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MICROSTRUCTURE OF THE TECTUM SCULPTURE VISIBLE UNDER SEM – A DIAGNOSTIC FEATURE FOR THE BOTANICAL AFFINITY OF FOSSIL POLLEN SPECIES

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ABSTRACT. In the Konin region, central Poland, are two brown coal seams of economic importance. The lower seam is dated as Middle Miocene and reaches a thickness of 90 metres. It formed only in small, isolated tectonic depressions and is worked in the Lubstów area. The pollen assemblages from this seam are dominated by conifer pollen, followed by angiosperm pollen containing a large number of tricolporate grains such as *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug, *T. dolium* (Potonié) Thomson et Pflug and *T. villensis* (Thomson) Thomson et Pflug. As the pollen material is perfectly preserved, the authors have attempted a more detailed classification of species of the *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug group on the basis of the exine sculpture visible under SEM. The sculpture changes observed under SEM in the fossilised material of *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug sensu lato examined can be arranged in a morphological sequence which proves the existence of similarities between the constitution of the structure of the fossil species and the Fagaceae (subfamily Fagoideae).

KEY WORDS: Middle Miocene, Poland, pollen grains, tectum sculpture, SEM, Fagaceae

INTRODUCTION

In the area of the Polish Lowlands in central Poland (Fig. 1), the Neogene continental sediments (created by rivers and lakes) with brown coal seams of various thickness are deposited on layers of marine Upper Cretaceous and Palaeogene deposits. The continental conditions of sedimentation and erosion existing in the Polish Lowlands during the Upper Oligocene and Miocene periods prove that there existed a system of rivers flowing across the swampy area of the contemporary Polish and German Lowlands towards the basin of the pre-North Sea. Continental sediments (of river, lake and swamp origin) formed a structure consisting of many layers and seams of brown coal. In the Konin region two of these seams are of economic importance, the lower one being exploited in the Lubstów area and the upper in several outcrop workings near Konin (Fig. 2 – Niesłusz, Morzysław, Gosławice, Jóźwin, Kazimierz and Pątnów).

DESCRIPTION OF THE SEAMS

The lower seam, reaching a thickness of 90 metres and dated at Middle Miocene, formed only in small and isolated tectonic depressions which were overgrown with lake and swamp vegetation (Piwocki 1994). A river sand layer of varying thickness occurs between the lower and upper seams. Cones, mainly of *Pinus*, have very often been found in these sands; they were roughly described in a master thesis. Above the sand layer, in many places near Konin (Fig. 3), there developed the so-called first brown coal seam dated to the Middle Miocene (Piwocki & Ziembińska-Tworzydło 1997); this narrow (6–15 metres) seam has been exploited for 50 years in several open-cast workings. In the uppermost part of the first seam a layer of tuffaceous sediments was discovered related to the Neogene volcanic period in the Paratethys region (Matl & Wagner 1987). Above this layer can be seen a thick layer of clay sediments with sand layers and pockets belonging to the Poznań Formation. These clays are associated with a shallow, freshwater environment. So far, no marine or brackish influence has been detected in the Neogene deposits of the Konin region.

The Konin Neogene flora has been studied several times with both macroflora and microflora remains being examined. Kremp's palynological studies in 1949 represent the earliest palaeobotanical research work from this region and were based on material from the first Morzysław open-cast mine. The next palynological studies were on profiles from the Gosławice open-cast mine (Mamczar 1960) and from drillings near the Pątnów mine (Sadowska & Giża 1991). The palynological profiles and xylitic macroflora described by Smólska (1959)

Fig. 1. Map of Poland

came from the upper exploited seam, while leaf and seed macroflora have also been described from the superstratum of this seam (Raniecka-Bobrowska 1954, 1959).

The lower seam, exploited nowadays only in the Lubstów area, has palynological descriptions of two drillings (Domagała 1982, Ciuk & Grabowska 1991), both descriptions being of a stratygraphical character. No macroflora remains have been found in the coal from the lower (Lubstów) seam. The petrography of this coal is unique. It is a detrital compact coal having a shell fracture lacking xylites or other plant parts. This homogeneous nature of the coal is also apparent in its microscopic image. The whole mass of coal is composed of amorphous humus with perfectly preserved pollen grains and isolated samples of fungal hyphae and spores.

The pollen assemblage visible in the spectrum is very rich and variable, but it changes only slightly over the whole profile (Fig. 4). Conifer pollen clearly predominates, primarity the saccate pollen of mainly *Pinus* and *Cathaya*; *Picea, Podocarpus* and *Tsuga* are rarely found. Non-saccate coniferous pollen is also richly represented, e.g. by *Sequoia, Sciadopitys* and *Cunninghamia*, with *Glyptostrobus* and *Taxodium* being present in small quantity.

Next in importance comes angiosperm pollen containing a large number of tricolporate grains, generally axially elongated, with pores set in the equator and with a more or less exposed thickening of colpi near the pores (costae colpi type). The shape of the grain is generally ellipsoidal, the polar areas being broadly to narrowly rounded. The colpi are long and vary from being straight to strongly bent in the equatorial part. The tectate grain sculpture ranges from granular to verrucose. Pollen grains with this morphology are usually classified into a fossil species group whose botanical affinity is still not clear. This group contains *Tricolporopollenites pseudo-*

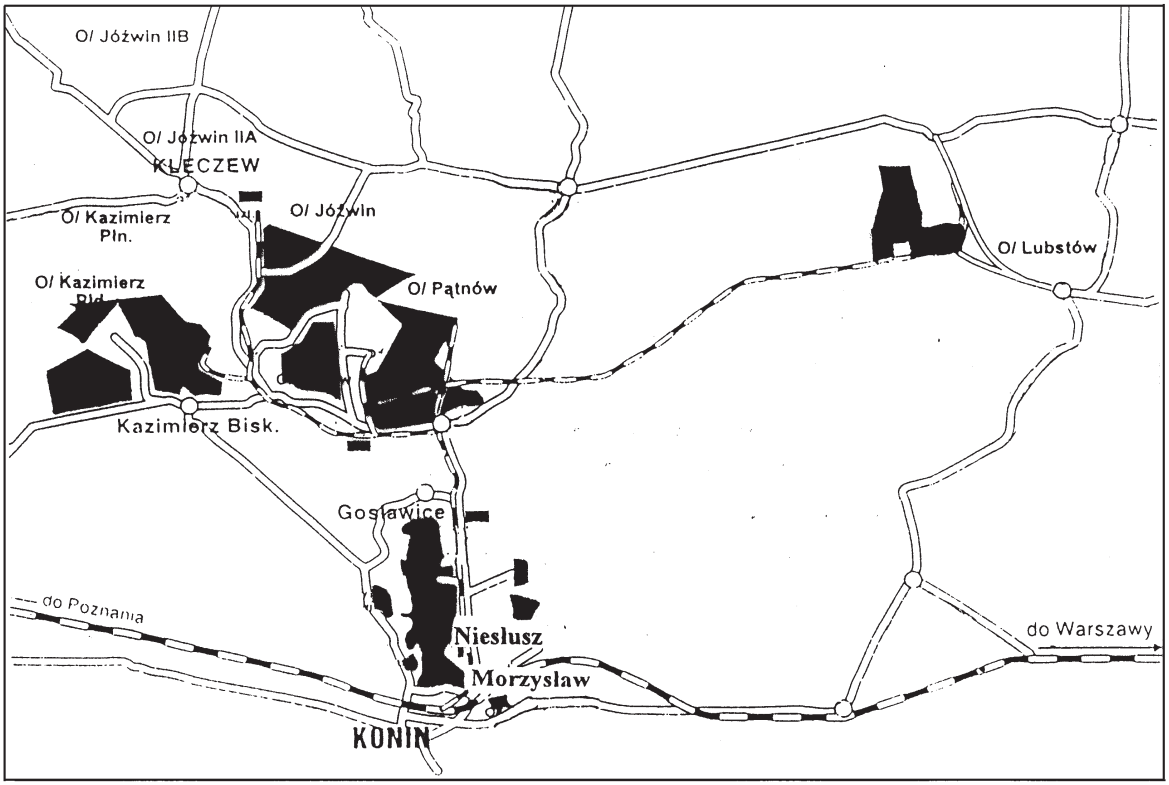

Fig. 2. Open-cast workings near Konin (Niesłusz, Morzysław, Gosławice, Jóźwin, Kazimierz and Pątnów)

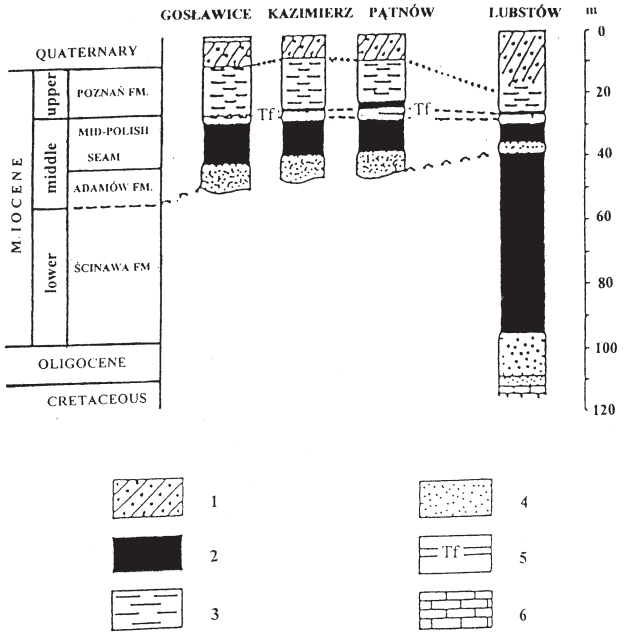

Fig. 3. Miocene brown coal sediments in the Konin area (after Matl & Wagner 1987) **1** – Quaternary till, **2** – brown coal, **3** – clay and silt, **4** – sand, **5** – tuff intercalation, **6** – Cretaceous limestone

cingulum (Potonié) Thomson et Pflug, *T. dolium* (Potonié) Thomson et Pflug and *T. villensis* (Thomson) Thomson et Pflug.

RESULTS

As the pollen material is perfectly preserved the authors have tried to make a more detailed classification of the species in the group on the basis of the exine sculpture visible under SEM. The main purpose of our research was examining to what extent it is possible to determine the botanical affinity of the analysed fossil taxa.

At the beginning of their research the authors found difficulty in determining the concept of the species *"pseudocingulum*" and *"dolium*" as defined by Potonié (1931a, b, 1934), Potonié & Venitz (1934) and Thomson & Pflug (1953). Thomson and Pflug (1953) agree that both these species were introduced by Potonié. However, from several different morphological types of the same species given by Potonié, Thomson and Pflug (1953) chose only one. As a result of this approach a morphological type for the species *"pseudocingulum",* as understood by Thomson and Pflug (1953, Pl. 12, figs 99–105), became a type of the species *"dolium",* as understood by Potonié (1931a, Pl. 1, fig. V45d) and Potonié et Venitz (1934, Pl. 3, figs 77–80), i.e. "a tricolporate pollen grain with colpi bent at the equator". On the other hand, a type of the species *"dolium"* according to Thomson and Pflug (1953, Pl. 12, figs 113–117) was a type of the species *"pseudocingulum"* according to Potonié (1931b, Pl. 1, figs 2–4 and 1934, Pl. 3, figs 28, 29) i.e. "a tricolporate

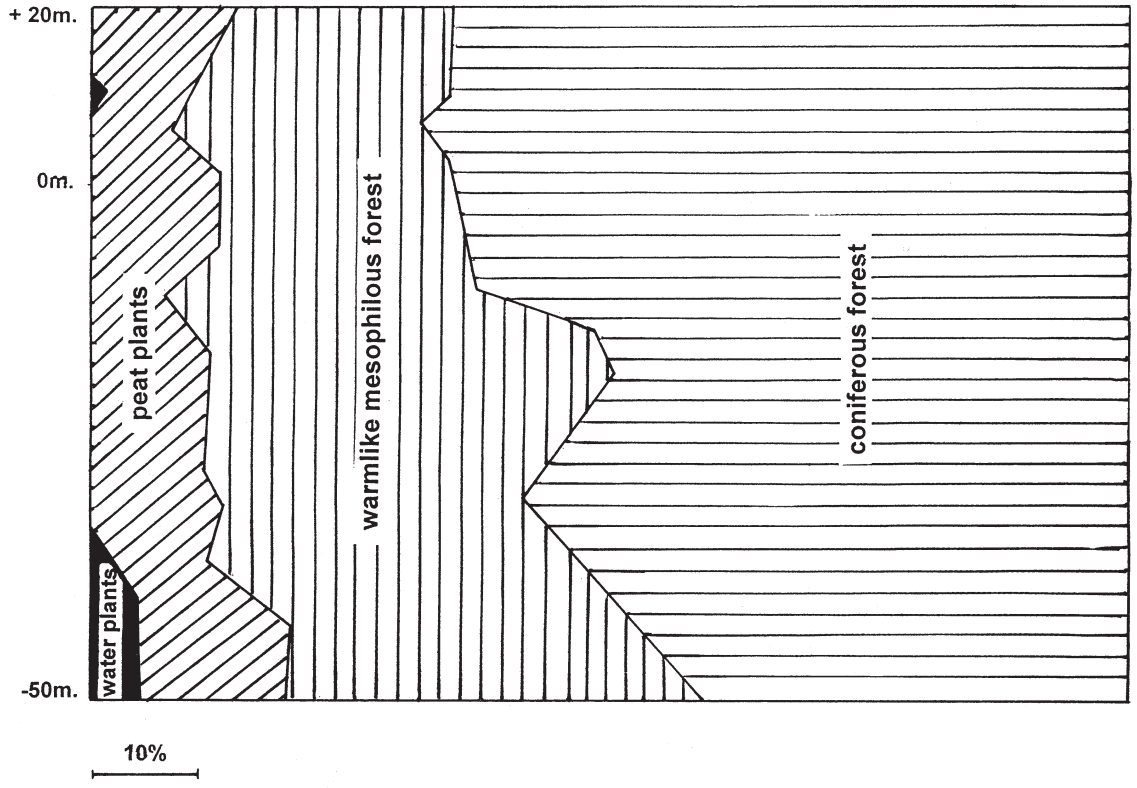

Fig. 4. Pollen assemblages from Lubstów brown coal mine

pollen grain with straight and +/- parallel colpi". Later clarification by the creator of the species *"pseudocingulum"* and *"dolium"* (Potonié 1960) was disregarded and in the literature there prevailed the concepts of the two species proposed by Thomson and Pflug (1953). On this basis the authors decided to accept the diagnosis of the species *Tricolporopollenites pseudocingulum, T. dolium* and *T. villensis* from Thomson and Pflug (1953). Up to the present, in the palaeobotanical literature, these taxa have been regarded as botanically related to contemporary representatives of the Anacardiaceae, Araliaceae, Cornaceae and Fagaceae.

The sculpture of the analysed fossil species is visible under SEM, making it possible to construct a morphological sequence of changes in this sculpture comparable with that of the pollen grains of the contemporary Fagaceae wich is divided into three subfamilies: the Fagoideae (*Fagus*), Castaneoideae (*Castanea*) and Quercoideae (*Quercus*). Among the contemporary representatives of this family occur three different morphological groups of pollen grain sculpture (observable under SEM). The Fagoideae pollen grain sculpture takes the form of irregularly merged rodlets with separate ends projecting upwards (Pl. 1, figs 1, 2); the Castaneoideae pollen grain sculpture takes the form of thin parallel rodlets more or less regularly arranged and grouped in bundles (Pl. 1, figs 5, 6); the Quercoideae pollen grains have a tubercular sculpture formed by partially merged rodlets (Pl. 1, figs 3, 4). On the basis of the observations carried out under SEM it may be concluded that the sculpture of the contemporary Fagacae consists mainly of single bacula arranged in different ways in the three subfamilies.

The sculpture changes observed under SEM in the examined fossil species of the *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug group can be arranged in a morphological sequence which demonstrates the existence of similarities between the structures of the pollen grains of the fossil species and those of the Fagaceae. The sequence reveals the gradual merging of separate and irregularly distributed rodlet-type elements in the sculpture. In the first stage (Pl. 2, figs 1–3) — *Tricolporopollenites pseudocingulum* type 1 (to be described as a new species) – the rodlets merge forming separate valla that tend to fold. Initially on the surface of valla there are visible separate primary elements. At the next stage (Pl. 2, figs 4–6) — *Tricolporopollenites pseudocingulum* type 2 (*Tricolporopollenites pseudocingulum* sensu stricto*.)* – the vallum-forming elements continue to merge and the primary structure gradually disappears. The valla formed by the merged bacula are tightly coiled; on their surface there are visible cuts of various depth. At the final stage (Pl. 2, figs 7–9) — *Tricolporopollenites pseudocingulum* type 3 (*Tricolporopollenites theacoides* (Roche et Schuler) comb. nov.) – the valla surface is almost flat; the elements which have merged completely are barely detectable and resemble tiny, almost invisible, ribs. Observations of the sculpture carried out under SEM show that within the whole group of the studied fossil species *Tricolporopollenites pseudocingulum* sensu lato, there is a basic similarity of structure. The surface develops from the same primary elements which form different types of sculpture during the process of merging. Under LM this is only partially visible and can be observed as changes in the surface sculpture from granular to verrucose (Pl. 2, figs 3a, b, 6a, b, 9a, b). From the sequence of surface changes visible under SEM described above, it may be concluded that the fossil species which, up to the present, have been classified taxonomically as the *Tricolporopollenites pseudocingulum* group on the basis of morphological similarities visible under the light microscope, are closely related. Their pollen has the same type of sculpture as that found in the pollen of the Fagaceae, and the morphological sequence shows an especially close relation to the subfamily Fagoideae.

Evolutionary trends in the morphology of the tectum of Fagaceae pollen will be the subject of further studies.

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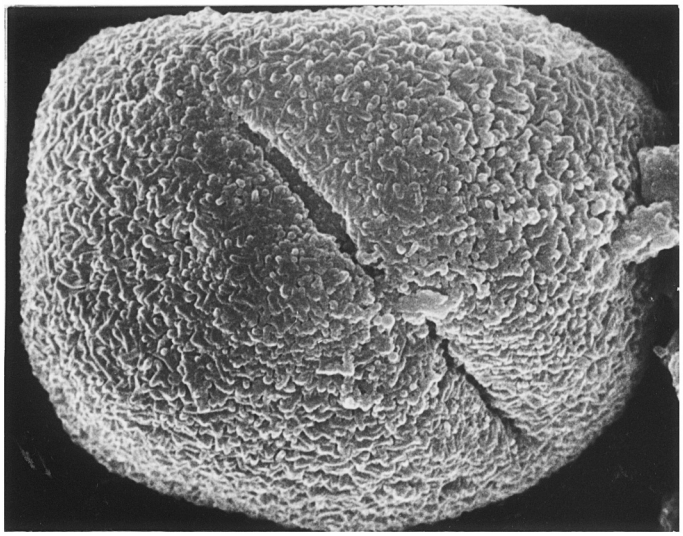
PLATES

Plate 1

1. *Faguspollenites verus* Raatz; Lubstów, Lower Miocene, SEM
   1a. – general view, × 3000
   1b. – part of sculpture, × 12000
2. *Faguspollenites verus* Raatz; Lubstów, Lower Miocene, LM, × 1000
   2a, b. – two optical sections
3. *Quercoidites henrici* (Potonié) Potonié, Thomson, Thiergart; Lubstów, Lower Miocene, LM, × 1000
4. *Quercoidites henrici* (Potonié) Potonié, Thomson, Thiergart; Lubstów, Lower Miocene, SEM
   4a – general view, × 4000
   4b – part of sculpture, × 8000
5. *Castaneoideaepollis pusillus* (Potonié) Grabowska; Lubstów, Lower Miocene SEM
   5a – general view, × 5000
   5b – part of sculpture, × 10000
6. *Castaneoideaepollis pusillus* (Potonié) Grabowska; Lubstów, Lower Miocene LM
   6a, b, c – three optical sections, × 1000



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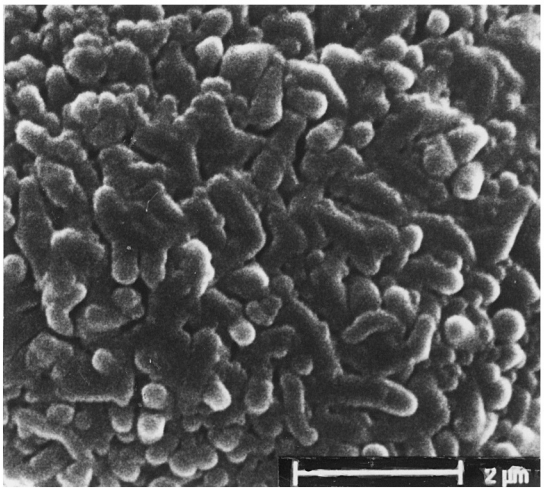

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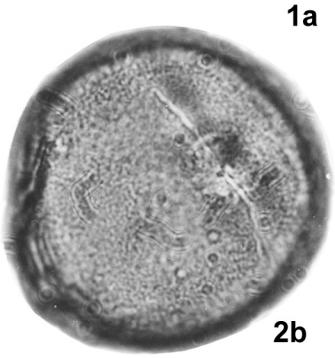

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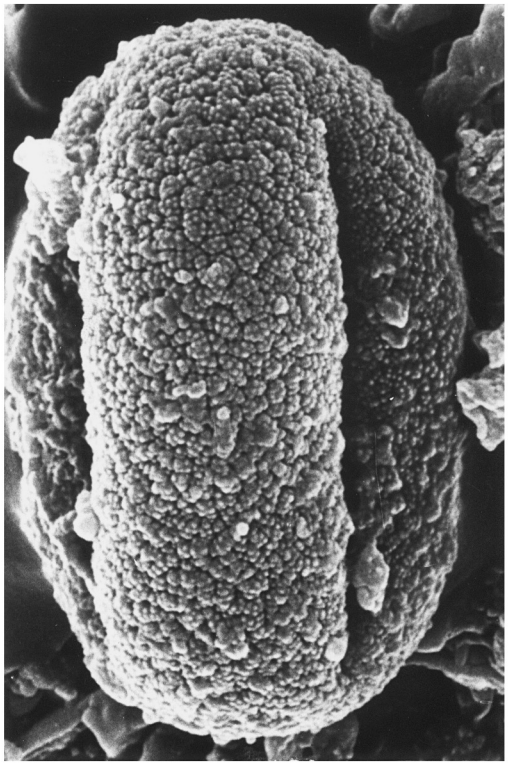

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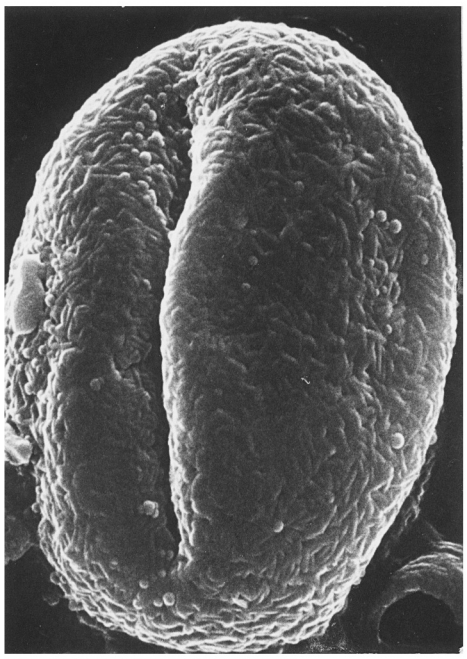

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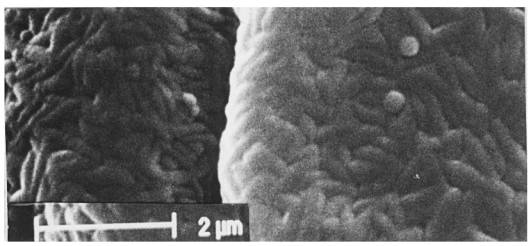
6a

6b



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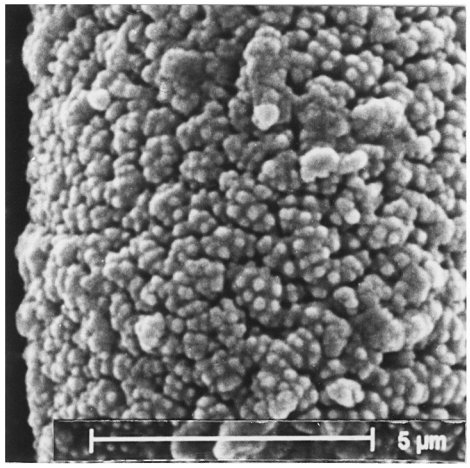


4b

Plate 2

Changes in tectum sculpture of the fossil *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug group observed under SEM and LM.

stage I — rodlets merge forming separate valla that tend to fold (figs 1–3)

1a. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 1, general view under SEM, × 2000

1b. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 1, part of sculpture under SEM, × 8000

2. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 1, rough sketch of sculpture

3a, b. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 1 under LM two optical sections, × 1000

stage II — The vallum-forming elements continue to merge and the primary structure gradually disappears (figs 4–6)

4a. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 2, general view under SEM, × 2000

4b. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 2, part of sculpture under SEM, × 10000

5. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 2, rough sketch of sculpture

6a, b. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 2 under LM, × 1000, two optical sections

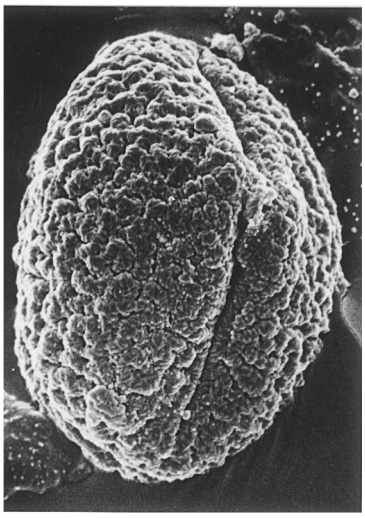
stage III — valla surface almost flat, elements that have merged completely are barely discernible (figs 7–9)

7a. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 3, general view under SEM, × 2500

7b. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 3, part of sculpture under SEM, × 20000

8. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 3, rough sketch of sculpture

9a, b. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug type 3 under LM two optical sections, × 1000



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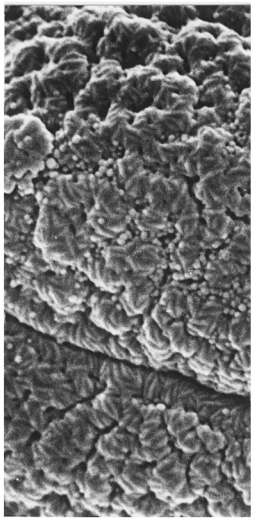

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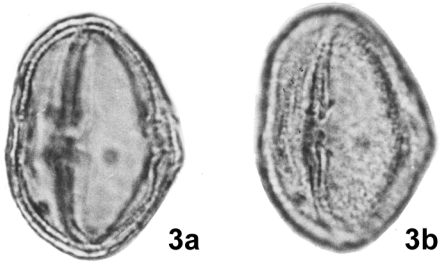

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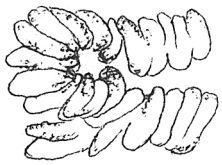

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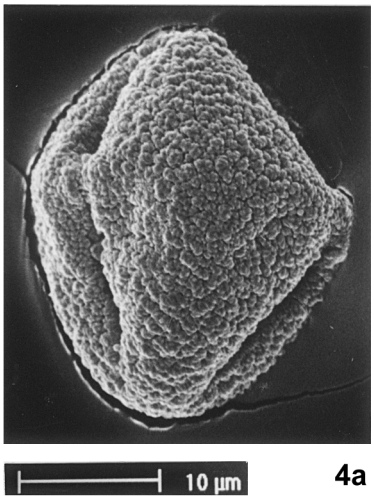

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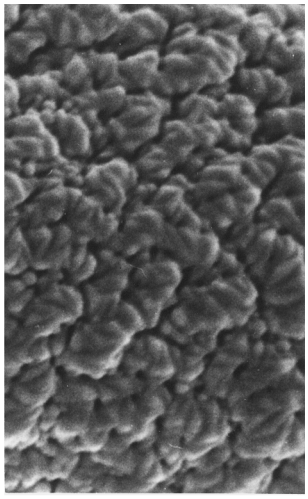

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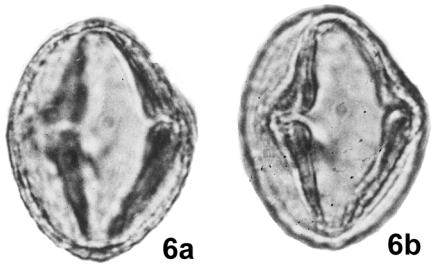

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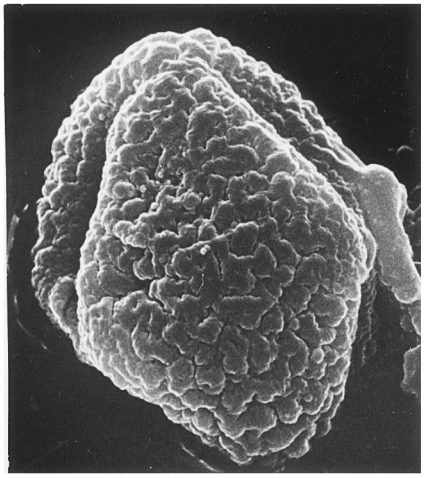
5



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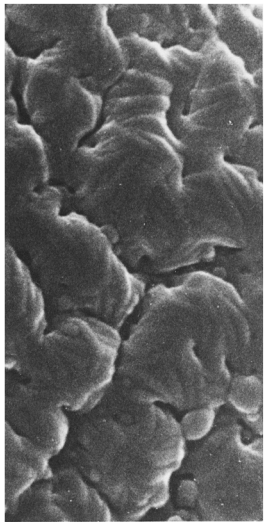

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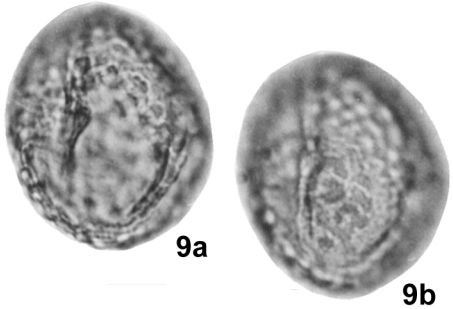

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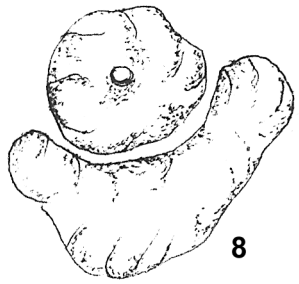

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