.) were drifted by prevailing currents or winds and the sessile species (*Donaldella insolens, D. mimica, D. virgata, Waputikia ramosa*, etc.) were readily detached by animals feeding among them or torn loose by currents or waves and drifted to their final resting place.

Manner of preservation.—The algal remains usually occur as shiny black films on the surface of the hard dark siliceous shale; this form of preservation is the same as for the medusae, sponges, annelids, crustaceans, etc., except that the algae were evidently more gelatinous and membranous; it appears to have made little difference whether the fossil was a flat, thin frond, a sphere, or a thick-bodied crustacean; all alike have been reduced to films of varying thickness without greatly distorting the original outline and arrangement of parts. The mucous or gelatinous mass of algae; the spongin and spicules of sponges; the flesh of annelids; the test and body of crustaceans, have all been replaced by a shiny black

[1] Smithsonian Misc. Coll., Vol. 57, No. 5, 1911, p. 119, pl. 23, figs. 1-3.

carbonaceous-appearing siliceous film containing pyrite in varying proportions. It is evident that the original organic and inorganic matter was removed by solution and replaced by the black film, the original convexity and relief being lost in the process and by subsequent compression.

The presence of spherical, barrel-shaped and broadly cylindrical cell-like bodies singly and in chains (pl. 43) of varying length in association with the fronds of *Morania confluens* at once raises the question as to their organic and inorganic origin. Rauff contends that such bodies are simple balls, cylinders, etc., of pyrite (FeS_2) and are of inorganic origin.[1] He states that such black pyrite balls and strings of balls occur not only in association with sponges and other organic remains, but also in limestones where there is no evidence of organisms, all of which I freely admit. In the case of the strings of balls and barrel-shaped cylinders associated with *Morania confluens,* there are the remains of an alga closely allied in appearance to the Blue-Greens (Cyanophyceae) which have cells similar in appearance and arrangement to the fossil forms; that they are preserved in pyrite is to be expected from the fact that the animal matter of the sponges and crustaceans is replaced by pyrite in the Burgess shale but in the form of microscopic cubes with glistening faces; such cubes occur in association with the spheres, cylinders, etc., found with *Morania.* I think we have here an illustration of organic and crystalline (inorganic) phenomena. It is difficult for me to conceive of strings of pyrite balls being assembled in curved lines of varying configuration unless there were organic structures that gave them form and direction.

Genera and species.—The following genera and species of algae have been identified:

CYANOPHYCEAE (MYXOPHYCEAE) (BLUE-GREEN ALGAE)
Order HORMOGONEAE
Family NOSTOCACEAE
Morania confluens, new species
Morania costellifera, new species
Morania elongata, new species
Morania fragmenta, new species
Morania frondosa, new species
Morania ? globosa, new species
Morania parasitica, new species
Morania ? reticulata, new species
Marpolia spissa, new species
Marpolia aequalis, new species

[1] Palaeontographica, Vol. 40, pp. 328-330, pl. 17, figs. 2, 3.

CHLOROPHYCEAE (GREEN ALGAE)
Yuknessia simplex, new species

RHODOPHYCEAE (RED ALGAE)
Waputikia ramosa, new species
Dalyia nitens, new species
Dalyia racemata, new species
Wahpia insolens, new species
Wahpia mimica, new species
Wahpia virgata, new species
Bosworthia radians, new species
Bosworthia gyges, new species

Comparison with recent Algae.—All comparisons of the fossil Cambrian algae with living algae with exception of the genus *Morania* are based on similarity of outward macroscopic characters and form of growth. Anyone possessing a slight acquaintance with living algae, knows that this is a very uncertain standard as essentially the same outward form may occur in different genera and even orders. We have in the fossil species only the pressed and flattened remains of fragments of the original plant and in one instance possible evidence of the microscopic structure; in their pressed condition, however, they may be compared with dried herbarium specimens with a prospect of at least pointing out resemblances that indicate that some of the algae of lower Middle Cambrian time closely resemble those of the present day.

Cyanophyceae.—The Cambrian genus attaining the greatest development in species and abundance of specimens is *Morania,* a form that is so closely allied to the living Blue-Green algae that I have ventured on both macroscopic and microscopic characters to refer it to the Order Hormogoneae and with some uncertainty to the Family Nostocaceae. *Marpolia* also may be tentatively placed with the Blue-Green algae, although it could quite as well be grouped under the Chlorophyceae.

Comparisons.—*Nostoc commune* Vaucher (pl. 46, figs. 1, 1*a*) has many points of exterior resemblance, also *Nostoc verrucosum* (Linn.) Vaucher (pl. 46, fig. 2), with *Morania confluens* (pls. 44, 45). Comparison should also be made with *Anabaena variabilis* Kützing (pl. 46, figs 4, 4*a*). The surface of *Morania confluens* (pl. 44, fig. 11) is sometimes wrinkled as it is in *Nostoc verrucosum* (pl. 46. fig. 2).

Morania ? costellifera (pl. 47, figs. 1, 2) may be compared with *Nostoc parmeloides* Kützing (pl. 46, figs. 3, 3*a-d*) and somewhat in surface characters to *Nostoc verrucosum* (pl. 46, fig. 2). In exter-

nal appearance the small masses of *Morania fragmenta* (pl. 48, fig. 1) resemble those of *Nostoc sphaericum* Vaucher (pl. 53, fig. 1). The large perforated frond of *Morania? frondosa* (pl. 49, fig. 1) and *M. reticulata* (pl. 52, fig. 2*a*) may be compared with that of *Anabaena variabilis* Kützing (pl. 46, fig. 4). The delicate disks of *Morania globosa* (pl. 48, figs. 2, 2*a-c*) resemble those of the living *Nostoc pruniforme* Agardh (pl. 53, fig. 2).

Marpolia spissa (pl. 52, figs. 1, 1*a-b*) had a form of growth apparently similar to that of *Cladophora arcta* (Dillw.) Kützing and *C. gracilis* (Griffiths) Kützing (pl. 51, fig. 1), and the transverse walls of the filaments are much like those of *C. fracta* (Vahl) Kützing and some species of *Chaetomorpha, C. clavata* (Agardh) Kützing, *C. aerea* (Dillw.) Kützing. Comparison should also be made for form of growth with *Ectocarpus mitchellae* Harvey, *E. elegans* Thuret, and *Pylaiella littoralis* (L.) Kjellman.

Chlorophyceae (Green Algae).—The genus and species included under the Chlorophyceae is *Yuknessia simplex* (pl. 54, fig. 1), which is a very doubtful reference.

Rhodophyceae (Red Algae).—This group is represented by a number of species that indicate that the algae of Middle Cambrian time had attained a development that included the highly organized Rhodophyceae, a conclusion that might be anticipated from the advanced stage of evolution of the associated sponges, holothurians, annelids and crustaceans.

The fossil forms may be compared with living species on the basis of external appearance and form.

Waputikia ramosa (pl. 54, fig. 2) has a somewhat similar mode of branching as *Dasya gibbesii* Harvey (pl. 53, fig. 3) and the form of stem and main branches is not unlike those of *Euthora cristata* (Linn.) J. Agardh. *Dalyia racemata* (pl. 56, figs. 1, 1*a-c*) has transverse lines on its branches that suggest those of *Halurus equisetifolius* (Lightf.) Kützing, and its branches suggest *Carpomitra cabrerae* (Clem.) Kützing, and its terminal branches *Griffithsia opuntioides* J. Agardh. *Wahpia insolens* (pl. 57, figs. 1, 1*a*) branches in similar manner to *Ahnfeldtia plicata* (Huds.) Fries and *Cystoclonium purpurascens* (Huds.) Kützing. Comparison should also be made with *Ahnfeldtia concinna* J. Agardh and *Gymnogongrus leptophyllus* J. Agardh. *Wahpia mimica* (pl. 55, fig. 2) with its round stem and manner of branching recalls *Ahnfeldtia plicata* (Huds.) Fries and *Ceramium rubrum* (Huds.) Agardh. *Wahpia virgata* (pl. 57, fig. 2) suggests *Ceramium nitens* (Agardh) J. Agardh.

Bosworthia simulans (pl. 57, fig. 3) probably had a form of growth not unlike that of *Dumontia filiformis* (Huds.) Greville (pl. 51, fig. 2) and possibly *Dictyota ciliata* J. Agardh and *D. fasciola* (Roth) Lamour.

We have also to consider that in this Burgess shale flora there is only a portion of the marine algal flora of Cambrian time, and this is represented by fragments of plants that grew in a very limited area tributary to the small basin into which they were drifted and deposited; the marvelous part is that we have anything preserved as fossils of such delicate and evanescent plants; what the larger algal flora of the great Cambrian seas of North America, Europe and Asia may have been we do not know, but from this one rich spot in the Burgess shale, and the great extent and advanced development of the invertebrate Cambrian faunas in many areas it is probable almost to a certainty there was an algal flora present in Cambrian time along all shore lines and in all bays, inlets and small bodies of water very much as at the present time. That fresh-water algae also flourished is indicated by its presence in the pre-Cambrian Algonkian rocks of the Cordilleran region of western America.[1]

Dr. G. F. Matthew has named and described several species of supposed algae from the Cambrian formations of Acadia, none of which appears to me to be sufficiently well defined to satisfactorily prove that they were of undoubted algal origin.

I have examined the type specimens of *Palaeochorda setacea*,[2] which appear to be the casts of trails of annelids that were moving over and through the sand and mud; the surface characters described by Matthew are such as occur on casts of trails in a fine-grained sandstone matrix.

Phycoidella stichidifera[3] is represented by a specimen that is in poor condition and also obscure. I doubt if it is of algal origin.

The types of the remaining species I have not seen and cannot express an opinion on them; they are microscopic in size, and the illustrations are more or less diagrammatic.

During the forty years in which I have been collecting and examining other collections except those from the Burgess shale, I have seen a few fragments that indicated the existence of algae in

[1] See Smithsonian Misc. Coll., Vol. 64, No. 2, 1914, Pre-Cambrian Algonkian Algal Flora, pp. 77-156, pls. 4-23.

[2] Trans. Royal Soc. Canada, Vol. 7, Sec. 4, 1890, p. 145, pl. 6.

[3] Idem, p. 144, pl. 5, figs. 5*a-d*.

the Cambrian strata, but none of the specimens gave satisfactory evidence of their undoubted algal origin. Many annelid trails, tidal water markings, trails of crustaceans and drifting medusae had been referred to as of algal origin but all were susceptible of some other interpretation.

Acknowledgments.—I wish to express my gratitude to the late Dr. Charles A. Davis for cutting thin sections and photographing them. The photographs of specimens were made by Mr. L. W. Beeson of the U. S. National Museum, and the necessary retouching of the background by Mrs. Mary Vaux Walcott. Mr. William R. Maxon, U. S. National Herbarium, has been most helpful in calling attention to sources of information in the collections of the National Herbarium and in botanic literature. Dr. Marshall A. Howe, New York Botanical Garden, kindly read the proof to verify the nomenclature of the recent algae.

CALCAREOUS ALGAE

Two species of calcareous algae have been found in thin sections of the Burgess shale from which most of the algal remains described in this paper have been obtained. Other genera and species have been described from various Cambrian formations, but as this is a preliminary study of the forms from the Burgess shale they will not be considered at this time.

DESCRIPTION OF SPECIES

CYANOPHYCEAE (MYXOPHYCEAE) (BLUE-GREEN ALGAE)

Order HORMOGONEAE[1]

"Plants multicellular, filamentous, attached to a substratum or free-floating; filaments simple or branched, usually consisting of one or more rows of cells within a sheath; reproduction occurs by means of hormogones or resting gonidia."[1]

Family NOSTOCACEAE[2]

"Sheaths forming a more or less distinct mucous, gelatinous or membranaceous tegument, mostly confluent, often not present; trichomes consisting of a single row of uniform cells, with heterocysts, usually twisting and entangled, not branched, showing no differentiation of base and apex, reproduction by means of vegetative division, hormogones and gonidia."[2]

Genus MORANIA, new genus

Plant mass (colony) at first small, irregularly globose or spheroidal with surface raised in low rounded bosses that give the flattened

[1] Tilden, J.: Minnesota Algae, Vol. 1, 1910, Minn., p. 56.
[2] Idem, p. 160.

mass an irregularly circular outline. As the mass expanded it assumed various forms, bullose, filiform, globose, and spread out in perforated or non-perforated membranous sheets; solid or hollow; mucous, gelatinous or leathery;[1] made up of tangled trichomes often torulose (chain-like); cells irregularly spherical, barrel-shaped or broadly cylindrical, larger heterocysts, cells intercalary; gonidia undetermined. (The cell description is tentative as it is based on such material as is illustrated on pl. 43.)

Genotype.—Morania confluens Walcott.

Stratigraphic range.—Middle Cambrian, lower 10 feet (3.05 m.) of the Burgess shale member of the Stephen formation.

Geographic distribution.—Western slope of ridge connecting Wapta Peak and Mount Field, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia, Canada.

Observations.—The above generic outline follows that of *Nostoc* Vaucher, as defined by Josephine Tilden.[2] It is based on the study of a large series of specimens and many thin slides. The question may arise as to why not place the Middle Cambrian species under *Nostoc* as they so closely resemble species of that genus. I would do so were it probable that a genus of the Nostocaceae had persisted from early Middle Cambrian time to the present. Representatives of the family might persist for millions of years, but we hesitate to conclude that the genus has not changed and therefore prefer to use a new generic term to include the Cambrian forms.

The species referred to *Morania* are:

Morania confluens Walcott
Morania costellifera Walcott
Morania elongata Walcott
Morania fragmenta Walcott
Morania frondosa Walcott
Morania ? globosa Walcott
Morania parasitica Walcott
Morania ? reticulata Walcott

MORANIA CONFLUENS, new species

Plate 43, figs. 1-6; plate 44, figs. 1-11; plate 45, figs. 1, 1*a*; plate 58, fig. 3

Plant mass (colony) free as far as known, gelatinous, more or less firm in early stages and irregularly spheroidal in form but quickly spreading out in very irregular flat or convex forms or in

[1] See second paragraph under "Manner of Preservation," p. 221.

[2] Minnesota Algae, 1910, p. 161.

membranous perforated sheets that are torn and broken into large and small fragments. The lacunae or perforations vary greatly in size, number, and arrangement. Often a group of small colonies are held together by the gelatinous-appearing base which forms a film on the surface of the shale; color unknown; strands flexuous and more or less entangled; no sheaths or distinct entire trichomes observed; cells [1] spherical, barrel-shaped; heterocysts irregularly spherical and larger than the cells. (See pl. 43, figs. 2, 4.) Gonidia unknown.

Observations.—There is no uniform outline or base, or point of attachment of any portion of the fragments of this perforated membranous frond-like alga. No two pieces agree in size and outline or in the size and form of the openings through the dark glistening surface of the frond. With a magnification of 20 times, long, fine, irregular, more or less interlacing, flattened, branching strands or fibers may be seen which run in the general direction of the longitudinal axis of the fragment of alga in which they occur. The interlacing effect may have been produced by the matting down of several layers of irregular strands upon each other. The general appearance of the alga on the surface of the shale is shown by figures 1-6, plate 43. From the study of these and several hundred additional specimens I conclude the alga was in the form of a mucous, gelatinous mass that formed a plant colony which assumed an irregular frond-like shape when pressed flat in the shale; it was built up of flexuous, curved, more or less tangled strands embedded in a gelatinous matrix. We do not know the original form of the plant mass further than it must have been elongate and presumably frond-shaped with numerous perforations through it of various size. It was recumbent and was deposited from the water in great profusion on the firm surface of the mud.

Microscopic structure.[2]—Through the courtesy of the late Dr. Charles A. Davis of the United States Bureau of Mines I obtained a series of thin slides made from the membranous fossil remains of this species. With great skill he cut sections parallel to the flattened surface which showed in a remarkable manner chains of cells, some of which are illustrated on plate 43, figures 1-4.

The cells appear to have been spherical, elongate oval, barrel-shaped and cylindrical; the sections include long chains of cells that curve

[1] See second paragraph under "Manner of Preservation," p. 221.

[2] Idem.

and bend (figs. 2-4) very much as in the recent Nostocaceae, or the cells may be in groups or single (fig. 1). The sections illustrated were cut parallel to the surface of the alga and to the lamination of the shale which accounts for the success in getting long chains of cells. No traces of body sheaths have been observed.

Mode of occurrence.—This species occurs abundantly in several layers of the siliceous Burgess shale and also less frequently throughout the band of shale which carries a large crustacean fauna; over 1,500 specimens were collected and many more might have been brought in.

The plant mass may be represented by (*a*) a small, delicate, irregularly circular film on the shale (pl. 44, figs. 3, 4) which is the remains of a flattened spheroidal mass; (*b*) a grouping of the bodies (*a*) pressed together on the shale (figs. 6, 7); (*c*) the beginning of a flattened membranous sheet (fig. 10); (*d*) irregularly strung out group in a gelatinous base (figs. 8, 9); (*e*) small membranous fragments (figs. 5, 11); (*f*) large, irregular, perforated membranous fragments in one thickness on the shale (pl. 45, figs. 1, 1*a*) or (*g*) lying in layers forming beds several millimeters in thickness. The largest fragment in the collection is 15 cm. in width and 20 cm. in length.

Comparison with recent algae.—Of recent forms, *Nostoc commune* Vaucher (pl. 46, figs. 1, 1*a*) has many points of resemblance. These include the small spherical-shaped colonies that form irregular disks when flattened; the highly irregular, torn and perforated sheets; also essentially the same form of chains of cells. It may also be compared with *Nostoc verrucosum* (Linn.) Vaucher (pl. 46, fig. 2) as the latter has a similar habit of growth in outward form and the surface of *M. confluens* is sometimes wrinkled as in *N. verrucosum,* but it does not have the same characteristic surface.

Comparison should also be made with *Anabaena variabilis* Kützing (pl. 46, figs. 4, 4*a*) which occurs as floating masses on the surface of the water and in many other forms but these are not as close to *Morania confluens* as *Nostoc commune.* Torn fragments of the red alga *Kallymenia perforata* J. Agardh resemble the larger perforated fragments of *M. confluens* as do those of *Ulva reticulata* Forsk.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

MORANIA COSTELLIFERA, new species

Plate 47, figs. 1, 2

Plant mass (colony) free as far as known; irregularly circular or elongate oval as they occur flattened on the surface of the shale; probably discoid or semiglobose when uncompressed; gelatinous or leathery, strong and not readily torn or broken; surface with more or less irregular costae or wrinkles that vary in strength on different specimens, the costae may be the result of the shrinkage of globose hollow colonies. No traces of strands have been observed; microscopic characters unknown.

Plant masses referred to this species have a diameter of from 3 mm. to 20 mm.

Observations.—This species differs from *Morania globosa* and the round form of *M. confluens* in its more leathery appearance, wrinkled surface and firm outline. In exterior outlines the flattened colonies of this species resemble the recent *Nostoc parmeloides* Vaucher (pl. 46, fig. 3) and somewhat in surface *Nostoc verrucosum* (Linn.) Vaucher.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

MORANIA ELONGATA, new species

Plate 47, figs. 3, 3*a*

Plant mass (colony) free as far as known with an irregular circular outline as though spheroidal bodies 1 to 2 mm. in diameter had been flattened to a film on the shale while held together in a gelatinous matrix; some of them appear to have split up so as to give a ragged and sharp outline to the thin films as they occur singly and in groups in association with the more circular bodies. The colonies were held together in long strings of gelatinous matter that trailed in narrow masses in the water; these elongate masses are usually 2 to 3 cm. broad and 10 cm. or more in length and with indefinite outlines; some examples appear as if they had been smeared over the mud as a thin film, while others show laminations caused by the crushing down of several thicknesses on each other.

Observations.—The form of the colonies of this species seems to be similar to those of *Morania fragmenta* (pl. 48) but their grouping is quite different as they string out into long irregular masses while

M. fragmenta forms masses of definite outline; many of these resemble long slender worms broken up and flattened out and smeared over the shale, while others are definite in outline; the irregular appearance is also increased by the presence of trails of small annelids that evidently sought the floating algae and went to the bottom with it.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

MORANIA FRAGMENTA, new species

Plate 48, figs. 1, 1*a*

Plant mass (colony) free as far as known, irregularly circular, oval or elongate, and from 0.75 to 2 mm. in diameter when flattened on the surface of the shale; these smaller bodies are grouped in circular, elongate, and variously outlined clusters that were apparently held together in a mucous or gelatinous matrix. The clusters average about 3 to 5 mm. in diameter and occur widely scattered over the surface of the shale or they may form relatively thick masses about the carapace of a crustacean [1] as though they had been gathered on the bottom by an eddy in the water; these circular groups vary in size from 5 to 20 cm. and may include torn fragments of *Morania confluens*. The impression made by the examination of a large number of specimens is that the small colonies formed balls or globose masses of varying shape held together by a mucous or gelatinous matrix and that when flattened out they formed disks, circular, oval, elongate or broken and irregular in outline; the larger number of specimens represent broken masses, hence the specific name *fragmenta*.

Observations.—This species differs from others referred to *Morania* by having the small colonies united in groups to form irregular masses that average 3 to 5 mm. in diameter.

In external form the colonies of *M. fragmenta* resemble the living *Nostoc sphaericum* Vaucher (pl. 53, fig. 1); they appear to have floated free in the water both singly and in groups held together by a mucous or gelatinous matrix.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge

[1] Usually *Hymenocaris* or *Hurdia*.

between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

MORANIA ? FRONDOSA, new species

Plate 49, figs. 1, 1*a*

Only one specimen of this species has been found in the collections; this is a portion of a large frond-like mass on the surface of the shale that appears to have formed a thin membranous film perforated by numerous more or less oval openings, lacunae, varying from 1 to 3 mm. in greatest diameter. It looks similar to the thin gelatinous masses of *Anabaena variabilis* Kützing (pl. 46, fig. 4) as they appear when dried out on blotting paper. The latter species often forms gelatinous scums floating on the surface of the water, and it is very easy to imagine that a similar condition existed in the case of *M. frondosa.*

The type and only specimen of this species is 11 cm. in length by 6 cm. in width up to where a break in the shale cuts it off.

Observations.—The only other form known to me from the Burgess shale that in any way may be compared with *M. frondosa* is *M. reticulata,* and only to the extent that both appear to have been thin floating masses that dropped to the muddy bottom and left a trace of their general form on its surface.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

MORANIA ? GLOBOSA, new species

Plate 48, figs. 2, 2*a-d*

Plant masses (colonies) free as far as known, disk-shaped as they occur flattened out on the shale but probably spheroidal or elongate-globose before compression. The plant masses now appear as dark, thin shiny membranous films, circular, oval or elongate-oval in outline, with their surface mottled by irregular patterns of bright silvery material. The specimens in the collection vary in size from 13 mm. to 90 mm., and all appear to have been very delicate gelatinous or mucous-like bodies with sufficient firmness of structure to preserve their outline when compressed in the thin layers of mud and to also wrinkle slightly by lateral compression; no traces of strands comparable with those of *Morania confluens* (pl. 44, fig. 11)

have been observed or lacunae perforating the frond; color and microscopic structure unknown.

Observations.—This species is readily distinguished from the globular or disk-shaped forms of *M. confluens* by regularity of outline, more delicate and thinner film on the shale and absence of strands and lacunae; from *M. costellifera* it differs in its thin delicate film, smooth surface and outline on the shale.

Among recent species, herbarium specimens of *Nostoc pruniforme* Agardh (pl. 53, fig. 2) resemble the delicate membranous disks of *M. globosa* both in outline and smooth surface.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

MORANIA PARASITICA, new species

Plate 50, figs. 1, 1*a*, 2

Plant mass (colony) free as such but in groups lying on and attached to the smooth surface of the carapace of crustaceans and that of the membranous film of *Morania globosa*. The individual masses are about 1 mm. in diameter; they occur singly and in irregular clusters or they may be so pressed together as to form a continuous surface; they were probably held together by a gelatinous exudation from the colonies.

Observations.—The first impression of this incrusting form was that it represented masses of *Morania fragmenta* (pl. 48) that had become attached to, and spread irregularly over, the surface of smooth objects; the small round disk-like masses are similar in shape but after examining a large number of specimens I think we may tentatively separate them as distinct from *M. fragmenta*.

The incrusting alga may occur scattered thinly over the surface or cover it entirely; in no instance has it been seen to extend beyond the edge of the crustacean carapace or membranous alga on which it occurs. I thought that perhaps the incrusting form might be a secondary deposit of mineral origin and asked Dr. George P. Merrill of the United States National Museum to examine and test it with this in view. He very kindly did so and reported as follows: "The material giving the sheen to these fossil impressions is not, as I had been inclined at first to think, of a metallic-sulphide nature but is wholly untouched by acids, even aqua regia.

I am, therefore, inclined to regard it as of a carbonaceous or graphitic nature. It cannot be due to an impregnation of liquid hydrocarbon but rather to vegetable or animal growth and contemporaneous with the shale."

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

MORANIA ? RETICULATA, new species

Plate 52, figs. 2, 2a

This species, like *M. frondosa,* appears to have been in the form of a gelatinous floating film that when pressed flat on the muddy bottom left only a trace of its form; this indicates that the mass was perforated by numerous small openings, which give the surface the appearance of an irregularly reticulated, slightly roughened, more or less torn membrane that may be compared with herbarium specimens of *Anabaena variabilis* Kützing (pl. 46, fig. 4).

Observations.—The specimen illustrated has an irregular mass of *M. confluens* attached to it.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

MARPOLIA, new genus

All that is known of this genus is described under the type species.

Genotype.—Marpolia spissa Walcott.

Stratigraphic range.—Middle Cambrian: Stephen formation; *Ogygopsis* shale, on Mount Stephen; Burgess shale and superjacent thin-bedded limestone, which give a vertical range of about 450 feet (137.25 m.).

Geographic distribution.—At Burgess Pass fossil quarry, in Burgess shale, on western slope of ridge connecting Wapta Peak and Mount Field, and on west slope of Mount Field one mile (1.6 km.) northeast of Burgess Pass above Field, also on northwest slope of Mount Stephen above Field, British Columbia, Canada.

Observations.—The second species, *M. aequalis,* apparently has a definite axis and branches, which probably arises from the twisting together of the filaments and their imperfect preservation; fragments

of *M. spissa* occur in the same beds which have the characteristic shiny silvery appearance of *M. aequalis*.

MARPOLIA SPISSA, new species

Plate 52, figs. 1, 1*a-b*

Thallus formed of slender, flexuous branched filaments that, twisted together, form an irregular axis from which the filaments extend in tufts or dense masses in the same general direction as they branch at narrow angles; the form of the thallus appears to depend upon how the floating mass of algae happened to settle on the surface of the muddy bottom; often the cæspitose tufts have been so completely torn apart that the shiny, silvery filaments nearly cover the surface of the shale (fig. 1*b*); the filaments are marked by transverse lines into sections a little longer than wide as in the living *Cladophora fracta* (Vahl) Kützing; the outer walls are slightly indented opposite the transverse lines, but I have not been able to discover further details of structures.

The larger tufts average from 3 to 5 cm. in length, and may spread out to 4 or 5 cm. at the top.

Microscopic structure unknown.

Observations.—This species is very abundant on several layers of the shale either as tufts (figs. 1, 1*a*) or scattered filaments. The plants were probably epiphytic, growing in tufts attached to any object and from which they were readily detached by currents or annelids and crustaceans moving about among them. The form of growth is somewhat similar to that of the living *Cladophora arcta* (Dillw.) Kützing, and *C. gracilis* (Griffiths) Kützing (pl. 51, fig. 1), and the transverse walls of the filaments are macroscopically much like those of *Cladophora fracta* (Vahl) Kützing and some species of *Chaetomorpha, C. clavata* (Agardh) Kützing, *C. aerea* (Dillw.) Kützing; comparison should also be made for form with *Ectocarpus mitchellae* Harvey, *E. elegans* Thuret, and *Pylaiella littoralis* (L.) Kjellman.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass; and (14s) *Ogygopsis* zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, both above Field on the Canadian Pacific Railroad, British Columbia, Canada.

MARPOLIA AEQUALIS, new species

Plate 55, fig. 1

Thallus a tuft of fine branching filaments that when twisted together give the appearance of a central stem and strong branches; the filaments appear to be a little larger than those of *M. spissa,* and they are not as much flattened on the shale; traces of transverse lines are clearly shown on some of the filaments. The one specimen referred to this species has a length of about 4 cm.

Microscopic structure unknown.

Observations.—This form is closely related to *M. spissa* (pl. 52); it differs in being somewhat more robust and in its larger filaments. It may be compared with the living *Cladophora scopaeformis* (Ruprecht) Harvey in its robust habit of growth.

Formation and locality.—Middle Cambrian: (14s) *Ogygopsis* zone of the Stephen formation; about 2,300 feet (701 m.) above the Lower Cambrian and 3,540 feet (1,089 m.) below the Upper Cambrian in the *Ogygopsis* zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railroad, British Columbia, Canada.

CHLOROPHYCEAE (GREEN ALGAE)

Genus YUKNESSIA, new genus

The description of the type species includes what is known of the genus.

Genotype.—*Yuknessia simplex* Walcott.

Stratigraphic range.—Middle Cambrian: Stephen formation; *Ogygopsis* shale, on Mount Stephen; Burgess shale and superjacent thin-bedded limestone, which give a vertical range of about 450 feet (137.25 m.).

Geographic distribution.—At Burgess Pass fossil quarry, in Burgess shale, on western slope of ridge connecting Wapta Peak and Mount Field, and on west slope of Mount Field one mile (1.6 km.) northeast of Burgess Pass above Field, also on northwest slope of Mount Stephen above Field, British Columbia, Canada.

YUKNESSIA SIMPLEX, new species

Plate 54, figs. 1, 1*a-c*

Thallus small, 2 to 3 mm. in diameter; main stem large, hollow, and covered with closely arranged conical plates, each plate probably forming the base of a long flexuous stipe that shows no evidence of

jointing, bifurcating or carrying branches; the stipes are slender and form a thin shiny film on the shale; there does not appear to be any terminal bifurcation, although on one specimen it is suggested by the presence of two whorls of terminal branchlets of *Dalyia racemata* (pl. 56).

Microscopic structure unknown.

Observations.—I placed this form as a possible sertularian when making a preliminary examination of the collection, but it shows no structure warranting it nor is it closely allied to any recent algae; some of the Codiaceae have a strong stem supporting a mass of bifurcating branches, *Penicillus* and *Rhipocephalus,* but here the resemblance ceases as the stipes of *Yuknessia* are unbranched and the stem is covered with plates. Dr. Rudolph Ruedemann describes a somewhat similar form from Ordovician, Trenton, limestone of New York[1] which he placed tentatively with the algae; this has a large plated stem, but the stipes are branched as in *Penicillus.*

There are three well-defined specimens in the collection; one shows a portion of the side of the main stem and the other two the rounded top of the main stem with a number of stipes radiating from it.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

RHODOPHYCEAE (RED ALGAE)

Family RHODOMELACEAE

Genus WAPUTIKIA, new genus

All that is known of this genus is described under the type species. Its geographic distribution and stratigraphic range are the same as for the genus *Morania* (p. 225).

Genotype.—*Waputikia ramosa* Walcott.

WAPUTIKIA RAMOSA, new species

Plate 54, figs. 2, 2*a-b*

Thallus consisting of a rather strong, somewhat flexuous central stem or stipe with relatively strong branches springing from it at irregular intervals; the primary branches give off short secondary

[1] New York State Museum Bull. 133, 1908, pp. 206-207, pl. 3, figs. 1-5.

branches, which give rise to minor branches, and these again divide into branches each having several slender filamentous branchlets attached apparently to the outer side of the branch.

The largest specimen in the collection, which is probably a fragment broken off from a large frond, has a length of 6 cm. with a width of 3 cm.

The central stem and all branches have a black, smooth shiny surface without traces of linear or transverse lines or markings and resemble thin carbonaceous films.

Microscopic structure unknown.

Observations.—The mode of branching of this species recalls the genus *Dasya* of the Rhodophyceae, notably *D. gibbesii* Harvey (pl. 53, fig. 3), which has a more slender stem and branches, but its terminal filaments form foliage-like clusters that resemble those of *Waputikia ramosa* to a surprising degree. The form of the stem and main branches is somewhat similar to those of *Euthora cristata* (Linn.) J. Agardh as shown by herbarium specimens.

When stripped of the terminal filaments the branches resemble those of a branch of a deciduous bush without leaves.

This form is rare as only five specimens were met with in the six years' collecting at the Burgess Pass quarry.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

DALYIA, new genus

The description of the type species includes practically all that is known of the genus.

Genotype.—Dalyia racemata Walcott.

The other species referred to the genus is *D. nitens,* which occurs in the same layer of shale with *D. racemata.*

Stratigraphic range.—Middle Cambrian: Stephen formation; *Ogygopsis* shale, on Mount Stephen; Burgess shale and superjacent thin-bedded limestone, which give a vertical range of about 450 feet (137.25 m.).

Geographic distribution.—At Burgess Pass fossil quarry, in Burgess shale, on western slope of ridge connecting Wapta Peak and Mount Field, and on west slope of Mount Field one mile (1.6 km.) northeast of Burgess Pass above Field, also on northwest slope of Mount Stephen above Field, British Columbia, Canada.

DALYIA RACEMATA, new species

Plate 55, figs. 4, *4a-b;* plate 56, figs. 1, *1a-c*

Thallus formed of narrow slender stems or stipes 0.4 to 0.6 mm. in diameter, branching from a simple central stem; the stems are usually pressed flat and show only a smooth surface, but there are a few that have traces of transverse lines, and one fragment of a thallus has distinct transverse lines about a diameter of the stem apart, giving it a jointed appearance, in this respect resembling the stems of the living *Halurus equisetifolius* (Lightf.) Kützing; a single branch may extend out at nearly a right angle to the central stem, as one on each side, or there may be a grouping of three or four radiating from the distal end of the central stem; the plain, straight branches support at their distal end a whorl of stipes or branchlets that vary in length from 3 to 10 mm., and these may also have one or more short branchlets in a whorl of not to exceed five short stipes, as now known. The largest thallus has a length of about 4 cm. Microscopic characters unknown.

Observations.—This species is moderately abundant in a more or less broken up state in one layer of shale along with drifted fragments of crustaceans; it probably flourished in the waters near by and was drifted along by gentle currents until the fragments found a resting place on the muddy bottom.

Among fossil forms *Callithamnopsis fructiosa* (Hall) Whitfield[1] has simple branches bearing terminal whorls of branchlets very similar to those of *D. racemata,* but the general arrangement of the branching is quite dissimilar.

Among living algae fragments of *Griffithsia opuntioides* J. Agardh suggest the terminal branchlets of *Dalyia racemata,* but the branching from the central stem is more like that of *Carpomitra cabrerae* (Clem.) Kützing.

D. racemata differs from *D. nitens* in the attachment of the branches to the central stem and in the form of the whorls at the end of the branches.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge betwen Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, also (14s) *Ogygopsis* zone of the Stephen formation; about 2,300 feet (701 m.) above the Lower Cambrian and 3,540 feet (1,089 m.) below the Upper Cambrian, at the great

[1] Bull. American Museum Nat. Hist., Vol. 6, 1894, p. 354, pl. 11, figs. 4-8.

" fossil bed " on the northwest slope of Mount Stephen, both above Field on the Canadian Pacific Railroad, British Columbia.

DALYIA NITENS, new species

Plate 55, fig. 3

Thallus known only by a single specimen, consisting of a fragment of the central stem, with two branches that are attached to globose or pyriform enlargements of the main stem; the straight, slender branches have a pyriform enlargement at the distal end that supports a whorl of at least five slender branchlets or pinnules that do not show in the specimen evidence of further division; the appearance of the flattened stem suggests that it was hollow and of a carbonaceous nature. The fragment of the thallus preserved has a length of 15 mm.

Microscopic characters unknown.

Observations.—Among fossil forms this species may be compared with the Ordovician species *Callithamnopsis fructiosa* Whitfield,[1] with respect to its slender branches with enlarged distal end and whorl of branchlets; the latter species does not have the enlargement of the main stem where the branches arise, and its general aspect is dissimilar. There does not appear to be any recent alga that resembles this species in external appearance.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

Genus WAHPIA, new genus

The description of the type species includes all that is known of the genus.

Genotype.—Wahpia insolens Walcott.

Stratigraphic range.—Middle Cambrian: Stephen formation; *Ogygopsis* shale, on Mount Stephen; Burgess shale and superjacent thin-bedded limestone, which give a vertical range of about 450 feet (137.25 m.).

Geographic distribution.—At Burgess Pass fossil quarry, in Burgess shale, on western slope of ridge connecting Wapta Peak and Mount Field, and on west slope of Mount Field one mile (1.6 km.) northeast of Burgess Pass above Field, also on northwest slope of Mount Stephen above Field, British Columbia, Canada.

[1] Bull. American Museum Nat. Hist., Vol. 6, 1894, p. 354, pl. 11, figs. 4-8.

WAHPIA INSOLENS, new species

Plate 57, figs. 1, 1*a*

Thallus consisting of a long central stem with long slender branches that spring from it at an angle of about 45°; these give rise to a few minor branches of the same character. A second specimen has four successive branchings with possibly a very delicate branching at the end of the fourth member. The surface of the stem and larger branches is marked by a strong median line with clearly defined edges, which indicates that they represent hollow stems flattened on the shale. Microscopic structure unknown.

The largest specimen has a total length of 8 cm.

Observations.—Both of the two specimens found of this species appear to be drift fragments from which most of the finer branches have been broken off. *W. insolens* branches in a similar manner to the recent marine algae *Ahnfeldtia plicata* (Huds.) Fries and *Cystoclonium purpurascens* (Huds.) Kützing. A stem of the latter with extensions of the branches broken off, resembles closely *W. insolens*. Comparison should also be made with *Ahnfeldtia concinna* J. Agardh and *Gymnogongrus leptophyllus* J. Agardh, which have a somewhat similar form of branching.

Formation and locality.—Middle Cambrian: (14s) *Ogygopsis* zone of the Stephen formation; about 2,300 feet (701 m.) above the Lower Cambrian and 3,540 feet (1,089 m.) below the Upper Cambrian, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railroad, British Columbia, Canada.

WAHPIA MIMICA, new species

Plate 55, fig. 2

Of this species only one broken specimen of the thallus has been found. The stem and branches are narrow, rigid, and have left a strong impression on the shale; the primary branches are numerous and alternate on opposite sides of the stem in their flattened condition; the secondary branchlets are also numerous and have the same arrangement as the main branches; some of the long secondary branches appear to bifurcate towards their distal end.

Microscopic structure unknown.

Observations.—This form has several of the characters of *Wahpia insolens,* but it differs in its more numerous branches and branchlets. Its round stem and manner of branching strongly suggest the recent

Ahnfeldtia plicata (Huds.) Fries or *Ceramium rubrum* (Huds.) Agardh.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

WAHPIA VIRGATA, new species

Plate 57, fig. 2

This species differs from *W. insolens* and *W. mimica* in having a larger proportional central stem and more flexuous branches and branchlets. The mode of branching and flexuous branches and branchlets may be compared with the recent species *Ceramium nitens* J. Agardh.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

BOSWORTHIA, new genus

All that is known of this genus is described under the type species. Its geographic distribution and stratigraphic range are the same as the genus *Morania* (p. 225).

Genotype.—Bosworthia simulans Walcott.

BOSWORTHIA SIMULANS, new species

Plate 57, fig. 3; plate 58, figs. 1, 1*a*

Thallus formed of flexuous, membranous branches decompoundly branched to a limited degree and with two or three narrow branchlets near the extremities of the larger branches; as flattened out on the shale the stipes vary from 2.5 mm. in width to 0.5 mm. at the outer ends; the thin membranous ribbon-like stipes were evidently easily folded, twisted and sprawled on the surface of the mud, or the thallus may have been compact and when pressed flat in the laminations of the muddy sediment the stipes were matted down on each other; only traces of the carbonaceous matter remain on the specimens.

The thallus known to us has a length of 8 cm. and a width of 3.5 cm.; it narrows at the base as though attached to a central stem at the base, and also narrows slightly towards the top.

Observations.—Of this form only two specimens have been found; one of them (pl. 58, fig. 1) shows the branches grouped closely and matted down on each other, and in the other (pl. 57, fig. 3) they have been spread out and more or less displaced as though a portion of the thallus had been torn off and drifted along by the current.

Among living algae *Dumontia filiformis* (Huds.) Greville (Rhodophycea) has a somewhat similar form of growth, and possibly some species of the Phaeophyceae, *Dictyota ciliata* J. Agardh and *D. fasciola* (Roth) Lamour. may be compared with *B. simulans*. The recent species have similar flexuous, membranous stipes that branch in nearly the same manner. Among fossil forms *Polyaedictyota ramulosa* (Spencer)[1] of the Silurian has a somewhat similar form of growth and appearance.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

BOSWORTHIA GYGES, new species

Plate 58, fig. 2

Thallus formed of delicate ribbon-like branches rising from a central base and forming a compact frond-like mass on the shale; the branches as flattened on the shale are about 1 mm. in width and the branching is obscured by their close grouping; the one specimen known of the species has a length of about 3.25 cm.

Microscopic structure unknown.

Observations.—This species differs from *B. simulans* in its compact thallus and less flexuous branches. It adds one more species to the relatively rich plant life of the Burgess shale and seems to be worthy of recognition.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

CALCAREOUS ALGAE

Genus SPHAEROCODIUM Rothpletz

Sphaerocodium Rothpletz, 1890, Bot. Centralbl., vol. 41, p. 9.

[1] See Whitfield, Bull. American Mus. Nat. Hist., Vol. 16, 1902, p. 399, pl. 53, figs. 1, 2.

SPHAEROCODIUM ? PRAECURSOR, new species

Plate 59, figs. 1, 1*a-c*

This species occurs as a very small free thallus as shown by transverse sections found in thin sections cut from the Burgess shale. The exterior walls have been destroyed by solution and replaced by a mass of fine calcite crystals (figs. 1, 1*a-b*). The interior of the mass is filled with sections of what were probably irregular tubes that have been obscured and often destroyed by the recrystallization of the mineral matter of the original structure. The convolutions of the tubes appear to have been short and without any recognizable arrangement in the sections available for study.

Measurements.—The larger masses are from 0.6 mm. to 1.75 mm in diameter with tubes about 0.01 to 0.015 mm. across.

Observations.—This species is represented by larger specimens than *Sphaerocodium ? cambria* and its tubular structure is also coarser and less definitely arranged; its structure may be compared with that of *S. munthei* Rothpletz[1] (pl. IV, fig. 4) but owing to its imperfect condition none of the finer details can be determined.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

SPHAEROCODIUM ? CAMBRIA, new species

Plate 59, fig. 2

This is a microscopic form the thin sections of which show numerous fine, irregularly arranged tubes that resemble those of *S. gothlandicum* Rothpletz.[1] The thallus and tubes are much more minute than those of *S. praecursor*.

Dimensions.—The type specimen is broken off along the margins—it is approximately 0.0255 mm. across; the tubes are about 0.0006 to 0.0008 mm. in diameter.

Observations.—Only one specimen of this species has been located in the slides although several were seen in a preliminary examination of slides when a locating and measuring stage was not available.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

[1] Sveriges Geol. Unders., Ser. Ca, No. 10, 1913, p. 19, pl. 4, figs. 1, 2.

DESCRIPTION OF PLATE 43

PAGE

MORANIA CONFLUENS Walcott (See pls. 44, 45 and 58) 226

FIG. 1. (×90.) Strings of round, cell-like bodies formed of pyrite and broken strings of smaller and similar bodies; cubes of pyrite are scattered in the thin rock slide, which is photographed by transmitted light. (Slide No. 25.)

2. (×200.) Still further enlargement of strings of cell-like bodies formed of pyrite. (Slide No. 81.)

3, 3*a*. (×1,000.) A few scattered balls of pyrite, some of which show in outline a botryoidal appearance. (Slide No. 81.)

4. (×400.) A broken chain of round cell-like bodies. (Slide No. 81.)

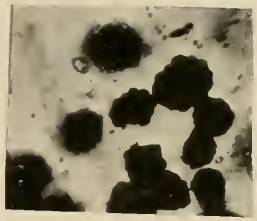
5. (×60.) A flexuous chain crossed at the lower end by a fragment of a chain. (Slide No. 96.)

6. (×250.) Enlargement of the lower end of the chain represented by fig. 5.

The chains and balls represented by the above-described figures occur in thin rock sections cut on the plane of flattened specimens of the alga *Morania confluens* (See pls. 44, 45) as it occurs on the surface of the shale.

The specimens represented on this plate are from locality 35, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

1



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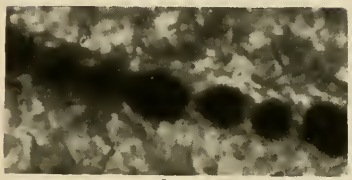
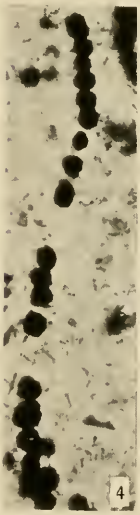


3*a*



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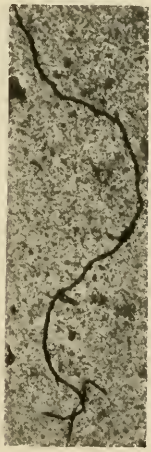

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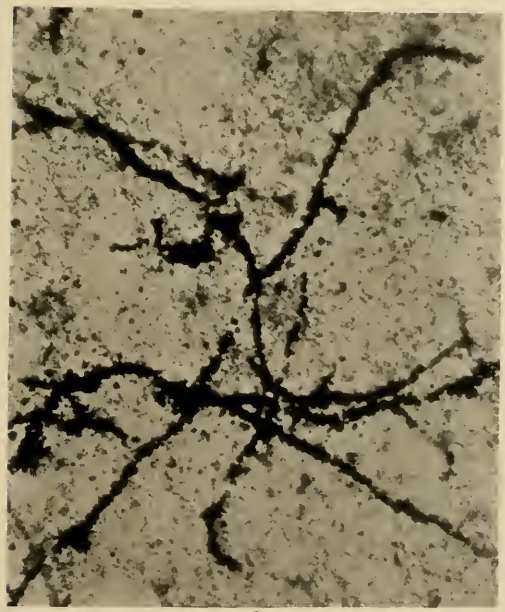


2

6

CHAINS AND BALLS ASSOCIATED WITH MORANIA CONFLUENS Walcott

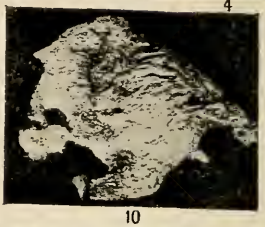
1

2

3

4

5



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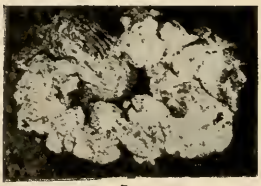

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8

9

11

MORANIA CONFLUENS Walcott

DESCRIPTION OF PLATE 44

PAGE

MORANIA CONFLUENS Walcott (See pls. 43, 45, and 58) 226

FIGS. 1 and 2. (Natural size.) Two small groups or colonies that were held together by a gelatinous mass which now forms a film on the surface of the shale. U. S. National Museum, Catalogue Nos. 35378 and 35379.

3 and 4. (×2.) Small, irregular and somewhat thicker films than those represented by figs. 1 and 2. U. S. National Museum, Catalogue Nos. 35380 and 35381.

5. (×2.) Portion of a membranous frond that has been distorted and torn. U. S. National Museum, Catalogue No. 35382.

6. (Natural size.) Several small plant masses that have been flattened down together on the shale, some of which have the outlines shown by figs. 1 and 2. U. S. National Museum, Catalogue No. 35383.

7. (Natural size.) Another group of small plant masses with one on the upper side that appears to be *Morania ? costellifera*. (See pl. 47, figs. 1, 2.) U. S. National Museum, Catalogue No. 35384.

8. (Natural size.) An irregular plant mass with part extended on the shale. U. S. National Museum, Catalogue No. 35385.

9. (×2.) A small plant mass similar to that represented by fig. 8, with what may have been an annelid trail extending down from it. U. S. National Museum, Catalogue No. 35386.

10. (×2.) Fragment of a plant mass with lacunae extending through it. U. S. National Museum, Catalogue No. 35387.

11. (×3.) Portion of a large plant mass that has been laterally compressed so as to give it an irregularly finely wrinkled surface. U. S. National Museum, Catalogue No. 35388.

All of the specimens represented on this plate are from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railway, British Columbia, Canada.

DESCRIPTION OF PLATE 45

PAGE

MORANIA CONFLUENS Walcott (See pls. 43, 44, and 58) 226

FIG. 1. (×4.) A torn, irregular fragment of a large plant mass with numerous lacunae. The surface is striated or finely wrinkled longitudinally by lateral compression. U. S. National Museum, Catalogue No. 35389.

1*a*. (Natural size.) A fragment of a gelatinous-appearing plant mass with numerous lacunae. U. S. National Museum, Catalogue No. 35390.

The specimens represented on this plate are from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railway, British Columbia, Canada.

MORANIA CONFLUENS Walcott


1


1a


2


3

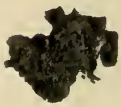

3a


3b


3c


3d


3e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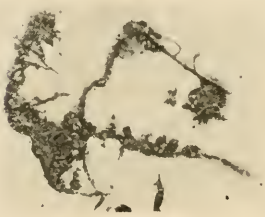
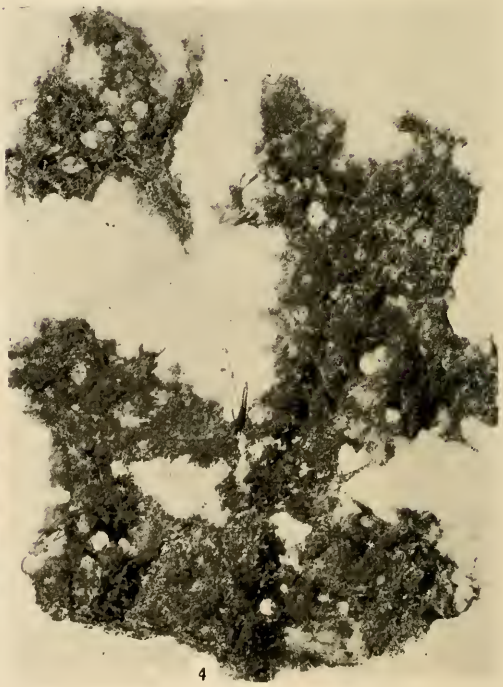

3g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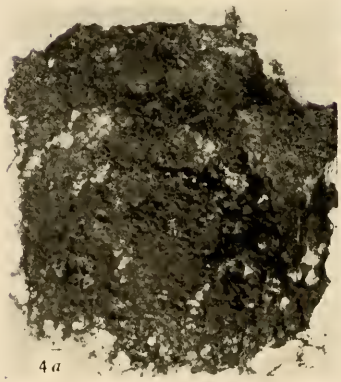

4a

RECENT ALGAE

1. Nostoc commune Vaucher
2. Nostoc verrucosum (Linn.) Vaucher
3. Nostoc parmeloides Vaucher
4 Anabaena variabilis Kützing

DESCRIPTION OF PLATE 46

PAGE

NOSTOC COMMUNE Vaucher 228

FIG. 1. (Natural size.) Fragment of a plant mass flattened by pressure, for comparison with the fossil form *Morania confluens* (fig. 1, pl. 45).

1*a*. (Natural size.) A plant mass with unbroken outline, flattened by pressure, for comparison with the fossil forms of *Morania confluens* (figs. 1-5, pl. 44) and *M. ? globosa* (figs. 2, 2*a-c*, pl. 48).

NOSTOC VERRUCOSUM (Linn.) Vaucher 228, 229

FIG. 2. (Natural size.) Portion of a plant mass, flattened by pressure, that has a finely wrinkled surface similar to that of some fossil specimens of *Morania confluens* (fig. 11, pl. 44).

NOSTOC PARMELIOIDES Kützing 229

FIGS. 3, 3*a-d*. (Natural size.) More or less circular plant masses, flattened by pressure, that suggest the fossil form *Morania costellifera* (figs. 1, 2, pl. 47).

3*e-g*. (Natural size.) Broken and irregular plant masses that may be compared in form with the fossil *Morania fragmenta* (fig. 1, pl. 48).

ANABAENA VARIABILIS Kützing 228, 231

FIG. 4. (Natural size.) Plant mass flattened on paper. The lacunae and mode of spreading out suggest the fossil forms, *Morania confluens* (fig. 1, pl. 45), *M. frondosa* (fig. 1, pl. 49), and *M. reticulata* (fig. 2*a*, pl. 52).

4*a*. (Natural size.) A more dense mass of this species.

All of the figures on this plate are reproductions of photographs of specimens of recent algae in the National Herbarium at the Smithsonian Institution.

DESCRIPTION OF PLATE 47

PAGE

MORANIA COSTELLIFERA Walcott..... 229

FIGS. 1 and 2. (×3.) Two specimens showing sharp wrinkles of costae which have given the name to the species. U. S. National Museum, Catalogue Nos. 35391 and 35392.

MORANIA ELONGATA Walcott..... 229

FIG. 3. (Natural size.) Portion of a specimen as it appears on the shale. U. S. National Museum, Catalogue No. 35393.

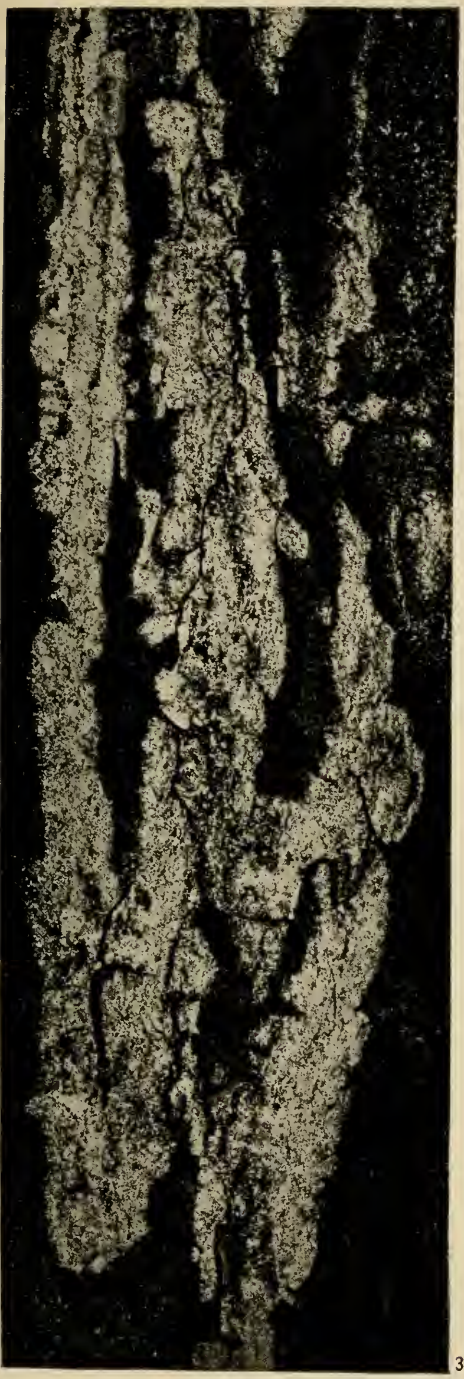
3*a*. (×4.) Enlargement of the central portion of the specimen represented by fig. 3, illustrating the general appearance of the species.

The specimens represented on this plate are all from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railway, British Columbia, Canada.

1

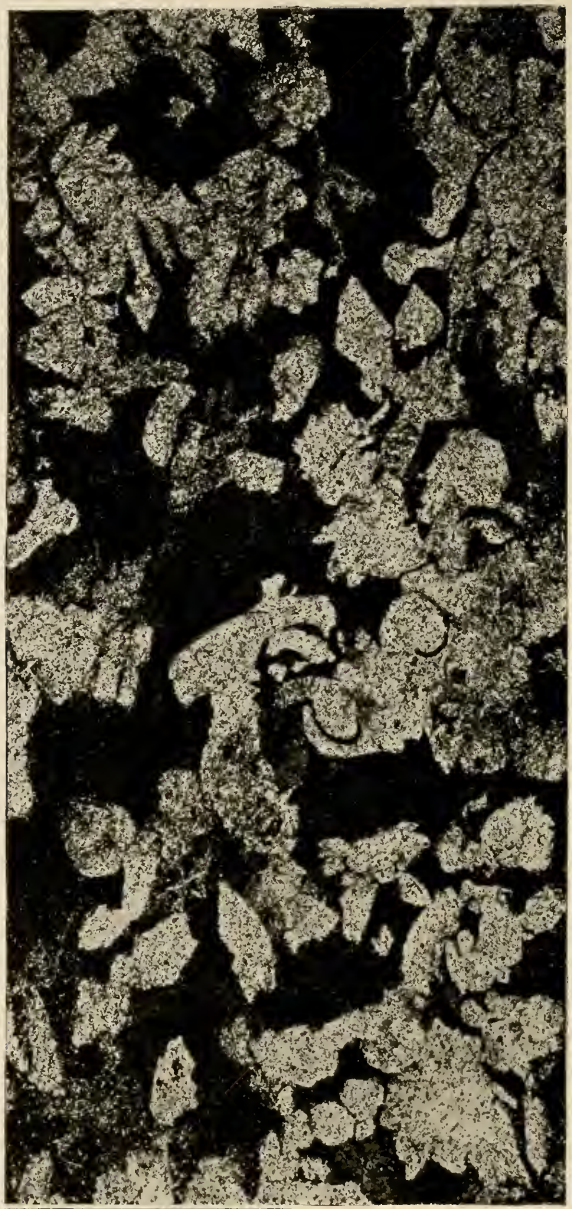
2

3

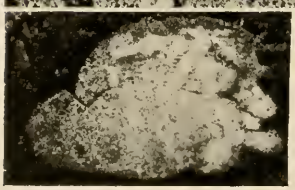


3*a*

1, 2. Morania ? costellifera Walcott
3, 3*a*. Morania elongata Walcott



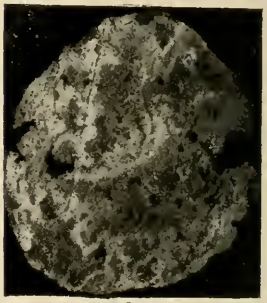
1a



2d

2b

1



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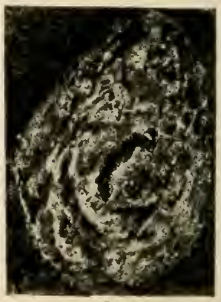
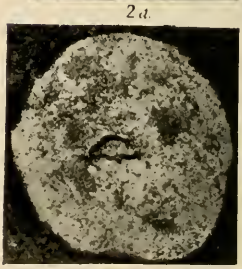


2a



2c

1. Morania fragmenta Walcott
2. Morania ? globosa Walcott

DESCRIPTION OF PLATE 48

PAGE

MORANIA FRAGMENTA Walcott 230

FIG. 1. (Natural size.) A typical illustration of this species as it occurs on the surface of the shale. U. S. National Museum, Catalogue No. 35394.

1a. (×4.) A portion of the specimen represented by fig. 1, enlarged to show the character of the fragments.

MORANIA ? GLOBOSA Walcott 231

FIG. 2. (Natural size.) A specimen flattened on the shale and showing only a thin gelatinous appearing film. U. S. National Museum, Catalogue No. 35395.

2a. (×2.) A still more gelatinous appearing specimen than that represented by fig. 2. U. S. National Museum, Catalogue No. 35396.

2b. (Natural size.) A small round specimen resembling that illustrated by fig. 2. U. S. National Museum, Catalogue No. 35397.

2c. (×3.) Enlargement of the specimen represented by figure *2b*.

2d. (×2.) A distorted specimen which may be one of the smaller plant masses of *Morania confluens*. U. S. National Museum, Catalogue No. 35398.

The specimens represented on this plate are all from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railway, British Columbia, Canada.

DESCRIPTION OF PLATE 49

PAGE

MORANIA ? FRONDOSA Walcott 231

FIG. 1. (Natural size.) Portion of the frond described in the text. U. S. National Museum, Catalogue No. 35399.

1*a*. (× 2.) Enlargement of a portion of the specimen represented by fig. 1, to illustrate the lacunae.

MORANIA species undetermined .....

FIG. 2. (Natural size.) Fragment of what may have been an undetermined species of *Morania*. U. S. National Museum, Catalogue No. 35400.

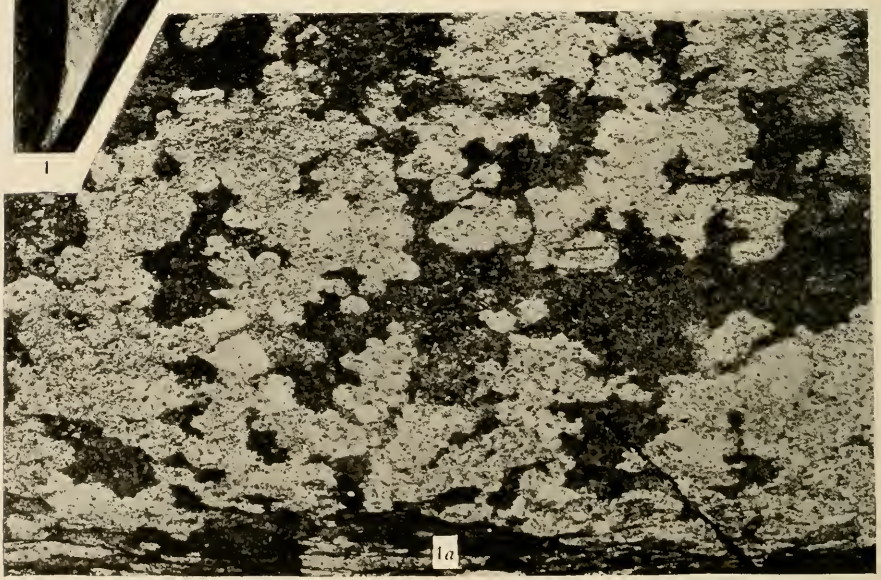
The specimens represented on this plate are from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railway, British Columbia, Canada.

1*a*

1. Moranla frondosa Walcott
2. Moranla sp. undt.

1

2



1*a*

MORANIA PARASITICA Walcott

DESCRIPTION OF PLATE 50

FIG. 1. (Natural size.) A specimen of *Hurdia victoria*[1] more or less encrusted with this species. U. S. National Museum, Catalogue No. 57718.

1*a*. (×3.) Enlargement of a portion of the surface of the specimen represented by fig. 1.

2. (×3.) Portion of a specimen of *Morania ? globosa* encrusted with this species. U. S. National Museum, Catalogue No. 35401.

The specimens represented on this plate are from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railway, British Columbia, Canada.

[1] Smithsonian Misc. Coll., Vol. 57, 1912, p. 186, pl. 32, fig. 9.

DESCRIPTION OF PLATE 51

PAGE

CLADOPHORA GRACILIS (Griffiths) Kützing..... 234

FIG. 1. (×2.) Portion of a plant mass spread and flattened on a card, for comparison with the fossil form, *Marpolia spissa* (figs. 1, 1*a-b*, pl. 52).

DUMONTIA FILIFORMIS (Huds.) Greville..... 242

FIG. 2. (Natural size.) Portion of a plant opened and pressed flat on a card for comparison with the fossil form *Bosworthia simulans* (fig. 1*a*, pl. 58).

All of the figures on this plate are reproductions of photographs of specimens of recent algae in the National Herbarium at the Smithsonian Institution.

1

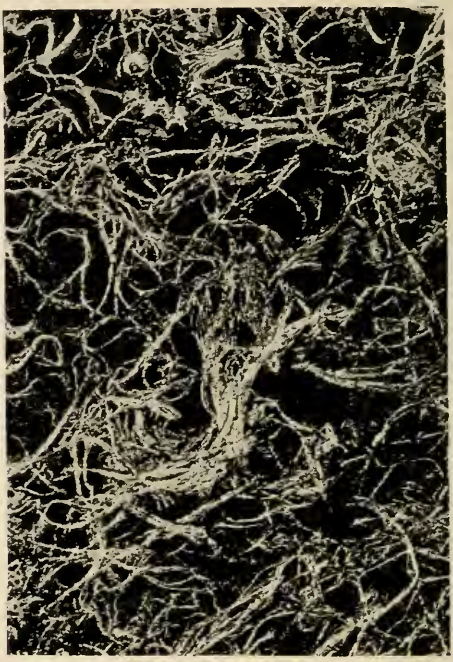
2

RECENT ALGAE

1. Cladophora gracilis (Griffith) Kützing
2. Dumontia filiformis (Huds.) Greville

1

1a



1b

2a

2

1. Marpolia spissa Walcott
2. Morania reticulata Walcott

DESCRIPTION OF PLATE 52

PAGE

MARPOLIA SPISSA Walcott 234

FIG. 1. (×2.) Portions of a thallus with the filaments twisted into stems and extending as tufts as they branch at narrow angles. U. S. National Museum, Catalogue No. 35403.

1*a*. (×2.) A specimen with the filaments more loosely arranged than in fig. 1. U. S. National Museum, Catalogue No. 35404.

1*b*. (×4.) Enlargement of a portion of the surface of a fragment of shale that is thickly strewn with broken filaments of this species. U. S. National Museum, Catalogue No. 35405.

MORANIA ? RETICULATA Walcott 233

FIG. 2. (Natural size.) A frondlike mass of this species partly covered by *Morania confluens*. U. S. National Museum, Catalogue No. 35402.

2*a*. (×4.) Enlargement of a portion of specimen represented by fig. 2, to illustrate the lacunae of the frond.

The specimens represented on this plate are all from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railroad, British Columbia.

DESCRIPTION OF PLATE 53

PAGE

NOSTOC SPHAERICUM Vaucher 231

FIG. 1. (Natural size.) A group of plant masses, flattened on a card, for comparison with the smaller specimens of the fossil species of *Morania ? globosa* (fig. 2*b*, pl. 48), and when broken, with *Morania fragmenta* (figs. 1, 1*a*, pl. 48).

NOSTOC PRUNIFORME (Linn.) Agardh 232

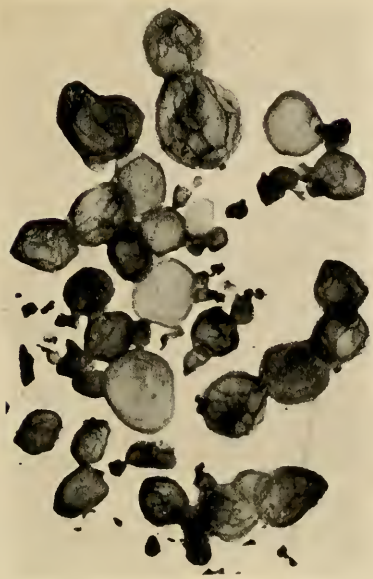
FIG. 2. (Natural size.) Two plant masses flattened on a card that resemble very closely similar circular films of the fossil species *Morania globosa* (figs. 2, 2*a*, 2*c*, pl. 48).

DASYA GIBBESII Harvey 237

FIG. 3. (×2.) Portion of a plant flattened on a card, for comparison with the fossil species *Waputikia ramosa* (fig. 2, pl. 54).

3*a*. (×2.) Portion of a stem for comparison with the stem of the fossil species *Waputikia ramosa* (fig. 2*b*, pl. 54).

All of the figures on this plate are reproductions of photographs of specimens of recent algae in the National Herbarium at the Smithsonian Institution.



1

2

3

3*a*

RECENT ALGAE

1. Nostoc sphaericum Vaucher
2. Nostoc pruniforme (Linn.) Agardh
3. Dasya gibbesii Harvey

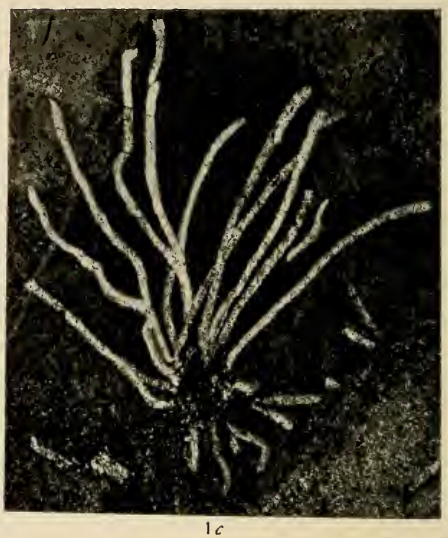
1

1*b*

1*a*

2*a*

2*b*



1*c*

2

1. Yuknessia simplex Walcott
2. Waputikia ramosa Walcott

DESCRIPTION OF PLATE 54

PAGE

YUKNESSIA SIMPLEX Walcott 235

FIG. 1. (×2.) Type specimen flattened on the shale. U. S. National Museum, Catalogue No. 35406.

1*a*. (×3.) Sketch of specimen illustrated by fig. 1.

The specimen represented by figs. 1, 1*a* is from locality 14s, Middle Cambrian: *Ogygopsis* zone of the Stephen formation; about 2,300 feet (701 m.) above the Lower Cambrian and 3,540 feet (1,089 m.) below the Upper Cambrian, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railroad, British Columbia.

1*b*. (×3.) The upper portion of a small specimen showing the radiating stipes. U. S. National Museum, Catalogue No. 35407.

1*c*. (×4.) Stipes radiating from the summit of the central body of a relatively large specimen. U. S. National Museum, Catalogue No. 35408.

WAPUTIKIA RAMOSA Walcott 236

FIG. 2. (×2.) A flexuous stem with branches illustrating the appearance of the plant when pressed flat on the shale. U. S. National Museum, Catalogue No. 35409.

2*a*. (×3.) Fragment of a small stem and main branches that have been stripped of the secondary branches and branchlets. U. S. National Museum, Catalogue No. 35410.

2*b*. (×2.) A central stem with branches partly stripped of the secondary branches and branchlets. U. S. National Museum, Catalogue No. 35411.

The specimens represented by figs. 1*b*, 1*c*, 2, 2*a-b* are from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railroad, British Columbia.

DESCRIPTION OF PLATE 55

PAGE

MARPOLIA AEQUALIS Walcott 235

FIG. 1. (×2.) An elongated tuft of branching filaments, portions of which twisted together give the appearance of a central stem and branches. U. S. National Museum, Catalogue No. 35412.

From locality 14s, Middle Cambrian: *Ogygopsis* zone of the Stephen formation; about 2,300 feet (701 m.) above the Lower Cambrian and 3,540 feet (1,089 m.) below the Upper Cambrian, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railroad, British Columbia.

WAHPIA MIMICA Walcott 240

FIG. 2. (×2.) Type specimen illustrating stem and form of branches. U. S. National Museum, Catalogue No. 35413.

DALYIA NITENS Walcott 239

FIG. 3. (×3.) Central stem with branches and whorl of branchlets at the end of each. U. S. National Museum, Catalogue No. 35414.

DALYIA RACEMATA Walcott (See pl. 56) 238

FIG. 4. (×4.) Whorl of branchlets that may belong to this species. U. S. National Museum, Catalogue No. 35415.

4*a*. (×3.) Branches and whorls of branchlets that may belong to this species, but more probably indicate a distinct form. U. S. National Museum, Catalogue No. 35416.

4*b*. (×3.) A fine branch showing variation in form from those represented on plate 56, U. S. National Museum, Catalogue No. 35417.

The specimens represented by figs. 2-4, 4*a* are from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railroad, British Columbia.

4*c*. (×3.) A specimen of this species occurring in the Mount Stephen fossil bed, 3 miles (4.8 km.) in an air line from the Burgess Pass quarry. U. S. National Museum, Catalogue No. 35418.

From locality 14s, as given above under fig. 1.

1

2

3

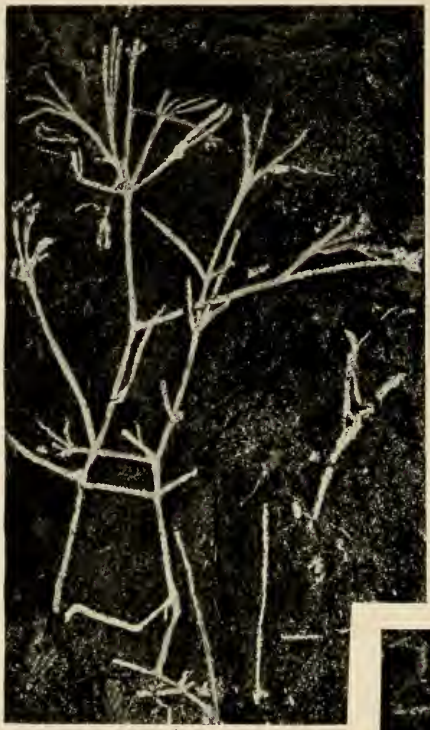
4*a*

4

4*c*

4*b*

1. Marpolia aequalis Walcott
2. Wahpia mimica Walcott
3. Dalyia nitens Walcott
4. Dalyia racemata Walcott



1

1*a*

1*b*

1*c*

DALYIA RACEMATA Walcott

DESCRIPTION OF PLATE 56

PAGE

DALYIA RACEMATA Walcott (See pl. 55) 238

FIG. 1. (×2.) A group of stems with branches and whorls enlarged on a smaller scale than the specimens represented by figs. 1*a*, 1*b*, and 1*c*. U. S. National Museum, Catalogue No. 35419.

1*a*, 1*b*. (×3.) Specimens illustrating variation in the mode of branching. The center upper stipe of fig. 1*a* results, I think, from the pressing together of a number of short branchlets. This tendency is shown in fig. 1*c*. U. S. National Museum, Catalogue Nos. 35420, 35421.

1*c*. (×4.) Specimen with closely grouped branchlets on the terminal whorls which suggest the specimen illustrated by fig. 4, pl. 55. U. S. National Museum, Catalogue No. 35422.

The specimens represented on this plate are all from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railroad, British Columbia.

DESCRIPTION OF PLATE 57

PAGE

WAHPIA INSOLENS Walcott 240

FIGS. 1, 1*a*. (Natural size.) Two specimens flattened on the shale, illustrating the mode of branching. U. S. National Museum, Catalogue Nos. 35423, 35424.

From locality 14s, Middle Cambrian: *Ogygopsis* zone of the Stephen formation; about 2,300 feet (701 m.) above the Lower Cambrian and 3,540 feet (1,089 m.) below the Upper Cambrian, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field, on the Canadian Pacific Railroad, British Columbia.

WAHPIA VIRGATA Walcott 241

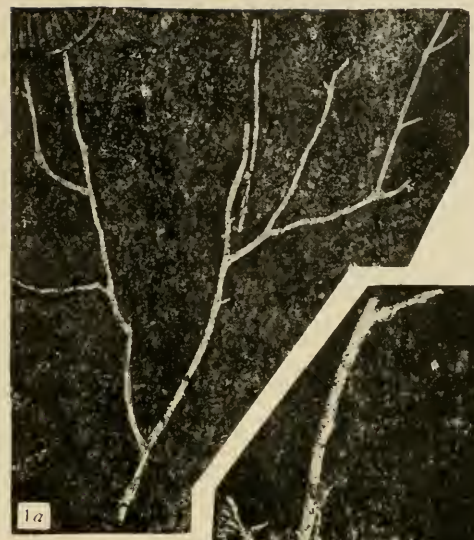
FIG. 2. (×3.) Type specimen of the species. U. S. National Museum, Catalogue No. 35425.

BOSWORTHIA SIMULANS Walcott (See pl. 58, fig. 1) 241

FIG. 3. (×2.) Illustration of the flexuous branches pulled apart and pressed flat on the surface of the shale. U. S. National Museum, Catalogue No. 35426.

The specimens represented by figs. 2 and 3 are from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railroad, British Columbia.

1

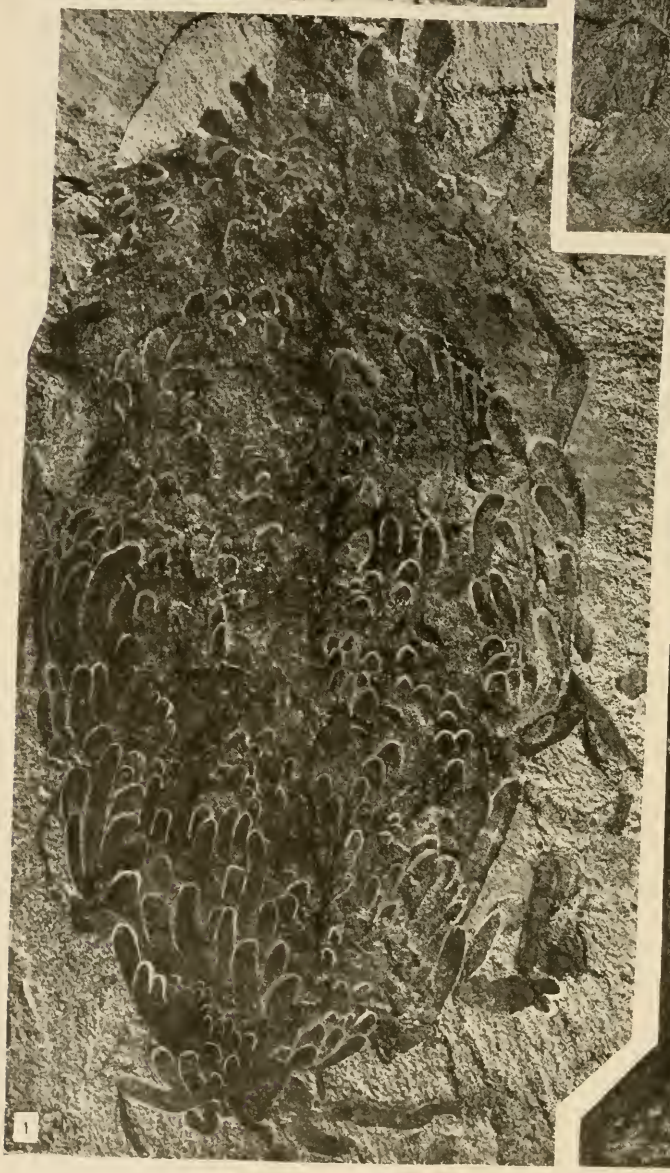


1a

2

3

1. Wahpia insolens Walcott
2. Wahpia virgata Walcott
3. Bosworthia simulans Walcott



1. Bosworthia simulans Walcott
2. Bosworthia gyges Walcott
3. Morania confluens Walcott
4. Morania with trilobites

DESCRIPTION OF PLATE 58

PAGE

BOSWORTHIA SIMULANS Walcott (See pl. 57, fig. 3) 241

FIG. 1. (×2.) A specimen illustrating the probable outline of the thallus when occurring in a compact form. U. S. National Museum, Catalogue No. 35427.

1*a*. (Natural size.) Specimen illustrated by enlarged figure on pl. 57, fig. 3. U. S. National Museum, Catalogue No. 35426.

BOSWORTHIA GYGES Walcott 242

FIG. 2. (×2.) Type specimen illustrating the form and mode of growth of this species. U. S. National Museum, Catalogue No. 35428.

MORANIA CONFLUENS Walcott (See pls. 43, 44, 45, and 58) 226

FIG. 3. (×3.) Portion of the surface of a frond showing fine strands and wrinkles. U. S. National Museum, Catalogue No. 35429.

MORANIA and Trilobites 220

FIG. 4. (×2.) The upper trilobite (*Oryctocephalus reynoldsi* Reed) is resting on a piece of *Morania*, and the lower trilobite (*Ptychoparia*) is covered with a thin layer of it as described in the text. U. S. National Museum, Catalogue No. 35430.

The specimens represented on this plate are all from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, on the Canadian Pacific Railroad, British Columbia.

DESCRIPTION OF PLATE 59

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SPHAEROCODIUM ? PRAECURSOR Walcott.....243

FIGS. 1 (× 73) and 1*a*. (× 85.) Thin sections across the thallus of two small specimens. The outer wall is replaced by a narrow band of calcite crystals that extend somewhat irregularly into the sponge and the irregular tubular structure fills in the entire central space. Slide No. 79. 1 is located on stage at 101.5 + 43; 1*a* on stage at 102 + 48.2. U. S. National Museum, Catalogue No. 35431.

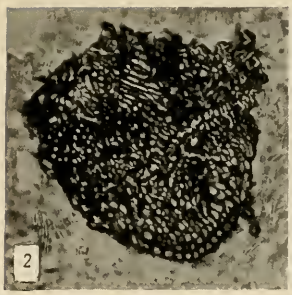
1*b*. (× 365.) Further enlargement of a portion of the thallus on the left side of the specimen represented by fig. 1.

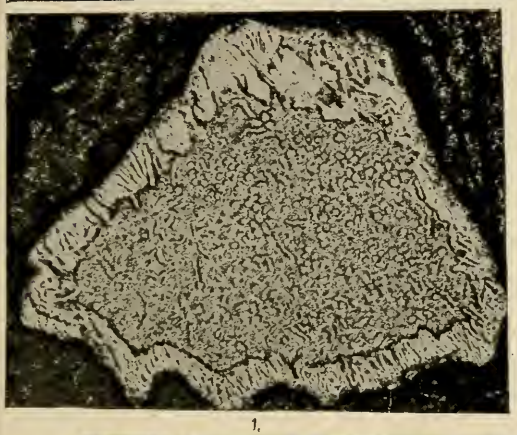
1*c*. (× 500.) Enlargement of a portion of specimen in slide No. 78, located on stage at 109 + 43. U. S. National Museum, Catalogue No. 35431.

SPHAEROCODIUM CAMBRIA Walcott.....243

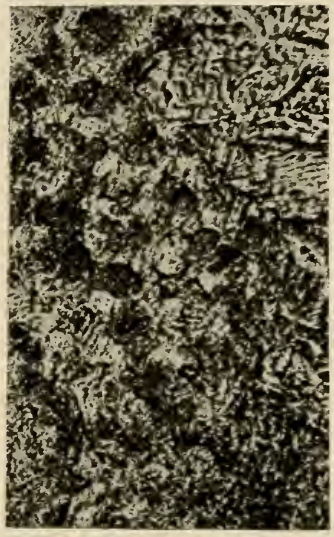
FIG. 2. (× 1200.) A minute thallus showing the ends and oblique sections of the twisting, irregularly distributed tubes. Thin rock slide No. 45, located on stage at 105.5 + 39. U. S. National Museum, Catalogue No. 35432.

The specimens represented on this plate are all from locality 35k, Middle Cambrian: Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

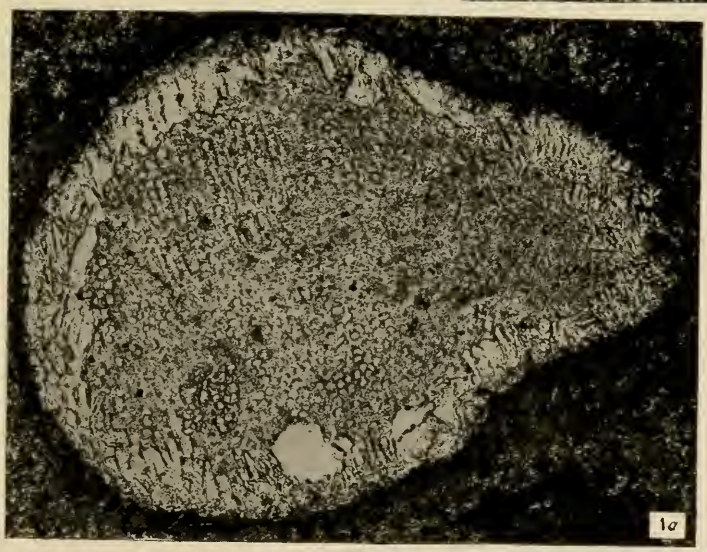




1.



1c



1. Sphaerocodium ? praecursor Walcott
2. Sphaerocodium ? cambria Walcott