FOSSIL ALGAE FROM THE SALT RANGE

S. R. NARAYANA RAO* & C. P. VARMA**

I — PERMIAN ALGAE FROM THE MIDDLE PRODUCTUS BEDS

ABSTRACT

Three species of the genus *Gymnocodium* are described and figured from the upper part of the Middle Productus beds of the Nammal Gorge. This alga is found associated with late Permian fusulinid genera which are known from the Capitan limestones of Texas and the Maiya series of Japan.

INTRODUCTION

THE material described in this paper was collected by the senior author in 1946 from the Middle Productus beds of the Nammal Gorge (32°40′: 71°48′) of the Punjab Salt Range. These beds attain a thickness of nearly 500 ft. About 200 ft. from the base is a band of limestone about 12 ft. in thickness containing the reef building sponge *Amblysiphonella* and the coral *Lonsdaleia indica*. Thin sections of the limestone have yielded the alga *Gymnocodium* described in this paper. Associated with this alga are the following aberrant types of fusulinids: *Leëla, Codonofusiella* and *Nipponitella*; the two former genera are known to be restricted to the *Polydiexodina* horizon (latest Permian) of Texas. *Nipponitella* has been described from the Maiya group (Upper Permian) of the Kitakami region of Japan. The Middle Productus of the Salt Range has hitherto been regarded as Middle Permian and the presence of the fusulinids and the algal genus *Gymnocodium* now being recorded indicate that the Middle Productus bed is Upper Permian.

The algal genus *Gymnocodium* Pia has long been recognized as an index fossil for the late Permian Bellerophon limestones occurring along the Mediterranean regions; it has lately been found in the late Permian of Texas (JOHNSON, 1946). Attention was called to its presence in the Middle Productus limestones of the Salt Range by one of the authors (RAO, 1948).

The systematic position of the genus *Gymnocodium* has long been in doubt. According to Pia (1937, p. 832), it was first regarded as a bryozoan(?) by Gümbel (1873) and later as a member of the Dasycladaceae by Gümbel (1874), Rothpletz (1894), Pia (1912) and Jablonszky (1919).

In 1912, Pia described the only species known till then under the name *Macroporella bellerophontis* (Dasycladaceae). The branches were regarded as verticillate and inclined upwards, their calcified extremities forming the outermost cortical zone. In a later publication (1927) Pia gave a different interpretation to the structures seen and removed the species from Dasycladaceae to Codiaceae; the plant was compared to such alga as *Boueina* and *Halimeda* (Codiaceae) and the so-called 'branches' were now regarded as radiating 'perforations' within the thick cylindrical wall (*see* ELIAS, 1947, p. 57). In a later paper (1937) Pia thought that the genus *Gymnocodium* resembled the recent genus *Galaxaura* Lamouroux and he brought it under Chaetangiaceae. The systematic position of the genus is still unsettled and better preserved specimens are necessary before any opinion can be expressed.

DESCRIPTION

Gymnocodium bellerophontis var. *pygmaeum* var. nov.

Pl. 1, Figs. 1, 3-6; Pl. 2, Fig. 7

1948, *G.* cf. *bellerophontis* Rao, S. R. N., *Palaeobotany in India* — VI: 249, Pl. 12, Fig. 7

Thallus jointed and branched (PL. 1, FIGS. 6, 4), length unknown, circular in cross-section. Segments known up to 1·8 mm. long and 0·28-0·9 mm. broad, segments separated from each other by constrictions. Segments composed of a loose medulla consisting of branching filaments, occasionally calcified (PL. 1, FIGS. 1, 4; PL. 2, FIG. 7) giving rise to a loose cortex formed by their laterals composed of 2-4 swollen cells 32-80 μ (mostly 49-65 μ) broad, forming a more or less compact surface. Outermost cortical cells gradually widening outwards to attain

* Professor of Geology, Lucknow University.
** Lecturer, Birbal Sahni Institute of Palaeobotany, Lucknow.

a cyathiform structure. Sporangium[1] about 0·24 mm. and immersed in the medulla (Pl. 1, Fig. 1).

To facilitate a close comparison with the photos given by Pia for *G. bellerophontis* (1937, Taf. 11, Figs. 1-6) all the specimens of *Gymnocodium* shown here have also been photographed at the same magnification (× 28) except one (Pl. 1, Fig. 4). Our specimens reveal that these forms are essentially similar to those described by Pia except for the smaller size of the various structures. The real shape of the sporangia (spindle shaped in *G. bellerophontis* Pia) could not be ascertained in our forms as none of the longitudinal sections of the thallus show sporangia.

The specimens shown in Pl. 1, Fig. 1, exhibit two transverse and one obliquely longitudinal section of *Gymnocodium bellerophontis* var. *pygmaeum*. The bigger cross-section which is better preserved shows a sporangium 0·24 mm. wide. The oblique longitudinal section passes through a segment with indications of constriction (evidently not very deep) above and below. It also reveals the calcified medulla loosely filled with the branching filaments showing constrictions. From these originate laterally 2-4 swollen cells which form a loose cortex, the end cells gradually broadening outwards to form a more or less compact surface.

Pl. 1, Fig. 3, shows a nearly longitudinal section passing through a member between two constrictions, showing an uncalcified medulla which is here filled with the matrix. The calcified cortical zone is seen to be made up of 2-4 swollen cells.

Pl. 1, Fig. 6, shows a cross-section passing through the narrower part of the thallus and an obliquely longitudinal section passing through a constriction of two adjoining members. Here also the medulla is seen to be uncalcified. On the extreme right of this specimen are seen the circular openings of the outermost cortical cells which appear to be alternately arranged.

The specimen shown in Pl. 2, Fig. 7, is an oblique section very much magnified to show the calcified medulla with the medullary filaments, not uniformly thick, from which are seen laterally arising 2-4 swollen cells to form the cortical zone.

1. The term sporangium has been used in the text to indicate the reproductive bodies and not strictly in accordance with the botanical terminology.

Pl. 1, Fig. 4, shows a part of the branched thallus of *G. bellerophontis* var. *pygmaeum*. In this specimen also the medulla is seen to be made up of the calcified filaments, and forming the cortex by their lateral cells. A similar case of branching has also been recognized by Pia (1937, p. 832; Pl. 11, Fig. 4) in *G. bellerophontis*.

Pl. 1, Fig. 5, shows an obliquely cut section of *Gymnocodium bellerophontis* var. *pygmaeum* associated with *Leëla*, a fusulinid very characteristic of late Permian horizons.

The above description with comparison and photos of *G. bellerophontis* and *G. tenellum* (the latter was established by Pia, 1937, p. 834, with a very inadequate description) indicates that the Nammal forms are very similar to *G. bellerophontis*. They differ only in the smaller size of the members (or segments) of the thallus, medullary filaments and the cortical cells. Because of these differences and the great distance separating the two localities the Salt Range species is considered to be a variety of *G. bellerophontis* and the name *G. bellerophontis* var. *pygmaeum* is proposed for it.

Gymnocodium cf. *solidum* Pia

Pl. 1, Fig. 2

Gymnocodium solidum is described by Pia (1937, p. 833, Taf. 9, Fig. 1, Taf. 13, Figs. 1, 2) as a stately, long, almost cylindrical species with egg-shaped sporangia and the cortical cells smaller than in *G. bellerophontis*. In sterile specimens (or sterile part of the thallus) calcification occasionally reaches up to the middle of the medulla.

The specimens here referred to *G. solidum* are long, almost cylindrical with mostly uncalcified medulla. Pl. 1, Fig. 2, shows one such fragment with indications of a scantily calcified medulla. On the inner side of the specimen, the cavity is seen to be filled with the matrix and no trace of the medullary filaments is observed. Evidently the medullary filaments disintegrated more readily than the cortical filaments which appear to have become calcified earlier and are also better preserved. No fertile specimen with sporangia could be discovered. One specimen (Pl. 1, Fig. 2) referred to *G. solidum* runs up to 1·7 mm. in length with a skeletal diameter ranging from 330 to 600 μ and the diameter of the medulla up to 247 μ.

Gymnocodium Piai sp. nov.
Pl. 2, Figs. 8, 9

The species which we are provisionally referring to the genus *Gymnocodium* has a thallus composed of spherical members comparable to those observed in the well-known Permian genus *Mizzia*. No trace of reproductive structure has been observed in *Mizzia* so far, while in the alga now described sporangia appear to be present. The Nammal Gorge species appears to be generically similar to *Gymnocodium moniliforme* and *G. fragile* which Pia (1937, p. 834) has described as possessing spherical segments. A close comparison with these is, however, not possible as they have not yet been adequately described.

The thallus of *Gymnocodium Piai* sp. nov. shows a beaded form which is well seen in Pl. 2, Fig. 8, where the two adjacent spherical members have been longitudinally cut. One member is incomplete while the other one, which is complete, shows an ovoid body embedded within the calcite matrix comparable to a sporangium. The size of this ovoid body is 132 × 99 μ. In another specimen, Pl. 2, Fig. 9, just below the cortical zone a number of ovoid bodies are present. The circular sections range from 1·4 to 2·1 mm. in diameter and the medullary zone ranges between 1-1·7 mm. in diameter. The cortical zone, about 115 to 247 μ thick, is formed by 2 to 3 elongated cells (not swollen cells as in the case of *G. bellerophontis* and *G. tenellum*), the end cells becoming slightly widened to bind but not so much as to come in close contact with each other.

There is little information regarding *G. moniliforme* and *G. fragile* for comparison with our species which, however, is easily distinguished by the smaller size of the members and also the sporangia, the latter being embedded in the medulla.

REFERENCES

ELIAS, M. K. (1947). *Permopora Keenae*, a late Permian alga from Texas. *Journ. Pal.* **21**(1): 46-58.

GÜMBEL, C. W. (1873). Geognostische Mittheilungen aus den Alpen. I. Das Mendel- und Schlerngebirge. *Sitzungsber. bayer. Ak. Wiss., math. phys.* Kl. 1873: 14. München. (Quoted from PIA, 1937.)

JOHNSON, J. H. (1946). Late Palaeozoic algae of N. America. *Midland Nat.* **36**: 264-274.

KÜHN, O. (1933). Das Becken von Isfahan — Saidabad und seine altmiocäne Korallenfauna. Mit Beiträgen von F. Heritsch und F. Kahler. *Palaeontogr.* **79A** : 143. Stuttgart. (Quoted from PIA, 1937.)

PIA, J. (1912). Neue Studien über die triadischen Siphoneae verticillatae. *Beitr. Pal. Geol. Öest. Ung.* **25**: 25.

Idem (1927). Thallophyta. In Hirmer: *Handbuch der Paläobotanik.* **1**. *München und Berlin.*

Idem (1937). Die wichtigsten Kalkalgen des Jungpaläozoikums und ihre geologische Bedeutung. *Deuxième Congrès pour l'avancement des études de stratigraphie carbonifère.* Heerlen. **2**: 765-856.

Idem (1936). Algen als Leitfossilien. In *Problems of Paleontology. Pub. Lab. Paleont. Univ. Moskow.* **1**: 1-11.

RAO, S. R. N. (1948). *Gymnocodium* cf. *bellerophontis* Pia from the Productus beds in the Salt Range, Punjab. *Palaeobotany in India, VI — Jour. Ind. Bot. Soc.* **26**(4).

TAYLOR, W. R. (1928). The marine algae of Florida. *Pub. Carneg. Inst. Washington.*

II — *SOLENOMERIS*(?) *DOUVILLEI* SP. NOV. FROM THE LAKI (LOWER EOCENE) LIMESTONES

ABSTRACT

An alga with very close resemblance to the European Lower Eocene genus *Solenomeris* known from a single species *S. O'Gormani* Douvillé is doubtfully referred to this genus and described under the name *Solenomeris*(?) *Douvillei* sp. nov. The genotype, because of the large size of the cells unusual in calcareous algae and the absence of conceptacles, has been regarded as a hydrozoan and not an alga. The species now described comes from the Laki beds (Lower Eocene) of the Nammal Gorge in the Punjab Salt Range and closely resembles *Solenomeris*. The presence of conceptacles in the Salt Range species shows that it is an alga. It is an encrusting type of alga and specifically differs from the European species which is nodular.

INTRODUCTION

This new species comes from the Laki limestone (Lower Eocene) of the Nammal Gorge section. These limestones are rich in calcareous algae and a description of several species of *Archaeolithothamnium* found in these has recently been published (VARMA, 1952). In 1924 Douvillé created the algal genus *Solenomeris* (under the Corallinaceae) for certain calcareous nodules found extensively in the Lower Eocene of Bearn (France). This alga is characterized by unusually large cells but no conceptacles had been discovered. Mlle Pfender (cited by GARWOOD, 1931), however, thought that the organisms were more likely the remains of a hydrozoan, such as *Clathrodictyon*.

The present note deals with an encrusting type of an Eocene alga from the Punjab Salt Range which resembles very closely the European genus *Solenomeris* and its plant nature is beyond doubt because of the presence of conceptacles and thus differing from encrusting type of foraminifera (CUSHMAN, 1950; HANZAWA, 1939).

Another form *Peysonnelia polymorpha* Decaisne (TAYLOR, 1928, p. 202) seems comparable at first sight but differs considerably in various structural details of the thallus and in its reproductive features.

DESCRIPTION

Diagnosis — Encrusting thallus (PL. 2, FIG. 12) usually interlaminated with the thalli of other algae or round foraminifera, 0·03-1·70 mm. or more in thickness, not differentiated into a hypothallium. Shape of the perithallial cells pentagonal to hexagonal or more commonly as laterally broadened domes. Cells of the adjoining layers alternately arranged or one above the other in which case zigzag lines running across the thickness of the thallus are visible. The horizontal rows run concentrically and are undulated. Outer zone of the massive thalli is made up of smaller cells about 13 μ high and the inner zone of bigger cells 18-40 μ high. Horizontal walls fairly thick. Two sections showing conceptacles (PL. 2, FIGS. 10, 11), 72·8-115·5 × 280-412 μ, with round to oblong bodies inside about 31-78 μ in diameter have been noted. The cells of the thallus often obliterated while only the reproductive organs are preserved and some cells of the thallus are wrapped round the conceptacles in 2 or 3 layers.

Comparisons — The above alga resembles *Solenomeris O'Gormani* Douvillé very closely in its vegetative characters and in not having a hypothallium, while it differs in the size of the cells [in *Solenomeris O'Gormani*, size of smaller cells not given by Douvillé, bigger cells 35-30 μ high; in *S.*(?) *Douvillei* smaller cells 13 μ high and bigger cells 18-40 μ high] and in its encrusting habit, that of the French fossil being mamillated masses of limestones with smooth surfaces.

Remarks — The French and the Salt Range fossils compared above come from essentially the same horizon (Lower Eocene). Generically the two are probably identical and differ specifically in their habits and the size of the cells forming the thallus. The Salt Range form has, therefore, been regarded as a separate species. We have named it after H. Douvillé who described the French fossils. In *Solenomeris O'Gormani*, Douvillé did not notice the presence of reproductive organs and he put it among the Melobesieae on grounds of the vegetative characters only. The algal nature of *S. O'Gormani* has been questioned by Pfender (cited in GARWOOD, 1931). Pia, however, has classified it under Solenoporaceae. Douvillé compared his genus with *Solenopora, Solenoporella*, etc., in none of which the reproductive organs are known. The Salt Range forms prove their algal nature beyond doubt because of the presence of the conceptacles. It seems to have much in common with the type species of *Solenomeris* so that we prefer to refer it provisionally to that genus. The Salt Range fossil is also classified under the Melobesieae on the following grounds:

1. Cell dimensions range within the variable limits of the cells of the Melobesieae.
2. The reproductive bodies are enclosed in conceptacles.

REFERENCES

CUSHMAN, J. A. (1950). Foraminifera: Their classification and economic use. *Harv. Univ. Press. Cambridge* (*Mass.*).

DOUVILLE, H. (1924). Un nouveau genre d' algue calcaire. *Compt. Rendu. Soc. Géol. Fr.* S. 169.

GARWOOD, E. J. (1931). Important additions to our knowledge of the fossil calcareous algae since 1913 with special reference to Pre-Cambrian and Palaeozoic rocks. *Quart. Jour. Geol. Soc. London.* **87**.

HANZAWA, S. (1939). On the occurrence of *Acervulina*, an encrusting form of foraminifera in the Jurassic Torinosu limestone from the Kwanto Mountain land, Central Japan. *Jour. Geol. Soc. Japan.* **46**: 547.

PIA, J. (1927). Thallophyta. In Hirmer: *Handbuch der Paläobotanik.* **1**. *München und Berlin.*

TAYLOR, W. R. (1928). Marine algae of Florida. *Pub. Carneg. Inst. Washington.*

VARMA, C. P. (1952). An algal flora from the Laki (Lower Eocene) beds of the Nammal Gorge, Punjab Salt Range. I. *Archaeolithothamnium. Proc. Nat. Inst. Sci. India.* **18**(4): 301-308.

EXPLANATION OF PLATES

PLATE 1

Gymnocodium

1. *Gymnocodium bellerophontis* var. *pygmaeum* var. nov. A section showing three specimens, one member cut longitudinally (only a part preserved) and two transversely cut. In the upper transverse section is seen a sporangium in the medulla. × 28.

2. *G.* cf. *solidum*. A longitudinal section through the thallus. × 28.

3. *G. bellerophontis* var. *pygmaeum*. A longitudinal section through a member with uncalcified medulla; the cortex made up of 2 or 4 swollen cells. × 28.

4. *G. bellerophontis* var. *pygmaeum*. A part of the thallus which shows branching. × 56.

5. *G. bellerophontis* var. *pygmaeum*. Several fragments associated with the fusulinid *Leëla* which is seen on the left corner. × 28.

6. *G. bellerophontis* var. *pygmaeum*. An oblique longitudinal section passing through a constriction (joint) of two adjoining members. On the top left is seen a cross-section. × 28.

PLATE 2

Figs. 7-9, *Gymnocodium*; Figs. 10-12, *Solenomeris*

7. *Gymnocodium bellerophontis* var. *pygmaeum* var. nov. A specimen much enlarged to show the medullary filaments and the laterals. × 88.

8. *G. Piai* sp. nov. A section passing through two members, the upper one preserved partly. The lower member showing a sporangium(?). × 20.

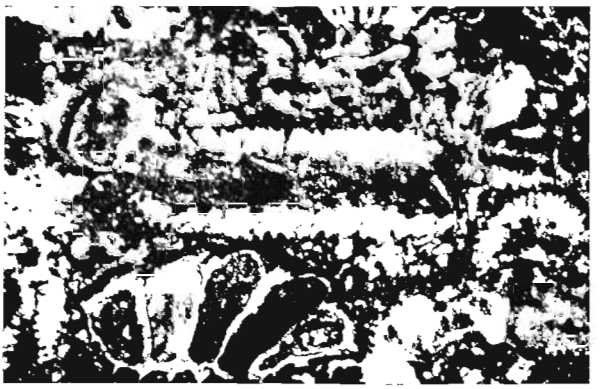
9. *G. Piai* sp. nov. A single member showing a number of partly preserved sporangia(?) seen on the right side just below the cortical zone. × 20.

10. *Solenomeris*(?) *Douvillei* sp. nov. A vertical section passing through two thalli. Thallus on the upper part of the photo shows a conceptacle (c) with rounded bodies inside. Another thallus (s) on the lower side. In between the two thalli are other members of the Melobesieae. × 40.

11. *S.*(?) *Douvillei* sp. nov. A vertical section through a conceptacle of a mutilated thallus encrusting the branch of a *Mesophyllum*. In the conceptacle are seen round to oblong bodies. × 80.

12. *S.*(?) *Douvillei* sp. nov. A transverse section showing the encrusting nature of the thallus. × 6·5.

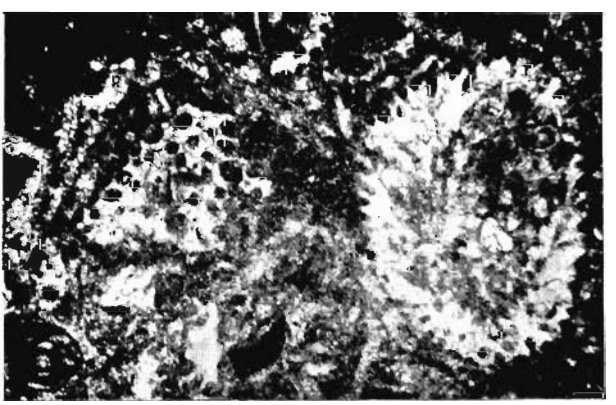
1



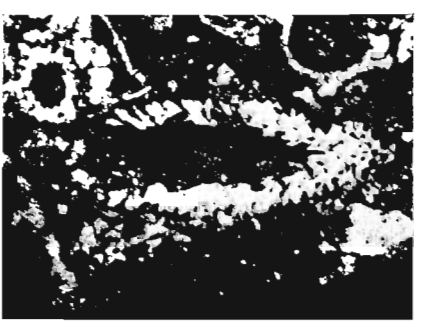
2

3

4



5



6

7

8

9

10

11

12