ON THE GENUS *POTHOCITES* PATERSON

by M. CHAPHEKAR

ABSTRACT. Specimens of cones identified as *Pothocites grantonii* Paterson from compressed material are described. In the light of the present findings, reasons are given for regarding *Pothocites* as the legitimate name for all known cones of *Archaeocalamites* (*Asterocalamites*), including those from petrified material, which have been previously described under the name *Protocalamostachys* Walton.

THE cones of *Archaeocalamites* from compressed material have been noted and described by most earlier investigators under the name of *Pothocites grantonii* Paterson. Two species of petrified cones believed to have been borne on *Archaeocalamites* stems have been described under the names *Protocalamostachys arranensis* (Walton 1949) and *Protocalamostachys pettycurensis* (Chaphekar 1963).

Walton (1949) compared *Protocalamostachys arranensis* with *Pothocites grantonii* and concluded that the petrified and the compressed cones were probably similar in general structure and size. However, due largely to the compressed nature of the fossils to which the name *Pothocites* is given, little is known about their internal structure. Further information concerning the structure has been obtained from the specimens of *Pothocites* described below.

Material. The following specimens from the Calciferous Sandstone Series of the Lower Carboniferous were used in the present investigation :

(i) Three specimens from Loch Humphrey Burn, Kilpatrick Hills, Dumbartonshire, Scotland, Kidston Collection (Geological Survey Museum) numbers 5373–5375.

(ii) Two specimens from Glencartholm, Eskdale, Dumfriesshire, Scotland, British Museum (Natural History) Collection, numbers V195 and V758.

SYSTEMATIC DESCRIPTION

Genus POTHOCITES Paterson 1841

1949 *Protocalamostachys* Walton

Emended diagnosis. Strobilus or fertile axis bearing non-alternating whorls of sporangiophores. Sporangiophore consisting of a main shaft bearing at the distal end four curved pedicels each with a single terminal oblong sporangium orientated parallel to the sporangiophore shaft. Axis of strobilus containing a ring of mesarch xylem strands which do not anastomose. Sporangium wall cells with fold or peg-like thickenings on the anticlinal walls. Spores of the *Calamospora* type.

Type species. Pothocites grantonii Paterson.

Other species. Pothocites arranensis (Walton) comb. nov.
Pothocites pettycurensis (Chaphekar) comb. nov.

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Pothocites grantonii Paterson

Plate 18, figs. 1–6; text-fig. 1

Synonymy. See Kidston (1883).

Material. The identification of the cones described here as *Pothocites grantonii* is based on their morphological similarity to Paterson's (1841) original specimens as judged from his illustrations and description and from the work of Kidston (1883) who re-examined Paterson's material. Unfortunately I have been unable to trace the type specimens at the Royal Botanic Garden, Edinburgh (Kidston 1883). Although all fossil plants from the Garden are believed to have been transferred to the Royal Scottish Museum, the *Pothocites grantonii* type material is not in the collections of that institution and is presumed lost.

The specimens from the two localities are closely similar in general structure and size (Table 1). The two specimens from Glencartholm, although poorly preserved, are as long as 8·5 cm. and 11 cm. respectively, and show the characteristic segmentation of the cone illustrated originally by Paterson (1841) and again more convincingly by Kidston (1883). Kidston illustrated one specimen which showed evidence of whorls of leaves or bracts at the constrictions.

The specimens from Loch Humphrey Burn are much better preserved than those from Eskdale and have yielded good spores as well as certain information concerning the internal structure.

Description. Specimens 5373 (Pl. 18, fig. 1) and 5375 are longitudinally split and show the axis of the cone with attached sporangiophores. Specimen 5374 (Pl. 18, fig. 2) shows part of the outer surface of the cone on which the ends of sporangiophores with sporangia arranged in crosswise manner can be seen. By measuring the diameter of the cone and the distance between the ends of two adjacent sporangiophores in a whorl, it was possible to calculate the probable number of sporangiophores occupying the circumference of the cone (i.e. the number of sporangiophores per whorl); for cone specimen 5374, the number was twelve. Text-fig. 1A shows part of the cone axis in which the coaly material has split so as to expose what is probably one side of the vascular cylinder. If the four ridges are assumed to represent four adjacent vascular strands, then the total number of vascular strands in the axis may be calculated in a similar way to the number of sporangiophores per whorl; this number is eight.

If the two specimens upon which these calculations are based are similar, and both had eight vascular strands and twelve longitudinal series of sporangiophores, then eight of the sporangiophores in each whorl were probably attached in pairs opposite vascular strands and four attached singly. The sporangiophores are 2·5 mm. long and 0·25 mm.

EXPLANATION OF PLATE 18

Figs. 1–6. *Pothocites grantonii* Paterson. 1, Longitudinally split cone showing axis with whorls of sporangiophores bearing sporangia; specimen 5373; approx. ×6. 2, Cone in surface view, showing whorls of sporangiophores with sporangia arranged in crosswise manner; specimen 5374; approx. ×5. 3, Part of the macerated sporangium showing group of spores adhered together (the inner body in some spores has dropped out); slide 1, ×120. 4, Intact spore showing distinct trilete mark and faint granulations of the inner layer; slide 2, ×480. 5, Spore with outer layer only, showing trilete mark; slide 3, ×480. 6, Freed inner bodies showing granulations very clearly; slide 1, ×480.

in diameter. These measurements were obtained from specimens 5373 and 5375. At the distal end of the sporangiophore there are attached four sporangial pedicels which terminate in sporangia. Text-figs. 1C and 1D, drawn from specimen 5374, show sporangiophores in surface (end) view. Portions of the pedicels can be seen attached to some of the sporangia.

A number of sporangia were separated by immersing a small fragment of the cone in hydrofluoric acid for one day. The acid was decanted off and the fragments washed thoroughly in water. Some of the isolated sporangia also showed part of the attached

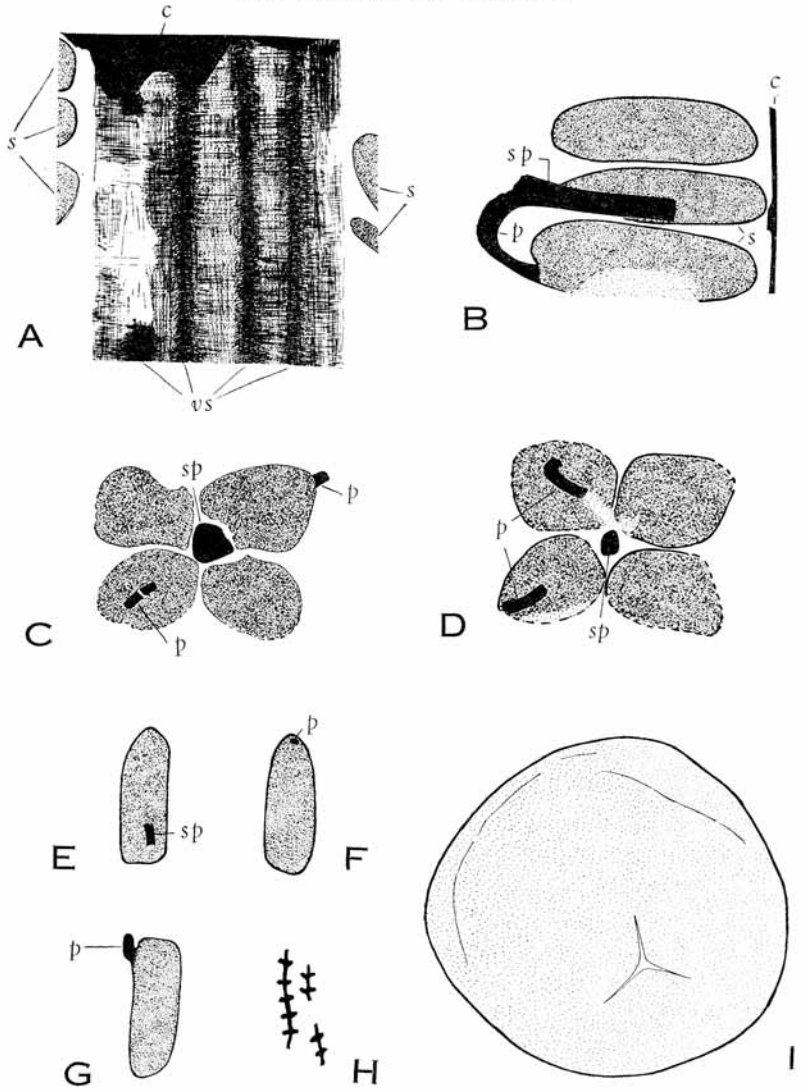
TABLE I

Specimens	*Diameter of cone*	*Distance between Sporangiophore whorls*	*Sporangia*		*Spores*
			length	*width*	
Pothocites grantonii					
5373 Loch Humphrey Burn.	8 mm.	1·6–1·8 mm.	2·6 mm.	0·8 mm.	82 μ
5374	6·5 mm.	1·5 mm.	..	0·7 mm.	..
5375	7 mm.	1·7 mm.	2 mm.	0·8 mm.	82 μ
V195 Glencartholm.	7·5–9·0 mm.	1·5–1·8 mm.	2 mm.	0·75 mm.	104 μ
V758	8 mm.	1·3–1·5 mm.	..	..	..
Protocalamostachys arranensis . .	7·9 mm.	0·8 mm (?)	1·2 mm.	0·65 mm.	66 μ
P. pettycuresis . .	4 mm.	1 mm.	0·9 mm.	0·4 mm.	38 μ

pedicel (*p*) (text-fig. 1G). As in *Protocalamostachys pettycurensis* the pedicels are attached to the sporangia on the side away from the main shaft of the sporangiophore. This is seen well in a portion of specimen 5373 illustrated in text-fig. 1B. Further evidence of this is seen in some of the isolated sporangia where a portion of the sporangiophore stalk can be seen adhering to the sporangium wall on the side opposite the remnant of the pedicel (text-figs. 1E, F). Small cellulose acetate 'pulls' were prepared from one specimen in a region where some sporangia were exposed. The surface was first flooded with acetone and then a cellulose acetate film was gently lowered on to it. The 'pulls', which were removed after drying for about thirty minutes, pulled away fragments of sporangial walls. The sporangial wall cells have ridges or thickenings on their anticlinal walls (text-fig. 1H) similar to those found in *Protocalamostachys*.

The spores were extracted by immersing some isolated sporangia in Schulze's macerating fluid for different periods ranging from 6 to 24 hours. The fluid was then removed by thorough washing and the sporangia treated with dilute ammonia. Macerated sporangia were mounted in dilute glycerine. The spores generally remained firmly in contact with one another even after complete maceration. Some separation was obtained by squashing or teasing with a needle. The spores vary in size from 72 μ to 95 μ. The average of thirty-five individually measured spores from two separate cones was 82 μ in each case.

The spore coat appears to consist of two layers, an outer brownish layer bearing a small though distinct trilete mark and an inner yellowish layer or body with a faint



TEXT-FIG. 1. *Pothocites grantonii* Paterson. A, Part of the longitudinally split specimen 5373, to show four vascular strands (*vs*), cortex (*c*), and sporangia (*s*); ×14. B, One sporangiophore (*sp*) from the specimen in A, to show attachment of one of its four sporangia; *p*, pedicel; ×14. C–D, Surface view of the distal end of the sporangiophore to show the crosswise arrangement of sporangia with parts of attached pedicels (*p*); *sp*, sporangiophore; specimen 5374, ×21. E–F, Abaxial and adaxial view of an isolated sporangium to show the attachment of pedicel (*p*) in F, on the opposite side of the sporangiophore (*sp*); ×9. G, Isolated sporangium with attached pedicel (*p*); ×9. H, Surface section through sporangial wall, ×210. I, Spore, ×520.

trilete mark. The spores adhere together in the macerated sporangia (Pl. 18, fig. 3). The intact spore (Pl. 18, fig. 4) shows faint granulations. These markings belong to the inner layer, for in spores from which the inner body has dropped out, the wall is seen to be quite without granulations (Pl. 18, figs. 3, 5) and freed inner bodies show the granulations very clearly (Pl. 18, fig. 6). The two layers, at least after maceration, appear to be free from one another and the inner structure appreciably smaller than the outer. Thus when the outer layer ruptures the inner layer tends to fall out. The inner layer does not withstand severe maceration as well as the outer. In samples which had been macerated for twenty-four hours, the inner layer was very distorted and no trilete mark could be discerned.

The interpretation of the apparently two-layered wall of these spores is difficult. It is possible that it is an artifact due to the preservation or macerating treatment. Perhaps the inner layer is comparable to the 'inner body' reported in over-macerated microspores of the lycopod cone *Porostrobus zeilleri* (also a compressed cone) by Bharadwaj (1959). The trilete mark as seen on the outer layer of the spore (Pl. 18, fig. 4 and text-fig. 11) has rays about 18 μ in length. It is smaller and less pronounced than in *Protocalamostachys pettycurensis*.

The spores of these *Pothocites* specimens can be regarded as being of the general *Calamospora* kind only if the inner layer of the wall is neglected. It is, however, of interest that *Calamospora microrugosa* (Ibrahim) Schopf (Playford 1962) has been reported as sometimes having a minutely granulate exine; it is also of the same size as the *Pothocites* spores described here (62–104 μ; mean 82 μ). The spores from specimen V195 were somewhat larger in size, varying from 90 μ to 115 μ. The average size of nineteen individually measured spores was 104 μ. This larger size could have been due to the swelling of the very poorly preserved spores. The trilete mark showed only very indistinctly.

Discussion. The present investigations have shown that while in its general structure *Pothocites grantonii* is essentially similar to the two known species of *Protocalamostachys*, it cannot be regarded as identical to either of these species. There is, however, no known morphological distinction to separate it generically.

Only one morphological character observed in certain specimens of *Pothocites grantonii* has not so far been demonstrated in the petrified cones; this is the more or less regular constrictions along the length of the cone at which whorls of leaves or bracts were probably borne. The fact that no such constrictions have yet been reported in the petrified cones seems likely to be due only to the fragmentary nature of these specimens.

Cones of the *Pothocites* type have been found attached to leafy shoots of *Archaeocalamites radiatus* (Bgt.) Stur [= *A. scrobiculatus* (Schloth.)] (Stur 1875) and cones of *Protocalamostachys pettycurensis* have been reported in attachment to slender stems of *A. goeppertii* (Chaphekar 1963).

There is thus good reason for classifying all these cones showing a similar morphological organization and belonging to *Archaeocalamites* under the name having priority, i.e. *Pothocites* Paterson, regardless of mode of preservation.

The cone originally named *Bornia radiata* by Renault (1893–6) is almost certainly to be regarded as a *Pothocites*, in spite of Renault's interpretation of the sporangiophores as being truly peltate. From the apparent number of sporangiophores in the whorl, it may be identical to *Pothocites arranensis*.

The status of Nathorst's (1914) *Pothocitopsis bertilli* is uncertain. Enquiries made of the Swedish Museum of Natural History and of the Palaeontological Museum, Oslo, failed to bring to light the original specimen. However, there is nothing in Nathorst's description to provide any evidence that the cone was anything other than a poorly preserved specimen of *Pothocites*. From its dimensions, it would probably be classifiable as *Pothocites grantonii*.

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Location of Collection. The slides are preserved at the Geological Survey Museum, London.

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M. CHAPHEKAR
Department of Botany,
Imperial College,
London, S.W. 7

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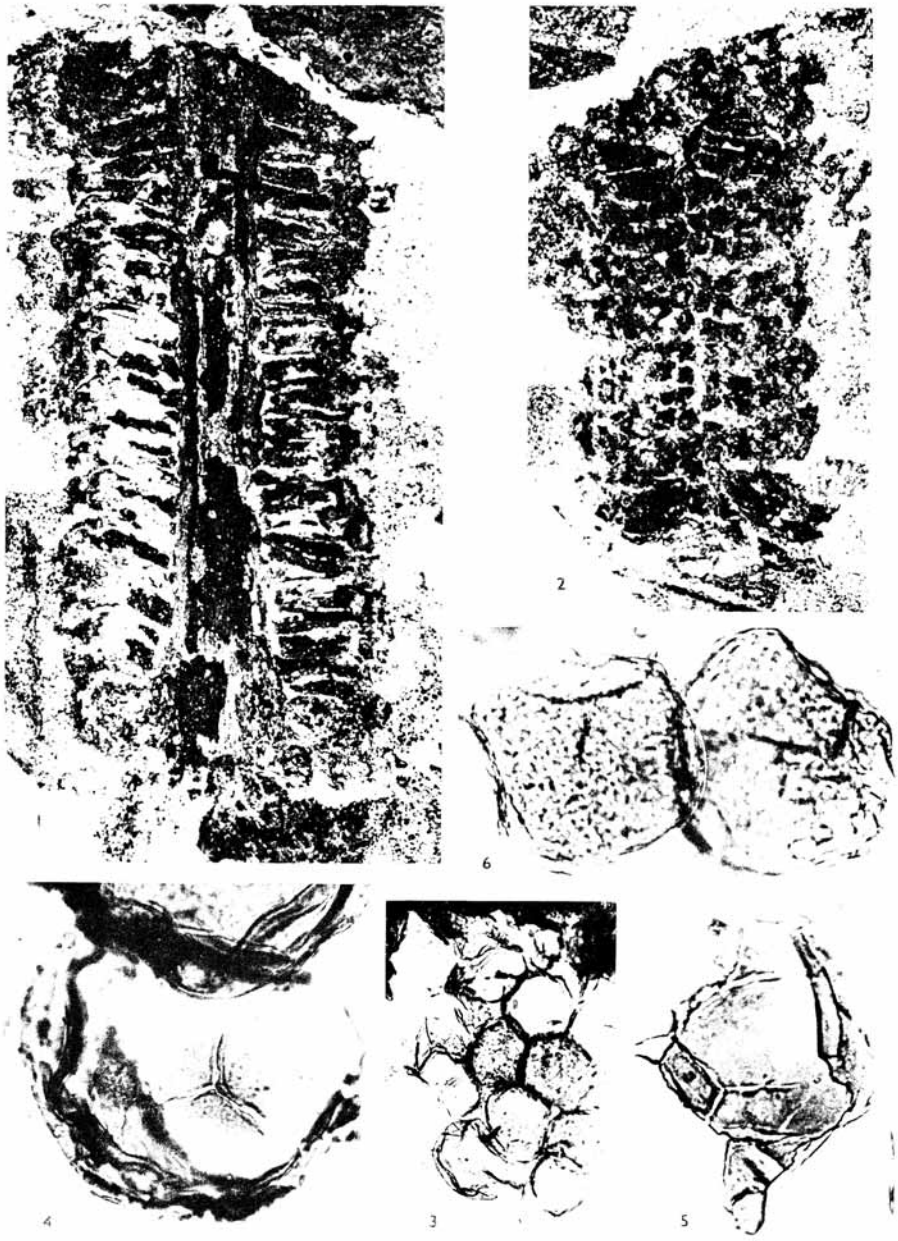

CHAPHEKAR, Lower Carboniferous *Pothocites*