

Exine Ultrastructure in Pollen Grains of *Classopollis* Pflug from the Cretaceous of Lebanon

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Abstract—Pollen grains of *Classopollis* Pflug from the Cretaceous deposits of Lebanon were studied by means of light and electron microscopy. Ultrastructurally, they are similar to pollen grains, extracted from *Classostrobus comptonensis* Alvin, Spicer et Watson from the Barremian of England. The differences concern the shape and size of spinules, ultrastructure of apertural regions, and preservation of the endexine. An analysis of our data and published results revealed three types of infratectum existed in members of Circumpolles: (1) with branchy elements, (2) with columella-like non-branching elements, and (3) with large granules arranged in one row. The palynological assemblage is described in detail; problems of dating are discussed.

Key words: Cheirolepidiaceae, exine sculpture, exine ultrastructure, Cretaceous, Lebanon.

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INTRODUCTION

Due to long-time intensive electron-microscopic studies of *Classopollis* Pflug, this genus represents a promising object for study of evolution in palynomorphological characters (Petrosianz and Bondarenko, 1983; Pocock et al., 1990; Kedves, 1994). The earliest members of the genus are described from the Late Triassic. Members of the genus are numerous in the Jurassic and Cretaceous deposits worldwide. The long geological history of the genus as well as already accumulated data on the morphology and ultrastructure of its members of different ages allow one to estimate the morphological diversity of the genus throughout its existence, to trace changes in the exine ultrastructure, which possibly encompass evolutionary meaning, and to hypothesize about the origin of the Cheirolepidiaceae, which produced pollen grains of *Classopollis*-type.

To achieve these aims, some data from scanning electron microscope (SEM) and transmission electron microscope (TEM) have been still insufficient: those on the latest species of *Classopollis* and the earliest species of this genus and other members of group

Circumpolles. Thus, the latest members of *Classopollis* so far ultrastructurally studied are dated to the Barremian (Taylor and Alvin, 1984). There are also some data on the exine ultrastructure of *Classoidites glandis* Amerom, 1965 from the Late Cretaceous of Portugal (Kedves and Párdutz, 1973; Kedves, 1986, cited according to Kedves, 1994) and from the Turonian of France (Médus, 1977). This paper presents results of our study of the morphology and exine ultrastructure of a late member of *Classopollis*, *C. martinottii* Reyre, 1970.

A palynological spectrum has been chosen for this study from the Cretaceous deposits of the locality of Chomsieh, in central Lebanon (Figs. 1, 2), which is dominated by well-preserved pollen grains of *Classopollis*, in hope to distinguish all possible ultrastructural details in the exine. Apart from *Classopollis*, numerous members of this rich spectrum include angiosperm pollen grains and striate gymnospermous pollen grains. Since the dating based on the analysis of the palynological spectrum differs significantly from the generally accepted dating, we have found suitable to describe and illustrate the spectrum under study. In particular, we showed

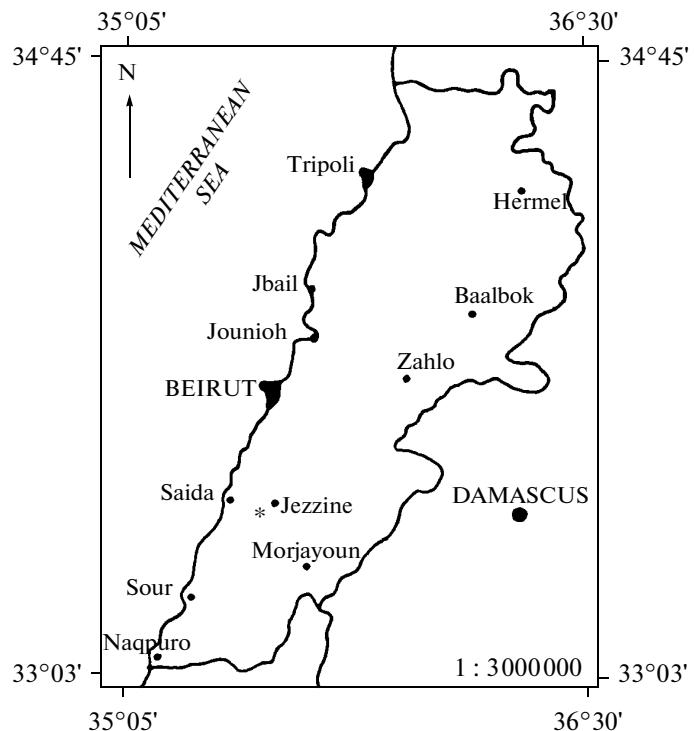


Fig. 1. Schematic map of Lebanon showing the position of the locality studied (asterix).

stratigraphically important taxa as well as several peculiar palynological types of so far undetermined affinity (Fig. 3).

Although the majority of paleobotanists traditionally classify the Cheirolepidiaceae (parent plants of *Classopollis*) within conifers, some authors point out on significant differences between cheirolepidiaceous and conifer pollen grains (Krassilov, 1982; Hughes, 1994). Krassilov (1982) believes that the pollen morphology and ultrastructure of the Cheirolepidiaceae and the morphology of their reproductive organs (*Hirmerella*) show similarities to gnetophytes. In this relation, we have studied by means of light microscopy (LM) and SEM in the spectrum some palynological types, which were possibly produced by gnetophytes (Figs. 3h, 3j–3n, 3u–3w, 4).

MATERIAL AND METHODS

The sample under study was collected by one of the authors (M. Mroueh) from deltaic deposits of section Chomsieh-2 (near the village of Chomsieh, southern part of central Lebanon; Fig. 1) in course of his work on the doctoral thesis (Mroueh, 1977). The base of the section is composed of Jurassic limestones, overlaid by thick sandstones, which are terminated with a pisolite layer (Fig. 2). Samples

nos. 3–5 from the lower 15.5 m of the sandstones did not contain palynomorphs. Samples, which were collected upwards the section (nos. 6–23, total thickness about 140.3 m) yielded a palynological assemblage earlier dated to the Barremian (Smirnova and Mroueh, 1980; Mroueh and Smirnova, 1986, 1996); no palynomorphs were extracted from the next four samples (nos. 24–27, total thickness about 27 m); and samples amassed from the upper portion of the sandstones (nos. 28–39, total thickness about 75 m) contained a palynological assemblage of the Albian–Cenomanian aspect. Sample no. 31, which was studied in the present work, was collected at the base of the upper portion of the sandstones, from layer no. 31 (4 m thick), represented by alternating thin sublayers of gray middle-grained sandstones and pinky gray clays with admixture of iron hydroxides.

The palynological spectrum was extracted by conventional maceration and studied in transmitted light. Specimens of *Classopollis* picked out from the organic residue were studied consecutively with help of LM, SEM, and TEM, in order to obtain the complete information on the general morphology, sculpture, and exine ultrastructure of each particular specimen. We have used AXIOPLAN-2 Zeiss LM (PIN), Camscan SEM, and Jeol 100 B and Jeol 400 TEMs (Laboratory of electron microscopy, Biological fac-

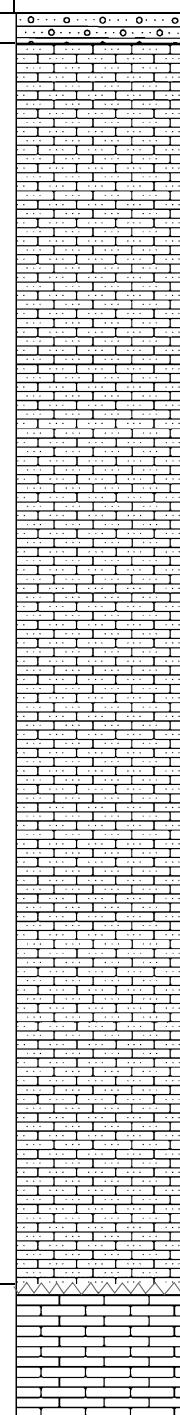
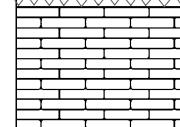
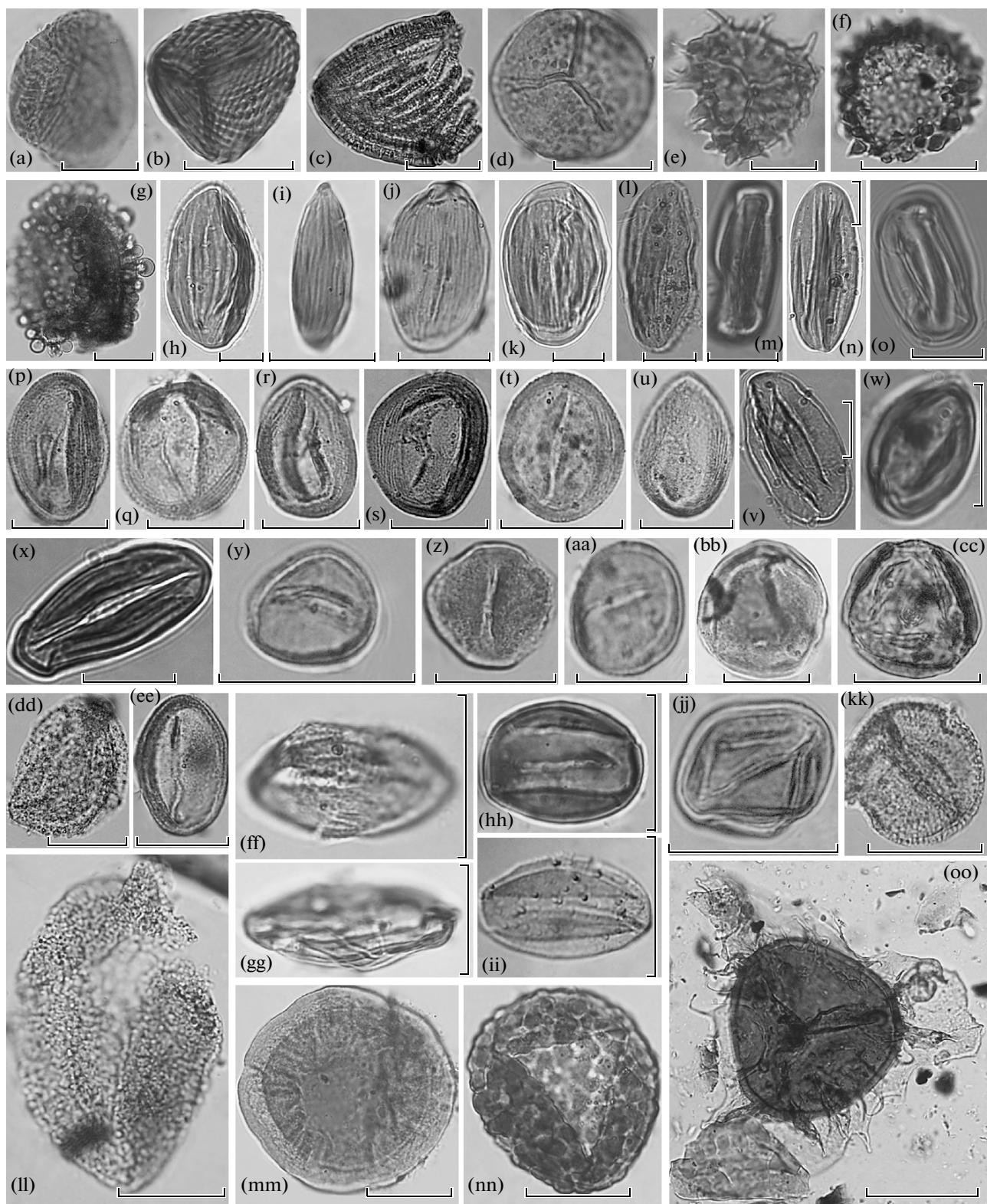
Units	Thick-ness, m	Lithology	Sample, nos.	Palynological assemblage
	6.3		40	
	257.8		28-39	of Albian-Cenomanian aspect (see the text)
			*	
			24-27	not found
			6-23	of Barremian aspect (Smirnova and Mroueh, 1980; Mroueh and Smirnova, 1996)
			3-5	not found
Chouf sandstones (=Grés de base=Basal Cretaceous sandstones)	8		1.2	not studied

Fig. 2. Schematic section of Chomsieh-2, the position of the sample studied is asterisked.



ulty of Moscow State University, MGU). Striate pollen grains were studied by means of LM and SEM (Fig. 4). For TEM study, pollen grains were embedded in mixture of epoxy resins (technique after Meyer-Melikian and Tel'nova, 1991) unstained. Ultrathin sections were made with an LKB Ultratome V. The organic residue (sample no. 2-31) is kept at the Department of Paleontology, Geological Faculty of MGU. Resin blocks enclosing pollen grains, grids with ultrathin sections, films and files documenting ultramicrographs are kept at the Laboratory of Paleobotany, PIN.

PALYNOLOGICAL SPECTRUM COMPOSITION AND DATING OF THE ENCLOSING DEPOSITS

According to currently accepted knowledge, the sandstones (Chouf sandstones, or Grès de base, or Basal Cretaceous sandstones) in the upper portion of which the sample was collected are considered Barremian in age (Walley, 1983; Ferry et al., 2007). The Barremian/Aptian boundary is posed on the pisomite layer (uppermost layer in the section of Chomsieh). Sandstones considered as Aptian overly the pisomite layer in other sections of Lebanon. So-called deposits of Falaise de Jezzine (Muraile blanche) are situated within these Aptian sandstones and mark the upper part of the Lower Aptian. Upwards the section, sandstones, clayish carbonates, clays, limestones, and carbonates are presently dated to the Late Albian and Cenomanian (Walley, 1983; Ferry et al., 2007).

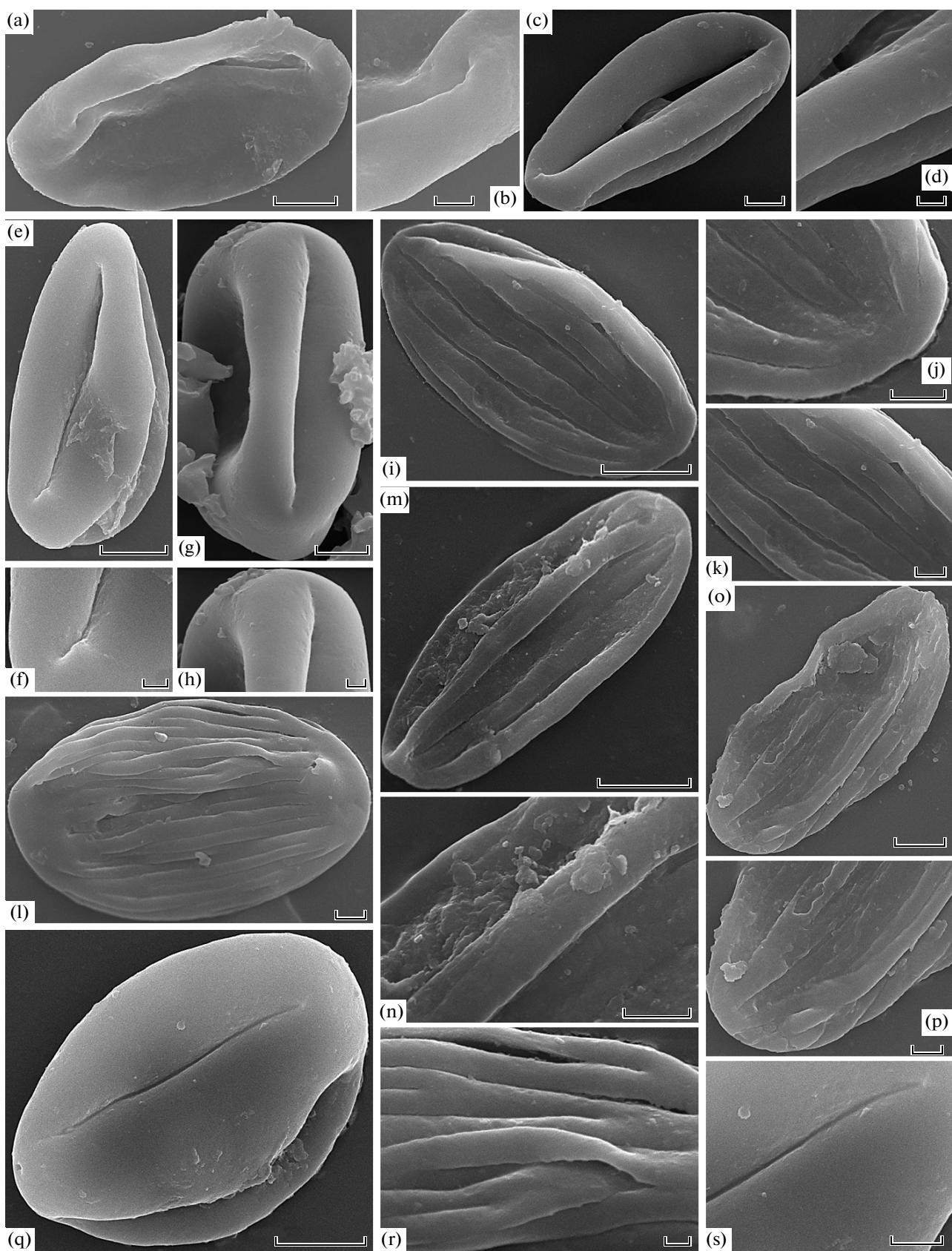
It should be stressed out that palynological assemblages are so far only paleontological remains that have been currently studied from the section of Chomsieh. Below, a spectrum from the upper portion of the sandstones is outlined, stratigraphically important taxa are mentioned, and the complete list of determined taxa is provided (Fig. 3, Table 1). Several stratigraphically important taxa have been found in the spectrum indicating younger than Barremian age of

the enclosing deposits, which does not fit the currently accepted correlation and cannot be solved within the scope of the present paper. Nonetheless, it is our hope that this information will stimulate studies on other groups of paleontological remains and will be helpful to future integrated solution of this problem as other data are accumulated.

The very diverse palynological spectrum is dominated by pollen grains of *Classopollis*, constituting up to 72% from the total of the assemblage. Lycophyte and fern spores are diverse. Bisaccate conifer pollen grains are virtually absent (with an exception of solitary pollen grains of *Phyllocladidites membrabilis* Petrosjan, 1971 and *Pityosporites alatipollenites* (Rouse) Singh, 1964). Asaccate gymnosperm pollen grains are present. Among angiosperm pollen, not only various forms with one aperture, but also forms with three and many apertures are detected.

The spectrum under consideration includes several members which first (or most common) appearance is dated to deposits younger than Barremian. Thus, *Classopollis brasiliensis* Herngreen, 1975 was described from the Cenomanian of Brazil (Herngreen, 1975). *Aporina* aff. *striatella* Bolkhovitina, 1953 was reported from the Cenomanian of Gabon (Boltenhagen, 1968). *Clavatipollenites incisus* Chlonova, 1976 was described from the Albian–Cenomanian of the Kiya Formation (Chlonova, 1976). *Stephanocolpites fredericksburgensis* Hedlung et Norris, 1968 was described from the Albian of Oklahoma (Hedlung and Norris, 1968). *Rousea delicipollis* Srivastava, 1977 was found in the Upper Cenomanian–Turonian of northwestern Egypt (Ibrahim, 1996). *Hexaporotricolpites potoniei* Boltenhagen, 1969 was described from the Cenomanian of Gabon (Boltenhagen, 1969). *Foveomorphomonocolpites rashadi* Ibrahim, 1996 was described from the Upper Cenomanian–Turonian of northwestern Egypt (Ibrahim, 1996). *Retimonocolpites eckarti* Ibrahim, 1996 was described from the Turonian of northwestern Egypt (Ibrahim, 1996). A miospore similar to *Clava-*

Fig. 3. Palynological spectrum from the locality of Chomsieh, Lebanon, LM: (a) *Cicatricosisporites intersectus* Rouse, 1962; (b) *Cicatricosisporites hallei* Delcourt et Sprumont, 1955; (c) *Cicatricosisporites* sp.; (d) *Verrucosisporites rotundus* Singh, 1964; (e) *Acanthotriletes varispinosus* Pocock, 1962; (f) *Apiculatisporis ferox* Müller, 1968; (g) *Clavatisporites* sp.; (h) *Ephedripites* sp., see SEM in Figs. 4i–4k; (i) *Ephedripites* sp.; (j) *Steevesipollenites* sp.; (k) *Ephedripites* sp., see SEM in Fig. 4l; (l) *Ephedripites* sp., see SEM in Figs. 4o, 4p; (m) *Eucommiidites* sp., see SEM in Figs. 4g, 4h; (p, q) *Classopollis brasiliensis* Herngreen, 1975; (r) *Classopollis revrei* Laing, 1973 ex Svobodová–Pekna, 1977; (s–u) *Classopollis* ssp.; (v) *Cycadopites* sp., see SEM in Figs. 4a, 4b; (w) *Eucommiidites* sp., see SEM in Figs. 4q, 4s; (x) *Eucommiidites* sp., see SEM in Figs. 4c, 4d; (y) *Clavatipollenites incisus* Chlonova, 1976; (z, aa) *Clavatipollenites* sp.; (bb, cc) *Tricolpopollenites* ssp.; (dd) *Rousea delicipollis* Srivastava, 1977; (ee) *Foveomorphomonocolpites rashadi* Ibrahim, 1996; (ff, gg) *Hexaporotricolpites potoniei* Boltenhagen, 1969; (hh–jj) *Tricolpopollenites* sp.; (kk) *Retimonocolpites eckarti* Ibrahim, 1996; (ll) *Arecipites microfoveolatus* Ibrahim, 2002; (mm) *Callialasporites dampieri* (Balme) Dev, 1961; (nn) *Kornilovites trisegmentatus* Kalmeneva, 1971; (oo) *Crybellosporites pannuceus* (Brenner) Srivastava, 1975. Scale bar 20 µm, except (e) 10 µm and (oo) 50 µm.



tisporites sp. was reported by Kotova (1990) from the Middle Albian of Syria. The microfossils of unknown affinity *Kornilovites trisegmentatus* Kalmeneva, 1971 were previously reported from the Albian–Cenomanian of Kazakhstan and from the Albian–Cenomanian of the Kiya Formation in western Siberia (Chlanova, 1976).

MORPHOLOGY AND ULTRASTRUCTURE OF POLLEN GRAINS OF *CLASSOPOLLIS* *MARTINOTTII* REYRE, 1970

Ten specimens of *C. martinottii* were studied with LM and SEM, four of which were further processed with TEM (Pl. 36, 37; Figs. 5, 6). Pollen grains occur mostly as monads (Pl. 37, fig. 1), dyads (Fig. 5a), and tetrads (Fig. 6a); triads are rare (Pl. 36, fig. 1). The pollen grains are spheroid or slightly flattened from poles; the central area is limited by an equatorial girdle; subequatorial rimula, proximal trilete scar, and distal pseudopore are present. Pollen grains are from 14×35 (in flattened specimens) to 27.5×25 μm in size. The girdle is of equal thickness within one and the same pollen grain, 7 μm on average; five to seven interrupted ribs can be counted. The proximal trilete scar is a triangular area 5 to 9.5 μm in size and not always clearly visible. The rimula is narrow. The distal pseudopore is rounded, about 10.5–12.5 μm in diameter.

The sculpture is spinulose, spinules are with obtuse apices, numerous, densely situated, more or less regularly covering the pollen surface (Pl. 36, figs. 2, 3; Pl. 37, figs. 2–4; Figs. 5b–5d, 6b–6e).

The exine includes the following layers (from the outermost layer towards the inner cavity of the pollen grain): supratectum, tectum, infratectum, and endexine (Pl. 36, fig. 6; Pl. 37, fig. 5; Figs. 5e, 5f). The supratectum is about 0.2–0.34 μm thick. It forms the sculpture, which elements appear in sections as granules or baculae. The supratectum is less electron-dense than other layers of the exine. The tectum is homogeneous, 0.2 μm thick, becomes thinner in the areas of the rimula, pseudopore, and trilete scar (Pl. 36, figs. 4, 7; Pl. 37, figs. 6–8). The infrate-

ctum is about 0.5–0.7 μm in average thickness, consists of columella-like elements attached to the internal surface of the tectum; small granules are situated between the columella-like elements also attaching to the internal surface of the tectum. The infratectum reaches its maximal thickness (1.3 μm) in equatorial areas (Pl. 36, fig. 7; Pl. 37, fig. 8). Columella-like elements of the girdle fuse into uninterrupted ridges; in transmitted light, these ridges are visible through the tectum, and the pollen grain appear striate (Pl. 36, fig. 5; Pl. 37, fig. 9; Figs. 5g, 5h, 6g). Up to 11 ridges can be counted in some oblique sections. In transverse sections, the ridges are slightly wider than infratectal elements of other ectexine (Pl. 37, fig. 9; Figs. 5h–5j; 6g, 6h). In areas with reduced thickness of the exine (pseudopore, rimula, and proximal scar), the infratectum is lacking, the tectum becomes thinner, supratectal elements retain (Pl. 36, fig. 6; Pl. 37, fig. 6–8). In addition, filamentous remains of the endexine are visible at places (Pl. 36, fig. 6; Pl. 37, fig. 8; Fig. 5e).

DISCUSSION

Among pollen grains of *Classopollis* studied with SEM and TEM, Barremian *Classopollis* from England extracted from pollen organs of *Classostrobus comptonensis* Alvin, Spicer et Watson are most close in age (Taylor and Alvin, 1984). The endexine of Lebanese pollen grains is represented by filamentous remains only at places detected, whereas English specimens show a distinct multilamellate endexine. Most probably, this difference should be explained by poorer preservation of the dispersed pollen grains in comparison with the in situ ones.

The pollen grains under comparison are similar in the morphology of the most characteristic layer of the ectexine, infratectum. Moreover, judging from illustrations (e.g., Taylor and Alvin, 1984, fig. 3), infratectal elements in English pollen grains are wider in the area of the girdle than in other areas of the exine, similarly to Lebanese pollen grains reported here. Small granules occurring between columella-like elements of the infratectum and attached to the internal surface

Fig. 4. Some gnetophyte pollen grains from the palynological spectrum under study, SEM: (a) *Cycadopites* sp., general view, LM Fig. 3v; (b) *Cycadopites* sp., morphological details, LM Fig. 3v; (c) *Eucommiidites* sp., general view, LM Fig. 3x; (d) *Eucommiidites* sp., morphological details, LM Fig. 3x; (e) *Eucommiidites* sp., general view, LM Fig. 3m; (f) *Eucommiidites* sp., morphological details, LM Fig. 3m; (g) *Eucommiidites* sp., general view, LM Fig. 3o; (h) *Eucommiidites* sp., morphological details, LM Fig. 3o; (i) *Ephedripites* sp., general view, LM Fig. 3h; (j, k) *Ephedripites* sp., morphological details, LM Fig. 3h; (l) *Ephedripites* sp., general view, LM Fig. 3k; (m) *Ephedripites* sp., general view, LM Fig. 3n; (n) *Ephedripites* sp., morphological details, LM Fig. 3n; (o) *Ephedripites* sp., general view, LM Fig. 3l; (p) *Ephedripites* sp., morphological details, LM Fig. 3l; (q) *Eucommiidites* sp., general view, LM Fig. 3w; (r) *Ephedripites* sp., morphological details, LM Fig. 3k; (s) *Eucommiidites* sp., morphological details, LM Fig. 3w. Scale bar (a, e, o, q) 5 μm , (b, p, s) 2 μm , (c, g, j–l, n) 3 μm , (d, f, h, r) 1 μm , (i, m) 10 μm .

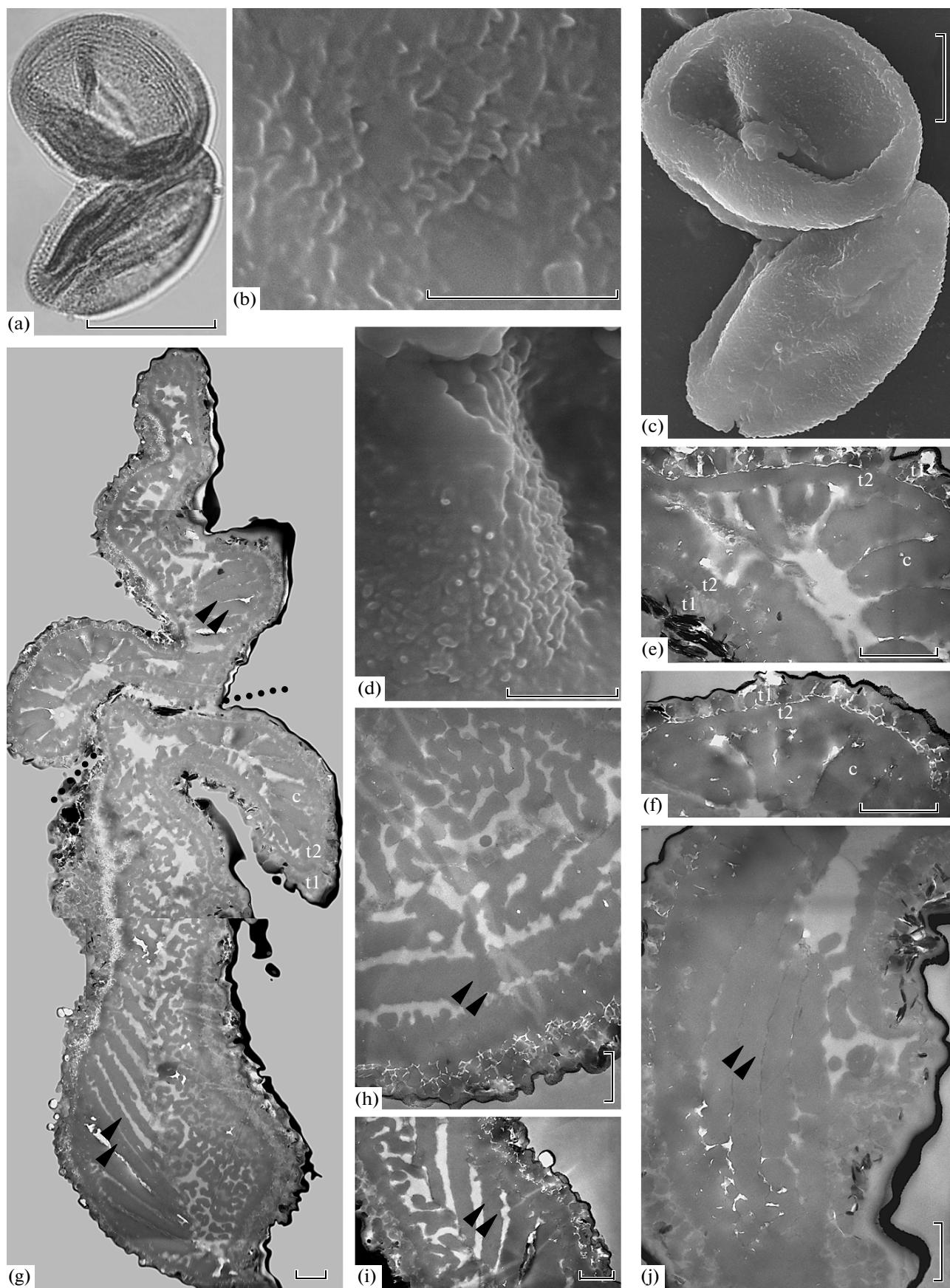


Fig. 5. Morphology, sculpture, and ultrastructure of pollen grains of *Classopollis martinottii* Reyre, 1970 from the palynological spectrum from the locality of Chomsieh, Lebanon: (a) LM; (b, d) SEM, surface; (c) SEM, general view; (e, f) TEM, exine region; (g) TEM, oblique section, note columella-like elements of the girdle fused into one of continuous ridges visible in transmitted light; (h, i) exine region, oblique section; (j) exine region. Scale bar (a) 20 µm, (b, d) 3 µm, (c) 10 µm, (e-g) 1 µm, (h-j) 0.67 µm; (t1) supratectum; (t2) tectum; (c) columella-like elements of the infratectum; double arrowheads indicate columella-like elements of the girdle fused into one of continuous ridges visible under LM; dotted line indicates boundary between pollen grains.

in Lebanese pollen grains supposedly occur in English pollen grains. There are some differences in the ultrastructure of apertural regions. The tectum becomes thinner in the areas of the rimula, cryptopore, and proximal scar in Lebanese pollen grains; for English specimens, a thinner tectum was mentioned only for the rimula, and it was perforated.

The sculpture in both Lebanese and English pollen grains is spinulose. Both bear sculptural elements also in apertural areas. The sculptural elements in Lebanese pollen grains is about 0.2–0.3 µm high, and those in English specimens are 0.5 µm. The apices of the sculptural elements in English pollen grains are pointed, occasionally curved, whereas they are obtuse in Lebanese pollen grains.

According to Reyre (1970), the type of sculpture can reflect differences between species. Thus, the sculpture of *Classopollis aquitanus*, *C. pujoli*, and *C. mirabilis* Reyre is represented by pointed spinules, whereas spinules of *C. martinottii* are with obtuse apices. As far as we can judge by the morphological characteristics and measurements obtained with LM and SEM, the pollen grains under study fit the latter species, originally described from the Berriasian–Valanginian of Israel (Reyre, 1970) and also recorded in the Albian of the United States (Srivastava, 1976). The structure of infratectum in non-apertural area that was revealed in a thick section under SEM by Srivastava (1976, text-fig. 8C) answers our idea of infratectal elements as non-branching columella-like elements. Besides, text-fig. 9C in Srivastava (1976) clearly shows that ribs of the girdle are formed by fused infratectal elements.

Consequently, the differences revealed between the pollen grains under study and those extracted from *Classostrobus comptonensis* can be differences between species. Unfortunately, all species described by Reyre (1970) were based on dispersed material. However, final conclusion about the significance of the sculpture as a specific character can only be made after intraspecific and individual variability in the sculpture of pollen grains will be studied on in situ material.

The ultrastructure of Late Cretaceous pollen grains of *Classoides glandis*, a member of a very close genus sometimes included into *Classopollis*, was studied by Kedves (1973, 1986; cited by Kedves, 1994) and by Médus (1977). These publications are not as detailed as that of Taylor and Alvin (1984) and do not allow a complete comparison with our data. Nevertheless, branching elements of the infratectum of *Classoides* should be mentioned.

A list of pre-Cretaceous members of *Classopollis* also shows an infratectum with columella-like elements, similar to the infratectum of the pollen grains under study (Pettitt and Chaloner, 1964; Médus, 1977; Rowley and Srivastava, 1986; Krassilov et al., 1997; Zavialova, 2003; Zavialova and Tekleva, 2005).

To conclude, an infratectum with branching elements (latest members of the group) and infratectum with columella-like non-branching elements occur within the group Circumpolles. In addition, our unpublished data on the ultrastructure of Rhaetian *Classopollis* show that their infratectum is formed by large granules arranged in one row. Lugardon (1985) hypothesized that infratectum composed of such granules characterized all members of Circumpolles, that is now confirmed for early members of Circumpolles.

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Table 1. List of taxa present in the palynological spectrum from specimen 31, Chomsieh-2 section, near the village of Chomsieh in central Lebanon

Spores	<i>Lycopodiacidites canaliculatus</i> Singh, 1971 <i>Osmundacidites wellmanii</i> Couper, 1953 <i>Todisporites major</i> Couper, 1958 <i>T. minor</i> Couper, 1958 <i>Cicatricosisporites brevilaesuratus</i> (Couper, 1958) Kemp, 1970 <i>C. hallei</i> Delcourt et Sprumont, 1955 (Fig. 3b) <i>C. intersectus</i> Rouse, 1962 (Fig. 3a) <i>C. pseudotripartitus</i> (Bolkhovitina) Dettmann, 1963 <i>C. spiralis</i> Singh, 1971 <i>C. stoveri</i> Pocock, 1964 <i>Cicatricosisporites</i> sp. (Fig. 3c) <i>Clavatisporites</i> sp. (Fig. 3g) <i>Plicifera delicata</i> (Bolkhovitina) Bolkhovitina, 1968 <i>Ornamentifera baculata</i> Singh, 1971 <i>Cyathidites australis</i> Couper, 1958 <i>C. minor</i> Couper, 1958 <i>Densoisporites velatus</i> Weyland et Krieger, 1953 <i>Matonisporites suemegensis</i> M. Juhász, 1979 <i>Matonisporites</i> sp. <i>Phlebopterisporites harskutensis</i> M. Juhász, 1979 <i>Concavissimisporites punctatus</i> (Delcourt et Sprumont) Brenner, 1963 <i>Converrucosporites utriculosus</i> (Krasn) Pocock, 1970 <i>Pilosporites</i> sp. <i>Leptolepidites verrucatus</i> Couper, 1953 <i>Verrucosporites rotundus</i> Singh, 1964 (Fig. 3d) <i>Acanthotriletes varispinosus</i> Pocock, 1962 (Fig. 3e) <i>Apiculatisporis ferox</i> Müller, 1968 (Fig. 3f) <i>Chomotriletes fragilis</i> Pocock, 1962 <i>Crybellosporites pannuceus</i> (Brenner) Srivastava, 1975 (Fig. 3oo) <i>C. punctatus</i> Dettmann, 1963 Insertae sedis no. 3		<i>Equisetosporites multistriatus</i> Pocock, 1964 <i>E. rousei</i> Pocock, 1964 <i>Ephedripites</i> sp. (Figs. 3h, 3i, 3k, 3l, 3n, 4i–4p, 4r) <i>Steevesipollenites</i> sp. (Fig. 3j) <i>Chomsiipites libanicus</i> Smirnova, 2010 <i>Eucommiidites troedsonii</i> Erdtman, 1948 <i>Eucommiidites</i> sp. (Figs. 3m, 3o, 3w, 3x; 4c–4h, 4q, 4s) <i>Callialasporites dampieri</i> (Balme) Dev, 1961 (Fig. 3mm) <i>Sequoiapollenites?</i> sp. <i>Phyllocladidites memorabilis</i> Petrosjan, 1971 <i>Taxodiaceae pollenites hiatus</i> (Potonié) Kremp, 1970 <i>Pityosporites alatipollenites</i> (Rouse) Singh, 1964
Gymnosperm pollen grains	<i>Cycadopites</i> spp. (Figs. 3v, 4a, 4b) <i>Araucariacites australis</i> Cookson, 1947 <i>Classopollis brasiliensis</i> Herngreen, 1975 (Figs. 3p, 3q) <i>C. aff. brasiliensis</i> Herngreen, 1975 <i>C. revrei</i> Laing, 1973 ex Svobodová-Pekna, 1977 (Fig. 3r) <i>C. martinottii</i> Reyre, 1970 (Pls. 36, 37; Figs. 5a–5j, 6a–6f) <i>Classopollis</i> sp. (Figs. 3s–3u) <i>Aporina</i> aff. <i>striatella</i> Bolkhovitina, 1953	Angio-sperm pollen grains	<i>Clavatipollenites hughesi</i> Couper, 1958 <i>C. incisus</i> Chlonova, 1976 (Fig. 3y) <i>C. minutus</i> Brenner, 1963 <i>C. rotundus</i> Kemp, 1968 <i>Clavatipollenites</i> sp. (Figs. 3z, 3aa) <i>Foveomorphomonocolpites rashadi</i> Ibrahim, 1996 (Fig. 3ee) <i>Monocolpollenites spheroidites</i> Jardiné et Magloire, 1965 <i>Proxapertites</i> sp. <i>Retimonocolpites eckarti</i> Ibrahim, 1996 (Fig. 3kk) <i>Stellatopolls</i> sp. <i>Transitoripollis praesimilis</i> Juhász et Goczan, 1976 <i>T. similis</i> Juhász et Goczan, 1976 <i>Tricolpites</i> spp. <i>Arecipites microfoveolatus</i> Ibrahim, 2002 (Fig. 3ll) <i>Tricolpopollenites distinctus</i> Groot et Penny, 1960 <i>Tricolpopollenites</i> spp. (Figs. 3bb, 3cc, 3hh–3jj) <i>Fraxinoipollenites venustus</i> Singh, 1971 <i>Hexaporotricolpites potoniei</i> Boltenhagen, 1969 (Figs. 3ff, 3gg) <i>Rousea delicipollis</i> Srivastava, 1977 (Fig. 3dd) <i>Psilastephanocolporites daportae</i> Herngreen, 1965 <i>Stephanocolpites fredericksburgensis</i> Hedlund et Norris, 1968 <i>Trifossapollenites ivoirensis</i> Jardiné et Magloire, 1965 <i>Tetracolpites</i> sp. <i>Triporopollenites</i> sp.
		Inser-tae sedis	<i>Kornilovites trisegmentatus</i> Kalmeneva, 1971 (Fig. 3nn) <i>Inaperturopollenites</i> sp. Insertae sedis no. 4.

Fig. 6. Morphology, sculpture, and ultrastructure of pollen grains of *Classopollis martinottii* Reyre, 1970 from the palynological spectrum from the locality of Chomsieh, Lebanon: (a) LM; (b) SEM, general view of the tetrad, asterisk indicates the distal cryptopore; (c, d) SEM, pollen surface; (e) SEM, the area of contact between the members of the tetrad, asterisk; (f) TEM, tetrad sectioned; (g, h) exine region. Scale bar (a, b) 10 µm; (c–e) 3 µm; (f) 1 µm; (g, h) 0.67 µm.

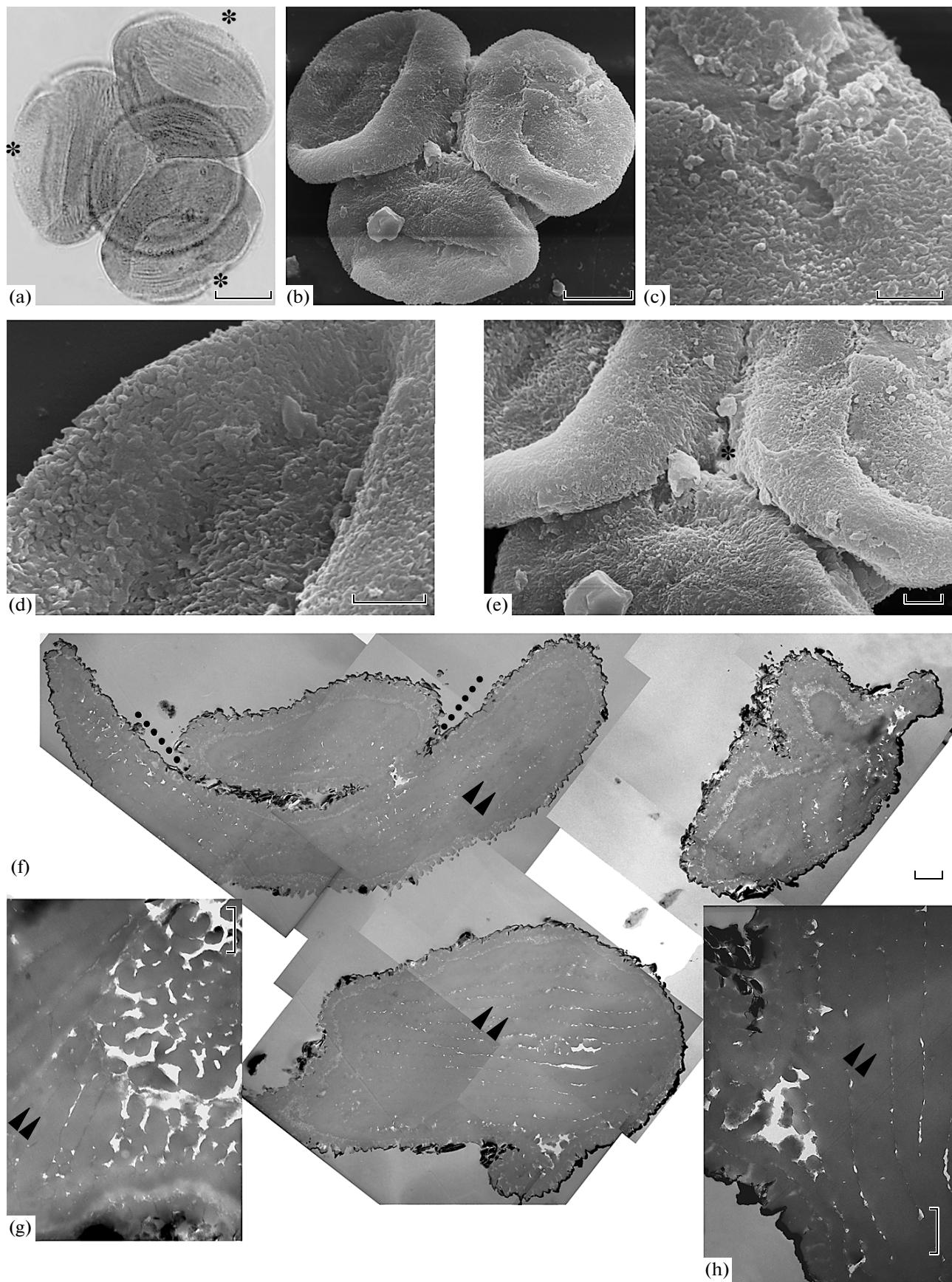


Plate 36

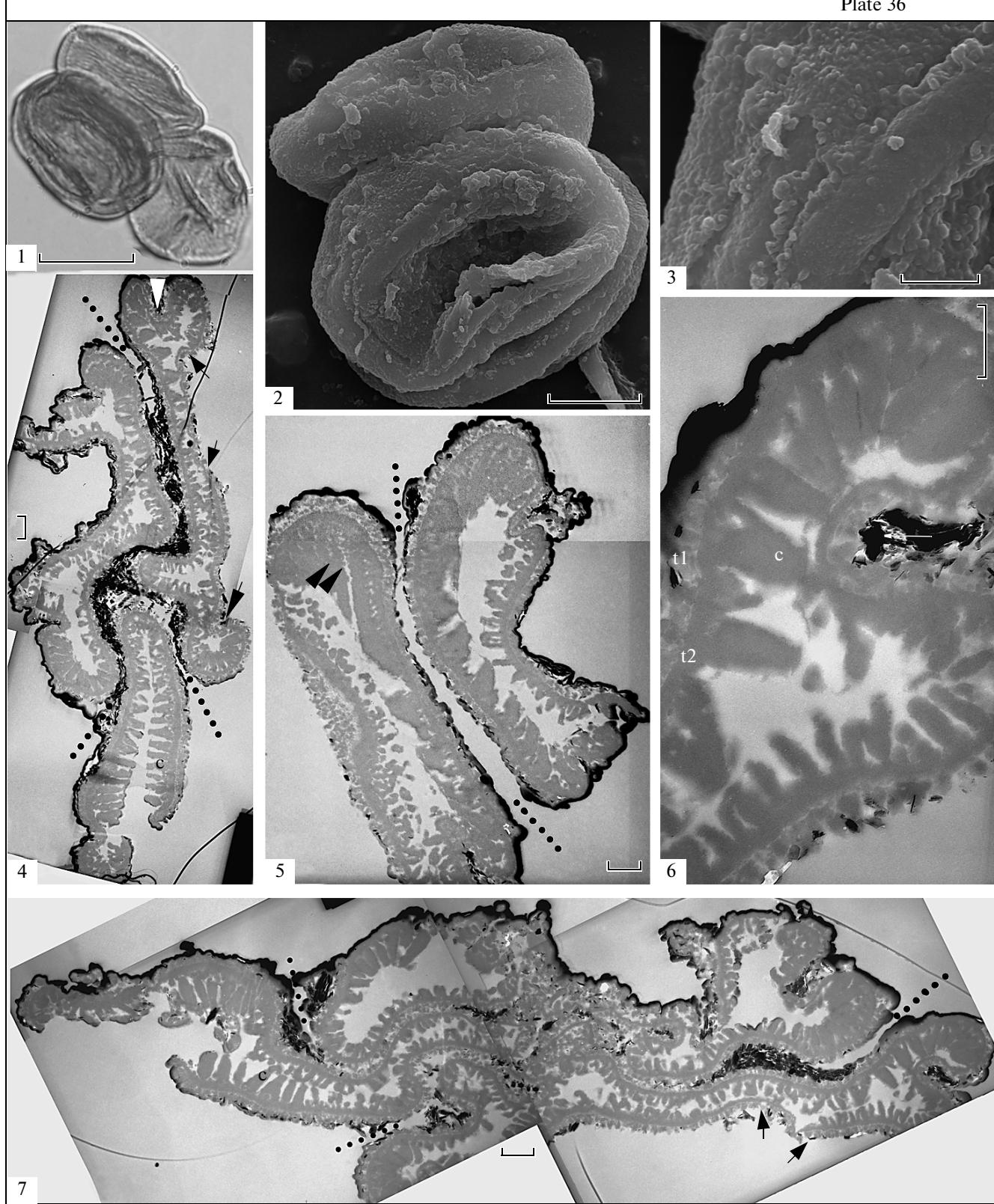
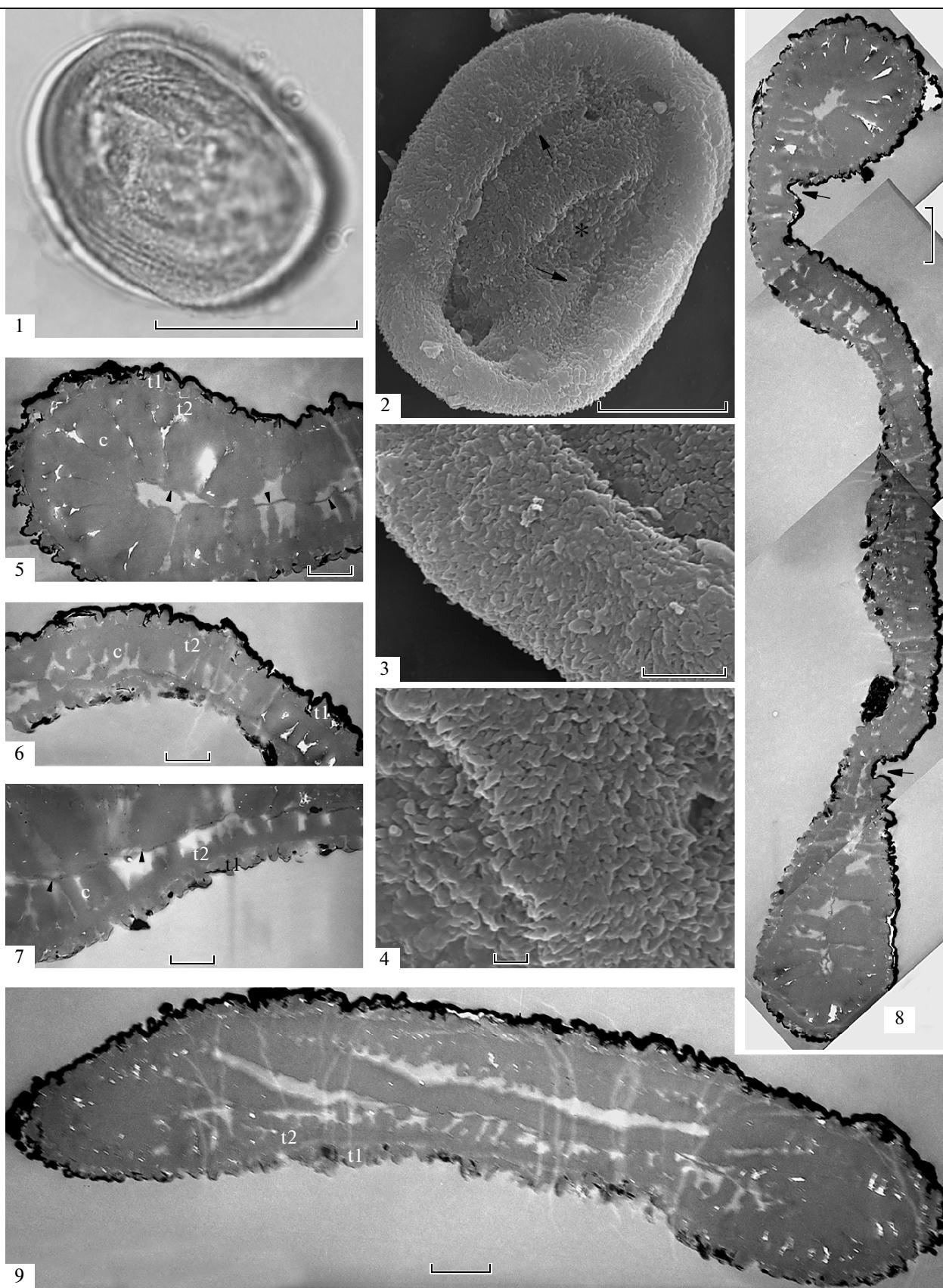


Plate 37



Explanation of Plate 36

Figs. 1–6. Morphology, sculpture, and ultrastructure of pollen grains of *Classopollis martinottii* Reyre, 1970 from the palynological spectrum from the locality of Chomsieh, Lebanon: (1) LM, scale bar 20 µm; (2) SEM, general view, scale bar 10 µm; (3) SEM, exine surface, scale bar 3 µm; (4, 7) TEM, general view, sections through rimula (arrowheads) and cryptopore (arrows), scale bar 1 µm; (5) TEM, note columella-like elements of the girdle fused into one of continuous ridges visible under LM, scale bar 1 µm; (6) TEM, area of the exine, consisting of the supratectum and tectum, columella-like elements of the infratectum, and endexine that is preserved in places, arrow points on the section through the rimula, scale bar 0.67 µm. Designations: (t1) supratectum; (t2) tectum; (c) columella-like elements of the infratectum.

Explanation of Plate 37

Figs. 1–9. Morphology, sculpture, and ultrastructure of pollen grains of *Classopollis martinottii* Reyre, 1970 from the palynological spectrum from the locality of Chomsieh, Lebanon: (1) LM, scale bar 20 µm; (2) SEM, general view of the pollen grain, note the distal cryptopore (asterisk) and rimula (arrows), scale bar 10 µm; (3) SEM, exine surface, scale bar 3 µm; (4) exine surface, scale bar 1 µm; (5–7) TEM, exine area, note endexine remnants (arrowheads), scale bar 0.67 µm; (8) TEM, general view of the pollen grain section, arrows indicate areas of the section through the rimula, scale bar 1.25 µm; (9) TEM, oblique section, note columella-like elements of the girdle fused into one of continuous ridges visible under LM, scale bar 1 µm. Designations: (t1) supratectum; (t2) tectum; (c) columella-like elements of the infratectum.

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