

## Chapter 5 Pollen and Spores

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### INTRODUCTION

This chapter contains an account of the assemblage of pollen and spores which has been extracted from six samples of the Ciniza Lake Beds. The assemblage is compared with those previously described from the Chinle Formation, Dockum Group, Newark Group, and certain other Triassic units. Four samples analyzed (FW1-2a, 2c, 2e, 3h) are in stratigraphic succession at one locality (section FW1) as shown in chapter 1, figure 17, whereas the other two came from section FW6 (chap. 1, fig. 4). Palynomorphs are abundant and well preserved in all samples, but the assemblage is not very diverse as it contains only 19 species. In general, it is dominated by nonstriate bisaccate grains and contains only a few trilete forms.

Random counts of 200 palynomorphs were made from each sample (fig. 1). In terms of relative abundance, only four species, *Pityosporites chinleana*, *Klausipollenites* sp., *Patinasporites densus*, and *Minutosaccus schizeatus* are important. *Klausipollenites* sp. and *Pityosporites chinleana* fluctuate as the dominant species. The lower portion of the lake beds is characterized by abundant *Minutosaccus schizeatus* whereas *Patinasporites densus* is more abundant in the upper lake bed. The two samples from section FW6 are stratigraphically equivalent to the upper lake beds at section FW1 and have percentages comparable to the uppermost sample (FW1-2h).

### COMPARISONS AND AGE OF THE LAKE CINIZA ASSEMBLAGE

From the distribution chart (table 1) it can be seen that the assemblage of pollen and spores extracted from the sedi-

ments of Lake Ciniza compares quite closely with only two previously described assemblages. One has been incompletely described (Daugherty 1941, Peabody and Kremp 1964, Gottesfeld 1972) from the Chinle Formation in Petrified Forest National Park in Arizona (table 1). The similarity is not unexpected as both assemblages occur in the lower part of the Chinle at localities only about 113 km apart. As shown in the table (column 1), the assemblages contain 9 of the same genera and 4 of the same species. Particularly noteworthy is the fact that they both contain three distinctive forms—*Alisporites oppi*, *Pityosporites chinleana*, and *Equisetosporites chinleana*—which are not known beyond the southwestern United States. Undoubtedly, when the Petrified Forest assemblage is described fully, it will be found to contain many more of the Lake Ciniza forms.

The Lake Ciniza assemblage also compares remarkably closely with the one described in detail by Dunay (1972) from the Late Triassic Dockum Group at several localities about 645 km east of Fort Wingate in the Texas panhandle. A comparison (table 1) of the two assemblages shows that they contain at least 12 of the same genera and 8 identical species. In addition, the Dockum assemblage also contains the 3 distinctive forms mentioned above, and there is little doubt the two are closely related.

On the other hand, the Lake Ciniza assemblage is remarkably unlike that described (Schultz and Hope 1973) from the lower part of the Upper Triassic Newark Group in the Pekin Formation of North Carolina. That assemblage is also distinct from other Late Triassic ones now known from

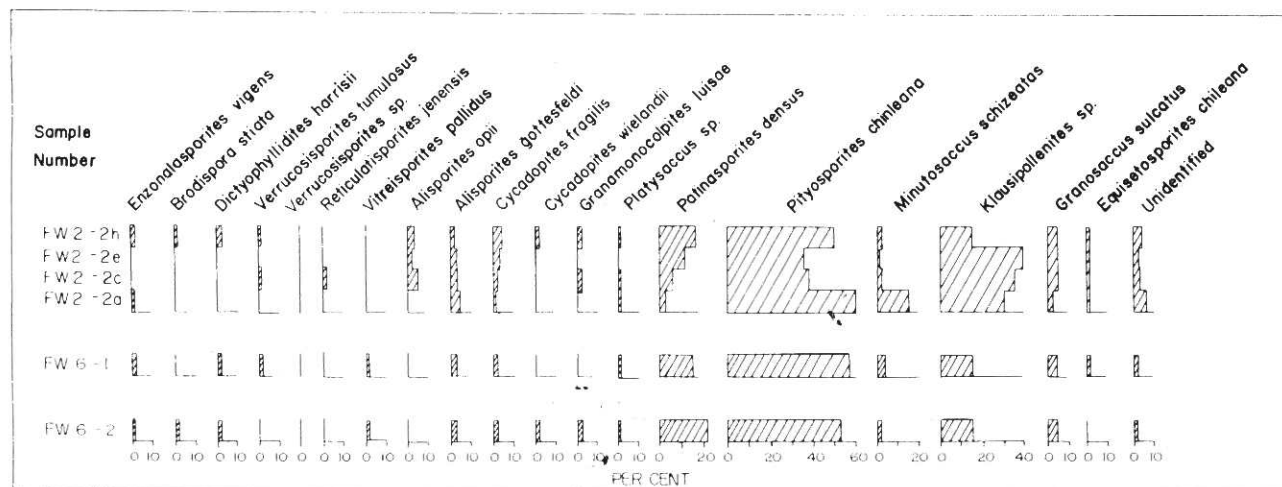


FIGURE 1.—Relative abundance of the species of palynomorphs extracted from certain samples of the Ciniza Lake Beds. The position of the sample localities is shown in chapter 1, figure 21.

TABLE 1

DISTRIBUTION OF THE 19 SPORES IDENTIFIED IN THE DEPOSITS OF LAKE CINIZA AT SELECTED UPPER TRIASSIC LOCALITIES. X, same species and genus. O, genus only represented. \*, distinctive Chinle-Dockum species not known beyond the Southwest.

MIOPORE \ LOCALITY	North America						Europe								
	Arizona	Texas	North Carolina	North Carolina	Canada		England	England	Switzerland	Switzerland	Austria	Austria	Germany	Australia	
	1	2	3	4	5		7	8	9	10	11	12	13	14	15
<i>Enzonalsporites vigens</i>		x					x	x	x	x	o	o			
<i>Bradisporea striata</i>							x	x							
<i>Dictyophyllidites harrisii</i>	o	o	o	o								x			x
<i>Verrucosiporites tumulosus</i>	o	x		o		o	o		x		o	x		o	
<i>V. sp.</i>	o	o		o		o	o		o		o	o		o	
<i>Reticulatisporites jenensis</i>			o						o						
<i>Vitreisporites pallidus</i>	x								o				x <sup>2</sup>	o	
* <i>Alisporites opii</i>	x	x	o	o	o	o	o	o				o	o	o	o
<i>A. gottesfeldi</i> n. sp.	o	o	o	o	o	o	o	o				o	o	o	o
<i>Cycadopites fragilis</i>	o	x	o	o	x	o	o	o <sup>1</sup>				o			o
<i>C. weilandii</i>	o	o	o	o	o	o	o	o <sup>1</sup>				o			o
<i>Granamonomolpites luisae</i>						o									
<i>Platysaccus</i> sp.		o			o		o						o	o	o
<i>Patinasporites densus</i>	o	x	o	o		o	o	x	x	x	o	x	x		
* <i>Pityosporites chinleana</i>	x	x		o					o		o	o			
<i>Minutosaccus schizeatus</i>		o											x		
<i>Klausipollenites</i> sp.	o	x		o	o	o	o					o			
<i>Granosaccus sulcatus</i>													x		
* <i>Equisetosporites chinleana</i>	x	x													

## LOCALITIES AND SOURCES OF DATA

1. Chinle Formation, Petrified Forest, Arizona: Daugherty 1941, Peabody and Kremp 1964, Gottesfeld 1972.
2. Dockum Group, panhandle of Texas: Dunay 1972, Dunay and Traverse 1971.
3. Newark Group (Pekin Formation), North Carolina: Schultz and Hope 1973.
4. Newark Group (Cummock Formation), North Carolina: Koob 1961, Gottesfeld 1972.
5. Heiberg Formation, Ellesmere Island, Canada: McGregor 1965.
6. Los Rastros Formation, Argentina: Herbst 1965, 1970.
7. Keuper Marl, England: Clarke 1965.
8. Arden Sandstone and Keuper Marls, England: Fisher 1972.
9. Keuper (Karnian), Switzerland: Leschik 1955.
10. Keuper, Switzerland: Scheuring 1970.
11. Keuper, Austria: Klaus 1960.
12. Keuper, Austria: Bharadwaj and Singh 1964, Dunay 1972.
13. Keuper, Germany: Madler 1964.
14. Ipswich Coal Measures, Australia: de Jersey 1962.
15. Brady Formation and "feldspathic sandstone," Tasmania: Playford 1965.

<sup>1</sup>As *Monosulcites*.

<sup>2</sup>As *Caytonipollentes*.

the Southwest (table 1). These findings are rather unexpected as it was assumed that the Chinle-Dockum sequences were of about the same age as the Newark and contained a similar assemblage (Gottesfeld 1972). According to the work of Schultz and Hope, the Pekin does not contain any of the species in the Ciniza Lake Beds, including the distinctive Chinle-Dockum forms. In fact it contains only 5 genera known from the Ciniza Lake Beds, and most of them range from the Permian into the Jurassic or into even younger rocks (table 2). The Pekin assemblage is dominated by circular and triangular trilete forms, and it contains only a few bisaccate forms in contrast to the assemblage described here which consists mainly of bisaccate forms. One noteworthy form described from the Pekin is *Classopollis*. Representatives of that genus are not known from either the Chinle or the Dockum, but elsewhere they occur in the rocks of latest (Rhaetian) Triassic age.

The assemblage described here contains 7 of the same genera that occur in the Cumnock Formation in the Newark Group of North Carolina (Koob 1961, Gottesfeld 1972). Most of them, however, are long-ranging forms, such as *Alisporites*, and thus are not particularly useful for correlation. Although Gottesfeld (1972) stated that "at least 50% of the species [of the Chinle and Cumnock assemblages] are the same or closely related," he did not name any of them. Thus it is impossible to compare the two assemblages on a specific level at this time.

The Lake Ciniza assemblage is not very closely related to the assemblage found in the Upper Triassic Heiberg Formation of Canada's Ellesmere Island. Although that unit contains more than 50 species (McGregor 1965), only one of them and 4 of the genera have been identified in the Ciniza Lake Beds (column 5, table 1). The assemblage described here is also distinct from the small assemblage described (Herbst 1965) from the Upper Triassic Los Rastros Formation in Argentina as that microflora contains only 4 of the same genera (column 6, table 1). Just a few of the many species and genera that have been described from the Upper Triassic (Keuper) of Europe occur also in the sediments of Lake Ciniza (columns 7-13, table 1). Eight genera and 3 species of the Lake Ciniza assemblage were reported in the Keuper of England (Clarke 1965, Fisher 1972). In Germany 5 of the same genera and 3 of the same species were described from the Upper Triassic rocks by Mädlar (1964). Leschik (1955) and Scheuring (1970) report 6 of the same genera and 3 of the same species in the Keuper of Switzerland. Klaus (1960) and Dunay (1972) have described 8 of the Lake Ciniza genera and 2 of the species in the Keuper of Germany. The Upper Triassic rocks of Australia and Tasmania have yielded several fairly large assemblages, yet they contain only 5 of the same genera and 1 of the same species that occur in the Ciniza Lake Beds.

In summary, the assemblage of pollen and spores described here compares rather closely with those known from the Chinle Formation in the Petrified Forest of Arizona and the Dockum Group in the panhandle of Texas. Many species and genera are common to the three assemblages including 3 distinctive forms unknown outside the southwestern United States. The Lake Ciniza assemblage contains only a few genera known from the Newark Group of the eastern United States, the two assemblages appear to be not very closely related. Although many Lake Ciniza genera and a few species do occur in certain other Upper Triassic localities elsewhere in the world, it is apparent that those assemblages are not

very closely related. In general, it seems that the farther one goes from the Southwest with comparisons, the fewer Lake Ciniza (and Chinle-Dockum) species are found and the more distinct the assemblages become.

These results agree with those of Ash (1970), who found that the Chinle-Dockum plant megafossils appear to be only distantly related to other Upper Triassic floras. The distinctive nature of the Chinle-Dockum floras may be due to the paleoecological conditions in the Southwest during the Late Triassic. Or it may be due to the fact that no flora of equivalent age has yet been described. Whatever the reason, it seems that a major portion of the Upper Triassic vegetation is restricted to the Southwest and thus cannot be used for close correlation with other areas.

The absence of many Lake Ciniza (and Chinle-Dockum) spore and pollen species beyond the Southwest makes it difficult to determine the age of the deposit. The genera, however, are somewhat more widely distributed so they can be useful in this regard as discussed by Dunay (1972) in his study of the pollen and spore flora of the Dockum Group. Much of what he says is applicable to the present investigation as his assemblage contains many of the same genera as the Lake Ciniza sediments (and the Chinle in the Petrified Forest). Many of them are long ranging and are not very useful for dating, as shown in table 2. For example, *Alisporites* and *Pityosporites* first appear in the geologic record in the Pennsylvanian (Fredericksen 1972). Others, such as *Vitreisporites*, extend into the Cretaceous (Hughes 1969). Three of the genera, *Enzonalasporites*, *Brodipora*, and *Granosaccus*, however, are restricted to the Upper Triassic and suggest that the assemblage is probably of Late Triassic age. This probability is substantiated by the fact that typical Middle Triassic striate forms and typical latest Triassic (Rhaetic) forms, such as *Classopollis* and *Cerebrepollenites*, are absent. Therefore, it is concluded that the Lake Ciniza sediments are of early to middle Late Triassic (Carnian-Norian) in age.

#### AFFINITIES

Only a few of the palynomorph species recognized in this study appear to be related to the plant megafossils found in the deposits of Lake Ciniza or in adjacent sediments (Ash chap. 4). For example, *Dictyophyllidites harrisii* may be related at the Order level to the fern *Phlebopteris smithii* or *Cladophlebis daughertyi*, and *Verrucosisporites tumulosus* may be related at the Order level to *Clathropteris walkeri* (Ash 1970). The cycadlike pollen species *Cycadopites fragilis*, *Cycadopites weilandii*, and *Granomonocolpites luisae* probably have affinities at the Order level with the megafossils *Nilssoniopteris ciniza*, *Zamites powelli*, and *Williamsonia nizhonina*. The probable botanical affinities of these and the other pollen and spore form genera and species found in the deposits of Lake Ciniza are indicated in table 3.

#### PALEOECOLOGICAL INTERPRETATION

The abundant elements are wind-dispersed bisaccate pollen produced by plants that could have grown at some distance from the site of deposition. On the other hand, the trilete spores and cycadlike pollen are thought to have originated from plants growing adjacent to the lake or along streams that drained into the lake. The relative abundances shown in figure 1 approximate those given by Gottesfeld (1971, p. 37, fig. 7) for fluvial sediments of the Chinle

Formation except that Gottesfeld's samples contained a lower abundance of *Pityosporites chinleana*.

The relative abundance data for *Patinasporites densus* (fig. 1) indicates an apparent relationship between the abundance of the species and the developmental history of the lake. At least two explanations seem feasible: (1) The steady increase of *P. densus* upward in the lake beds (samples 1a-2h) may represent a successional change in the plant community surrounding the lake with the parent plant of *P. densus* becoming better established as the lake developed and became filled with sediments. (2) The increase in *P. densus* may represent a response on the part of the parent plant to climatic change. If the plant producing *P. densus* were well adapted to arid

conditions, a trend toward a drier climate would have allowed it to become more abundant and at the same time would have resulted in the eventual destruction of the lake. This explanation seems reasonable as it has been suggested that *Patinasporites densus* is an indicator of an arid climate (Dunay 1973 pers. comm.).

#### SYSTEMATIC DESCRIPTIONS

Kingdom Plantae

Division Uncertain

Genus ENZONALASPORITES Leschik, 1955

Type species: *Enzonalasporites vigens* Leschik, 1955

*Enzonalasporites vigens* Leschik, 1955

(fig. 2a)

TABLE 2

STRATIGRAPHIC RANGE OF THE MIOSPORE GENERA RECOGNIZED IN THE DEPOSITS OF LAKE CINIZA.

\*Range given for *Equisetosporites* is that of *Gnetaceaepollenites* of Chaloner, probably the same taxa. Adapted from Chaloner (1969, fig. 14-1), Dunay (1972, p. 236), and Fredericksen (1972, text-fig. 1), with additional data from Visscher (1968), Reinhardt (1964), Rogalska (1962), and Wilson (1959).

<div>DIVISIONS OF GEOLOGIC TIME</div> <div>MIOAPORES</div>	Pre-Triassic	Lower Triassic	Middle Triassic	Upper Triassic			Post-Triassic
				Keuper		Rhaetian	
				Carnian	Norian		
<i>Enzonalasporites</i>					-----		
<i>Brodipora</i>							
<i>Dictyophyllites</i>							
<i>Verrucosporites</i>							
<i>Reticulatisporites</i>							
<i>Vitreisporites</i>							
<i>Alisporites</i>							
<i>Cycadopites</i>							
<i>Granamonocolpites</i>							
<i>Platysaccus</i>							
<i>Patinasporites</i>							
<i>Pityosporites</i>							
<i>Minutosaccus</i>							
<i>Klausipollenites</i>							
<i>Granosaccus</i>					-----		
<i>Equisetosporites</i>	---						

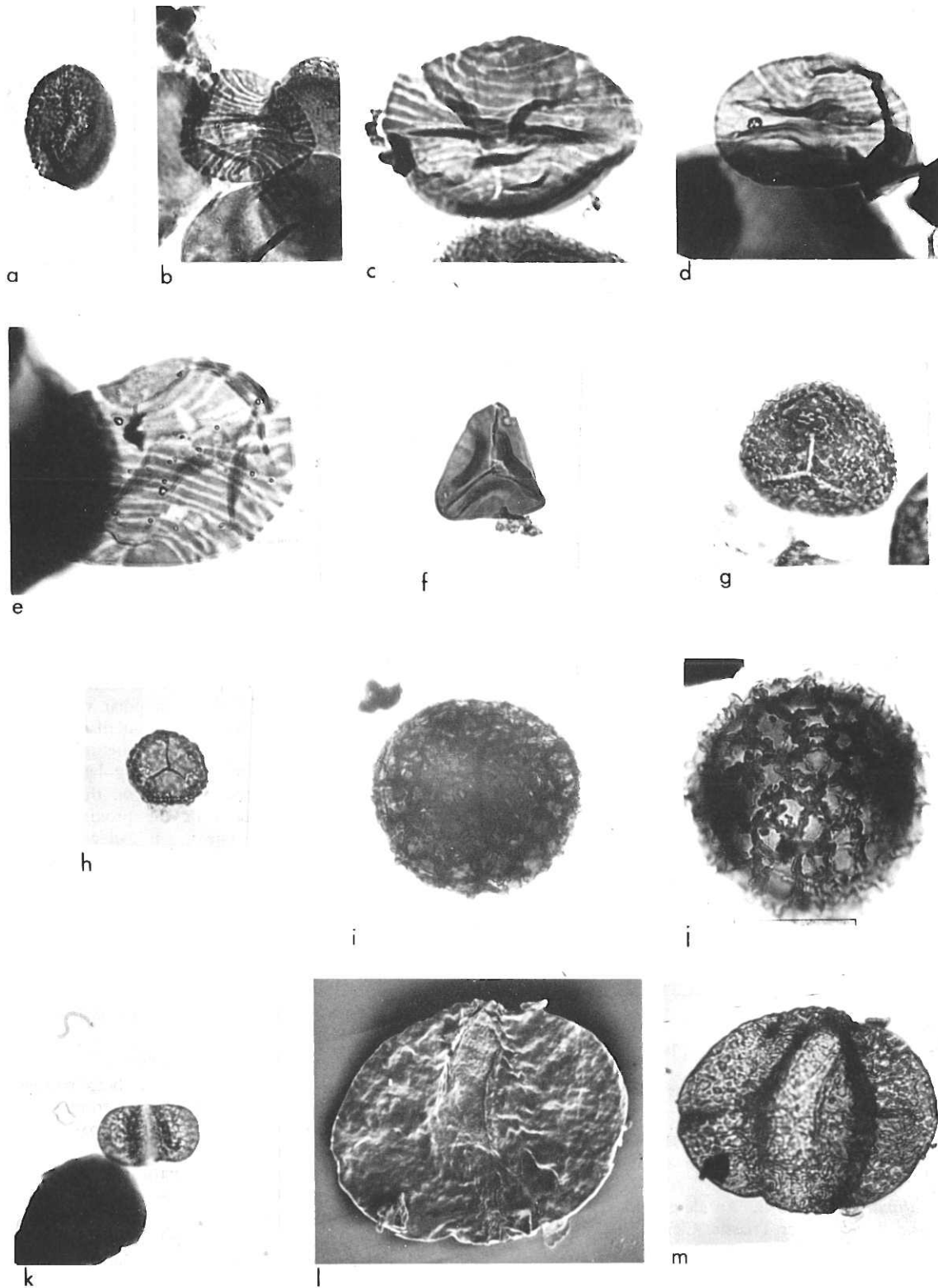


FIGURE 2.—Chinle spores and pollen. a.—*Enzonolasporites vigens* Leschik, 1955. Sample FW6-3, slide 21828A1, coordinates 27.1–113.4, 36 $\mu$ . b–e.—*Brodipora striata* Clarke, 1965. b, FW6-3, 23281A11, 23.3–112.3, 39 $\mu$ . c, FW6-3, 23281A12, 39.2–111.2, 42 $\mu$ . d, FW6-3, 23281A12, 27.0–114.8, 33 $\mu$ . e, FW6-3, 23281A12, 32.8–113.2, 44 $\mu$ . f.—*Dictyophyllidites harrisi* Couper, 1958. FW6, 21828A1, 36 $\mu$ . g.—*Verrucosporites tumulosus* Leschik, 1955. FW6-3, 21828A1, 27.5–112.7, 50 $\mu$ . h.—*Verrucosporites* sp. FW6, 21828A1, 24.0–125.6, 24 $\mu$ . i–j.—*Reticulatisporites jenensis* (Reinhardt and Schmitz) n. comb. i, FW1-2a, 29166A2, 34.1–116.1, 65 $\mu$ . j, FW1-2c, 29165A2, 35.0–125.7, 56 $\mu$ . k.—*Vitreisporites pallidus* (Reissinger) Nilsson, 1958. FW6, 21828A1, 26.7–117.4, 29 $\mu$ . l–m.—*Alisporites opii* Daugherty, 1941. FW6-3, SEM slide, 100 $\mu$ . l, Scanning electron micrograph. m, Photographed in air on a gelatin substrate, same specimen as figure 2l.



1955 *Enzonalasporites vigen* Leschik, p. 44, pl. 5, fig. 24.

1955 *Enzonalasporites obliquus* Leschik, p. 44, pl. 5, figs. 23, 25.

**Discussion.**—Clarke (1965) discussed the status of the related species of *Enzonalasporites* and *Zonalasporites* Leschik, 1955. The observed size is  $32\mu$  and  $36\mu$  for two specimens.

**Suggested affinities.**—Unknown. Leschik (1955) considered this form to be monosaccate, but this interpretation was questioned by Clarke (1965).

**Stratigraphic range.**—Upper Triassic. Leschik (1955), Clarke (1965), Warrington (1970).

TABLE 3

PROBABLE BOTANICAL RELATIONSHIPS OF PALYNOMORPH FORM GENERA AND SPECIES

Kingdom Plantae
Division Uncertain
<i>Enzonalasporites vigen</i> (spore?)
<i>Brodipora striata</i> (spore?)
Division Pterophyta
Order Filicales
Family Cheiroleuriaceae?
<i>Dictyophyllidites harrisii</i>
Family Zygopteridaceae
<i>Verrucosiporites tumulosus</i>
<i>Verrucosiporites</i> sp.
Family Uncertain
<i>Reticulatisporites jenensis</i> n. comb.
Division Pteridospermophyta
Order Pterodispermales
Family Caytoniaceae
<i>Vitreisporites pallidus</i>
Family Corystospermaceae
<i>Alisporites opii</i>
<i>Alisporites gottesfeldi</i> n. sp.
Division Cycadophyta or Ginkgophyta
<i>Cycadopites fragilis</i>
<i>Cycadopites weilandii</i> n. comb.
<i>Granomonocolpites luisae</i>
Division Coniferophyta
Order Coniferales
Family Podocarpaceae?
<i>Platysaccus</i> sp.
Family Pinaceae?
<i>Patinasporites densus</i>
<i>Pityosporites chinleana</i>
Order Coniferales?
<i>Minutosaccus schizeatus</i>
<i>Klausipollenites</i> sp.
<i>Granosaccus sulcatus</i>
<i>Equisetosporites chinleana</i>

Genus BRODISPORA Clarke, 1965

Type species: *Brodipora striata* Clarke, 1965

*Brodipora striata* Clarke, 1965

        (figs. 2b–2c)

1965 *Brodipora striata* Clarke, p. 300, pl. 36, figs. 6–9.

**Discussion.**—The observed size range is  $33\text{--}44\mu$  for five specimens.

**Suggested affinities.**—Unknown. An alete spore?

**Stratigraphic range.**—Upper Triassic. Clarke (1965).

Division PTEROPHYTA

Order FILICALES

Family CHEIROPLEURACEAE?

Genus DICTYOPHYLLIDITES Couper, 1958

Type species: *Dictyophyllidites harrisii* Couper, 1958

*Dictyophyllidites harrisii* Couper, 1958

        (fig. 2f)

1958 *Dictyophyllidites harrisii* Couper, p. 140, pl. 21, figs. 5–6.

**Discussion.**—The observed size range is  $32\text{--}36\mu$  for four specimens.

**Suggested affinities.**—Cheiroleuriaceae, *Dictyophyllum*.

**Stratigraphic range.**—Upper Triassic–Jurassic. Couper (1958), Bharadwaj and Singh (1964), Playford (1965).

Family ZYGopteridaceae

Genus VERRUCOSISPORITES (Ibrahim) Potonié and Kremp, 1954

Type species: *Verrucosiporites verrucosus* Ibrahim, 1933

*Verrucosiporites tumulosus* Leschik, 1955

        (fig. 2g)

1955 *Verrucosiporites tumulosus* Leschik, p. 16, pl. 1, fig. 17.

1964 *Verrucosiporites* sp. C Bharadwaj and Singh, p. 35, pl. 3, fig. 66.

**Discussion.**—*Trilites klausii* of Bharadwaj and Singh (1964) is similar, but the verrucae were described as being sparsely spaced. *Verrucosiporites* sp. C Bharadwaj and Singh, 1964, is synonymous. The observed size range of this study is  $40\text{--}58\mu$  for 4 specimens.

**Suggested affinities.**—Order Selaginellales and Order Filicales. Potonié (1962) related spores of *Verrucosiporites* to the megafossil *Sporangiostrabus rugosus* Bode, 1928 (Selaginellales), and to the megafossils *Zygopteris* Corda, 1845, and *Waldenburgia corynepteroides* Gothan, 1950.

**Stratigraphic range.**—Upper Triassic. Leschik (1955), Bharadwaj and Singh (1964).

*Verrucosiporites* sp.

    (fig. 2h)

**Discussion.**—The specimens are trilete with rays extending  $\frac{3}{4}$  of the spore radius. The shape in polar view is rounded triangular with strongly convex to subcircular sides. The ornamentation is verrucate. The verrucae are irregular in outline, elongate, and approximately  $4\mu$  long by  $2\mu$  wide. The verrucae are longer and more abundant on the distal surface. In contrast, the contact faces of the proximal surface are practically free of verrucae. The size is  $24\mu$  and  $30\mu$  for two specimens. The spore illustrated by Gottesfeld (1971, p. 34, fig. 6–20) as *Verrucosiporites* sp. may be identical.

**Suggested affinities.**—Order Selaginellales and Order Filicales.

**Stratigraphic range.**—Upper Triassic, Chinle Formation.

Family Uncertain

Genus RETICULATISPORITES (Ibrahim) Schopf, Wilson, and Bentall, 1944

Type species: *Reticulatisporites reticulatus* Ibrahim, 1932

**Discussion.**—The following species has been removed from *Lycopodium-sporites* because that genus is interpreted as having the ornament reduced or missing on the proximal face. The present generic assignment may require further investigation because of the supposed cingulate nature of the type species of *Reticulatisporites* (Neves 1964, Smith and Butterworth 1967), although the uniform reticulation is stressed by Kosanke (1969). The specimens under consideration are not cingulate and do have the reticulum on the proximal face.

*Reticulatisporites jenensis* (Reinhardt and Schmitz) n. comb.

    (figs. 2i, 2j)

1964 *Retitriletes jenensis* Reinhardt and Schmitz, p. 21, pl. 2, figs. 5, 6.

1965 *Lycopodiumsporites? jenensis* (Reinhardt and Schmitz)

Reinhardt, p. 610, text-fig. 1.

**Discussion.**—The muri of the Chinle Formation specimens are about  $2.5\mu$  wide, irregular in width and discontinuous. The lumina are  $5\text{--}11\mu$  wide. The reticulum closely resembles the reticulum illustrated in text-figure 3 of Reinhardt and Schmitz (1964). The observed size is  $56\mu$  and  $65\mu$  for two specimens.

**Suggested affinities.**—Order Sphenophyllales and Order Filicales. Potonié (1962) related *Reticulatisporites* to the sphenopid *Sphenophyllum* Koenig, 1825, and to the ferns *Schlerocleypus oviformis* Mamay, 1954, and *Scolecopteris major* Mamay, 1950.

**Stratigraphic range.**—Triassic. Reinhardt and Schmitz (1964).

Division PTERIDOSPERMOPHYTA

Order PTERIDOSPERMALES

Family CAYTONIACEAE

Genus VITREISPORITES Leschik, 1955

Type species: *Vitreisporites signatus* Leschik, 1955

*Vitreisporites pallidus* (Reissinger) Nilsson, 1958

(fig. 2k)

1940 *Pityosporites pallidus* Reissinger, p. 14.

1950 *Pityopollenites pallidus* (Reissinger) Reissinger, p. 109, pl. 15, figs. 1–5.

1958 *Caytonipollenites pallidus* (Reissinger) Couper, p. 150, pl. 26, figs. 7, 8.

1958 *Vitreisporites pallidus* (Reissinger) Nilsson, p. 77, pl. 7, figs. 12–14.

**Discussion.**—The observed size is  $29\mu$  for each of two specimens.

**Suggested affinities.**—Caytoniaceae, *Caytonanthus*. However, no plant megafossils have been found in the Chinle Formation which could be referred to the Caytoniaceae.

**Stratigraphic range.**—Triassic-Cretaceous. This species is widely reported in Triassic, Jurassic, and Cretaceous rocks from various parts of the world. Gottesfeld (1971).

Family CORYSTOSPERMACEAE

Genus ALISPORITES Daugherty emend. Jansonius, 1971

Type species: *Alisporites opii* Daugherty, 1941

*Alisporites opii* Daugherty, 1941

(figs. 2l, 2m, 3a)

1941 *Alisporites opii* Daugherty, p. 98, pl. 34, fig. 2.

**Discussion.**—Jansonius (1971) has redescribed and rephotographed the holotype of *A. opii*. The observed size range of the Lake Ciniza specimens is  $127\text{--}235\mu$  for three specimens.

**Suggested affinities.**—Pteridospermales, Caytoniaceae, and Corystospermaceae. Potonié (1962) related the genus *Alisporites* to the corystosperm *Pteruchus* Thomas, 1933, and to *Caytonanthus oncodes* Harris, 1941.

**Stratigraphic range.**—Upper Triassic. Daugherty (1941), Peabody and Kremp (1964), Gottesfeld (1971).

*Alisporites gottesfeldi* n. sp.

(fig. 3b–3f)

1971 *Alisporites* sp. Gottesfeld, p. 33, fig. 5–6, 507.

1971 *Alisporites* sp. Dunay and Traverse, p. 68, pl. 1, fig. 1.

**Diagnosis.**—Bisaccate pollen with a transversely elongate, oval central body and a distinct, wide sulcus.

**Description.**—The pollen is bisaccate with the sacchi totally enveloping the distal face and overlapping onto the proximal face. The pollen is broadly oval in polar view. The shape of the central body in polar view is oval and elongate transversely to the long axis of the grain. A cappa is not devel-

oped. The central body is psilate where free of the sacchi. The sacchi are "reticulate" in appearance but consist of pits and open areas (lumina?) that are irregular in outline and  $0.5\text{--}3\mu$  in length and surrounded by poorly delineated positive areas (muri?). A scanning electron micrograph indicates that the surface is wrinkled but not reticulate and permits the conclusion that the ornament is infrareticulate. A well-developed distal sulcus is present. The sulcus extends the full length of the central body. In width the sulcus is overlapping to  $2.5\mu$  wide at the center and broadens to  $5.5\mu$  at the ends. The size range of the longest dimension is  $55\text{--}72\mu$  as measured on nine specimens.

**Holotype.**—Figure 3b, Mobil Research and Development Corp., slide no. 23281A10, coord.  $34.7\text{--}122.0$ , from USGS fossil plant locality 10088, section FW6, Chinle Formation, Late Triassic, near Fort Wingate, McKinley County, New Mexico. The holotype is  $65\times 57\mu$ , and central body is  $34\mu$  wide.

**Discussion.**—Disaccate pollen type B of Peabody and Kremp (1964) may be conspecific. The type species is larger ( $100\text{--}135\mu$ ) and less distinctly sulcate than the specimens described here. *Alisporites progrediens* Klaus, 1964, is larger ( $120\text{--}150\mu$ ). *A. grauvogeli* Klaus, 1964, is similar but has a more distinct ornamentation and well-developed cappa. *A. robustus* Nilsson, 1958, is larger ( $74\text{--}81\mu$ ). *A. thomasi* (Couper) Nilsson, 1958, has a more or less circular central body and does not have a distinct sulcus. The species is named for Allen Saul Gottesfeld.

**Suggested affinities.**—Pteridospermales, Caytoniaceae, and Corystospermaceae.

**Stratigraphic range.**—Upper Triassic. Gottesfeld (1971), Dunay and Traverse (1971).

Division CYCADOPHYTA or GINKGOPHYTA

Genus CYCADOPITES Wodehouse ex Wilson and Webster, 1946

Type species: *Cycadopites follicularis* Wilson and Webster, 1946

*Cycadopites fragilis* Singh, 1964

(figs. 3g, 3h)

1962 *Monosulcites minimus* Cookson; Pocock, p. 77, pl. 13, figs. 206–8.

1964 *Cycadopites fragilis* Singh, p. 103, pl. 14, fig. 2.

**Discussion.**—The observed size range was  $37\text{--}46\mu$  for six specimens.

**Suggested affinities.**—Bennettitales, Cycadales, and Ginkgoales.

**Stratigraphic range.**—Upper Triassic-Cretaceous. Singh (1964), McGregor (1965).

*Cycadopites weilandii* (Jain) n. comb.

(fig. 3i)

1968 *Bharadwajapollentis weilandii* Jain, p. 36, pl. 10, figs. 161, 162.

**Discussion.**—Herbst (1970) has taken issue with the creation of a new genus based on size and placed *Bharadwajapollentis* Jain, 1968, in synonymy with *Cycadopites*. In concurrence, the present transfer is made. The observed size range was  $62\text{--}84\mu$  for four specimens.

**Suggested affinities.**—Bennettitales, Cycadales, and Ginkgoales.

**Stratigraphic range.**—Middle Upper Triassic. Jain (1968).

Genus GRANAMONOCOLPITES Pierce, 1961

Type species: *Granamonocolpites asymmetricus* Pierce, 1961

*Granamonocolpites luisae* Herbst, 1970

(figs. 3j–3n)

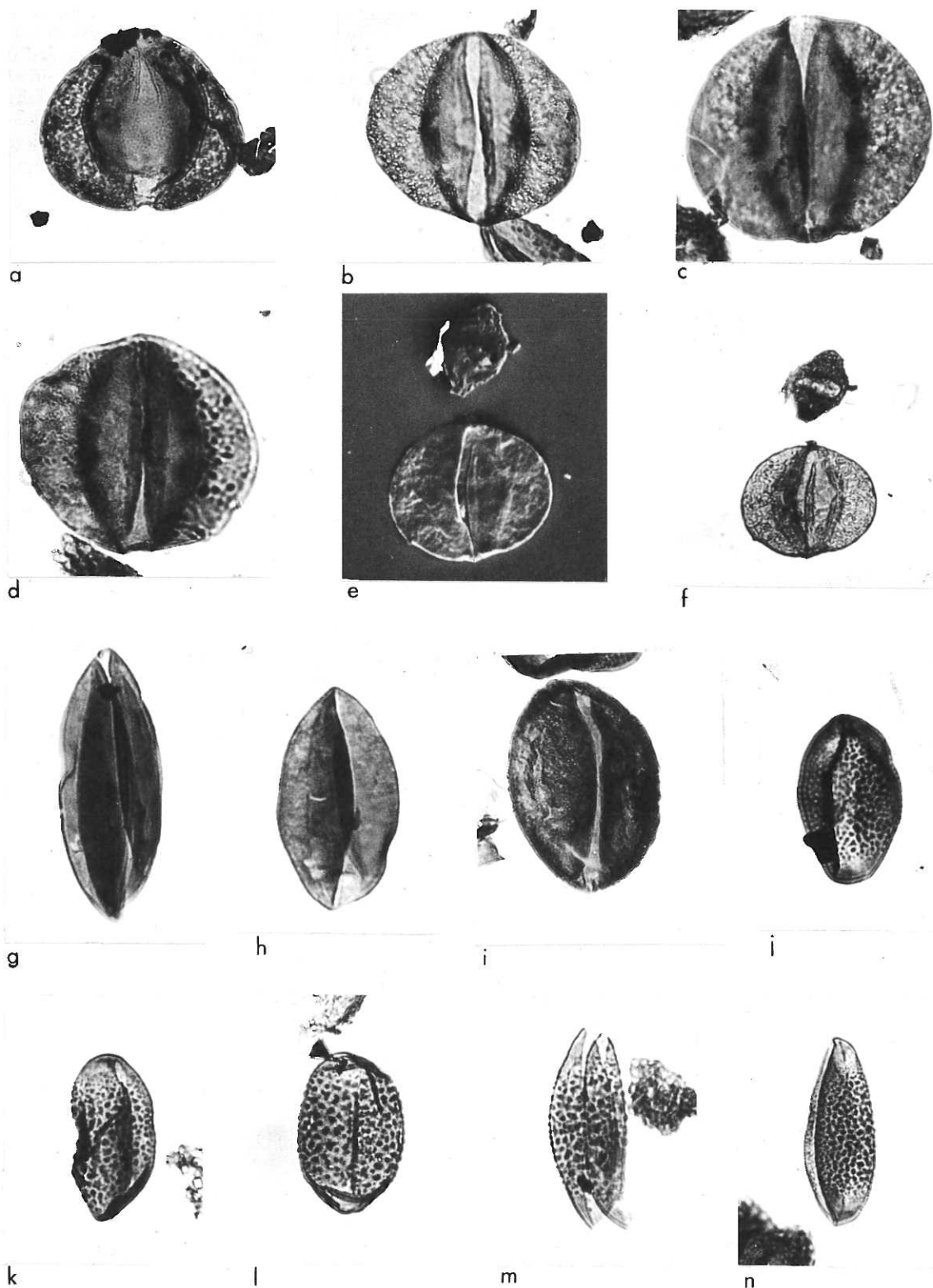


FIGURE 3.—Chinle pollen. a.—*Alisporites opii* Daugherty, 1941. FW1-2h, 29163A1, 33.2–123.2, 127 $\mu$ . b-d.—*Alisporites gottesfeldi* n. sp. b, Holotype, FW6-3, 23281A10, 25.4–120.5, 65 $\times$ 32 $\mu$ . c, FW6-3, 23281A12, 29.3–126.5, 69 $\mu$ . d, FW6-3, 23281A10, 34.7–122.0, 72 $\mu$ . e-f.—*Alisporites gottesfeldi* n. sp. and *Minutosaccus schizeatus* Mädlér, 1964. FW6-3, SEM slide, 57 $\mu$  and 28 $\mu$ , respectively. e, Scanning electron micrograph. f, Photographed in air on a gelatin substrate, same specimens as figure 3c. g-h.—*Cycadopites fragilis* Singh, 1964. g, FW6-3, 23281A12, 39.2–112.8, 46 $\mu$ . h, FW6-3, 23281A12, 41.9–114.9, 37 $\mu$ . i.—*Cycadopites weilandii* (Jain) n. comb. FW6-3, 23281A12, 29.0–124.7, 84 $\mu$ . j-n.—*Granamonocolpites luisae* Herbst, 1970. j, FW6-3, 23281A12, 29.7–126.5, 49 $\mu$ . k, FW6-3, 23281A12, 30.9–113.8, 49 $\mu$ . l, FW6-3, 23281A11, 32.3–121.0, 48 $\mu$ . m, FW6-3, 23281A12, 36.3–125.2, 58 $\mu$ . n, FW6-3, 23281A11, 36.6–115.5, 56 $\mu$ .



1970 *Granamonocolpites luisae* Herbst, p. 92, pl. 1, figs. 4, 5.

**Discussion.**—The assignment of the Chinle Formation specimens to this species is tentative because of their slightly larger size (36–59 $\mu$  for ten specimens) as compared to Herbst's (1970) specimens (20–35 $\mu$ ). Herbst (1970) did not mention the size reduction or absence of the granules in the polar area that is seen on some Chinle Formation specimens. De Jersey (1962) named a new species of granulate monulcate pollen *Ginkgocycadophytus granulatus* (24–55 $\mu$ ); however, the ornamentation of this species varies to papillate. *Granamonocolpites blance* Herbst, 1970, has poorly defined sculptural elements.

**Suggested affinities.**—Bennettitales, Cycadales, and Ginkgoales.

**Stratigraphic range.**—Middle Upper Triassic. Herbst (1970).

Division CONIFEROPHYTA

Order CONIFERALES

Family PODOCARPACEAE?

Genus PLATYSACCUS Naumova ex Potonié and Klaus, 1954

Type species: *Platysaccus papilionis* Potonié and Klaus, 1954

*Platysaccus* sp. Dunay and Traverse, 1971

(fig. 4a)

1971 *Platysaccus* sp. Dunay and Traverse, p. 56, pl. 1, fig. 2.

1972 P. N. sp. Dunay p. 209, pl. 30, fig. 5.

**Discussion.**—Specimens of this genus are infrequent, and the species has not been determined. The observed size range was 53–109 $\mu$  for four specimens.

**Suggested affinities.**—Order Coniferales, Podocarpaceae?

**Stratigraphic range.**—Upper Triassic. Dunay and Traverse (1971) and Dunay (1972). The genus is present in the Permian and Triassic. Chaloner (1969).

Family PINACEAE?

Genus PATINASPORITES Leschik emend. Klaus, 1960

Type species: *Patinasporites densus* Leschik, 1955

*Patinasporites densus* Leschik, 1955

(figs. 4b–4i)

1955 *Patinasporites densus* Leschik, p. 47, pl. 6, fig. 11.

1955 *Patinasporites pluritectus* Leschik, p. 47, pl. 6, fig. 12.

1955 *Patinasporites funiculus* Leschik, p. 48, pl. 6, fig. 13.

1955 *Patinasporites toralis* Leschik, p. 48, pl. 6, fig. 14.

**Discussion.**—A summary of the distinguishing characters of the genera *Patinasporites*, *Enzonalasporites* and *Zonalasporites* has been made by Clarke (1965). In excess of 100 specimens of *Patinasporites* from the Chinle Formation were studied and measured. A continuum of morphological variation was found that includes the four species described by Leschik (1955). The Chinle Formation specimens are placed in the type species. Leschik's species were differentiated by the development and disposition of the ridges and the relative width and demarcation of the central area and peripheral area. For example, *P. pluritectus* has principal and secondary ridges, *P. funiculus* was relatively free of sculpture on the central area, and *P. toralis* had a relatively narrow peripheral area.

The central area of the Chinle Formation specimens is usually distinctly outlined. It is thinner and hence more transparent. It appears to have torn and irregular areas, and the possibility of a detached central body should not be excluded. The peripheral area is cingulate in appearance. A scanning electron micrograph (fig. 4h) does not reveal a clear separation of the central and peripheral areas but does disclose the continuous distribution of the sculpture. It is not known if the ridges are solid (rugulate) or hollow (cavate)

as in *Tsugaepollenites* Potonié and Venitz emend. Potonié, 1958, and *Rugubivesculites* Pierce, 1961. The ridges are present on the entire surface but are better developed on the periphery, especially in the larger individuals. The width of the "cingulum" is on the order of 10–17 $\mu$ , and the central area is approximately 20–37 $\mu$  in diameter. The diameter of the central area is slightly less than half the total diameter in the smaller specimens and ranges up to half the total diameter in the larger specimens. The greatest overall dimension of 104 randomly selected individuals was measured. The size ranged from 26–74 $\mu$  with an average (arithmetic mean) of 45 $\mu$ .

A statistical analysis of measurements of the greatest dimension of individuals of *Patinasporites* using the Chi-square ( $\chi^2$ ) Goodness of Fit Test (Gemmell, Herring, and Shade 1967) demonstrates that the measurements are normally distributed. Because the frequency distribution curve of the greatest dimension approaches a normal curve (and is consequently unimodal), the specimens of *Patinasporites* probably represent a single species (fig. 5). Evidently size may not be used as a parameter in establishing species within the genus.

One hundred four "randomly" encountered specimens of *P. densus* were measured. These measurements were divided into 9 classes with a class interval of 5 microns. A null hypothesis ( $H_0$ ) assumed that the measurements were normally distributed. The alternate hypothesis ( $H_a$ ) was that the measurements were not normally distributed. The null hypothesis can be rejected if the chi-square statistic is greater than a chi-square of 6 degrees of freedom evaluated at the 0.05 level of significance (table 4).

$$\sum_{i=1}^{104} x_i = 4634$$

$$\text{Mean } \bar{X} = 44.5577$$

$$\text{Standard Deviation } s = 12.203$$

The chi-square statistic is

$$\chi^2 = \sum \frac{(f_i - e_i)^2}{e_i} \quad \text{with } m-3 \text{ degrees of freedom,}$$

where  $f_i$  is the observed frequency in the  $i^{\text{th}}$  interval ( $i=1, 2, 3, \dots, m$ )

$e_i$  is the expected frequency in the  $i^{\text{th}}$  interval

and  $m$  is the number of intervals into which the range of the sample distribution is divided.

$$\chi^2 = 11.494$$

Because  $\chi^2 = 11.494$  which is less than  $\chi^2_{.05,6} = 12.592$ , the null hypothesis that the measurements are normally distributed cannot be rejected at a confidence level of 95 percent. Therefore, recognition of more than one species based on size is unjustifiable.

*Patinasporites iustus* Klaus, 1960, and *Patinasporites obulus* Reinhardt, 1964, are distinct in that they possess a dark central area and a light peripheral area.

The analysis of *Patinasporites densus* presented here has not been reconciled with the work of Scheuring (1970) which excludes *P. funiculus* from the synonymy and includes *Zonalasporites explanatus* Leschik, 1955, and *Z. marginalis* Leschik, 1955.

**Suggested affinities.**—Coniferales, Pinaceae? Reissinger (1950) illustrated comparable pollen and related them to *Tsuga*. This assignment was discounted by Leschik (1955)

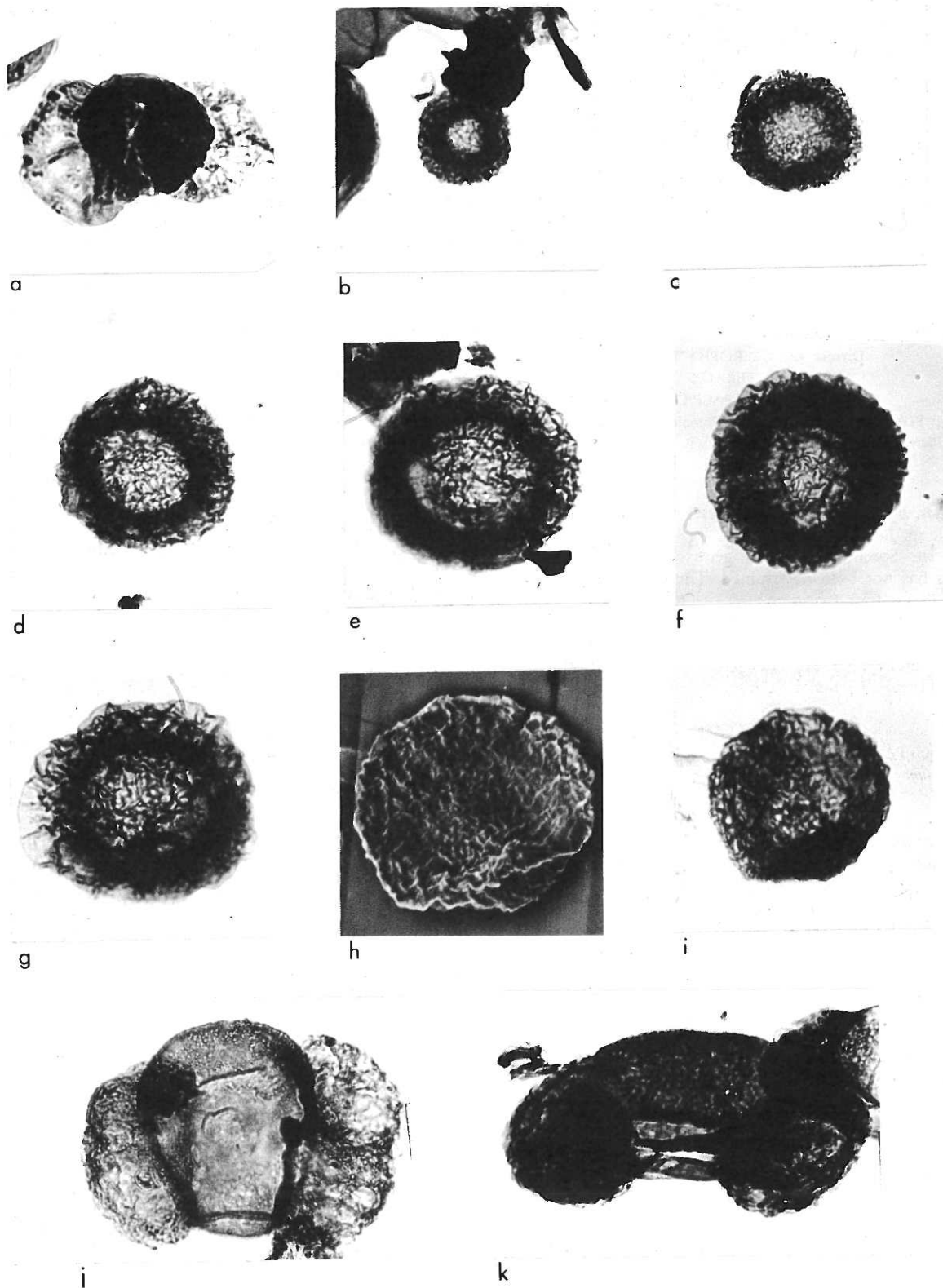


FIGURE 4.—Chinle pollen. a.—*Platysaccus* sp. Dunay and Traverse, 1971. FW6, 21828A2, 38.0–120.3, 69 $\mu$ . b–i.—*Patinasporites densus* Leschik, 1955. b, FW6-3, 23281A12, 37.3–126.0, 29 $\mu$ . c, FW6-3, 23281A10, 20.8–120.1, 42 $\mu$ . d, FW6-3, 23281A11, 43.5–117.3, 53 $\mu$ . e, FW6-3, 23281A12, 29.5–126.2, 62 $\mu$ . f, FW6, 21828A1, 24.4–118.2, 63 $\mu$ . g, FW6-3, 23281A12, 27.9–125.2, 73 $\mu$ . h, FW6-3, SEM slide, scanning electron micrograph. i, FW6-3, SEM slide, photographed in air on a gelatin substrate, same specimen as figure 4h. j–k.—*Pityosporites chinleana* Daugherty, 1941. j, FW6-3, 23281A11, 29.4–120.3, 95 $\mu$ . k, FW6, 21823A1, 23.0–111.2, 106 $\mu$ .

who considered the genus to be monosaccate. Clarke (1965) questioned the saccate nature of *Enzonalasporites*, and the same reasoning applies to *Patinasporites*. If the ridges are cavate, some relationship could be shown to *Tsugaepollenites*, but the question remains undecided.

**Stratigraphic range.**—Upper Triassic. Leschik (1955), Klaus (1960), Clarke (1965), Gottesfeld (1971).

Genus *PITYOSPORITES* Seward emend. Manum, 1960

Type species: *Pityosporites antarcticus* Seward, 1941

*Pityosporites chinleana* Daugherty, 1941  
(figs. 4j, 4k; 6a–6f)

1941 *Pityosporites chinleana* Daugherty, p. 93, pl. 34, fig. 5.

**Discussion.**—The sacci of the pollen grains described here are "reticulate" in appearance as indicated in the meager description by Daugherty (1941), but the surface is more precisely described as rugulate (wrinkled) and pitted with internal? granules. The scanning electron micrographs (figs. 6c, 6d) best depict the surface. The central body is microgranulate ( $0.5\mu$ ), and sparse, small pits are also present (weathering?). The cappa is continuous into a crest both of which are about  $2.5\text{--}3\mu$  in thickness as seen in optical section. A thinned distal sulcal area is present. The size range of the dispersed spores is  $40\text{--}106\mu$  with an average of  $70\mu$  for 25 specimens. Several well-preserved specimens were recovered from an underscribed fructification obtained by Ash (written comm. 1971) from a nearby locality in the Chinle Formation. The size range of the in situ specimens is more uniform:  $69\text{--}75\mu$  for 8 specimens.

**Suggested affinities.**—Pinaceae (Abietineae)? Daugherty (1941) thought the affinities of the species were with the Abietineae. Potonié (1962) related the genus to *Pteruchus* Thomas, 1933, in the pteridosperm family Corystospermaceae. The undescribed fructification that yielded in situ examples of this species more closely resembles a cone of the Corystospermaceae than a typical conifer, according to Ash (written comm. 1972).

**Stratigraphic range.**—Upper Triassic. Daugherty (1941). Gottesfeld (1971).

Order CONIFERALES?

Genus *MINUTOSACCUS* Mädlar, 1964

Type species: *Minutosaccus acutus* Mädlar, 1964

*Minutosaccus schizeatus* Mädlar, 1964  
(figs. 3c, 3f; 6g–6i)

1964 *Minutosaccus schizeatus* Mädlar, p. 120, pl. 12, figs. 4, 5.

**Discussion.**—The Chinle Formation specimens are placed in *M. schizeatus* because of the strongly developed,  $\pm 9\mu$ -wide sulcus. The size range of the central body is slightly smaller

( $21\text{--}30\mu$ ) but comparable to the range of *M. schizeatus* ( $30\text{--}38\mu$ ) as given by Mädlar. The ornament of the central body is granulate ( $\pm 1\mu$ , irregular in shape) and not infrapunctate with a smooth surface as indicated by Mädlar. The observed size was  $32\text{--}42\mu$  overall and  $21\text{--}30\mu$  for the central body. Dunay (1972) described some grains from the Dockum Group in the panhandle of Texas which resemble this species in all features except in size. The fossils from Texas are half again as large as those described here and the type specimens from Germany.

**Suggested affinities.**—Coniferales?

**Stratigraphic range.**—Upper Triassic. Mädlar (1964), Dunay (1972).

Genus *KLAUSIPOLLENITES* Jansonius, 1962

Type species: *Klausipollenites schaubergeri* (Potonié and Klaus) Jansonius, 1962

*Klausipollenites* sp.  
(figs. 6j, 6k; 7a–7e)

1972 *Klausipollenites* sp. Gottesfeld, p. 15, pl. 1, figs. 1–3.

**Discussion.**—The Chinle Formation specimens probably represent a new species of *Klausipollenites*. Naming of the species is awaiting evaluation of the many species of *Klausipollenites* (Jansonius 1962) and *Triadisporea* (Klaus 1964). This species resembles *T. falcata* (Klaus 1964 and Warrington 1970) except that it is smaller and lacks a trilete mark. The ornament appears more perforate than reticulate. The observed size was  $63\text{--}79\mu$  with an average of  $69\mu$  for 11 specimens. Comparable specimens have been illustrated by Peabody and Kremp (1964, p. 16, K. sp. 1) and Dunay and Traverse (1971, K. sp.).

**Suggested affinities.**—Coniferales?

**Stratigraphic range.**—Upper Triassic. Gottesfeld (1971).

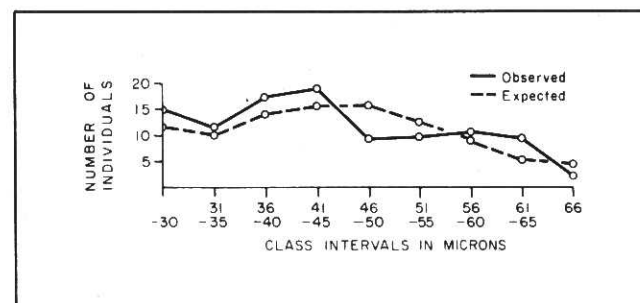


FIGURE 5.—Frequency distribution of the longest dimension of *Patinasporites* in the Chinle Lake Beds.

TABLE 4  
DISTRIBUTION OF MEASUREMENTS

Class	Class Range	Observed Frequency ( $f_i$ )	Standard Normal Probabilities	Expected Frequencies ( $e_i$ )
1	-30	15	$p_1 = .11702$	12.17
2	31-35	12	$p_2 = .10068$	10.47
3	36-40	17	$p_3 = .13799$	14.35
4	41-45	18	$p_4 = .16026$	16.67
5	46-50	9	$p_5 = .15769$	16.40
6	51-55	10	$p_6 = .13149$	13.67
7	56-60	11	$p_7 = .09106$	9.47
8	61-65	9	$p_8 = .05637$	5.86
9	66-70	0*	$p_9 = .04746$	4.94
10	71	3*		

\*Classes 9 and 10 must be combined to give an expected frequency  $> 5$ .

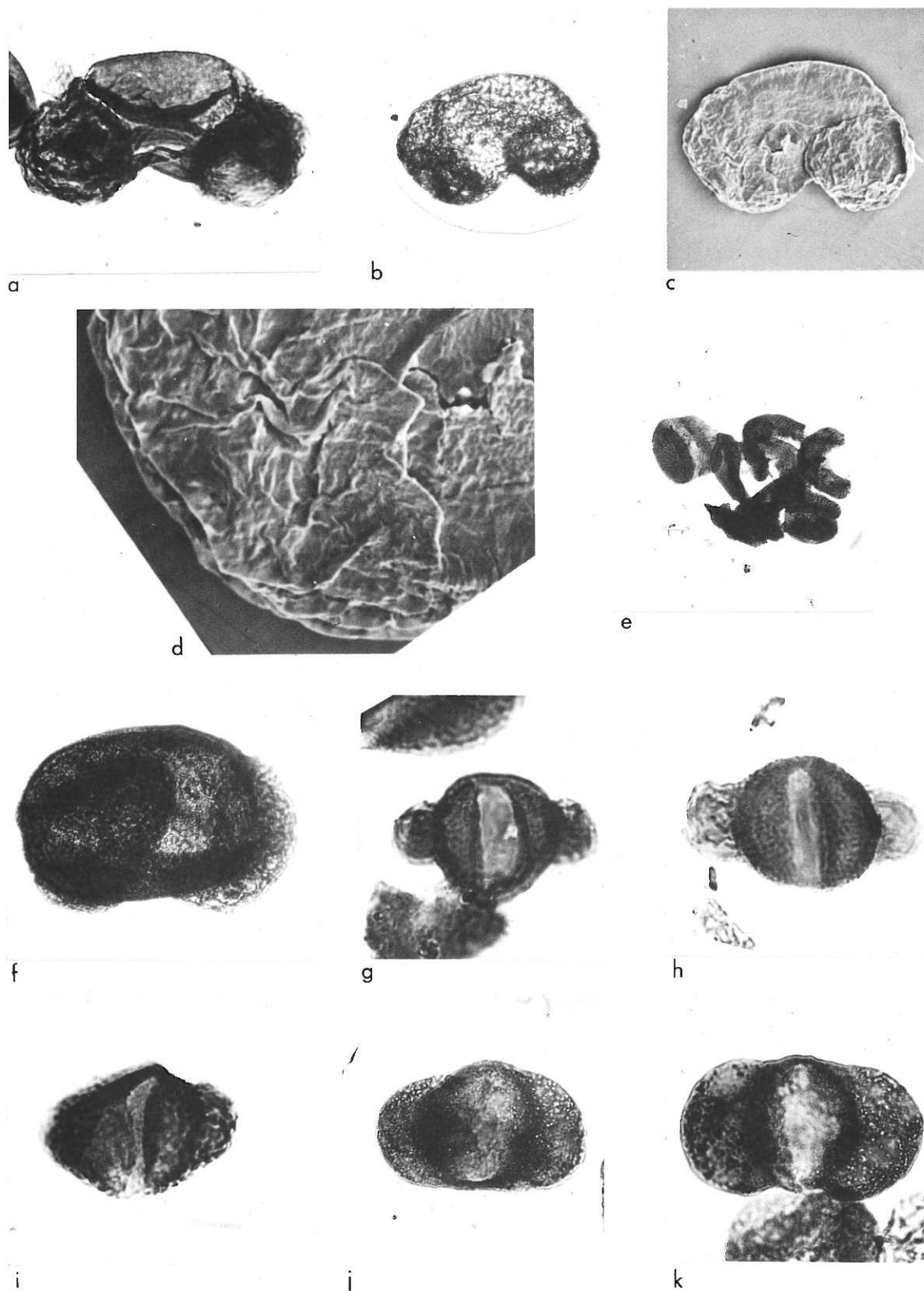


FIGURE 6.—Chinle pollen: a-f.—*Pityosporites chinleana* Daugherty, 1941. a, FW6-3, 23281A11, 36.1–114.8, 84 $\mu$ . b, FW6-3, SEM slide, photographed in air on a gelatin substrate, 84 $\mu$ . c, FW6-3, SEM slide, scanning electron micrograph, same specimen as figure 6b. d, FW6-3, SEM slide, scanning electron micrograph, enlargement of saccus. e, In situ, AZ-2, 28278A1, 20.6–112.9, maximum dimension of the group, 211 $\mu$ . f, In situ, AZ-2 28278A1, 26.3–113.1, 84 $\mu$ . g-i.—*Minutosaccus schizeatus* Mädlér, 1964. g, FW6-3, 23281A12, 34.8–125.5, 33 $\mu$ , 21 $\mu$  body. h, FW6-3, 23281A12, 40.8–126.2, 40 $\mu$ , 23 $\mu$  body. i, FW6-3, 23281A12, 30.4–112.2, 32 $\mu$ , 24 $\mu$  body. j-k.—*Klausipollenites* sp. j, FW6-3, 23281A10, 20.4–123.9, 63 $\mu$ . k, FW6-3, 23281A10, 36.8–120.9, 72 $\mu$ .

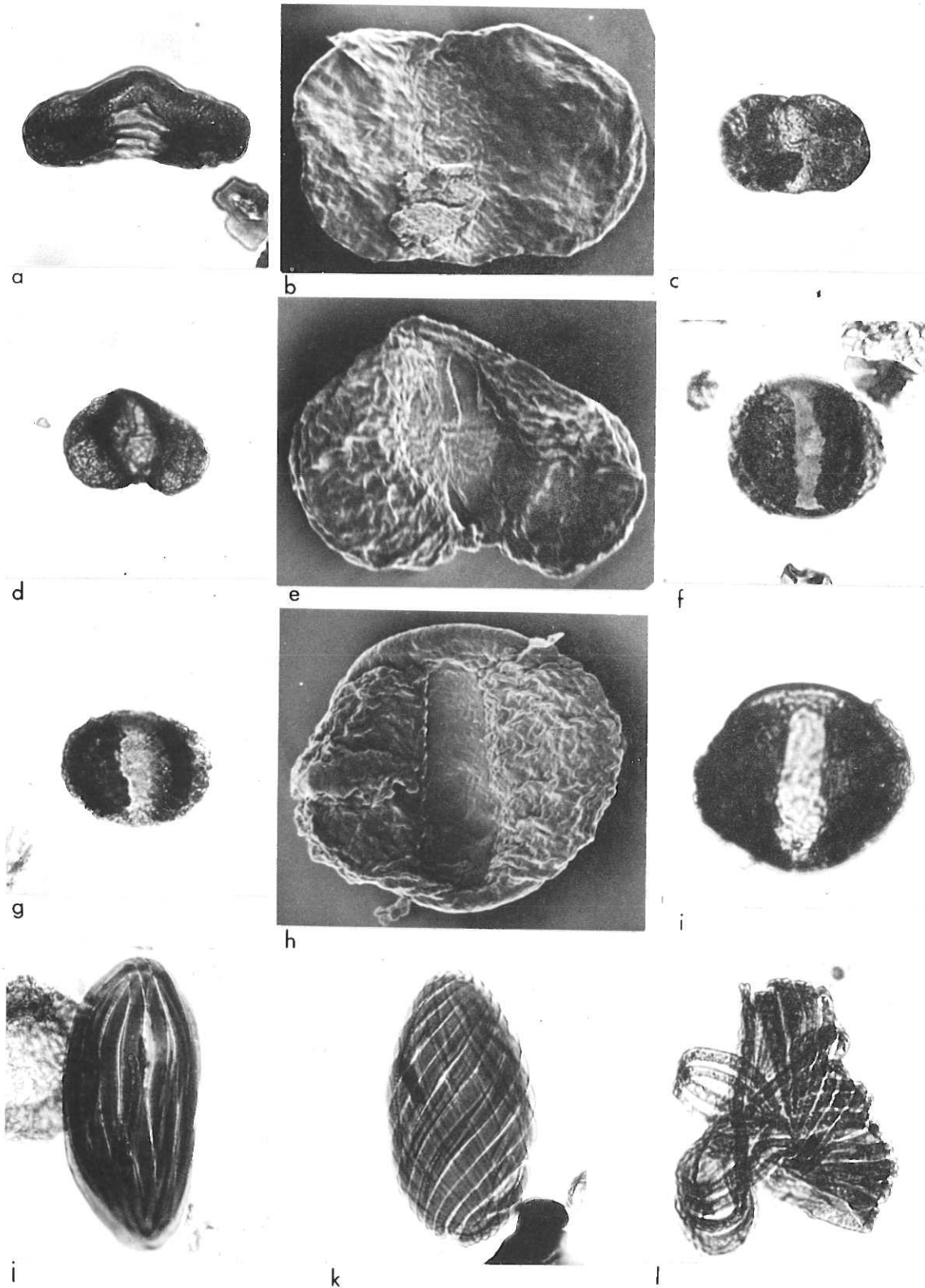


FIGURE 7.—Chinle pollen. a-c.—*Klausipollenites* sp. a, Equatorial view, FW6-3, 23281A11, 25.2–118.1, 69 $\mu$ . b, FW6-3, SEM slide, scanning electron micrograph, 67 $\mu$ . c, FW6-3, SEM slide, photographed in air on a gelatin substrate, same specimen as figure 7b. d, FW6-3, SEM slide, photographed in air on a gelatin substrate, 63 $\mu$ . e, FW6-3, SEM slide, scanning electron micrograph, same specimen as figure 7d. f-i.—*Granosaccus sulcatus* Mädlér, 1964. f, FW6-3, 23281A10, 20.3–120.0, 41 $\mu$ . g, FW6-3, 23281A12, 28.8–113.1, 47 $\mu$ . h, FW6-3, SEM slide, scanning electron micrograph, 61 $\mu$ . i, FW6-3, SEM slide, photographed in air on a gelatin substrate, same specimen as figure 7h. j-l.—*Equisetosporites chinleana* Daugherty, 1941. j, FW6-3, 23281A10, 36.8–126.4, 87 $\mu$ . k, FW6-3, 23281A11, 25.9–126.0, 79 $\mu$ . l, FW6-3, 23281A11, 24.4–125.0, 57 $\mu$ .



The range of the genus is Upper Permian-Triassic. Jansonius (1962), Klaus (1964).

Genus GRANOSACCUS Mädlér, 1964

Type species: *Granosaccus sulcatus* Mädlér, 1964

*Granosaccus sulcatus* Mädlér, 1964  
(figs. 7f-7i)

1964 *Granosaccus sulcatus* Mädlér, p. 121, pl. 12, figs. 6-8.

**Discussion.**—The validity of this genus has not been investigated. The sacchi appear granulate in transmitted light. Scanning electron micrographs show the sacchi to be rugulate with highly contorted rugulae.

**Suggested affinities.**—Coniferales?

**Stratigraphic range.**—Upper Triassic. Mädlér (1964).

Genus EUISETOSPORITES Daugherty emend. Singh, 1964

Type species: *Euietosporites chinleana* Daugherty, 1941

*Euietosporites chinleana* Daugherty, 1941  
(figs. 7j-7l)

1941 *Euietosporites chinleana* Daugherty, p. 63, pl. 34, fig. 4.

1960 *Ephedra chinleana* (Daugherty) Scott, p. 271, pl. 1, figs. 1, 8, 10-12, 14-18.

**Discussion.**—Refer to Singh (1964) for a discussion of the validity of the genus. The ridges are fused at the ends of the grain. The twisting of the ridges is considered by some to be an accident of preservation and not a specific character. The observed size range was 75-95 $\mu$  for 12 specimens.

**Suggested affinities.**—Coniferales. Pollen of this genus has been placed in the Ephedraceae because of its close morphological resemblance to the pollen of the living *Ephedra*. Ash (1972) has reported the occurrence of these grains in a coniferous cone called *Masculostrobilus clathratus*.

**Stratigraphic range.**—Upper Triassic. Daugherty (1941), Scott (1960), Gorttesfeld (1971).

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