

ON MONOSULCATE AND DISULCATE POLLEN GRAINS FROM THE ALBIAN-TURONIAN IN KAZAKHSTAN

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ABSTRACT. In the pollen floras of the Albian of Western Kazakhstan and the Cenomanian-Turonian in Northern Kazakhstan, monosulcate pollen of early Cretaceous form genera such as *Clavatipollenites* (*C. incisus* and *C. hughesii*), *Asteropollis asteroides*, *Retimonocolpites* and *Liliacidites* has been discovered. For correct determination of their systematic affinity they have been investigated under the SEM. Their exine is typically angiospermous with a reticulate tectum and columellae. Despite their close similarity, they do have some specific features. Alongside monosulcate pollen in the Cenomanian-Turonian, circular monosulcate and disulcate pollen occurred which perhaps implies the existence of an independent evolutionary line which led to the appearance of monocotyledons.

KEY WORDS: Albian, Senomanian-Turonian, pollen, ultrastructure, monocotyledons, evolution

INTRODUCTION

In the Upper Albian deposits of Western Kazakhstan (Daukara, Northern Priaralye) and the Cenomanian-Turonian deposits of Northern Kazakhstan (Sokolovka and Sarbay Quarries, northern Turgay Lowland), a rich assemblage of well-preserved pollen of flowering plants in association with spores has been discovered. These findings are interesting for their phylogenetic implications. Records of monosulcate pollen are discussed widely in connection with the origin of angiosperms, their phylogenetic trends and global distribution.

RESULTS

In the Cretaceous deposits of Kazakhstan occur *Clavatipollenites*, *Asteropollis asteroides* Hedlund et Norris, *Retimonocolpites*, *Liliacidites* and two types of disulcate pollen. *Clavatipollenites incisus* Chlonova (Pl. 1, figs 1, 2) was of Albian age while *C. hughesii* Couper (Pl. 1, figs 3, 4) was detected in the Cenomanian-Turonian deposits. The first and oldest *Clavatipollenites* fossil pollen to be discovered was described by Couper (1958) as *Clavatipollenites hughesii* from Barremian deposits in England, and possesses morphological features which are similar to those of modern *Ascarina* pollen (Chloranthaceae). Nowadays there is absolutely no doubt about attributing it to angiosperms as, since 1958, early angiosperm pollen has been found on different continents and in deposits of various ages, including the Barremian in England, Africa, continental Europe and some

regions of North America (Couper 1958, Huhges 1958, Kemp 1968, Doyle 1969, Doyle *et al.* 1977). *Clavatipollenites* pollen has recently been recorded in Albian deposits in Canada and Australia (Dettman 1973, Norris *et al.* 1975, Burger 1981). In Russia the first record of *Clavatipollenites* came from the Albian? – Cenomanian of Western Siberia (Chlonova 1976). Early Cretaceous monosulcate pollen has been described for other regions of Russia also (Vachrameev & Kotova 1977, Kotova 1979).

Since *Clavatipollenites* was found for the first time, new angiosperm taxa have been established on the basis of exine structure (Kemp 1968, Pierce 1961, Doyle *et al.*, 1975, Paden Phillips & Felix 1971, Chlonova 1977, Juhász & Góczán 1985) which differ from one another in reticulum detail and sulcus configuration. A number of diverse morphological types can be observed in sediments of the Potomac Formation of the Early Cretaceous (Doyle 1969, Walker & Walker 1984).

Frequently fossil species are difficult to distinguish under the LM which is inadequate for assessing the development of the tectate reticulum over the columellae. In early descriptions the *Clavatipollenites* reticulum was characterized as having distinct columellae (Couper 1958) or even as being retipilate. SEM micrographs show that the exine is intermediate between tectate-perforate and semitectate (Doyle *et al.* 1975, Walker & Walker 1984).

TEM studies of exine structure and stratification are of great importance. Synthesis of the available data sug-

gests that many structural characters are of systematic and phylogenetic significance. TEM examinations have shown (Doyle *et al.* 1975) that *Clavatipollenites hughesii* bears a columellar ectexine, while the thick nexine is composed almost entirely of footlayer. The authors were uncertain about the possible presence of a thin discontinuous inner layer (endexine) in areas remote from apertures. However, near apertures such a layer exists and differs from conspicuously lamellated footlayer, endexine being thick and irregularly sculptured on the inner side. Comparison of the ultrastructure of the exine of *Clavatipollenites hughesii* (Doyle *et al.* 1975) and *C. incisus* carried out by Chlonova and Surova (1988) have shown obvious differences between them. A thick lamellate endexine and a thinning of the footlayer near apertures – both characterize *C. incisus*. This species reveals a greater resemblance to the modern pollen of *Ascarina* than does *C. hughesii*. It is worthy of mention that preserved pollen of *Clavatipollenites* type has been found adhering to the stigmas of fruits extracted from the Earliest Cenomanian sediments of the Atlantic Coastal Plain (Pedersen *et al.* 1991). These pollen grains under the SEM looked like *C. hughesii* but the TEM revealed peculiarities in the structure of the endexine and footlayer in the aperture region. In contrast to *C. incisus* and *C. hughesii* the footlayer was thick and homogeneous near the aperture, while the endexine formed a massive granular layer there, i.e. the nexine structure of this species was characterized by an absence of evident lamellae. Comparison of the exine structure and stratification demonstrated three different types of exine arrangement in the pollen grains of *Clavatipollenites* and confirmed the existence of diverse relationships with different magnoliids (Walker & Walker 1984, Chapman 1987, Chlonova & Surova 1988, Pedersen *et al.* 1991).

Hedlund and Norris (1969) described *Asteropollis asteroides* from the Albian sediments of Oklahoma which is related to *Clavatipollenites*. Its pollen grains are radially symmetrical, heteropolar, oblate in equatorial and circular in polar views, having an special asteroid polar aperture and semitectate columellate exine. In our fossil material the pollen bears exclusively tetrachotomosulcate apertures – other modifications of the aperture, e.g. penta- or hexachotomosulcate, are not found at all (Pl. 1, figs 5, 6).

In the Cenomanian-Turonian pollen floras of Kazakhstan another reticulate monosulcate form was discovered, known as *Retimonocolpites* sp. (Pl. 1, figs 7, 8). This species is represented by small pollen grains of elongate or elliptical outline, with sulcus encircling the grain and dividing it into two more or less equal halves, and semitectate, columellate exine whose structure shows a definite similarity with that of *Clavatipollenites*. Pollen grains of this species could be identified with adequate precision since one of their distinctive features was

revealed by the SEM. It showed supratectate elements covering the surface of muri bearing parallel bands arranged so that they are continuous or became interrupted in the centre of the muri (Walker & Walker 1984).

In addition to *Clavatipollenites*, *Asteropollis*, *Retimonocolpites* and *Liliacidites* (Pl. 2, figs 7, 8) the fossil material contained disulcate pollen (Pl. 2, figs 1–6) probably connected with monocotyledons. Disulcate pollen has well-developed columellae and a fine reticulum, resembling the monosulcate *Clavatipollenites*. This type of pollen bears a semitectate-columellate exine and short lateral sulci covered by a membrane with small granules. Sometimes the membrane was lost during sedimentation (Pl. 2, fig. 4). This pollen possesses two types of reticulum – one without supratectate elements in the lumina of reticulum (Pl. 2, figs 1–3, 5), while the other has distinct supratectate elements in the form of tubercles frequently covering lumina (Pl. 2, figs 4, 6). These pollen grains possess sulci dividing the grain into two equal parts as shown in Pl. 2, figs 3, 4. Similar pollen occurs among both dicotyledons and monocotyledons. Pollen of disulcate type is found in primitive angiosperms (e.g. some of the Calycanthaceae, and Monimiaceae) described as having distal apertures (Erdtman 1952). Among monocotyledons some taxa of the Araceae, Liliaceae, Dioscoreaceae, Arecaceae and Amaryllidaceae possess a definite affinity with disulcate fossil forms. The pollen of *Calla palustris* L. (Araceae) has two sulci dividing the grains into two equal parts and a perforate tectum. *Tofieldia* pollen is semitectate-reticulate and *T. coccinea* Richards. even has supratectate elements like the fossil pollen (Pl. 2, fig. 6) which we studied earlier.

On the basis of the stratigraphic distribution of early angiosperm pollen types in the Barremian-Cenomanian of the Potomac Group of the Atlantic coastal plain of the USA, Wolfe *et al.* (1975) proposed an evolutionary scheme for angiosperms. This was based on generalized tectate-columellate monosulcate *Clavatipollenites*, *Retimonocolpites* spp. pollen type which gives two independent evolutionary lines. One reflects the evolution of the dicotyledons in which, in the authors' opinion, tricolpate pollen can originate from the monosulcate type through a reduction in the polar part of the asteroid aperture and the transformation of three radii into equatorial colpi. Another evolutionary line represents the monocotyledons. The first and only link in the scheme is presented by *Liliacidites* spp. from the Middle Albian. The circular sulcate pollen of *Retimonocolpites* sp. and the disulcate pollen in the Cenomanian-Turonian deposits of Kazakhstan represent more advanced types than the monosulcate pollen of *Liliacidites*. Probably they represent subsequent links which continue the independent evolutionary line leading to the appearance of modern monocotyledons.

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PLATES

Plate 1

- 1, 2. *Clavatipollenites incisus*, SEM, Daukara, Upper Albian
1 – whole grain, proximal side, $\times 1600$, 2 – exine surface, $\times 8400$
- 3, 4. *Clavatipollenites hughesii*, SEM, Sarbay, Cenomanian-Turonian
1 – whole grain, distal side $\times 2600$, 4 – exine surface, $\times 8800$
- 5, 6. *Asteropollis asteroides*, SEM, Sokolovka, Cenomanian-Turonian
5 – distal side, $\times 2300$, 6 – exine surface, $\times 11000$
- 7, 8. *Retimonocolpites* sp., SEM, Sarbay, Cenomanian-Turonian
7 – whole grain with circular sulcate aperture, $\times 1500$, 8 – exine surface, $\times 8000$

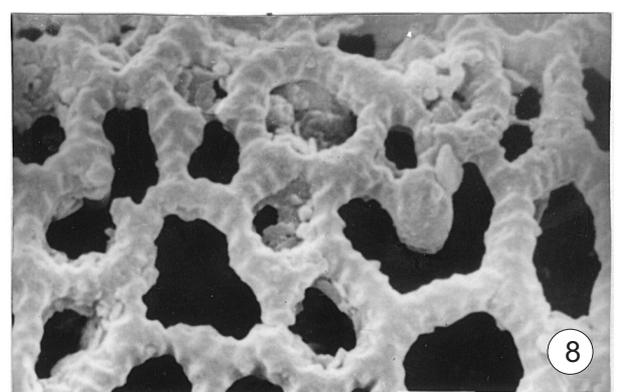
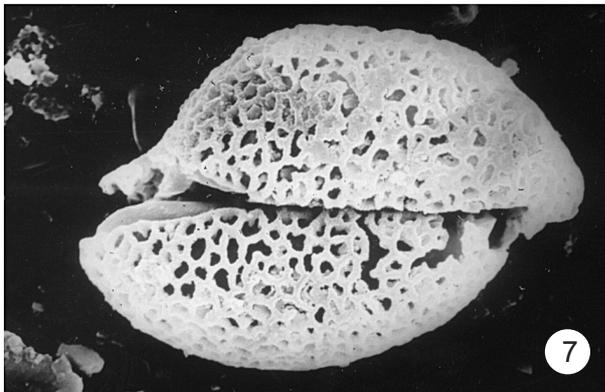
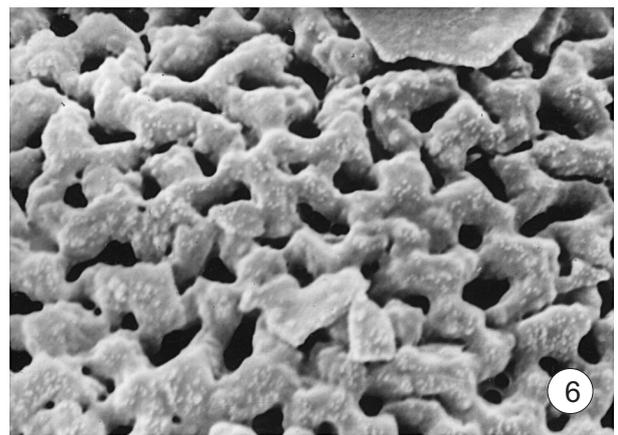
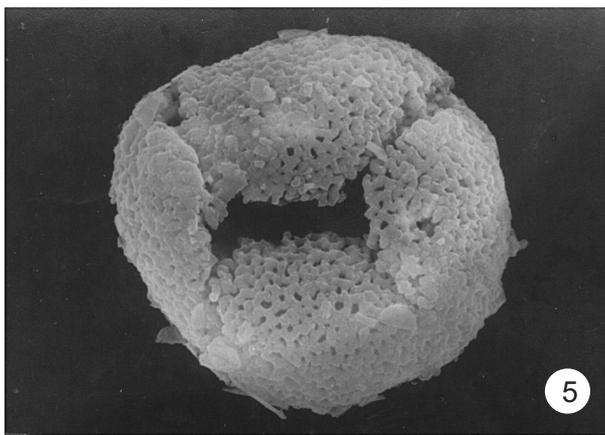
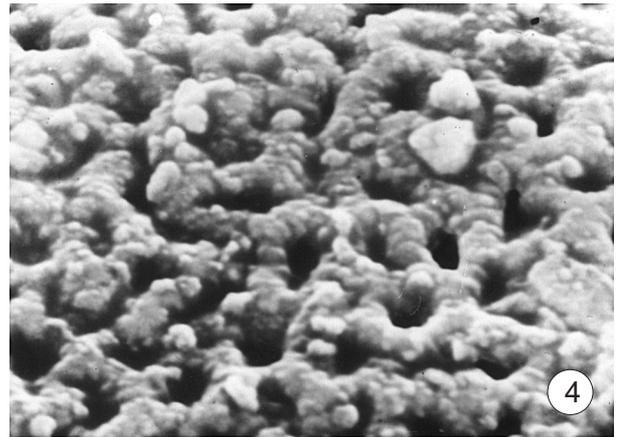
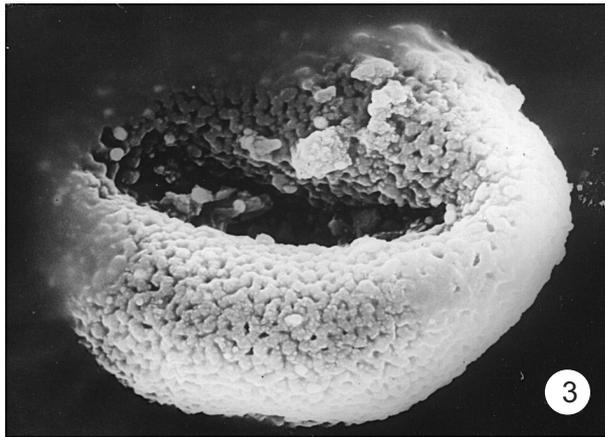
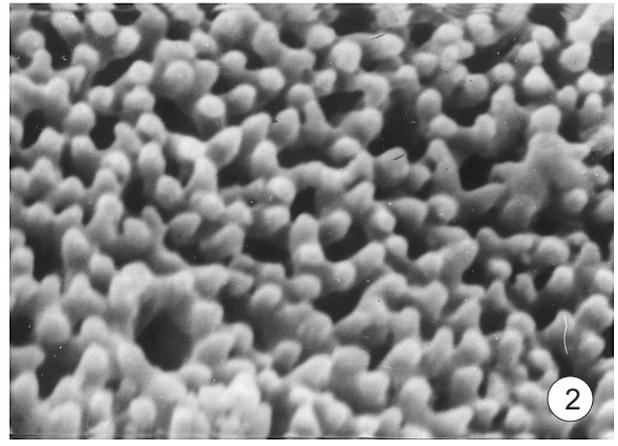


Plate 2

- 1–6. Disulcate pollen grains, SEM, Sarbay, Cenomanian-Turonian
1–4 – whole grains in different positions, (1 – \times 2500, 2 – \times 2800, 3 – \times 2700, 4 – \times 2200) 5, 6 – exine surface (6 – some lumina of the reticulate tectum covered with tubercles, \times 8000, 5 – \times 6900)
- 7, 8. *Liliacidites* sp., SEM, Sokolovka, Cenomanian-Turonian
7 – whole grain (colpa orbicula visible on the left), \times 2000
8 – exine surface, \times 11100

