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Late Carboniferous – Early Permian (Ghzelian – Artinskian) Palynomorphs

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The preliminary results of the palynological investigations in the Late Carboniferous – Early Permian of Northeast Libya indicate that at least two successive intervals can be readily recognised:

Ghzelian – Asselian interval. This lower interval is characterised by assemblages showing a dominance of saccate pollen; miospores usually occur in very low frequencies. Throughout the interval one may recognise (a) monosaccate pollen, attributable to genera such as *Potonieisporites, Plicatipollenites, Cannanoropollis* and *Barakarites;* (b) taeniate (striate) bisaccate pollen, identified as species of *Illinites, Protohaploxypinus, Strotersporites, Striatoabieites* and *Distriatites;* and (c) non-taeniate bisaccate pollen, represented by alete genera and *Limitisporites*.

Although some of the monosaccate elements may already occur in the Early Carboniferous of Libya, the observed diversification points to a Late Carboniferous – Early Permian age of the assemblages. Taeniate pollen grains are known to make their first appearance in the Moscovian (e.g., in the Donets Basin; compare Inosova *et al.*, 1976) but the observed diverse assemblages appear more characteristic for the latest Carboniferous and/or Early Permain, of both the Euramerican and Gondwana provinces (compare, e.g., Inosova *et al.*, 1976; Kemp *et al.*, 1977). Consequently, the authors consider the interval to represent a Carboniferous – Permian transition sequence, broadly comprising the Ghzelian and Asselian Stages. It should be noted, however, that the status of the Asselian Stage is still under discussion; some authors prefer the inclusion of this unit (or part of it) in the Carboniferous. From a palynological point of view the incoming of *Distriatites* could well mark a datum level corresponding to the Carboniferous – Permian boundary.

Sakmarian – Artinskian interval. An upper interval is characterised by saccate pollen, non-saccate pollen and miospores. Most of the taxa present in the preceding interval continues to occur in this unit. Characteristic additional elements include: (a) monosaccate pollen assignable to *Samoilovitchisaccites* and *Divarisaccus;* (b) species of the taeniate bisaccate genera *Corisaccites* and *Hamiapollenites; (c)* species of the taeniate non-saccate genera *Vittatina* and *Costapollenites;* and (d) a variety of miospores such as representatives of *Indotriradites, Columnisporites* and *Maculatasporites*.

Although some of these additional elements were already present in the older assemblages, on the basis of relatively well-dated successions in the U.S.S.R. (Chuvashov & Dyupina, 1973), Pakistan (Venkatachala & Kar, 1968; Balme, 1970) and Australia (Segroves, 1970; Kemp *et al.*, 1977; Foster, 1979) a younger age has however to be accepted. On an interregional scale, first-occurrences of *Corisaccites alutas* are probably within the Sakmarian. Some of the assemblages show a considerable resemblance to those from the Barakar Formation of India, which may represent the Artinskian Stage. On the basis of the evidence currently available, this upper unit must be regarded as Sakmarian – Artinskian. Within the material studied, there are so far no definitive indications for the presence of Late Permian assemblages.

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Explanation of Plate 37
All figures are × 500

Fig. 1. *Plicatipollenites malabarensis* (Potonié & Sah, 1958) Foster, 1975. A1-NC 92, 7550 ft., Slide 129 (4), Q42, AGC 411. (Serpukhovian – Permian).

Fig. 2. *Cannanoropollis janakii* Potonié & Sah, 1958. A1-NC 92, 7705 ft., Slide 130 (3), L33, AGC 412. (Serpukhovian – Permian).

Fig. 3. *Lycospora pusilla* (Ibrahim, 1932) Somers, 1972. A1-NC 92, 7405 ft., Slide 125 (2), E49, AGC 413. (Viséan–Permian).

Fig. 4. *Illinites unicus* Kosanke, 1950. A1-NC 92, 7550 ft., Slide 129 (4), R43/2, AGC 414. (Late Carboniferous – Permian).

Fig. 5. *Rimospora rimosa* Lele & Maithy, 1969. A1-NC 92, 7550 ft., Slide 129 (4), J38/4, AGC 415. (Serpukhovian – Permian).

Fig. 6. *Potonieisporites magnus* Lele & Karim, 1971. A1-14, 6860–7000 ft., Slide 861 (3), 035, AGC 416. (Serpukhovian – Permian).

Fig. 7. *Protohaploxypinus* sp. A1-NC 92, 7405 ft., Slide 128 (2), M41, AGC 417.

Fig. 8. *Protohaploxypinus goraiensis* (Potonié & Lele, 1961) Hart, 1964. A1-NC 92, 7405 ft., Slide 128 (2), K43, AGC 418. (Late Carboniferous – Permian).

Fig. 9. *Strotersporites indicus* Tiwari, 1965. A1-NC 92, 7550 ft., Slide 129 (4), H35/1, AGC 419. (Late Carboniferous – Permian).

Fig. 10. *Spelaeotriletes trisecatus* (Balme & Hennelly, 1956) nov. comb. A1-NC 92, 7550 ft., Slide 129 (4), W45/3, AGC 420. (Serpukhovian – Permian).

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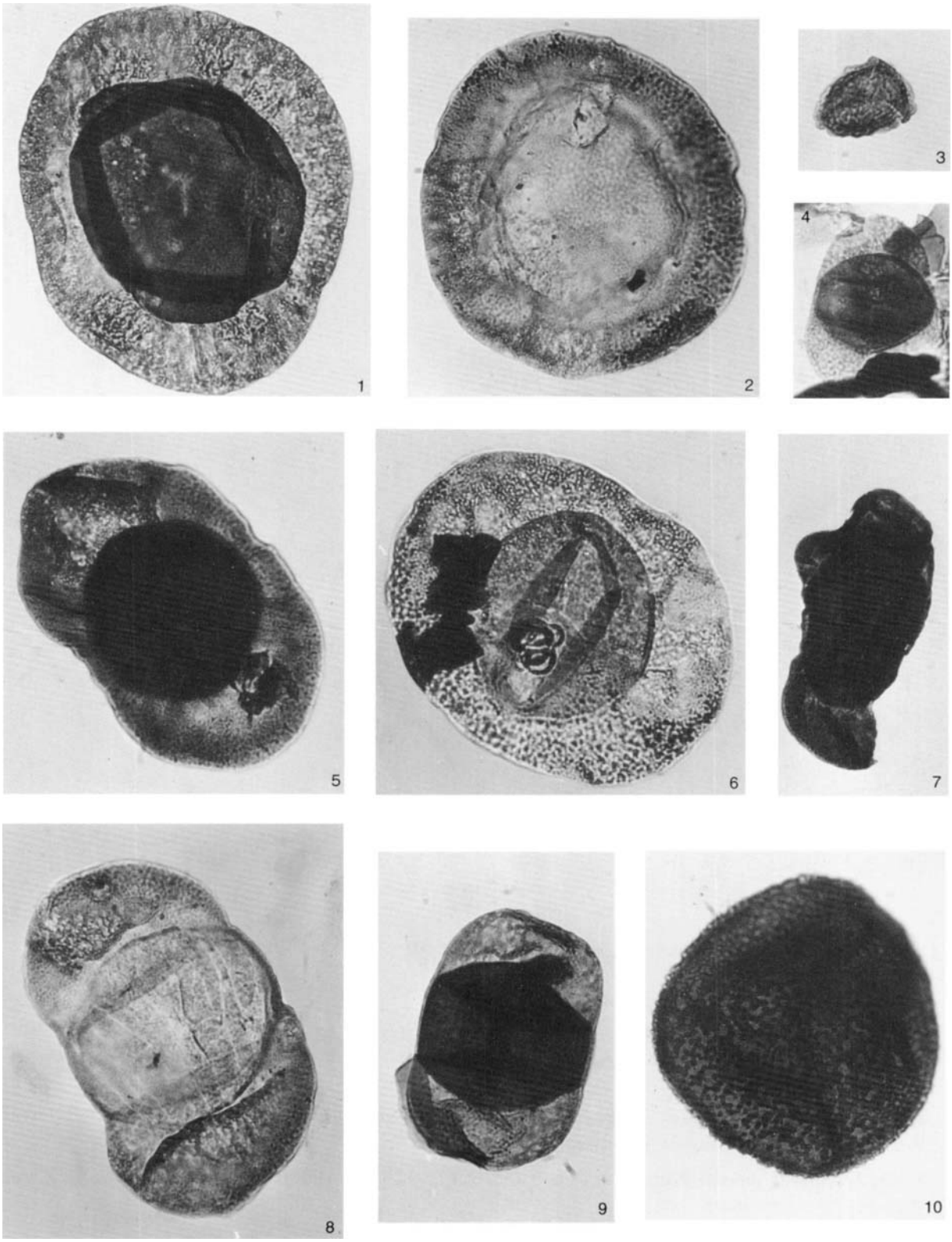
Plate 37

Late Carboniferous – Permian Miospores and Pollen



Explanation of Plate 38

All figures are × 500

Fig. 1. *Potonieisporties concinnus* Tiwari, 1965. A1-19, 10600–10700 ft., Slide 1006 (4), R45/1, AGC 421. (Permian).

Fig. 2. *Barakarites indicus* Bharadwaj & Tiwari, 1964. A1-19, 10400–10500 ft., Slide 1004 (4), P46/1, AGC 422. (Permian).

Fig. 3. *Potonieisporites magnus* Lele & Karim, 1971. A1-19, 10400–10500 ft., Slide 1004 (4), L34, AGC 423. (Serpukhovian – Permian).

Fig. 4. *Plicatipollenites malabarensis* (Potonié & Sah, 1958) Foster, 1975. A1-19, 10700–10800 ft., Slide 1007 (4), L29, AGC 424. (Serpukhovian – Permian).

Fig. 5. *Cannanoropollis janakii* Potonié & Sah, 1958. A1-19, 10500–10600 ft., Slide 1005 (3), Q42, AGC 425. (Serpukhovian – Permian).

Fig. 6. *Rugasaccites orbiculatus* Lele & Maithy, 1969. A1 – 19, 10900–10990 ft., Slide 1009 (3), J49, AGC 426. (Permian).

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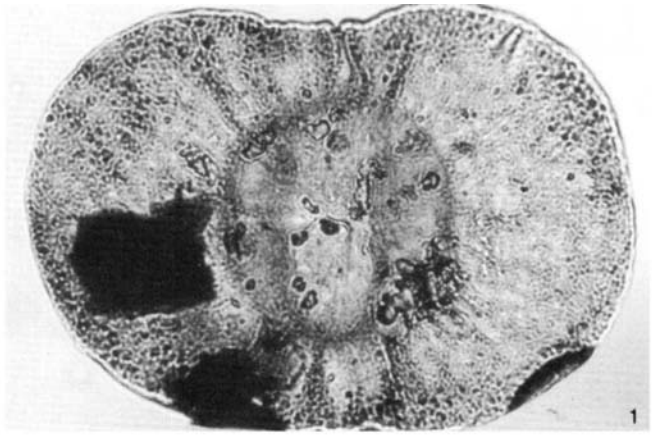
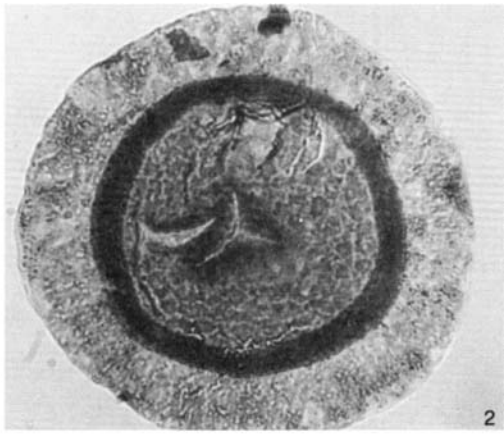
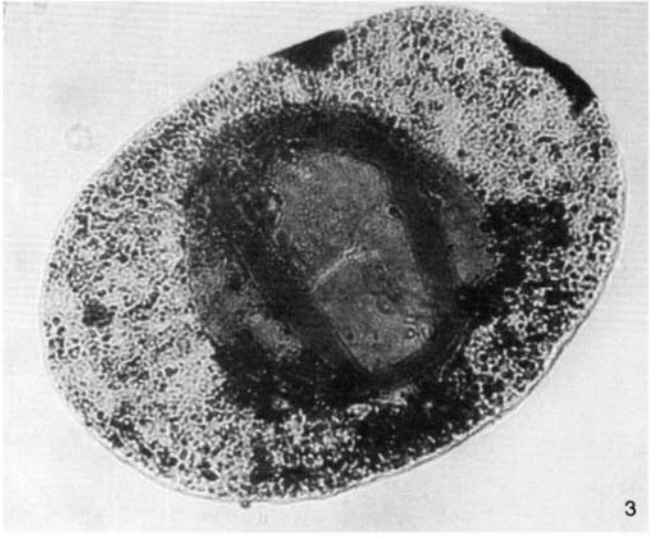
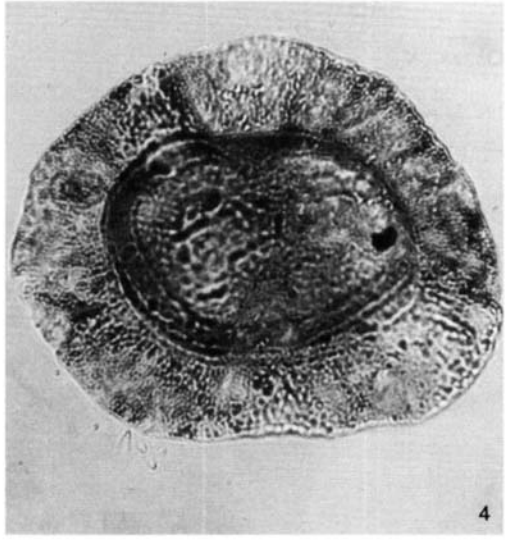
Plate 38

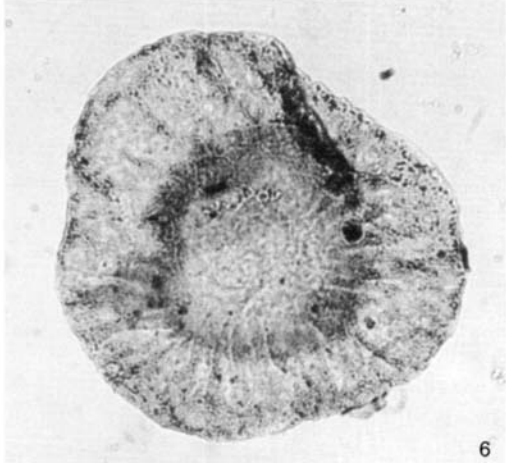
Late Carboniferous – Permian Pollen











Explanation of Plate 39
All figures are × 500

Fig. 1. *Distriatites insolitus* Bharadwaj & Salujha, 1964. A1-14, 6710–6840 ft., Slide 860 (3), R37/3, AGC 427. (Permian).

Fig. 2. *Distriatites insolitus* Bharadwaj & Salujha, 1964. A1-19, 10700–10800 ft., Slide 1007 (4), W34/3, AGC 428. (Permian).

Fig. 3. *Protohaploxypinus samoilovichii* (Jansonius, 1962) Hart, 1964. A1-19, 10900–10990 ft., Slide 1009 (4), U33/3, AGC 429. (Permian).

Fig. 4. *Protohaploxypinus jacobii* (Jansonius, 1962) Hart, 1964. A1-19, 10900–10990 ft., Slide 1009 (4), N34, AGC 430. (Permian).

Fig. 5. *Strotersporites indicus* Tiwari, 1965. A1-19, 10500–10600 ft., Slide 1005 (3), N30, AGC 431. (Late Carboniferous – Permian).

Fig. 6. *Protohaploxypinus limpidus* (Balme & Hennelly, 1955) Balme & Playford, 1967. A1-19, 10500–10600 ft., Slide 1005 (3), Q34, AGC 432. (Permian).

Fig. 7. *Strotersporites indicus* Tiwari, 1965. A1-19, 10500–10600 ft., Slide 1005 (3), × 40, AGC 433. (Late Carboniferous–Permian).

Fig. 8. *Protohaploxypinus fuscus* (Bharadwaj, 1962) nov. comb. A1-19, 10600–10700 ft., Slide 1006 (3), T44/3, AGC 434. (Permian).

Fig. 9. *Striatoabietites amplus* (Balme & Hennelly, 1955) nov. comb. A1-19, 10700–10800 ft., Slide 1007 (6), K44, AGC 435. (Permian).

Fig. 10. *Striatoabietites microcorpus* (Schaarschmidt, 1963) nov. comb. A1–19, 10500–10600 ft., Slide 1005 (4), M31/4, AGC 436. (Permian).

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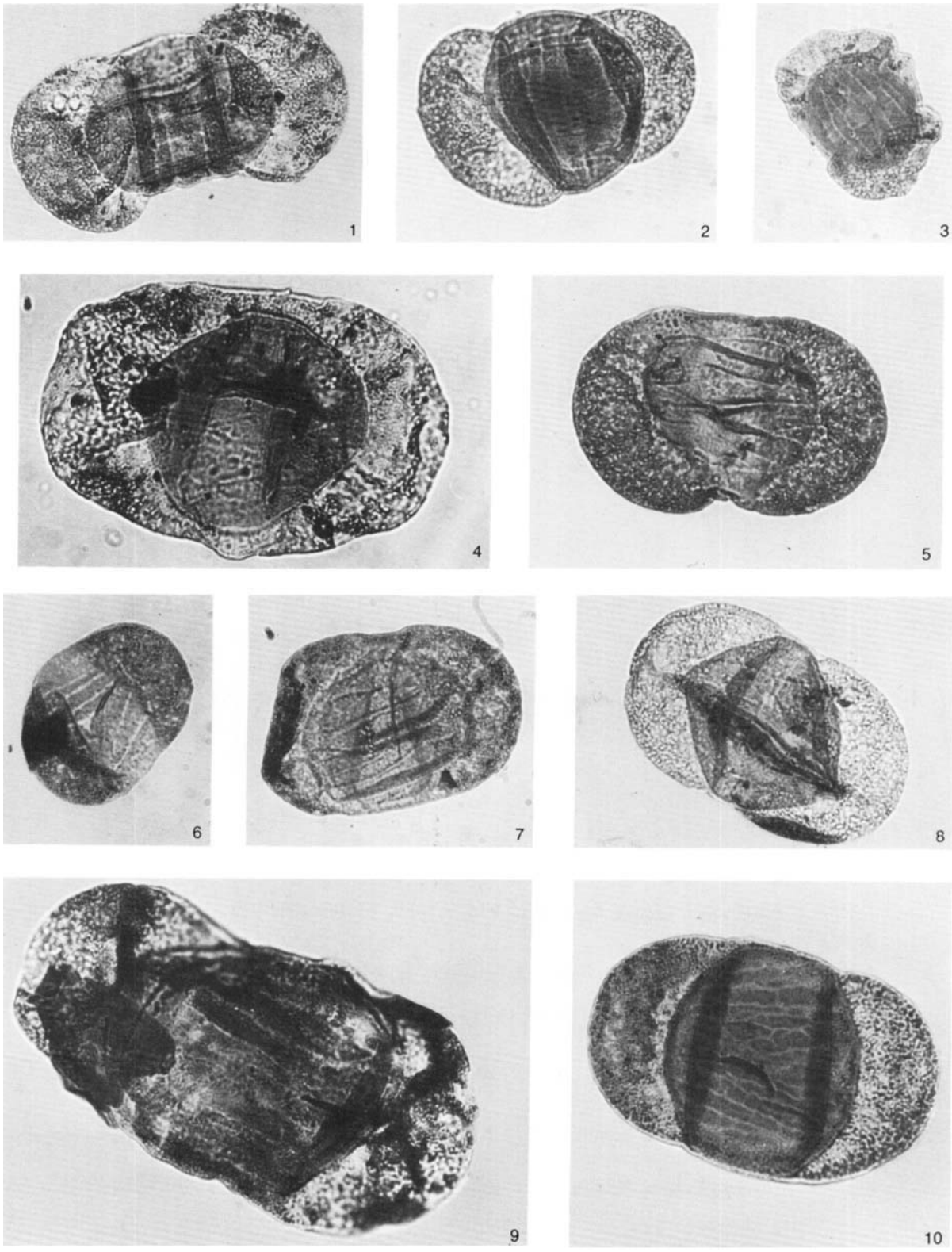
Late Carboniferous – Permian Pollen

Plate 39



Explanation of Plate 40

All figures are × 500

Fig. 1. *Circumstriatites talchirensis* Lele & Makada, 1976. A1-19, 10600–10700 ft., Slide 1006 (3), O 41/3, AGC 437. (Permian).

Fig. 2. *Pityosporites* sp. A1-19, 10900–10990 ft., Slide 1009 (4), S30/1, AGC 438.

Fig. 3. *Striatopodocarpites phaleratus* (Balme & Hennelly, 1955) Hart, 1964. A1-19, 10600–10700 ft., Slide 1006 (5), P40, AGC 439. (Permian).

Fig. 4. *Alisporites* sp. cf. *opii* Daugherty, 1941. A1-19, 10400–10500 ft., Slide 1004 (4),. R50/1, AGC 440. (Permian – Trias).

Fig. 5. *Limitisporites diversus* Lele & Karim, 1971. A1-19, 10800–10900 ft., Slide 1008 (3), N34, AGC 441. (Permian).

Fig. 6. *Limitisporites elongatus* Lele & Karim, 1971. A1-19, 10700–10800 ft., Slide 1007 (3), Z50/3, AGC 442. (Permian).

Fig. 7. *Sulcatisporites institatus* Balme, 1970. A1-19, 10800–10900 ft., Slide 1008 (4), Q47, AGC 443. (Permian – Trias).

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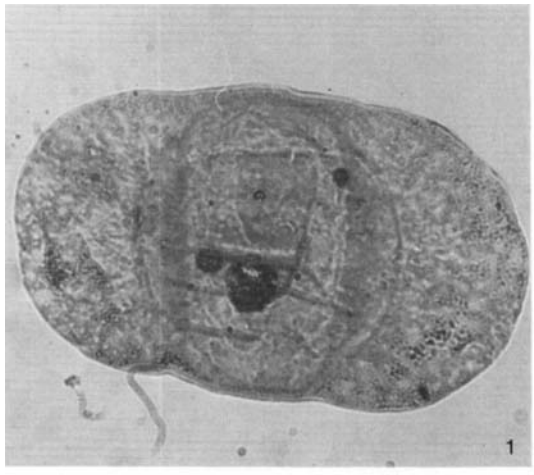
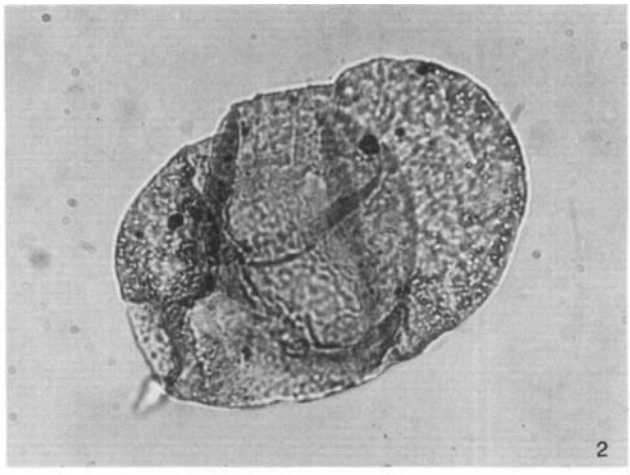
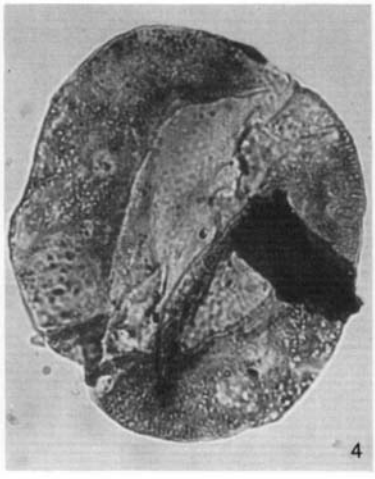
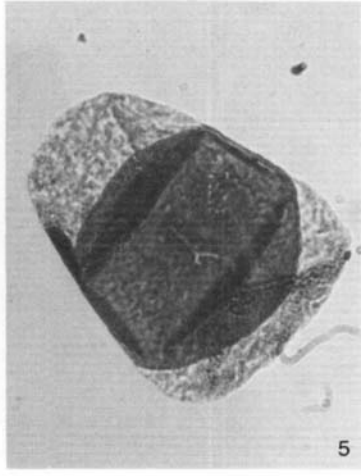
Plate 40

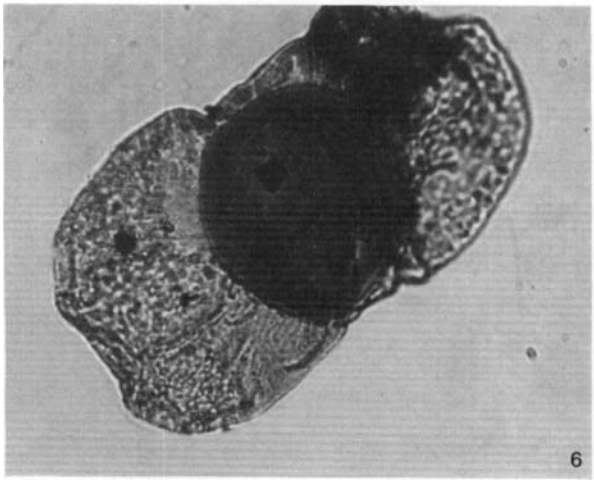
Late Carboniferous – Permian Pollen

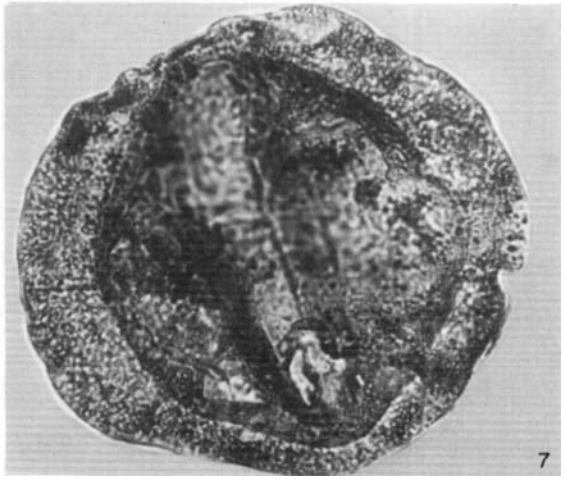












Explanation of Plate 41
All figures are × 1000

Fig. 1. *Vittatina foveolata* Tschudy & Kosanke, 1966. Ala-117, Core 3, 7030 ft., Slide 3, P42/3, AGC 444.

Fig. 2. *Vittatina foveolata* Tschudy & Kosanke, 1966. A1-19, 9100–9200 ft., Slide 3, Q39/4, AGC 445.

Fig. 3. *Hamiapollenites* cf. *saccatus* Wilson, 1962. A1-19, 8600–8700 ft., Slide 4, Q37/4. AGC 446.

Fig. 4. *Vittatina foveolata* Tschudy & Kosanke, 1966. Ala-117, 7200–7300 ft., Slide 3, P46/1, AGC 447.

Fig. 5. *Costapollenites ellipticus* Tschudy & Kosanke, 1966 A1-19. 9400–9500 ft., Slide 3, J32/2, AGC 448.

Fig. 6. *Vittatina simplex* Jansonius, 1962. Al-19, 8900–9000 ft., Slide 4, G30/4, AGC 449.

Fig. 7. *Distriatites dettmannae* (Segroves, 1969) Foster, 1979. A1-19, 8900–9400 ft., Slide 4, M40/1, AGC 450.

Fig. 8. *Hamiapollenites perisporites* (Jizba, 1962) Tschudy & Kosanke, 1966. Ala-117, 7100–7200 ft., Slide 3, Q36/3, AGC 451.

Fig. 9. *Distriatites insolitus* Bharadwaj & Saluhja, 1964. A1-19, 9200–9300 ft., Slide 3, F23/2, AGC 452.

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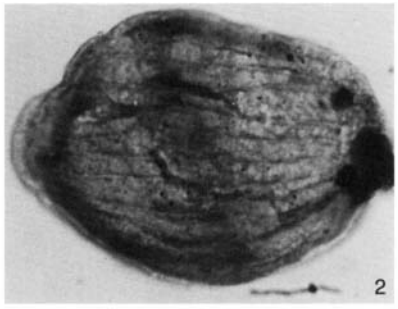
Permian Pollen

Plate 41


1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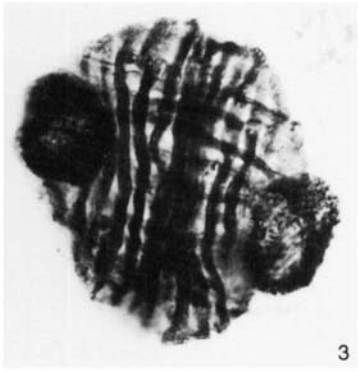
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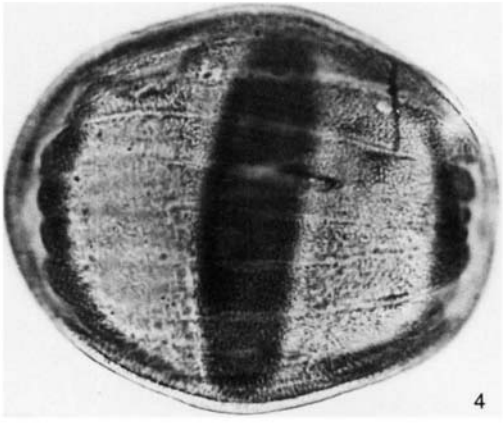
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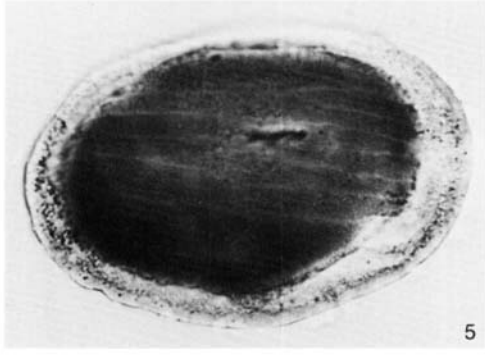
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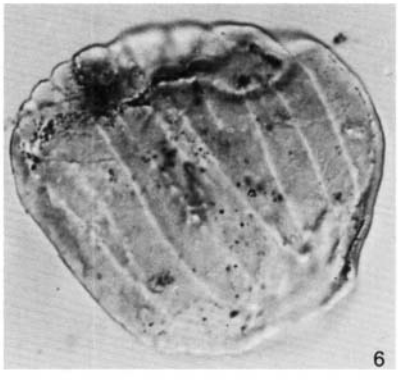
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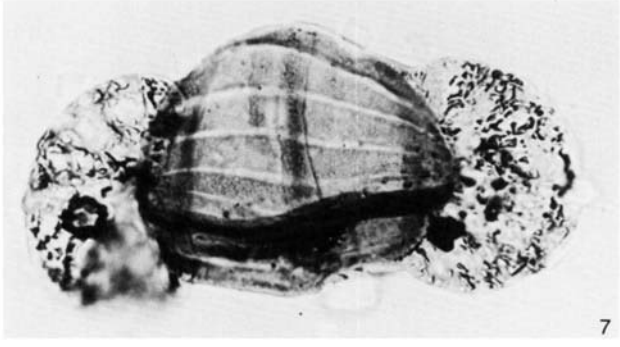
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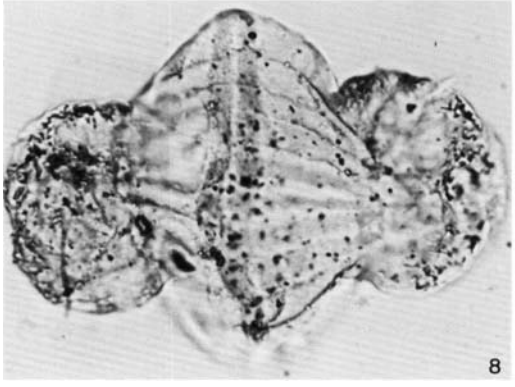
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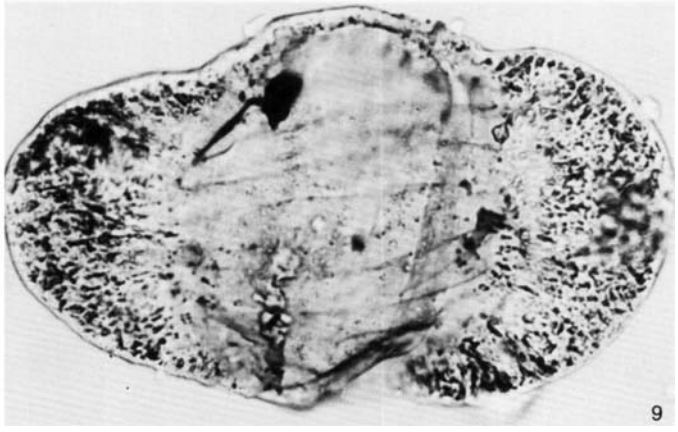
9

Explanation of Plate 42

Fig. 1a-b. *Indotriradites reidii* Foster, 1979. A1-19, 8900–9000 ft., Slide 3, L40/1, × 500, AGC 453. Fig. 1 a : proximal view, 1 b : distal view.

Fig. 2. *Maculatasporites indicus* Tiwari, 1964. Ala-117, Core 3, 7039 ft., Slide 4, J47/3, × 1000, AGC 454.

Fig. 3a,b. *Columinisporites peppersii* Alpern & Doubinger, 1973. Ala-117, 7100–7200 ft., Slide 4, N30/4, × 500, AGC 455. Fig. 3 a : upper focus, 3 b : lower focus.

Fig. 4. *Laevigatosporites vulgaris* (Ibrahim, 1933) Potonié & Kremp, 1956. emend. Alpern & Doubinger, 1973. A1-19, 10000–10100 ft., Slide 2, W41/2, × 1000, AGC 456.

Fig. 5. *Endosporites ornatus* Wilson & Coe, 1940. A1-19, 9800–9900 ft., Slide 2, V42/4, × 500, AGC 457.

Fig. 6. *Samoilovitchisaccites* sp. Ala-117, 7100–7200 ft., Slide 4, Y38/4, × 1000, AGC 458.

Fig. 7. *Corisaccites alutas* Venkatachala & Kar, 1966. Ala-117, Core 3, 7039 ft., Slide 4, P41/2, × 500, AGC 459.

Fig. 8. *Divarisaccus lelei* Venkatachala & Kar, 1966. Ala-117, Core 3, 7030 ft., Slide 4, T37/1, × 1000, AGC 460.

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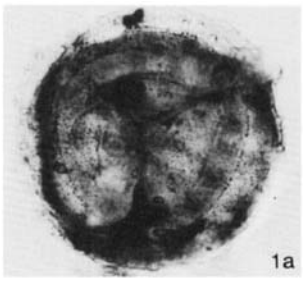
Permian Miospores and Pollen

Plate 42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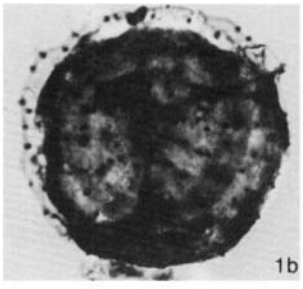
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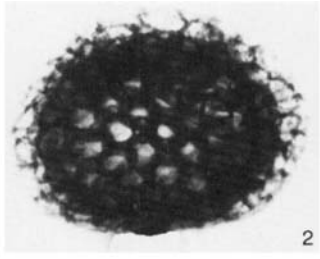
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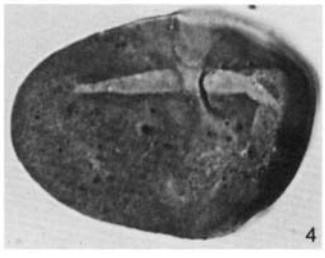
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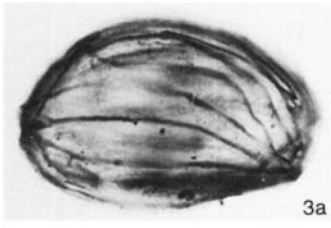
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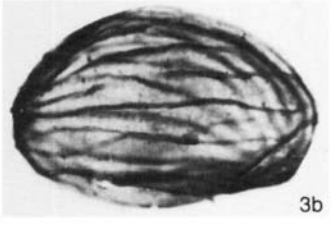
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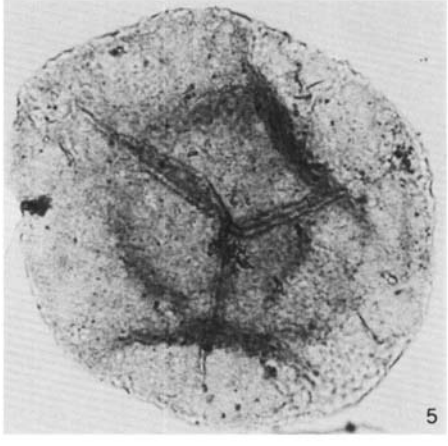
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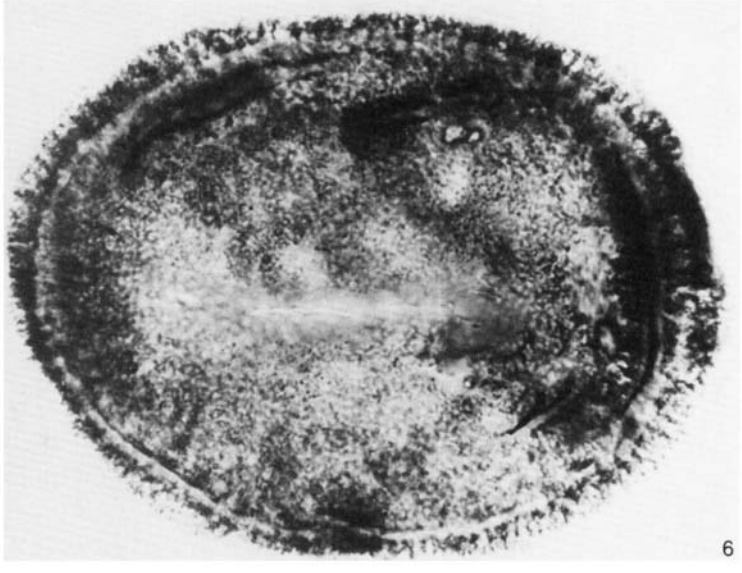
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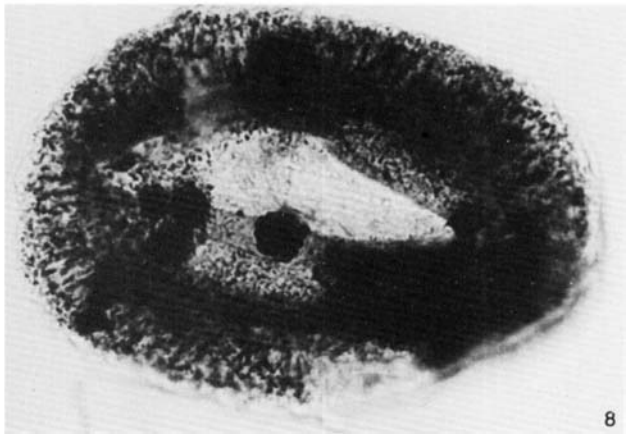
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