CALCAREOUS ALGAE FROM THE UPPER PERMIAN OF THE DOLOMITES (ITALY) WITH STRATIGRAPHY OF THE "BELLEROPHON-ZONE"

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ABSTRACT—The macro- and microscopic study of the hand specimens collected in the *Upper Permian* of the Cordevole and Gardena valleys (Dolomites) has made clear the ecological conditions during the deposition of the "*Bellerophon*-zone". The lithological succession indicates a slight transgression, owing to which from lagoonal conditions we pass on to a neritic facies with large meadows of calcareous algae. The lagoonal facies (lower part of the "*Bellerophon*-zone") is represented by gypsiferous beds, rauhwacke with tubular and globular cavities and pisolitic (or oolitic) layers, more evident to the South (Cordevole valley) than to the North (Gardena valley). The neritic facies (upper part of the "*Bellerophon*-zone") is represented by crystalline limestones and by marls, all bituminous and dark-coloured.

In the later levels the algal remains are abundant and concentrated on the bedding planes; they jut out on the worn surfaces. Together with the algae there are several species of *Bellerophon* or other little gastropods and of pelecypods (*Eumorphotis*, *Aviculopecten*, *Bakewellia*, *Oxytoma*, *Allorisma*); sometimes appear, too, isolated cone-shaped teeth of fishes; in the slides ostracods and foraminifera are common.

The calcareous algae are represented, in quantitative order, by *Gymnocodium bellerophontis* Rothpl., *Atractyliopsis lastensis* n.sp. and *Gymnocodium nodosum* Ogilvie-Gordon. The well preserved specimens have made it possible to make a closer comparison between the external morphologic details and the internal structure, and besides throwing light on various problems concerning these algae, which were largely diffused in the seas of the Permian Tethys.

In particular a detailed study of *Atractyliopsis*, a genus which had never been thoroughly described and explained so far (and which still presents difficult problems as regards internal structure) has been made.

INTRODUCTION

DURING the geological field researches which the Geological Institute of Ferrara University carried out in these last years in the Dolomites (Venetian Alps), the writer has collected a considerable number of hand specimens containing well preserved remains of calcareous algae.

The present paper is the result of the study of this material. I am very thankful to Dr. M. R. Sahni, Founder-President, Palaeontological Society of India, for inviting me to contribute this paper to the Inaugural Number of the Society's Journal.

All the hand specimens come from the *Upper Permian* ("*Bellerophon*-zone") ; the localities (see text-fig.1) which supplied the best specimens are :—(1) the Digonera-Laste-Salesei area, in the upper Cordevole valley; (2) the Soura Sas, on the northern side of the Padon range (this, too in the upper valley of the Cordevole river; (3) the Mount Pic, located on the North-North East of St. Cristina (upper Gardena valley). Other specimens not having such well preserved algae come from the western wall of Mount Seceda and from the village of Plan (upper Gardena valley).

The hand specimens collected (see Plates 7, 8 and 9) show on the worn surfaces beautiful and clear fragments of algae with well preserved internal structures; thus a comparative study between their external shapes and their structures has been possible.

The algae collected belong to the genera *Atractyliopsis* and *Gymnocodium ;* the latter is characteristic and abundant in the entire belt of the ancient Tethys, from Texas to Japan across the Alps range. The former (*Atractyliopsis*) has recently been labelled by

J. Pia and it is represented by algae which had not been taken into consideration before 1937. They are nevertheless available in Bosnia, in the Bükkergebirge (Hungary), in Sumatra and in ? Japan (Endo, 1952), and they abound in a few localities of the Dolomites. The generic name *Atractyliopsis* was given by Pia to the Permian species; a strictly similar form—though by far later—has been described by the same author from the *Ladinian* of the Burmo-Siamese frontier under the name *Aciculella*.

The hand specimens and slides studied in this work are in the collections of the Geological Institute of the Ferrara University (Italy). I take the opportunity to express my hearty thanks to Prof. Piero Leonardi, Director of the Institute, who made easier my researches both in the field and in the laboratory, and to Miss Dr. L. Ramazzina, who helped me with bibliographic research and in taking measurements.

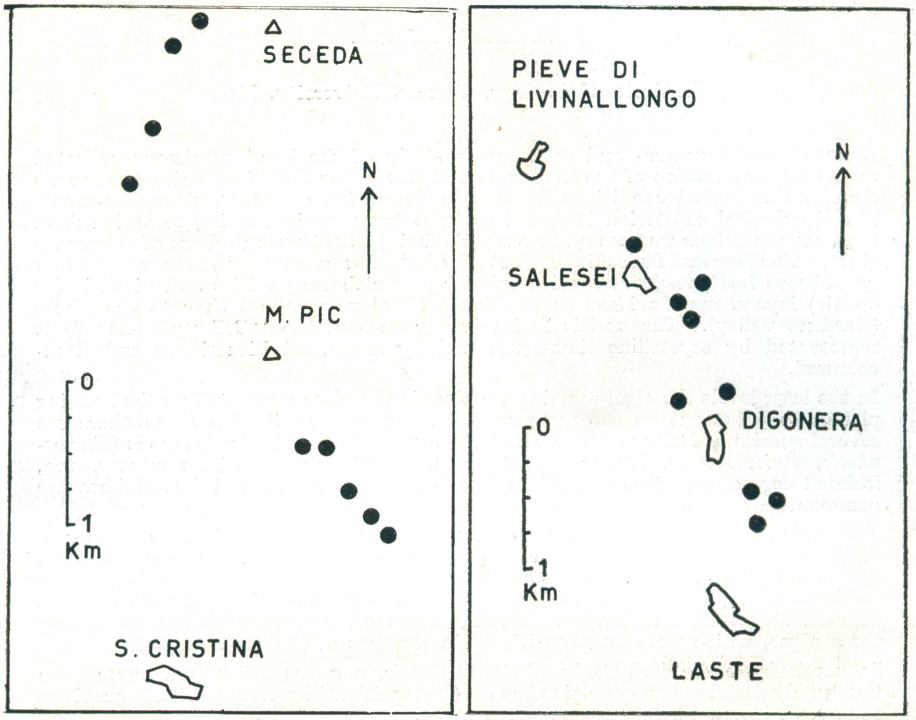


FIG. 1—Localities where the best hand specimens containing the algae described were collected (black circles). *Right:* Digonera area (upper Cordevole valley); the Soura Sas locality (6 Km. West of Pieve di Livinallongo) is not included in the sketch. *Left:* St. Cristina area (upper Gardena valley); the locality of Plan (5 Km. ESE of St. Cristina) is not included in the sketch.

STRATIGRAPHY OF THE FOSSILIFEROUS LOCALITIES

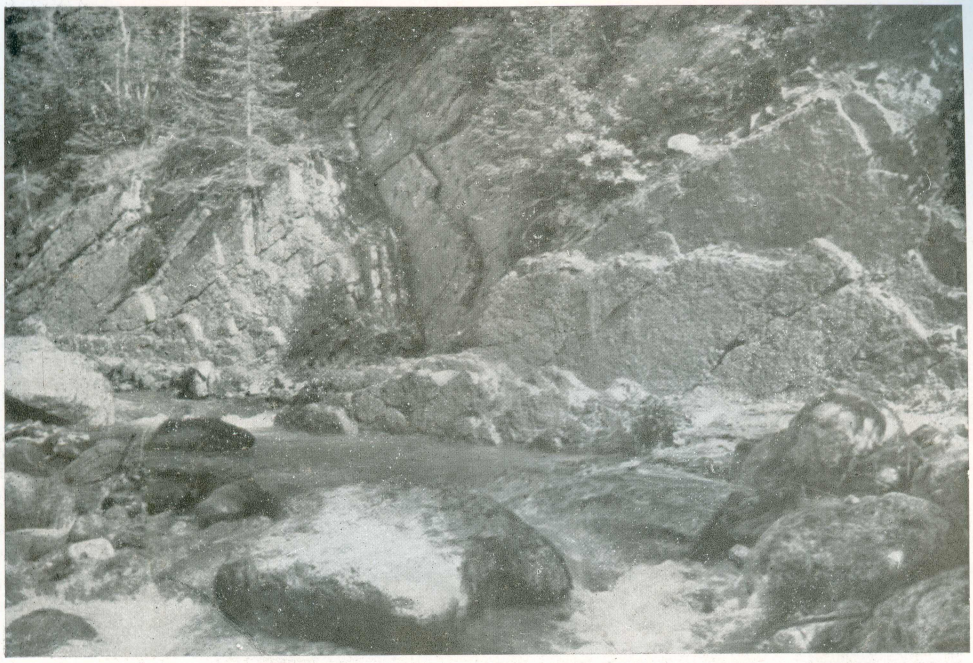
Upper Cordevole Valley

Hand specimens with algae were collected at the following localities of the upper Cordevole valley (see text-fig.1) :—

EXPLANATION OF PLATE 6

FIG. 1—Upper part of the "*Bellerophon*-zone", with bituminous limestones and marls containing *Gymnocodium bellerophontis* Rothpl. and *Atractyliopsis lastensis* n. sp. The river shown in the picture is the Cordevole, 500 metres NNE of the village of Digonera. The layer corresponding with the pine tree is the pisolitic bed illustrated in Pl. 8.

2—Lower part of the "*Bellerophon*-zone", with clear gypsiferous dolomites and *rauhwackes* followed by dark calcareous banks (small outcrops high up to the right under the trees) with *Gymnocodium bellerophontis* and *G. nodosum*. Digonera, near the road tunnel to the North of the village.



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(1) Digonera, near the two road tunnels and at the bottom of the valley, just where the river bends southwards. (2) Laste, along the road leading from Digonera to this village, between the first and the third turnings of the road itself. (3) Pian di Salesei, on the strata outcropping between the turnings of the road that climbs from Digonera to Pieve di Livinallongo. (4) Soura Sas, on the right side of the valley, near Arabba; here the algae are found in small outcrops at the axis of the Soura Sas anticline. The hand specimens collected in these localities contain all the algal species described in this work.

The stratigraphic succession of the *Upper Permian* in the district is as follows :

(6) *Early Trias.*

(5) Marls and limestones dark-gray coloured, scarcely compact, well stratified and having surfaces rich in small pelecypods and brachiopods (*Bakewellia*-strata) ; these levels close the Permian series and are not abundant in algal remains.

(4) Calcareous and bituminous beds of a gray-black colour, having yellowish surfaces full of algal remains; some of these banks are compact and rich in bituminous knots; the bedding planes are more or less argillaceous (Plate 6, fig. 1). Beside algae they contain foraminifera, ostracods, molluscan remains and columnals of crinoids; in one case even a nautiloid, broken and not classifiable, was found.

(3) Calcareous beds of a whitish or yellowish colour, friable, having rugose and rippled bedding planes (Plate 6, fig. 2) ; this rock is a gypsiferous *rauhwacke;* the many cavities are globular, shallow and of different size (up to a maximum diameter of 5–6 centimeters). All round these cavities there is sometimes a bituminous black film. On this level the algae are rare and scattered in the mass. In the lower part there is a bank equal to the preceding rock, but this one has many tube-shaped cavities which are normal to the bedding planes. These tubes cross the whole bank; they are almost parallel among themselves and are often rich in gypsum crystals; some of them are filled with bituminous gypsum. These banks outcrop on the northern side of the village of Digonera, just where the road-tunnel begins ; they are being destroyed now (Plate 6, fig. 2) because they are used as building material.

(2) Argillaceous and bituminous beds of a gray-black colour, full of algae; they appear at the surface along the road which from Digonera leads to Laste, above all as far as the second and third turning. They are modest outcrops containing foraminifera, ostracods and columnals of crinoids. The algae contained in the hand specimens have well preserved structures and are represented by the genera *Atractyliopsis* and *Gymnocodium.*

(1) Gypsum beds having alternate white and gray small layers; they too appear at the surface along the Digonera-Laste road.

Gardena Valley

The other important group of localities which have supplied well preserved remains of *Upper Permian* calcareous algae is in the upper Gardena valley; the fossiliferous hand specimens come from the following localities (text-fig.1) : (1) South South-Eastern side of Mount Pic, near St. Cristina; the fossils are available both in the *Upper Permian* outcrops and in the abundant landslide material at the foot of the slope. (2) Western wall of Mount Seceda, four kilometers North of St. Cristina; abundant

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EXPLANATION OF PLATE 7

FIG. 1—*Gymnocodium bellerophontis* Rothpl.; worn surface showing a great quantity of fragments and some small pelecypods. Besides the external shape of the species, numerous pores opening on the surface are to be seen. Also three ramified fragments appear (indicated by the black arrows). Digonera, a few metres past the road tunnel to the North of the village. ×4.8.

2—*Gymnocodium nodosum* Ogilvie-Gordon; worn surface full of basal straight fragments, of middle parts with barrel-shaped swellings and of club-shaped endings; they all have the same internal structure. The pores are bigger compared to the species *G. bellerophontis.* The black arrow indicates a ramified fragment. Digonera, just past the road tunnel to the North of the locality. ×7.

fossiliferous specimens are available here too in the landslide material and in the debris at the foot of the wall. (3) Plan, in the outcrops appearing at the bottom of the small valley on the East side of the village.

In this area the total thickness of the "*Bellerophon*-zone" is about 150 metres; its lower part is formed by marls and arenaceous marls of a dark-gray colour with numerous gypsum beds of different thickness, followed by a *rauhwacke* similar to the one already described for the upper Cordevole valley.

The largest quantity of algae comes from the highest part of the "*Bellerophon*-zone", which has the following stratigraphic succession :

(9) *Early Trias.*

(8) Stratified gray limestones with algal remains.

(7) Limestones and calcareous marls with ostracods, small pelecypods, gastropods and a few algal remains.

(6) Partly oolitic limestones, dark and full of algae; some outcrops contain a few specimens of *Bellerophon.*

(5) Brecciated limestones, often argillaceous, with crinoid remains, pelecypods and a few algal fragments.

(4) Bituminous dark-coloured limestones with many gastropods and fragments of algae.

(3) Bituminous black limestones, in thick banks with calcite veinlets alternating with argillaceous beds.

(2) Black crystalline limestones with many internal molds of large *Bellerophon* shells; they contain a few beds where *Gymnocodium* remains are concentrated.

(1) Crystalline limestones and gray dolomitic limestones with a few pelecypods. Under these limestones follows the *rauhwacke.*

Level (2) contains only *Gymnocodium* remains, while the levels from (4) to (8) contain also *Atractyliopsis* specimens.

SYSTEMATIC DESCRIPTION

Family DASYCLADACEAE

Genus ATRACTYLIOPSIS Pia, 1937

This genus was created and briefly described by J. Pia in 1937; it is not yet well known, though algae having an extensive distribution are concerned in it. The forms in question have simple structures: cylindric thallus (without bifurcations) with a thick calcareous wall and large round pores regularly arranged; in the slides, only a part of these seem to appear on the outside.

The first observations on forms analogous to these were made by J. Pia in 1930. In some slides of the upper Triassic material from the Burma-Siamese frontier Pia observed two new *Dasycladaceae* that he described as new genera and named *Holosporella* and *Aciculella;* he observed only a few badly preserved sections, and concluded that the round pores which were found on the inside of the calcareous wall did not appear on the outside; he therefore supposed that all the pores were sporangia, and that the spores came out when the alga died. This interpretation given by Pia is not satisfactory: not only for the fact—which is rather strange—that the spores must await the death of the thallus in order to be able to propagate, but also because the alga, after death breaks into fragments; and so only a small part of these cells shutting up the spores permit their exit.

A few years after, Pia observed similar forms in the Belgian *Carboniferous* and in

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EXPLANATION OF PLATE 8

FIGS. 1-2—Fragments of *Atractyliopsis lastensis* n. sp. forming the nucleus of calcareous concretions. By the Cordevole river, 500 metres NNE of the village of Digonera. Fig. 2 ; ×1.5. Fig. 1 : enlarged detail (natural weathering) of specimen shown in fig. 2 ; ×14.

3—*Atractyliopsis lastensis* n. sp. ; hand specimen with weathered fragments in which the openings on the surface of the big spherical cavities appear clearly. All the fragments have the cylindric shape. Road to Laste; ×3.

4—Hand specimen with *Gymnocodium bellerophontis* fragments. The two remains marked by the black arrows belong to *G. nodosum.* Mt. Pic; ×1.5.

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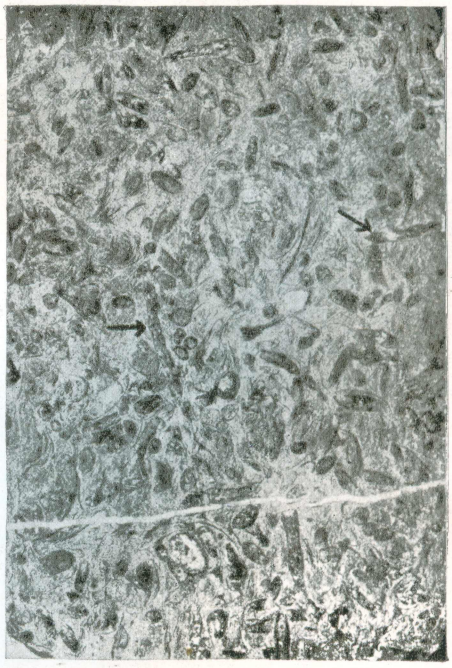

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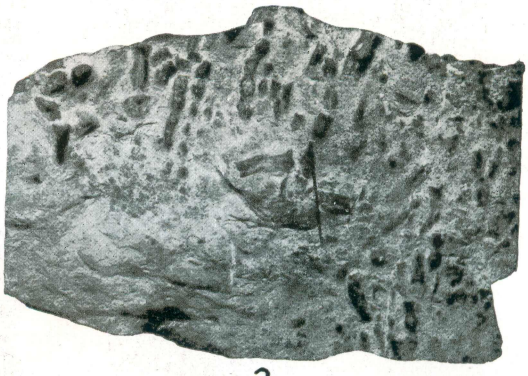

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old Permian slides from the Dolomites, Bosnia, Bükkergebirge (Hungary) and Sumatra : and other similar sections he observed in materials of the *Anisian*, *Ladinian* and *Karnian*. Owing to the different age and to some structural differences (not well specified), Pia reserved the names *Holosporella* and *Aciculella* for the Triassic genera, and created the new genus *Atractyliopsis* for the Palaeozoic forms, as on examining the sections he thought that the thallus of this genus was composed of fusiform segments; in reality the fusiform shape may be a characteristic of some species; but the specimens described in this study, well preserved both in regard to internal and external structures have cylindric shapes (see text-fig. 2). Therefore the name *Atractyliopsis**) concerns a nature which is perhaps peculiar to some species, but not to the genus.

In the various slides prepared from materials from different localities, Pia observed some differences which he considered as specific; he did not deem it necessary to describe their particular features and give a name to the new species, but he limited himself to the following conclusions (1937, p. 65) : "an abundant series of measurements on the Permian forms has convinced me that specific groups, hardly connected by transitional forms, may be separated according to the diameter of the sporangia. It is therefore a question of various species, at least 5 or 6".

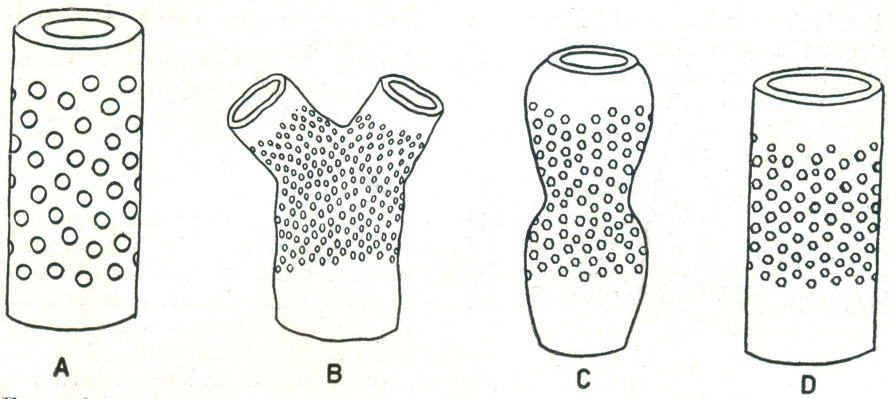


FIG. 2—External aspect (schematic) of the species described.
A = *Atractyliopsis lastensis* n. sp.; B = *Gymnocodium bellerophontis* Rothpletz ;
C & D = club-shaped and cylindrical fragments of *Gymnocodium nodosum* Ogilvie-Gordon.

The situation is as follows : Pia has given a name for the genus without describing it in detail and without basing himself on a genotype; besides, he has published the photographs (1937) of three different forms : (1) of the Belgian *Carboniferous* of Carlioux (Plate 7, fig. 4), (2) of the Belgian *Visean* of Flavion (Plate 7, fig. 7) and (3) of the *Upper Permian* of the Dolomites (Plate 10,

EXPLANATION OF PLATE 9

FIG. 1—*Gymnocodium nodosum* Ogilvie-Gordon ; it is perhaps in question a basal part of a colony with four cylindrical branches still in original position (the support of the colony is above to the right). In the centre there is a distal fragment with two club-shaped elements. The cylindrical fragments are very much like the genus *Macroporella* ; but the inside structure is proper to the *Gymnocodium* genus. Mount Pic. ×7.

2—*Gymnocodium nodosum ;* prevail the chains of club- and barrel-shaped members. Road to Laste ; ×2.

3—*Gymnocodium nodosum ;* small fault plane with natural sections ; Digonera, road tunnel to the North of the village ; ×2.5.

4—*Gymnocodium bellerophontis ;* hand specimen with worn fragments ; some swelling and blunt tips are to be seen. Pian di Salesei ; ×3.

* The name *Atractyliopsis* derives, although Pia does not specify it, from the Greek root *Atractyl* (fuse) and from *opsis* (likeness).

figs. 5 and 6). These three forms have been indicated by him as "*Atractyliopsis* n. sp."; the first and the second have perhaps different features, while the third seems to be the same as the one examined by the writer. One of the two microphotographs reproduced by Pia for this third species (Plate 10, fig. 5) shows a central channel, while the other (Plate 10, fig. 6) seems to be completely calcified ; even in the sections herein illustrated (see Plate 10) the central channel may be visible or not; the difference seems to depend on conditions of fossilisation.

The writer is therefore compelled to assign a specific name to the forms studied ; he thinks all these forms belong to one single species as the differences in the sizes and in the aspect of the central channel are continuous and gradual.

As to the genus, I remember that recently R. Endo (1952) has described a form from the *Middle Permian* of Japan doubtfully ascribed to the genus *Atractyliopsis*. The only photograph published by Endo does not permit us to clarify whether the above mentioned form belongs to the genus or not, but the differences between the Japanese form and ours are considerable.

Though the genus has only been recently observed, these algae (*Atractyliopsis* and allied form of Endo) have already been recognized in many localities (Belgian *Carboniferous*, *Permian* of the Dolomites, Bosnia, Hungary, Sumatra and Japan); in the *Permian* they had therefore a geographic distribution similar to the one indicated by K. Konishi for the genus *Gymnocodium* (1952, text-fig. 1) ; this latter has been recently found by Johnson also in Texas, while *Atractyliopsis* is still unknown in the Western Hemisphere.

ATRACTYLIOPSIS LASTENSIS n. sp.

Pl. 8, figs. 1–3 ; Pl. 10, figs. 1–12

1927 (SINE NOMINE) Ogilive-Gordon, M. M., *Abhandl. Geol. Bundesanst.*, XXIV, pl., IX fig. 10 and Pl. XIII, fig. 6.
1937. *Atractyliopsis* n. sp.—Pia J., *2e Congr. Strat. Carb. Herleen*, II, pl. 10, figs. 5 and 6.

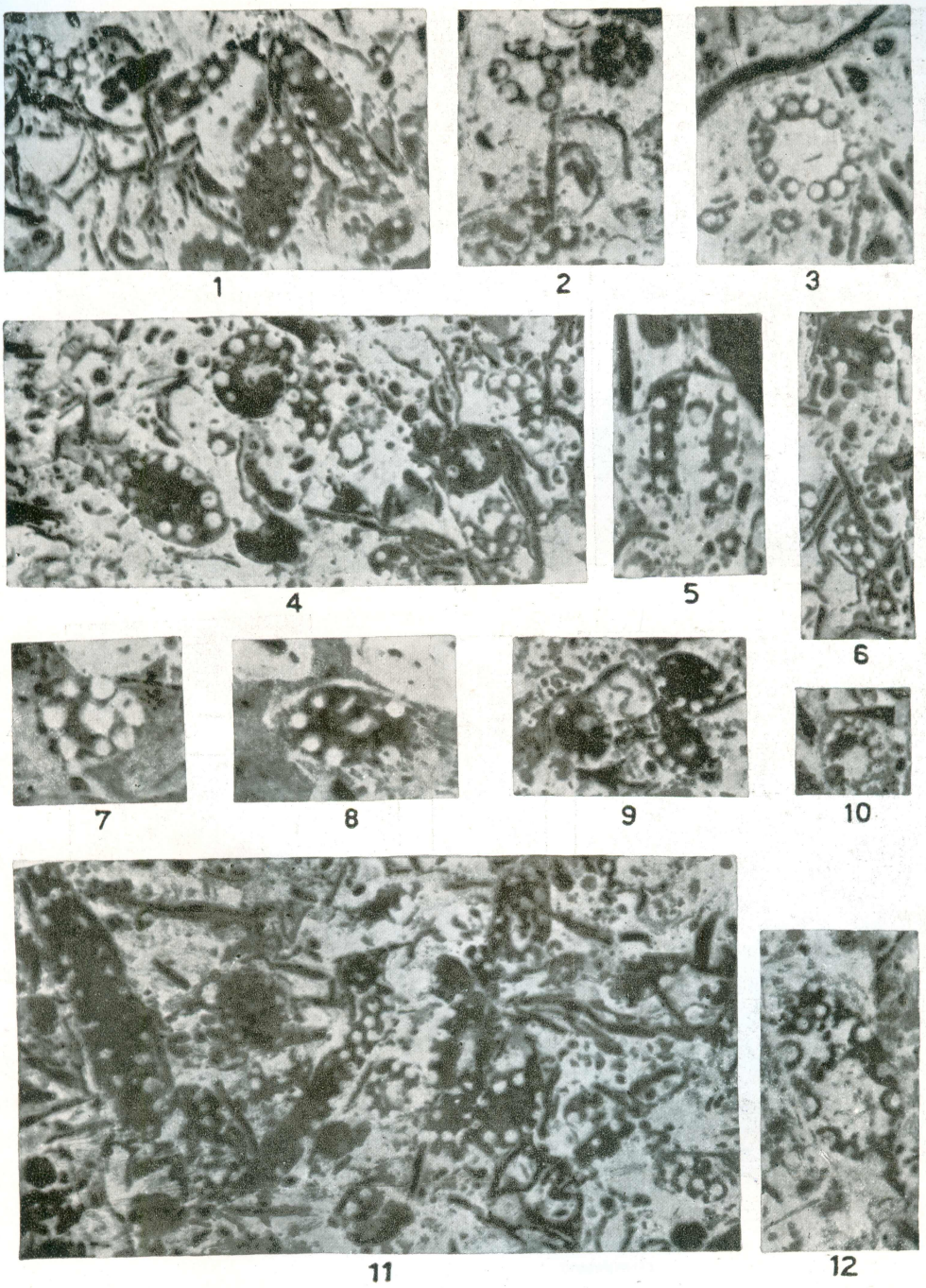
Description of the hand specimens and of external shape.—Fragments of this species are abundant at levels (1) and (4) in the Cordevole valley, and at levels 4 to 8 in the Gardena valley (see "Stratigraphy"). The *Atractyliopsis* remains are embedded in compact black limestones containing also small *Bellerophon* specimens, small molluscan and ostracod shells, various foraminifera and other organic debris; but they are by preference concentrated on bedding planes of calcareous marls (Plate 10, fig. 3). In the exposed and worn surfaces they jut out from the rock, and owing to their dark colour make a remarkable contrast with the grey ground. The big globules of the calcareous wall are almost visible to the naked eye because they are filled with light-coloured material. Other *Atractyliopsis lastensis* remains, not so abundant but well preserved, are contained in a gray argillaceous limestone (Pl. 8 figs. 1 and 2) with

EXPLANATION OF PLATE 10

ATRACTYLIOPSIS LASTENSIS n. sp.

FIGS. 1, 11—Longitudinal, tangential and oblique sections of fragments with the axial stem completely calcified. Road, Digonera—Laste, slide A_1.
2, 3—Cross sections with evident axial stem. M. Pic, slides A_1, and A_2.
4, 9, 10—Slightly oblique and cross sections with various degrees of calcification in the axial stem, and with adult and young elements. Note, to the left below fig. 4, the black dots (of unknown nature) appearing in the spherical cavities that may be seen also in many other sections. Road, Digonera—Laste, slide A_1.
5, 6—Longitudinal and tangential sections. In the centre of fig. 6 a foraminiferal section may be seen. The thick black lines which are present in all the figures of the Plate are sections of ostracods, pelecypods and other organic remains. Road, Digonera—Laste, slide A_1.
7, 8—Slightly oblique sections. The hand specimen was collected in the locality shown at fig. 1 of Pl. 6. Slide A_5.
12—Oblique section. M. Pic, slide A_{14}.

For better evidence of the details, the microphotographs were taken directly on sensitive paper, they are therefore *negatives* : the black parts correspond to transparent calcite, the white parts to opaque; amorphous, argillaceous and bituminous limestone. All the figures ×14.



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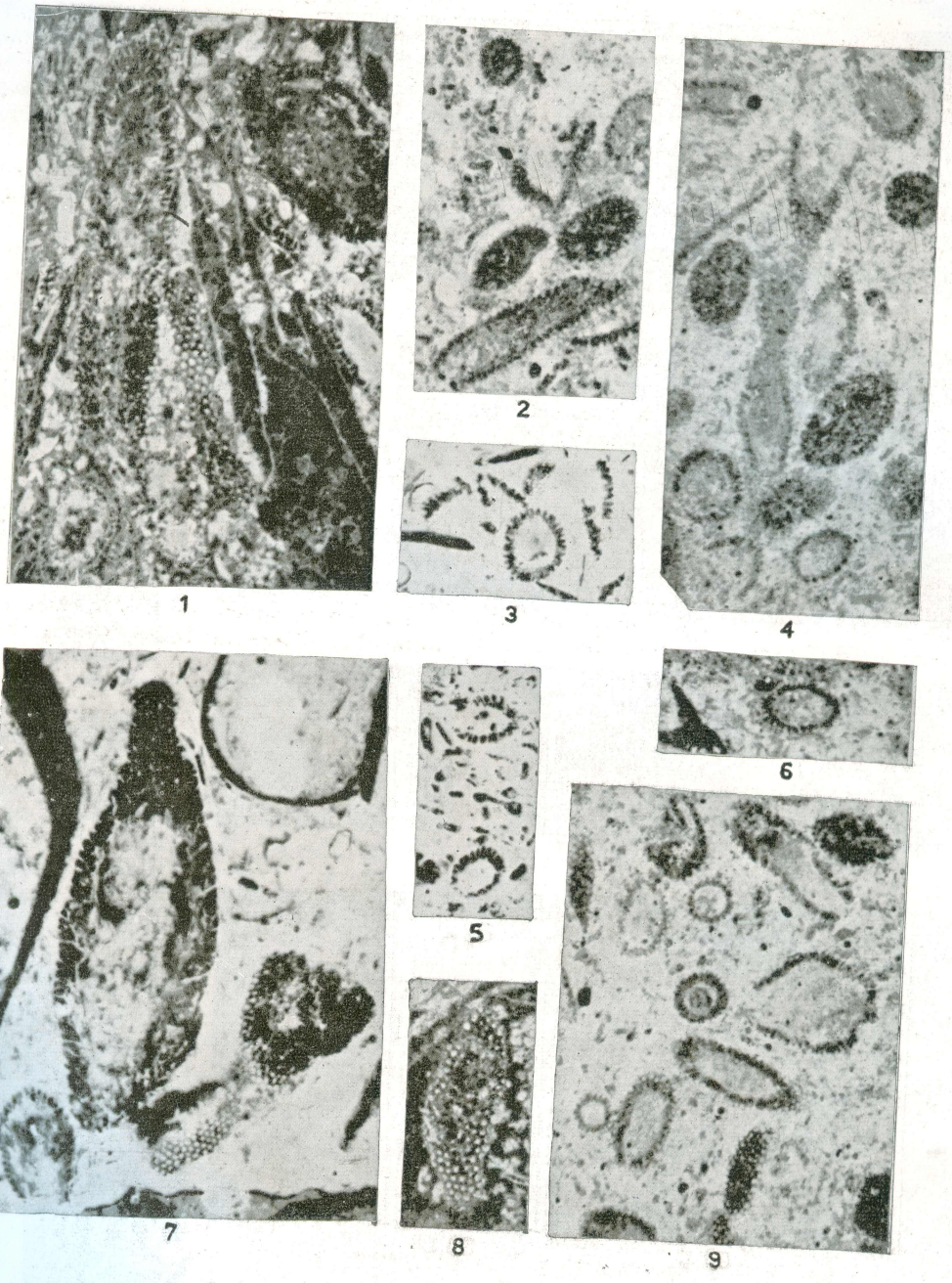

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numerous concretions; and the algal fragments form the nucleus of the flat and elongated pisolites. The concretions (some of them are oolites) have irregular shapes and grew round the organic nucleus owing to epigenetic deposition of amorphous limestone which is sometimes rich in iron oxide. Fig. 1 of Pl. 8 shows a worn pisolite with its algal nucleus.

The average length of the fragments is 4 mm.; the measurements of their width will be reported further on.

Internal structure (Plate 10).—The shape of the species is cylindrical, with an axial perforation piercing the cylinders from end to end and with a thick calcareous wall (fig. 2 in the text). The cylindrical fragments are straight and regular, both on the outside and towards the central channel; in no case was the shape of the distal end of the thallus observed. The axial perforation may be filled with argillaceous material; in this case it appears to be well delimited (Pl. 10, figs. 3, 10 and 12). In many fragments instead, the central channel may be, more or less filled with crystalline carbonate of lime; when completely filled, the alga appears to be without central channel.

In the calcareous wall there is a single layer of big globules, originally hollow, and filled at present with gray marl; they jut out on the external surface with a great round aperture. In the longitudinal axial sections the globules appear on the two sides of the thallus, while in the tangential sections (affecting only the external thick wall) the pores are scattered on the whole surface. The pore diameter varies in the slides according to their cut : either as a maximum circle or as a tangential section, not passing through the aperture ; this fact explains why only a part of the pores may be seen jutting out on the section contour. This feature is plainly shown by observation of the hand specimens. Many other pores seem to be completely shut up inside the calcareous wall; therefore J. Pia supposed all the globules to be sporangia and that the gametes would be able to come outside only when the alga died.

The number of pores in a circle varies from 7 to 11. In some pores very small calcareous bodies of obscure nature may be seen; their number varies, and sometime they appear arranged in circle.

The name given to this species derives from the village of Laste, where the best specimens were found.

MEASUREMENTS

Outer diameter of cylinders (average)	mm.	0.70
Outer diameter of the broadest fragment	,,	1.40
Diameter of central perforation (average)	,,	0.38
Thickness of the calcareous wall (average)	,,	0.16
Diameter of globules cut according to a maximum circle (average)	,,	0.14
Diameter of the broadest globule	,,	0.24

EXPLANATION OF PLATE 11

GYMNOCODIUM BELLEROPHONTIS Rothpletz

FIGS. 1, 7, 8—Longitudinal, tangential and oblique sections of giant forms with the central stem partly calcified ; they clearly show the filaments radiating from the central stem into the calcareous wall, with some bifurcatoins and with their widened opening on surface. M. Pic, slides A_{11}, and A_{11} bis ; ×8.

2, 4, 9—Longitudinal, oblique and cross sections with various calcification grades of the central stem ; the barrel-like form near the centre of fig. 4 belongs to *G. nodosum*. Fig. 9 shows a swollen and blunt distal tip (right, in the middle). M. Pic, slide A_{12}; ×13.

3, 5—Slightly oblique sections. Digonera, slides A_2 and A_7; ×13.

6—Slightly oblique section. Pian di Salesie, slide A_6 bis; ×13.

For better evidence of details, the microphotographs were taken directly on sensitive paper; they are therefore *negatives :* the black parts correspond to transparent calcite, the white parts to opaque, amorphous, argillaceous and bituminous limestone.

Occurrence.—Upper Permian of the following localities : Laste, Digonera and Soura Sas (Cordevole Valley) ; Mount Pic (Gardena Valley).

Repository.—Slides and hand specimens all in the collection of the Geological Institute of the Ferrara University (Italy). Type=slide n.A_1.

Family CHAETANGIACEAE

Genus GYMNOCODIUM Pia, 1919

The genus *Gymnocodium*, always classed among the *Codiaceae*, was transferred to the family *Chaetangiaceae* by Pia in 1937 after careful observations on the shape and the arrangement of the sporangia. For a long time the thallus of these algae has been thought to be unbranched, while later on branched specimens were found. Clearly branching elements are visible in our hand specimens (see Pl. 7).

In all the material collected only the two commonest species in the area were found: *G. bellerophontis* and *G. nodosum;* there is no trace of the numerous other species listed by Pia (1937) or created by Johnson (1951) and by Konishi (1952).

GYMNOCODIUM BELLEROPHONTIS

(Rothpletz), 1894

Pl- 7, fig. 1 ; Pl. 8, fig. 4 ;

Pl. 9, fig. 4 ; Pl. 11, figs. 1–9

For the bibliography see Pia, 1937.

Description of hand specimens and of external shape—The fragments of this species are found in all the algal banks described in the chapter "Stratigraphy". They abound above all in the argillaceous levels and stratification beds (Pl. 7, fig. 1), together with many organic debris, ostracods and mollusks. The fragments are not so well preserved in comparison with the other species described herein, because the degree of calcification is not high; that is why they are often deformed and pressed, and the remains appearing on the worn surfaces are nearly always eroded (Pl. 8, fig. 4; Pl. 9, fig. 4). Some of them are considerably developed; their width may even be up to 1, 8 mm., and their length up to 19 mm. They are often found associated with *Atractyliopsis* remains, while they are seldom mixed with *G. nodosum.*

The external shape of the fragments is elongate, subcylindrical, somewhat constricted or expanded. The central stem is wide compared to the external wall (text-fig. 2), and its width may vary slightly; the thalli terminate with a distal enlarged and blunt tip; ramified fragments are not rare. The openings on the external surface are numerous, very small and longitudinally elongated : on the transverse sections an average of 27 is found; their outline is of an irregular polygonal shape.

Description of the internal structure.—In the natural sections and in the slides the central cavity is very broad. In some cases it is full of crystalline calcite similar to that encrusting the wall (see for instance Pl. 11, fig. 2). The calcareous wall is pierced by the numerous filaments which rise vertically into a central stem, spread towards the outside, bifurcating and crossing the calcareous wall, and open obliquely on surface, assuming a funnel-shaped appearance (Pl. 11, fig. 7). In many specimens the grade of calcification of the cylinder is low, and the

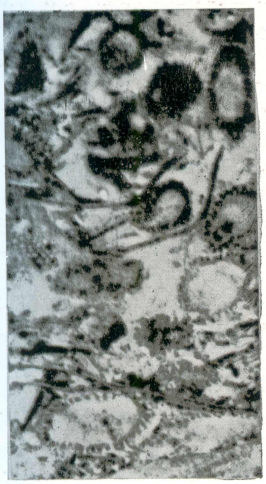
EXPLANATION OF PLATE 12

GYMNOCODIUM NODOSUM Ogilvie-Gordon

FIGS. 1–6 and 8—Oblique and cross sections; the axial stem shows various grades of calcification. In the upper part of fig. 8 a nearly longitudinal section of a pointed tip is visible. The abundant dark lines are sections of ostracods and pelecypods. Digonera, slide A_{10}; ×13.

7—Longitudinal and oblique sections of barrel-like elements. The cross sections in the upper left part of the figure belong to *G. bellerophontis.* M. Pic. slide A_{13}; ×13.

For better evidence of the details, the microphotographs, were taken directly on sensitive paper; they are therefore *negatives :* the black parts correspond to transparent calcite, the white parts to opaque, amorphous, argillaceous and bituminous limestone.



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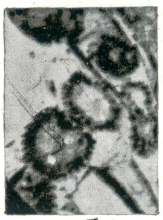

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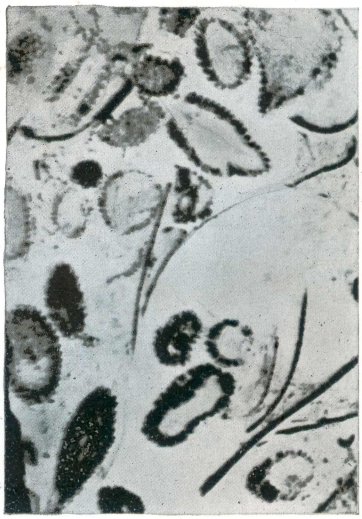

8

ACCORDI: CALCAREOUS ALGAE FROM UPPER PERMIAN, ITALY.

carbonate of lime is mixed with a bituminous substance. In the numerous sections no clearly recognizable sporangia were observed.

and crystalline limestone. From the several specimens observed, the writer assumes that the thallus had a cylindrical basal part with straight walls (text-fig. 2 D) followed

MEASUREMENTS

Outer diameter of the fragments (average)	mm.	0.93
Outer diameter of the broadest fragment	mm.	1.80
Diameter of the central perforation (average)	mm.	0.68
Thickness of the calcareous wall (average)	mm.	0.125
Number of pores on a transverse section (average)		27
Diameter of pores on the outer surface (average)	mm.	0.065

Occurrence.—Upper Permian of the following localities : Laste, Digonera, Pian di Salesei, Soura Sas (Cordevole Valley) : Mount Pic, Seceda, Plan (Gardena Valley).

Repository.—Slides and hand specimens, all in the collections of the Geological Insti. tute of the Ferrara University (Italy).

GYMNOCODIUM NODOSUM

Ogilvie-Gordon, 1927

Pl. 7, fig. 2 ; Pl. 8, part of fii. 4 ;

Pl. 9, figs. 1–3 ; Pl. 12, figs. 1–8

1927—*G. nodosum* ; Ogilvie-Gordon, M.M., *Abhandl. Geol. Bund.*, XXIV, p. 71, pI. IX, fig. 9 and pI. XIII fig. 5.
1937—*G. nodosum*; Pia, J., C.R. 2^{e} *Congr. Stratigr. Carb. Herleen*, p. 69, pl. XI fig. 7

Description.—Owing to their high grade of calcification, the specimens collected are very well preserved; thus, the reconstruction of the shape of the thallus is possible. The fragments are concentrated on bedding planes or on thin beds rich in argillaceous substance (see Pl. 4, fig. 2 and Pl. 6, figs. 1 and 2), while they are rare on beds of pure

by an intermediate portion with barrel-shaped swellings, and finally by a terminating part with many club-shaped elements (text-fig. 2 C). The distal tip is pointed. It is also proved that, in the upper Cordevole at least, the species had smaller dimensions in comparison to *G. bellerophontis*, while Ogilvie-Gordon observed quite the contrary.

The calcareous wall is as thin as in *G. bellerophontis*, and it is pierced obliquely by numerous branching filaments, larger than in *G. bellerophontis;* near the outside openings they grow broader assuming a funnel-shaped appearance. The pores on the external surface are equally distributed, and often arranged in quincunx; they are fairly large (Pl. 9, fig. 1) slightly elongated and have hexagonal outline. Owing to the arrangement and size of the pores, the straight and cylindrical parts of the thallus (Pl. 9, fig. 1) are almost the same as *Macroporella* fragments (see Pia 1937, Pl. 10, fig. 4), but the slides cut from the hand specimens figured herein on Pl. 9, fig. 1 have shown only structures referable to the species in question. Some ramified fragments are to be seen; no plainly recognizable sporangia have been observed.

MEASUREMENTS

Outer diameter of the cylindrical fragments (average)	mm.	0.65
Outer diameter of the club-shaped fragments (average in the middle)	mm.	0.89
Outer diameter of the broadest fragment	mm.	1.40
Diameter of the central perforation (average) referred to the cylindrical fragments	mm.	0.53
Thickness of the calcareous wall (average)	mm.	0.06
Number of pores on a transverse section		18
Diameter of pores on the outer surface	mm.	0.082

Occurrence.—*Upper Permian* of Digonera and Laste (Cordevole Valley) and of Mount Pic (Gardena Valley).

Repository.—Slides and hand specimens, all in the collections of the Geological Institute of the Ferrara University (Italy).

SUMMARY

The stratigraphy of the *Upper Permian* of the Cordevole and Gardena valleys is described, and the calcareous algae contained in the upper part of the "*Bellerophon*-zone" are illustrated in detail. The algal species described are ; *Atractyliopsis lastensis* n. sp., *Gymnocodium bellerophontis* Rothpletz and *G. nodosum* Ogilvie-Gordon. The relations between the external morphology and the internal structure of the two latter species are explained; a detailed description is given of the genus *Atractyliopsis* which was, so far, almost unknown.

RIASSUNTO

Nel presente studio viene descritta la stratigrafia del *Permiano superiore* dell'alta Valle del Cordevole e della Val Gardena, e vengono ampiamente illustrate le alghe calcaree contenute nella parte superiore della "zona a *Bellerophon*". Tali alghe appartengono alle specie *Atractyliopsis lastensis* n. sp., *Gymnocodium bellerophontis* Rothpletz e *G. nodosum* Ogilvie-Gordon. Delle ultime due specie, gia abbastanza note, vengono chiariti i rapporti tra la morfologia esterna e la struttura interna; il genere *Atractyliopsis* invece, pressochè sconosciuto finora, viene esaurientemente descritto.

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