ACTA PALAEOBOTANICA

XVIII (1): 3—12, 1977

T. M. HARRIS*

NOTES ON TWO OF RACIBORSKI'S JURASSIC FERNS

Uwagi o dwu jurajskich paprociach opisanych przez Raciborskiego

ABSTRACT. The author during his recent visit to Kraków investigated the original specimens of *Osmunda sturii* Raciborski — now *Osmundopsis sturii* (Raciborski) Harris — and of *Klukia exilis* (Phillips) Raciborski from the Jurassic of Grojec near Kraków, about which queries have been raised. It was found that in the specimens of *Osmundopsis sturii* the sporangia were borne on naked rachis branches like in the living *Osmunda*. It was also found that all taxa of *Klukia* described by Raciborski belonged to a single species which is identical with *Klukia exilis* from Yorkshire. Spores from detached sporangia found in a locality near Grojec are the same as in *Klukia exilis* from Yorkshire.

Raciborski (1894) described many Polish Jurassic ferns from Grojec, near Kraków and illustrated them with beautiful lithographs. The plants suggest a Middle Jurassic age (Upper Liassic or Bajocian) but there is no more precise dating (Jurkiewiczowa 1974). Queries have been raised about two species and a recent visit to Kraków enabled me to settle both to my satisfaction.

Flora and preservation. The Grojec flora is remarkable in that fully nine tenths of the specimens are fern leaves, the remainder represent various Mesozoic families. This preponderance is not due to selection as the backs of figured slabs show it too. The leaves are preserved in a whitish clay containing much kaolin and the matrix penetrated small spaces, between sporangia and into open ones but not into plant tissue. It must have consolidated without loosing much volume, so the fossils are often not fully flattened. At some time after

* Geology, University of Reading

consolidation all the plant substance vanished leaving an air cavity between the moulds of the upper and lower leaf surfaces. Other leaves seem to have rotted away before consolidation and the split rock merely shows the imprint of the upper surface.

The clay matrix shows the outlines of epidermal cells, particularly of the thick walled cells of sporangia and I checked some of Raciborski's drawings against the originals and saw the cells drawn. Photographs at natural size would look very like the drawings but light photographs at magnifications of up to x 65 would be only partly in focus. Scanning electron micrographs on the other hand might show even more. Since all the organic matter has vanished, balsam transfers cannot be prepared, nor can spores be isolated, but perhaps some sort of cast in a resin might be useful.

The locality, a commercial clay pit, has long been abandoned but Raciborski's collection is large and includes many unfigured duplicates. It is well curated and available for study.

1. *Osmunda sturii* Raciborski 1894, p. 19

This was the first Mesozoic fern fructification described as closely resembling the living *Osmunda* in bearing sporangia on naked rachis branches. The name has survived with only slight change but Raciborski's interpretation of the specimens has been vigorously challenged by Kilpper (1964). Seward (1910) placed it in *Osmundites* Unger because he disliked putting an incompletely known Mesozoic plant in a living genus and it was called *Osmundites sturii* till 1931 when I made it the type of the new genus *Osmundopsis*. I considered *Osmundites* unsuitable because Unger's type and nearly all the species are petrified stems. The name *Osmundites* Jaeger 1827 has long been dropped (see Andrews 1970 for references). Hirmer (1927) included a few Tertiary leaves as well as *O. sturii* in *Osmundites*.

In 1931 I described *Osmundopsis plectrophora* from the Lower Lias of E. Greenland. Andrews in Boureau 1970 accepts both as species of *Osmundopsis* but this part of the Traité was doubtless written before Kilpper's work could be considered. Kilpper (1964, p. 42) accepts *Osmundopsis plectrophora* but rejects Raciborski's *O. sturii* as probably a *Todites* and thus not suitable to be the type of *Osmundopsis*.

He rejected Raciborski's interpretation of *O. sturii* and also questioned the accuracy of his figures and called for a fresh study of the material. I have studied the specimens and am satisfied that the drawings are accurate. I give photographs of one of Raciborski's unfigured specimens which he mentions in the text as showing how the sporangia are borne on a tertiary rachis with no lamina. This specimen and indeed others show conclusively that the sporangia are not attached to veins underneath a lamina as in *Todea* and *Todites* but on

an otherwise bare rachis. Nevertheless it was well that Kilpper raised the question because important work deserves reexamination, particularly when the author had a great reputation else the weight of authority might be accepted as evidence.

The tertiary rachis branches of *O. sturii* are so thickly crowded with sporangia that they conceal it and usually appear as a continuous elongated mass. In *Osmunda regalis* they only look like this near the free end, below they are in well marked clumps on short lateral outgrowths. Raciborski's Pl. 6, fig. 10 alone shows a rachis bearing small lateral clumps of sporangia on the tertiary rachis which is visible because the rock had split along the rachis instead of along the outer ends of the sporangia as it does normally. The description of this specimen (p. 98) reads (in translation) "Pl. 6, fig. 10 represents the mode of growing of the sporangia on the sporophyll, the sporangia grew out at single points at which they are concentrated into distinct sori". Kilpper's comment is: "Diese Darstellung ist indessen nur als subjective Vorstellung zu werten, deren Richtigkeit nicht erwiesen ist". (This representation is however only to be rated as a subjective interpretation, the correctness of which is unproved).

The possibility proposed by Kilpper, that a concealed lamina might be present, was not one that Raciborski had overlooked. After remarking that it would be strange if every specimen showed just the under surface, he says (p. 20) (in translation) "As for the location of the sporangia on the pinnules, they stand so densely that on normal casts it is impossible to determine the point of their attachment. Only in a few specimens is a longitudinal section of the cast visible showing the rachis of the third order and it is possible to observe under a lens that the sporangia are located in groups of a few at certain intervals. The points of their attachment apparently represent the places where lateral veins should arise from the main vein in the segments of the third order". The Polish word I have rendered as tertiary "rachis" is however morphologically neutral, neither "rachis" or "axis".

If with Kilpper we reject Raciborski's Pl. 6, fig. 10 as in some way faulty it would be conceivable that a lamina might be present but concealed in the figured specimens. Such a lamina could take one of two forms. The whole set of "tertiary rachises" could be the lateral veins of a very large lamina segment, in which case it would be analogous to the fertile pinnule of *Todites denticulata* (see Harris 1961, Fig. 27) but its size would be many times greater. Raciborski's Pl. 6, fig. 12 which shows some lateral displacement of the ends of tertiary rachises makes this unlikely and the specimen figured here in which they converge, diverge or pass into different planes makes it impossible. In any case no specimen gives evidence of such a lamina.

A likelier possiblity is that there is a narrow lamina concealed beneath each elongated crowd of sporangia. This is how Kilpper (1964) interprets his *Todites* sp. A, (Pl. 8, fig. 10 and Text-fig. 23), which certainly does look rather like Raciborski's *O. sturii*. I have no reason to question Kilpper's interpretation of his specimen.

The specimen eliminates this possibility. The rock has split obliquely. First the plane passes over or through the sporangia, then it goes deeper along the tertiary rachis showing sporangia along its sides, then deeper still through the sporangia beneath or along their outer ends. At no level is there any lamina. What more evidence is needed?

Comparison of *O. sturii*. The most similar specimens are some indifferently preserved fragments from the Yorkshire Bajocian described as *Osmundopsis sturii* (Raciborski) Harris 1961, p. 99. They were coaly compressions and gave balsam transfers and spores. The absence of any lamina was demonstrated and it was also clear that the sporangia were attached directly to a slender rachis branch, one (Harris 1961, Fig. 32 C) shows them distributed along the rachis but another Fig. 32 A shows some of them in clumps. Kilpper comments that there are discrepancies between my figures and the earlier ones, but does not specify them and thinks that my figures also may be subjective. Certainly the very different preservation makes them look different.

Raciborski (1894) also described two small specimens as *Osmunda microcarpa* which are distinguished by having sporangia only half as large as those of *O. sturii*. His opinion was that here also there is no lamina, but the evidence is less. I note that in a good many plants of *Osmunda regalis* the ripe sporangia were of almost uniform size even though some of the plants had suffered from drought, so their small size in *O. microcarpa* may constitute a valid distinction.

Osmundopsis plectrophora Harris 1931 from the Lower Lias of Greenland and the closely similar specimens described by Kilpper as cf. *Osmundopsis plectrophora* from the Lower Lias of Iran is well distinguished by its widely separated clumps of sporangia, further apart than in *O. regalis*. The material included large fragments from the top, middle and base of the leaf, all fully fertile, suggesting that the fertile leaf was fully fertile, not partly as in the living genus. And the occurrence in the field of a peculiar *Cladophlebis* with the fertile specimens suggested that this might belong to the same plant but proof of the first idea could only come from complete fertile leaves and of the second from a stem bearing both kinds of leaf.

There is little to show the form of the whole leaf *O. sturii* because the specimens are all on small pieces of rock. One is clearly from the top of the leaf and there are some fairly large secondary pinnae evidently from lower down but there is nothing to show how low. The leaf might be like *O. regalis* or it might be fully fertile and Raciborski had no reason to pick one particular sterile leaf as belonging to the same plant.

It seems to be the generally held view that the way *Osmunda* bears its sporangia is derived from the *Todea* way by failure of a lamina to grow, and then proliferation of sporangia all over the ultimate rachis branchlets. This view is supported by the occasional production in *Osmunda* of partly fertile pinnules with sporangia along the veins as in *Todea*.

The common kind of intermediate pinnule with a narrow lamina and marginal sporangial clumps gives no evidence. I merely remark that this idea receives

little or no support from the fossils. *Todites* is indeed far more abundant than *Osmundopsis* and slightly older, but each genus when first met is fully differentiated.

2. ***Klukia exilis*** (Phillips) Raciborski p. 22

Raciborski (1894) founded *Klukia* on magnificent specimens of sterile and fertile leaves from Grojec. He identified his material with Yorkshire Bajocian fragments first named *Pecopteris exilis* by Phillips (1829, Pl. 8, fig. 16), a poor figure and figured better by Lindley & Hutton (1837), as *Pecopteris obtusifolia* Pl. 158 and with details of the sporangia by Bunbury (1851, Pl. 13, fig. 5). In addition he described three other taxa, *Klukia exilis* var. *parvifolia*; *Klukia acutifolia* (Lindley & Hutton) for their *Pecopteris acutifolia* and *Klukia phillipsi* (Brongniart) for *Pecopteris phillipsi* Brongniart. All three species of *Pecopteris* had been collected in the Bajocian Gristhorpe Bed. Seward in 1900 dropped *P. acutifolia* and *P. phillipsi* along with many other names of fern fragments and later workers have agreed that they are unnecessary names for barely determinable bits probably from the large leaves of better known species.

Raciborski's three species and the variety were all based on both sterile and fertile specimens and their distinction was mainly in the dimensions and shape of the ultimate lamina lobes (pinnules). Seward (1900, p. 131) and Harris (1961, p. 132) suggested that all of Raciborski's specimens probably belonged to a single species and Harris suggested that this species was distinct from *P. exilis* but proposed no new name. As a result of examining the specimens I continue to think that all of Raciborski's specimens belong to a single species, but that this species is identical with the Yorkshire original specimens of *K. exilis*.

Klukia is abundant at Grojec and the collection includes many specimens besides those figured. In my judgement this series — both for the sterile leaf and for the more or less fully fertile leaf show intergradation in length, width and lobing of the pinnules, their crowding or wider spacing, their convex or flat surface. The sporangia also vary and intergrade in size. The pinnules of different specimens differ from one another no more and no less than do the pinnules from different parts of mature leaves of *Pteridium aquilinum* (including sun and shade leaves and ones that never grew large).

This is mere opinion but if it had been possible to prepare spores from the sporangia, the opinion might have been strongly supported or disproved. Spores agreeing well with one another have been isolated from Yorkshire pinnules of almost equally diverse shapes. All I can say of the difference between Yorkshire and Polish material is that while the ranges of form of the Polish and Yorkshire leaves overlap to a great extent, the more abundant Polish specimens include

a few leaves larger than any known in Yorkshire. Two have rachises 5 mm thick, the largest from Yorkshire is 3 mm.

The commonest Yorkshire form of leaf is near Raciborski's *K. exilis parvifolia*. I have not seen any with fertile pinnules as long as in his Pl. 26, fig. 1 or sterile ones as in his Pl. 7, fig. 18 and other Polish specimens are nearly as large. I made no statistical survey but am convinced that there is a difference in mean size. In Yorkshire perfectly flat sterile pinnules are unusual, most are somewhat convex above. In Poland most are flat but in the collection I found some as convex as in typical Yorkshire ones. In the fertile pinnules I had imagined that there was an absolute difference but I realise I was mistaken for a few Yorkshire ones are at least partly flat and certain Polish ones are strongly convex though I cannot say if the margin was recurved (Raciborski Pl. 7, fig. 17). Such a specimen would be normal in Yorkshire. I figure Polish specimens with convex pinnules.

It seemed hopeless to try to prepare spores from Raciborski's sporangia, but I tried it without success. But happily a core taken from Zabierzów near Grojec macerated in bulk by Reymanówna (1968) yielded the characteristic sporangia of *Klukia*, some still attached to lamina fragments (cf. also Jurkiewiczowa 1974).

Their matrix is a grey shale, unlike Raciborski's white clay but their age is probably similar because she found seeds of *Allicospermum retemirum* Harris in the core and also in the dumps from the old workings. Their spores are ripe, very well preserved and are mostly between 52 μm and 58 μm wide. They show very coarse reticulate sculpture over the outer surface and small papillae on their contact faces exactly as in Yorkshire spores of *K. exilis*. I gave the average diameter of Yorkshire *K. exilis* spores as 60 μm and the observed range as 35 μm and 80 μm (Harris 1961). It is possible that some of the Yorkshire spores may have swollen slightly because more vigorous maceration was needed than for the Polish ones. As far as sporangia and spores can be identified, they are the same as Yorkshire *K. exilis*.

I think the slight differences between the Polish and the Yorkshire *Klukia* leaves may have two causes, neither taxonomic. The Polish specimens are more numerous and thus more likely to provide exceptional forms, particularly rachises 5 mm thick. But I suggest a more favourable environment for fern growth led to the frequent occurrence in Poland of leaves with long, broad and flat pinnules in contrast to the mostly smaller and convex ones in Yorkshire. In the Yorkshire *Klukia* localities, Gymnosperms are far more abundant than ferns, but the opposite is true in Raciborski's flora where I imagine ferns were flourishing exceptionally, perhaps seldom experiencing drought while drought may have been more frequent in Yorkshire. A difference occurs in such British ferns as can flourish both in humid woods and on exposed hillsides; those in exposure have smaller and convex pinnules of thicker substance. The difference may be caused by the brighter light but the effect is to make them more xeromorphic.

I am happy to express my gratitude to the Polish Academy of Sciences for their invitation to visit Kraków, to the staff of the Botanical Institute and Geological Laboratory of the Polish Academy in Kraków and especially to Dr. Maria Reymanówna for all possible help.

Department of Geology, University of Reading, Whiteknights, Reading RG6 2AB

REFERENCES

Andrews H. N. 1970. Index of generic names of fossil plants, 1820—1950. U. S. Geol. Surv. Bull., 1013.

Boureau É. 1970. Traité de Paléobotanique. IV, fasc. 1, Masson et C^ie^, Paris.

Bunbury C. J. F. 1851. On some fossil plants from the Jurassic strata of the Yorkshire coast. Quart. J. Geol. Soc. London, 7: 179—194.

Harris T. M. 1931. The fossil flora od Scoresby Sound East Greenland. Medd. Grønland, 85(2): 1—104.

— 1961. British Museum Catalogue. The Yorkshire Jurassic Flora Part 1: *Thallophyta — Pteridophyta*. London.

Hirmer M. 1927. Handbuch der Paläobotanik. I. Oldenbourg. München u. Berlin.

Jurkiewiczowa J. 1974. Rozwój jury środkowej we wschodniej części obszaru krakowskiego (summary: Development of the Middle Jurassic in the eastern part of the Cracow region). Inst. Geol. Bull., 278: 201—239.

Kilpper K. 1964. Über eine Rät Lias-Flora aus dem nördlichen Abfall des Alburs-Gebirges in Nord Iran. Teil 1: *Bryophyta* und *Pteridophyta*. Palaeontographica, 114 B: 1—78.

Lindley J. & Hutton W. 1831—1837. The fossil flora of Great Britain: or Figures and descriptions of the vegetable remains found in a fossil state in this country. 3 vols. London.

Phillips J. 1829. Illustrations of the geology of Yorkshire: or, A description of the strata and organic remains of the Yorkshire coast. York.

Raciborski M. 1894. Flora kopalna ogniotrwałych glinek krakowskich. Część I. Rodniowce *(Archaegoniatae)*. Pam. Akad. Umiej., 18: 143—234, Kraków.

Reymanówna M. 1968. On seeds containing *Eucommiidites troedssonii* pollen from the Jurassic of Grojec, Poland. J. Linn. Soc. (Bot.), 61 (384): 147—152.

Seward A. C. 1900. Catalogue of the Mesozoic plants in the British Museum. Jurassic Flora I. The Yorkshire coast. London.

— 1910. Fossil Plants. II, Cambridge.

STRESZCZENIE

UWAGI O DWU JURAJSKICH PAPROCIACH OPISANYCH PRZEZ RACIBORSKIEGO

Raciborski (1894) w rozprawie o jurajskiej florze z Grojca koło Krakowa opisał *Osmunda sturii* Rac. i *Klukia exilis* (Phillips) Rac., co do których zostały później wysunięte pewne wątpliwości. Zagadnieniem tym zajął się profesor

T. M. Harris zapoznając się w 1976 r. z oryginalną kolekcją M. Raciborskiego, przechowywaną w Zakładzie Nauk Geologicznych PAN w Krakowie.

Kilpper (1964, s. 42) podał w wątpliwość, czy u *Osmunda sturii* — obecnie *Osmundopsis sturii* (Rac.) Harris — liście zarodnionośne rzeczywiście nie posiadają blaszki, podobnie jak u współczesnej *Osmunda*, czy też może jej blaszka liściowa była ukryta pod zarodniami. W tym bowiem przypadku okazy Raciborskiego należałyby do rodzaju *Todea* względnie *Todites*. T. M. Harris stwierdził jednak, że okazy Raciborskiego posiadają liście zarodnionośne pozbawione blaszki jak u *Osmunda*.

Inne wątpliwości były wysuwane w związku z *Klukia exilis*. Raciborski utworzył rodzaj *Klukia* na podstawie materiału liści z Grojca i uważał gatunek *K. exilis* za identyczny z okazami z Yorkshire nazwanymi przez Phillipsa (1829) *Pecopteris exilis*. Oprócz gatunku *K. exilis* Raciborski opisał trzy inne taksony rodzaju *Klukia*, które późniejsi autorzy uważali za należące do tego samego gatunku, tj. *K. exilis*. W 1961 r. T. M. Harris wyraził opinię, że gatunek ten był inny niż *K. exilis* z Yorkshire.

Po zbadaniu okazów Raciborskiego, profesor Harris zmienił zdanie i sądzi obecnie, że wszystkie one należą do jednego gatunku, który jest identyczny z *K. exilis* z Yorkshire. Ponieważ z oryginalnych okazów nie udało się uzyskać zarodników, T. M. Harris wymacerował zarodniki z luźnych zarodni *Klukia* pochodzących z sąsiadującego z Grojcem stanowiska i stwierdził, że zarówno zarodnie, jak i zarodniki nie różnią się od tych organów u *K. exilis* z Yorkshire. Różnice w wyglądzie liści *Klukia*, na podstawie których sądził on poprzednio, że w obu florach rodzaj ten był reprezentowany przez inny gatunek, są jego zdaniem wywołane różnicą w warunkach siedliska.

PLATE

TABLICA

Plate I

1. *Klukia exilis*, partly fertile leaf with depressed pinnule margins; A III 12/22; × 4
2. *Osmundopsis sturii*. The 1st (top,) 2nd and 4th pinnae are split obliquely and show the pinna rachis partly, elsewhere sporangia are seen above or below it; the 3rd is damaged and the 5th shows distinct clumps of sporangia; A III, 12/157; × 4
3. *Klukia exilis*, fully fertile; pinnule margins strongly depressed; A III 12/22; × 4

4,5. *Klukia exilis*, spore at high and at low focus. In 4 the verrucae are faintly visible near the top right edge; × 400

6. *Klukia exilis*, proximal surface of another spore; verrucae partly obscured by ridges of distal surface; (same sporangium as 4 and 5); × 400

Figs. 1—3 are of unfigured specimens in the Raciborski collection.
Figs. 4—6 spores from a *Klukia* sporangium in the Zabierzów borehole core.

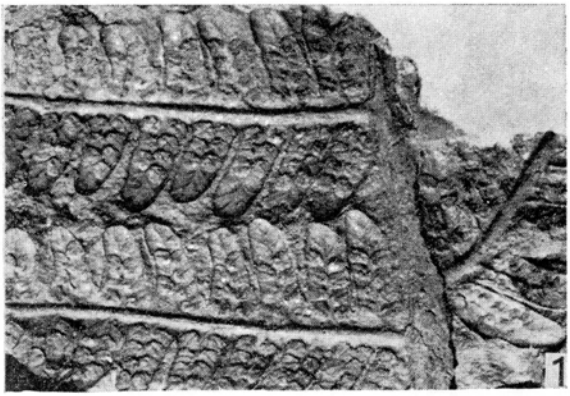
Tablica I

1. *Klukia exilis*, liść częściowo zarodnionośny o brzegach odcinków liścia zagiętych ku dołowi; A III 12/22; × 4
2. *Osmundopsis sturii*. Pierwszy (od góry), drugi i czwarty odcinek liścia jest pęknięty ukośnie i ukazuje częściowo osadkę, poza tym zarodnie są widoczne powyżej lub poniżej niej. Trzeci odcinek jest uszkodzony, a piąty ukazuje wyraźne grupy zarodni; A III 12/157; × 4
3. *Klukia exilis*, liść w całości zarodnionośny; brzegi odcinków liścia silnie zagięte ku dołowi; A III 12/22; × 4

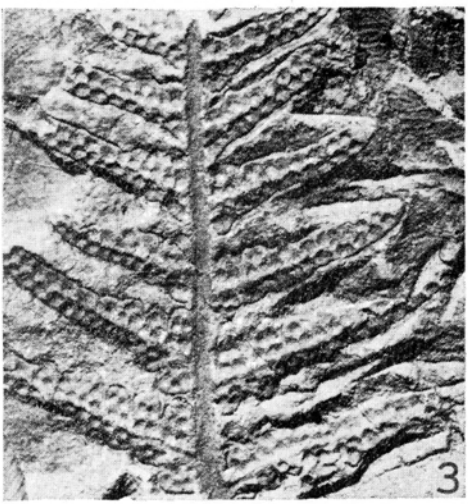
4,5. *Klukia exilis*, zarodnik w górnym i dolnym poziomie ostrości. Na 4 brodawki słabo widoczne w pobliżu prawej górnej krawędzi; × 400

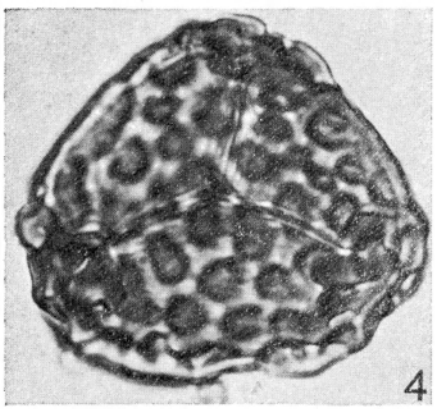
6. *Klukia exilis*, proksymalna powierzchnia innego zarodnika; brodawki częściowo zasłonięte przez listewki powierzchni dystalnej; × 4000

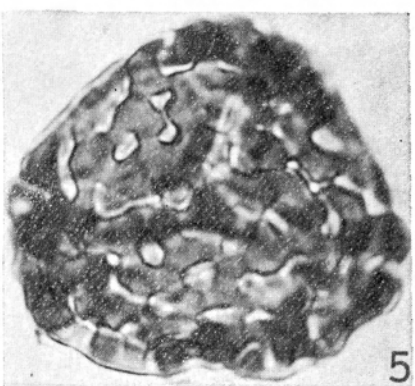
Fot. 1—3 pochodzą z okazów kolekcji Raciborskiego, które nie były zilustrowane w jego monografii. Fot. 4—6 przedstawiają zarodniki z zarodni *Klukia* uzyskanej z wiercenia w Zabierzowie.

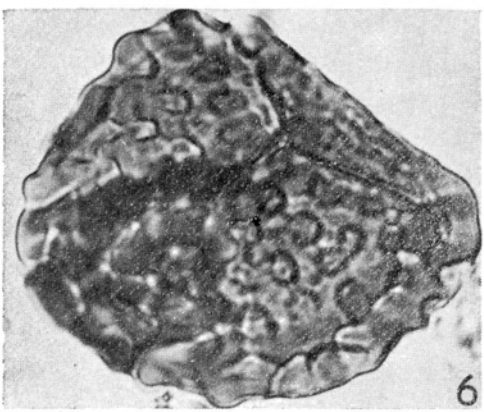

1


2


3


4


5


6