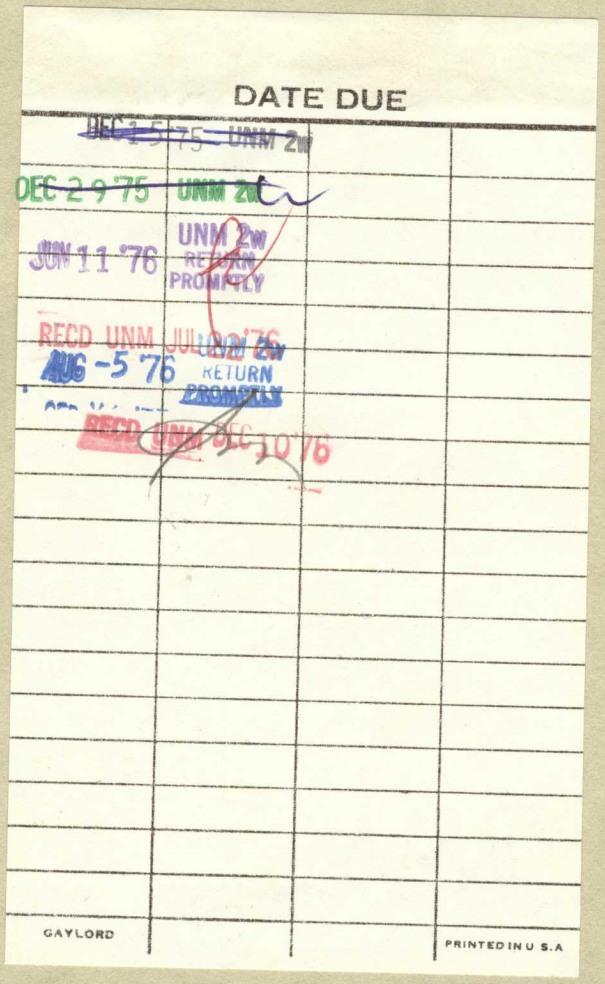
5-29-1959

Pennsylvanian Spores from the Sandia Formation Santa Fe County, New Mexico

Thomas L. Carten


DATE DUE
DEC 29 75 UNM 2W
JUN 11 '76 UNM 2W RETURN PROMPTLY
RECD UNM JUL 22 '76
AUG -5 '76 RETURN PROMPTLY
RECD UNM DEC 10 76
GAYLORD
PRINTED IN U.S.A.

MANUSCRIPT THESES

Unpublished theses submitted for the Master's and Doctor's degrees and deposited in the University of New Mexico Library are open for inspection, but are to be used only with due regard to the rights of the authors. Bibliographical references may be noted, but passages may be copied only with the permission of the authors, and proper credit must be given in subsequent written or published work. Extensive copying or publication of the thesis in whole or in part requires also the consent of the Dean of the Graduate School of the University of New Mexico.

This thesis by ....Thomas L. Carten..... has been used by the following persons, whose signatures attest their acceptance of the above restrictions.

A Library which borrows this thesis for use by its patrons is expected to secure the signature of each user.

NAME AND ADDRESS	DATE
W. O. Schemel, Shell Development Co.	11-59
Paul W Nygren, Standard Oil Co of Texas, P O Box 2766 Amarillo	Jan 14, 1960
James M. Schopf, U.S. Geol. Survey Coal Geol. Lab., Columbus	Feb. 1960
Arsenal T. Crooks, Pan American Petrol. Corp Research Center Tulsa, Okla.	11/11/60
Patricia Burbridge, Sun Oil Company	Feb., 1961
Lewis E. Stover, Jersey Production Research Co, Tulsa, Oklahoma	Feb, 1962
Anderson. Imperial Oil Ltd.	October 1962
Herbert J Sullivan, Pan American Petrol. Co. Tulsa	Feb. 1966

PENNSYLVANIAN SPORES FROM THE SANDIA FORMATION SANTA FE COUNTY, NEW MEXICO

By

Thomas L. Carten

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Geology

The University of New Mexico

1959

arter T.L.

This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of the University of New Mexico in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

E. H. Castetter
DEAN

May 29, 1959
DATE

Thesis committee

Roger Y. Anderson
CHAIRMAN

Stuart A. Northrop

Abraham Rosenzweig

CONTENTS

ILLUSTRATIONS

PLATES

FIGURES

ILLUSTRATIONS

PLATES

FIGURES

ABSTRACT

Several florules of plant microfossils were found in the samples collected in a survey of Pennsylvanian coals in New Mexico. The best preserved and most complete assemblage, from a coal seam near Santa Fe, New Mexico, was selected for detailed study. The coal is located in the upper clastic member of the Sandia formation and brachiopod and fusulinid faunas place this unit near the Atokan-Desmoinesian boundary. The Santa Fe coal sample includes 17 genera, 9 previously described species, 5 new species, and 12 additional unreferred species. The spores from the Santa Fe coal sample are very similar to forms previously described from the Mid-Continent region.

The age of the coal flora, as determined from the spores, is in close agreement with the faunal evidence and may be late Atokan or early Desmoinesian. However, an early Desmoinesian age is supported by the presence of four Desmoinesian genera not recorded from the Atokan, the total absence of the dominant Atokan genus Densosporites, and the presence of Triquitrites with spinose auriculae, typical of the Desmoinesian coals of the Mid-Continent region. This close agreement of age determinations by both faunal and floral evidence demonstrates the usefulness of spores in their application to Paleozoic stratigraphy.

ABSTRACT

Several floras of plant [illegible] were [illegible] in the samples collected in a survey of [illegible] coals in New Mexico. The best preserved and [illegible] assemblage, from a coal seam near [illegible] was selected for detailed study. The coal is [illegible] in the upper clastic member of the [illegible] brachiopod and fusulinid faunas place [illegible] Atokan-Desmoinesian boundary. The [illegible] includes 17 genera, 9 previously [illegible] species, and 12 additional unreported [illegible] from the Santa Fe coal sample are [illegible] previously described from the [illegible]

The age of the coal flora, as [illegible] the spores, is in close agreement with [illegible] and may be late Atokan or early [illegible] an early Desmoinesian age is supported by the [illegible] of four Desmoinesian genera not [illegible] the total absence of the dominant [illegible] and the presence of Triquitrites [illegible] typical of the Desmoinesian coals of [illegible] region. This close agreement of age [illegible] both faunal and floral evidence demonstrates the [illegible] fulness of spores in their application to [illegible] stratigraphy.

The results of a survey of the spore frequency in Pennsylvanian coal are included in this report.

INTRODUCTION

OBJECTIVES

The first part of the thesis deals with sampling and location of several Pennsylvanian coals, chemical maceration of the coal samples for study, and a tabulation of the frequency of the spores in the samples. The second part includes discussions of the locality, stratigraphic relationships, systematic relationships, and systematic descriptions of the spores found in the most complete and best preserved sample.

ACKNOWLEDGMENTS

The writer wishes to thank Mr. Roger Y. Anderson of the University of New Mexico under whose direction this work was done. Mr. Anderson's patience and advice throughout this project are greatly appreciated. Dr. Stuart A. Northrop of the University of New Mexico offered editorial guidance and advice. Dr. Frank E. Kottlowski of the New Mexico Bureau of Mines and Mineral Resources contributed several coal samples and information about the age of the coal bed at the Santa Fe locality. The writer also wishes to thank the New Mexico Geological Society for the grant to defray expenses of reproductions and photographic supplies.

Most of all I wish to thank my wife without whose help and inspiration this project would never have been attempted.

SURVEY OF SPORE FREQUENCY IN SOME PENNSYLVANIAN COALS OF NEW MEXICO

The Pennsylvanian coal localities of New Mexico (Fig. 1) are few and scattered, being best represented in the Sangre de Cristo Mountains north of Santa Fe, New Mexico, and being found mostly in the Sandia formation. Only locally do the Pennsylvanian coals attain a minable thickness and even then the coal is often impure and cannot be considered an important supply of coal for the State.

Several localities were visited and sampled by the writer during the summer of 1958. The samples were chemically macerated for microscopic examination of spore frequency and preservation. The localities and results of this survey are described below.

REVIEW OF THE LITERATURE ON PENNSYLVANIAN COAL OF NEW MEXICO

Literature on Pennsylvanian coal of New Mexico is sparse because of the poor representation of coal in the Pennsylvanian system. Nowhere in the State is there a known occurrence of coal which can be considered economically important; this contributes to the lack of

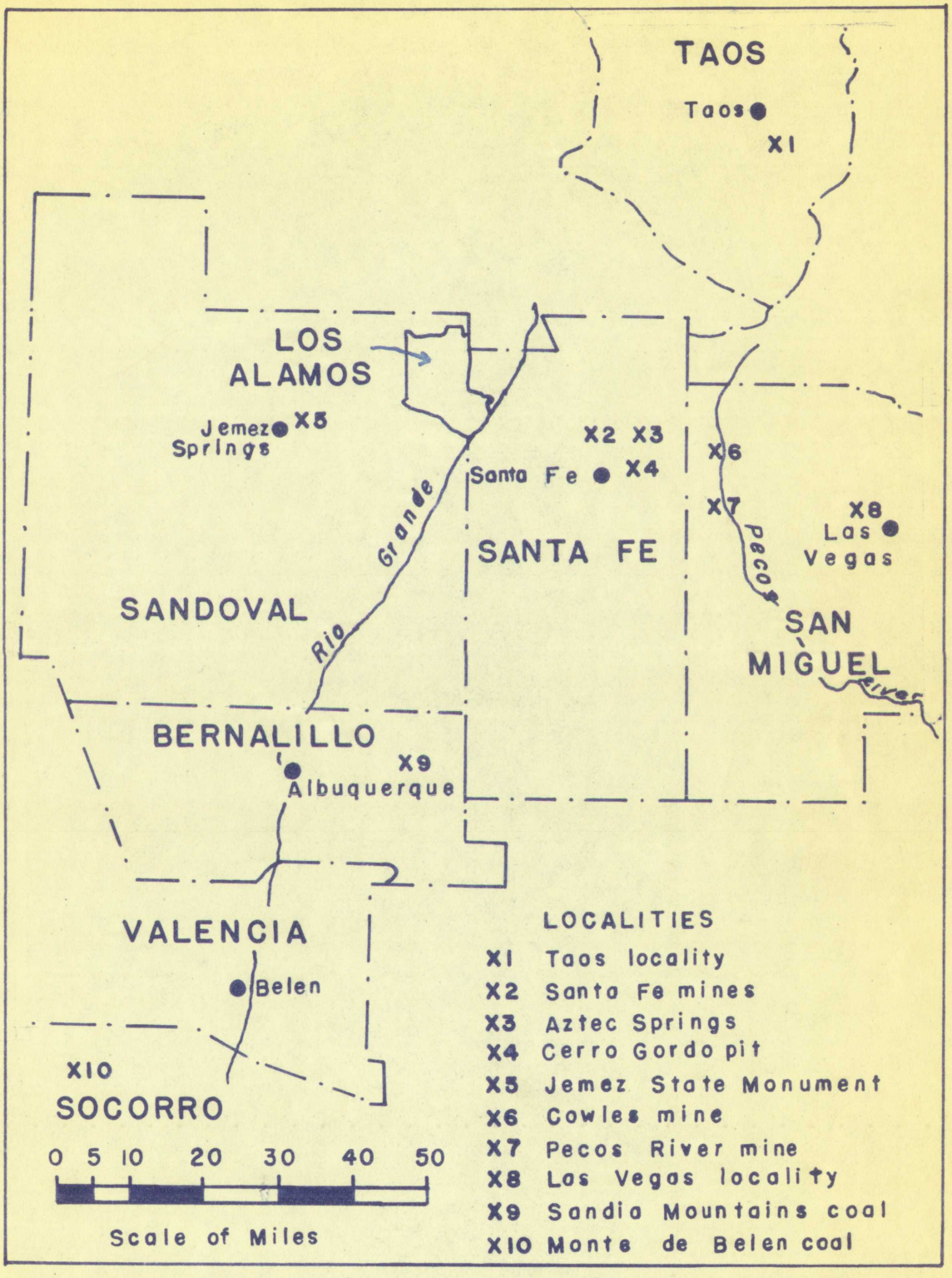


Figure 1.—Index map of some Pennsylvanian coal localities of New Mexico.

literature. There are brief notes on coal occurrences from work on the Pennsylvanian system contributed by Gardner (1910), Henbest and Read (1944), Herrick and Bendrat (1898), Kottlowski (1959), Lee and Girty (1909), Read (1958), Read and others (1950), Read and Wood (1947), and Thompson (1942).

As far as this writer knows, there are no published reports on Pennsylvanian spores of New Mexico. The only known investigations of Carboniferous spores from surrounding states are by Schemel (1950) concerning spores in Utah, and by Morgan (1955) and Wilson and Hoffmeister (1956).

LOCALITIES

Aztec Springs

The coal at this locality can be found by following Aztec Springs Creek 1.05 miles north from Canyon Road, Santa Fe, New Mexico. This coal is exposed in a small drift in an arroyo on the west side of the creek.

Two 6-inch beds of lignitic shale are separated by 2 feet of carbonaceous clay (Fig. 2), and the beds are found in the Sandia formation. The interval is topped by 2 feet, 6 inches of green sandstone and bottomed by a rusty-brown, carbonaceous underclay. The only section exposed was within the drift; above and below, slumping made accurate measuring and describing of the section impossible.

Santa Fe Mine A

The coal outcrop is located 0.15 miles south of Rancho Elisa in an arroyo on the east side of Hyde Park Road on the outskirts of Santa Fe, New Mexico. There are two mine openings at this locality. The first, designated here as Santa Fe mine A, is located about 50 yards up the south branching arroyo from the main arroyo which leads east from the road. The coal is part of the Sandia formation and is exposed by a drift opening directly into

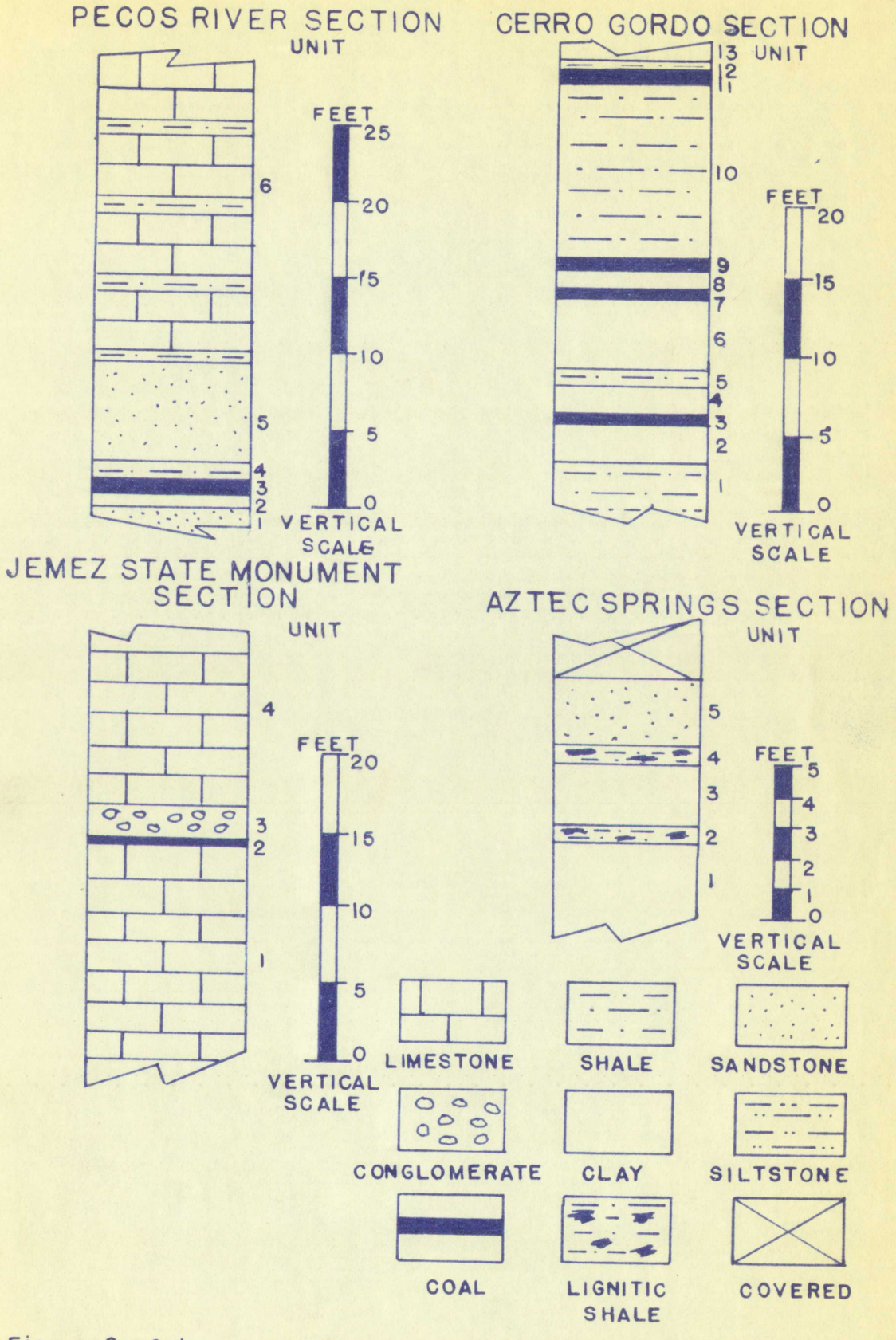


Figure 2.—Columnar sections of some Pennsylvanian coal localities.

the outcrop. Mining operations removed most of the coal but, judging from samples found on the dump outside the entrance to the mine, the coal was of a fairly good quality.

Santa Fe Mine B

Mine B is located approximately 100 yards east of the road up the main arroyo. The coal interval here is about 5 feet thick and is topped by sandstone and rests on underclay. The coal is probably related to that of mine A since the two are in such close proximity and no faulting is evident. The beds dip approximately 60° NW. The mine is dangerous due to the weakened condition of the timbers supporting the roof.

Cerro Gordo Pit

The exposure is located 2 miles northwest of the intersection of Cerro Gordo Road and Canyon Road within the city limits of Santa Fe. The coal at this locality is used locally as fuel and has been mined by open-pit methods.

This is probably one of the best coal occurrences of Pennsylvanian age occurring in the Sandia formation of New Mexico. Four seams of coal can be observed; the uppermost bed is lignitic shale, while the three lower seams are subbituminous in rank (Fig. 2). These four coal beds

occur within a stratigraphic thickness of 30 feet and each bed is laterally discontinuous and pinches out completely within 10 feet. The coal bearing unit is topped by a green sandstone and bottomed by a blue shale. Each coal bed is separated by a blue shale and rests upon an underclay. The coal beds range in thickness from 6 to 11 inches.

Pecos River Mine

The coal is exposed in the NE¼SE¼ Sec. 5, T. 16 N., R. 12 E., approximately 5.5 miles north on State Highway 63 from Pecos, New Mexico. This locality is easily seen from the highway and is recognizable by the large coal dumps on the west side of the Pecos River.

The coal bed occurs in the Sandia formation near the base of 1,400 feet of limestone interrupted occasionally by thin beds of clay, shale, and sandstone. It ranges from 8 to 15 inches in thickness (Fig. 2), is of poor quality, and contains a large percentage of mechanically mixed argillaceous material (Gardner, 1910, p. 570). The bed is inconsistent in thickness and pinches out completely at a distance of half a mile north and south of the outcrop. The coal bed itself is topped by a clay shale, bottomed by a carbonaceous underclay.

Cowles Mine

The coal at this locality was reported by Gardner

(1910, p. 570) to be located in T. 18 N., R. 12 E., and was at one time exposed in the west cliff of the Pecos River. The Pecos River mine coal bed and the coal bed exposed at the Cowles mine occupy practically the same horizon, but are separated by 8 miles of barren strata (Gardner, 1910, p. 570). The coal bed rarely exceeds 15 inches in thickness, has a bituminous roof shale 1 foot thick beneath heavy sandstone, and the floor is a sandy shale (Gardner, 1910 p. 570).

Jemez State Monument

This exposure is located on the northeast edge of the Jemez State Monument, 0.87 miles north on State Highway 4 from the Jemez Springs post office, Sandoval County, New Mexico.

The upper Magdalena group is exposed here and contains a 1-inch coal stringer in the lower part. The coal is found in a stream cut made by Jemez Creek and pinches out in 20 feet. The coal bed grades laterally into shale which contains thin coaly flakes. It is topped by a conglomerate and bottomed by an underclay (Fig. 2), is very low in quality (Henbest and Read, 1944), and is one of the few occurrences of coal in the Madera formation.

Other Localities

The Pennsylvanian system exhibits numerous other

occurrences of coal in New Mexico. The best occurrences are found in the Sangre de Cristo Mountains, and representative deposits can be found at Taos, Las Vegas, and in the area around Santa Fe.

In the vicinity of Socorro, coal laminae are present in much of the lower Magdalena group (Kottlowski, 1959). North of Socorro, in the area of the Lucero uplift, Thompson (1942, p. 28) has noted continental coal deposits in the Derry series at Cadronito Hill, later named Monte de Belen (Kelley and Wood, 1946).

TREATMENT OF SAMPLES

Initial breakdown of high-rank and unweathered coal is usually brought about by the use of Schultze's solution consisting of one part saturated solution of $KClO_3$ and two parts of concentrated HNO_3. However, the Pennsylvanian coals of New Mexico are low rank and for initial breakdown a 10-percent solution of KOH was used with excellent results. After the KOH treatment, concentrated HNO_3 was added and the samples were allowed to stand for several minutes before centrifuging after which concentrated HCl was added. The extra step with HNO_3 and HCl helped in clearing the spores by removing a great deal of the organic material.

Treatment of samples with KOH varied in length of time for each sample. However, two days was generally sufficient for initial breakdown. The sample can be tested by examining a drop of residue on a glass slide under a microscope for the presence of spores before proceeding further with the maceration schedule. Carbonaceous shales and underclays from the localities were treated with 52-percent HF before the KOH treatment. The spores did not readily take a stain, but staining may be accomplished by adding about 5 ml of concentrated safranin O stain and allowing the samples to stand from 1 to 2 hours. The procedure used was modified from the General Separation Schedule of Anderson which follows.

GENERAL SEPARATION SCHEDULE
(R. Y. Anderson)

Arenaceous and argillaceous sediments:

For most samples, steps 1, 2, 3 are sufficient, followed by staining and mounting.

Step 1. Removal of carbonates	Place about 1-2 cc of sample, broken into small chips less than 1/8 inch in diameter in a lustercoid centrifuge tube. Add 20% HCl until action stops. Centrifuge, decant supernatant.
Step 2. Removal of silica	Add 48-52% HF, allow to stand for 24-48 hours (or heat in water bath) until silica is dissolved. Centrifuge, decant supernatant. Add 20% HCl, stir. (Repeat HF and hot HCl if a gel forms.) Transfer to pyrex centrifuge tube. Centrifuge, decant supernatant.
Step 3. Nitric acid treatment (clears grains and helps break gel)	Add concentrated HNO_3, allow to stand for several minutes. Centrifuge, decant supernatant. Add 20% HCl, stir and immediately-centrifuge, decant supernatant.
Step 4. Acetolysis-removal of organic matter (for carbonaceous sediments)	Add glacial acetic acid. Centrifuge, decant supernatant. Add mixture of 9 parts acetic anhydride and 1 part conc. H_2SO_4 (note: add sulfuric acid to the acetic anhydride, make fresh each time). Heat in waterbath (boiling) for 10-20 minutes. Centrifuge, decant supernatant. Add glacial acetic acid. Centrifuge, decant supernatant.
Step 5. Bleaching (optional)	Add 5 ml glacial acetic acid. Add 3 drops of saturated solution of $NaClO_3$. Add 3 drops of conc. HCl. Centrifuge, decant supernatant.

Step 6. Flotation-separation of organic and inorganic fractions (for dense, sticky clays)	Add methanol. Centrifuge, decant supernatant. Repeat. Add bromoform mixture (2 parts bromoform to 1 part methanol--or sp gr of 2.2). Shake vigorously, allow to stand. Centrifuge, slowly at first. Decant supernatant into another pyrex centrifuge tube (repeat bromoform part if desirable). Add methanol to decanted supernatant (to 1/2 inch from top of tube to lower sp. gr.) Centrifuge, decant supernatant very carefully (if necessary decant only part of supernatant and add more methanol, centrifuge and decant).
Step 7. Staining	Add methanol, decant supernatant. Repeat. Add 5-10 drops of Safranine stain in methanol, stir. Add more methanol, centrifuge, decant.
Step 8. Mounting	Add xylene, centrifuge, decant. Repeat. Add xylene, centrifuge, decant all but a few drops. Place a drop of residue in xylene on a slide with a dropper. Allow excess xylene to evaporate, add one drop of Canada balsam (in xylene). Mix well with needle and add cover slip.
Step 9. Storage	Label and store slide. Add xylene to remaining residue, transfer to a labeled vial and store.
Peat:	Work powdered sample into pyrex centrifuge tube through 100-mesh screen. Add 10% KOH, place in boiling water-bath for about 10 minutes. Centrifuge, decant supernatant. Add distilled water. Repeat.

	Centrifuge, decant supernatant. Steps 4 and 5. Steps 7, 8, and 9.
Coal: Weathered and low rank	Break sample into small chips and place in a small beaker. Add 10% KOH and allow to stand until dispersed (indefinite period, 1 to many days).* Decant residue into pyrex centrifuge tube. Centrifuge, decant supernatant. Add distilled water. Repeat. Centrifuge, decant supernatant. Steps 4 and 5. Steps 7, 8, and 9.
Unweathered and high rank	As above, substituting Schultze's solution.

* May use Schultze's solution (HNO_3 and sat. $KClO_3$).

FREQUENCY OF SPORES IN THE SAMPLES

The relative spore frequency for each locality, sample, and lithologic unit was tabulated (Fig. 3). As a general rule the quality of the flora improved with the quality of the coal. Many samples were taken from each locality visited and the samples from each locality presented varying degrees of abundance. Preservation was generally poor and only a few samples yielded a flora that combined high frequency with good preservation. For each locality the samples varied in preservation and abundance, but the majority contained no recognizable spores. The best samples, representing both good preservation and fair abundance, came from the coal samples of Cerro Gordo pit. However, the most abundant and best preserved flora came from the first sample of Santa Fe mine B.

LOCALITY	SAMPLE NO.	UNIT	G	F	P	VP	A
Santa Fe mine A	SFa-1						X
	SFa-2		X				
	SFa-3						X
	SFa-4						X
	SFa-5						X
	SFa-6			X			
	SFa-7		X				
Santa Fe mine B	SFb-1		X				
	SFb-2						X
	SFb-3						X
	SFb-4					X	
	SFb-5					X	
	SFb-6					X	
	SFb-7						X
	SFb-8					X	
	SFb-9					X	
	SFb-10				X		
	SFb-11						X
Pecos River mine	P-1	4		X			
	P-2	3			X		
	P-3	2					X
	P-4	3				X	
	P-5	3		X			
	P-6	3		X			
	P-7	2			X		
Jemez State Monument	JS-1	2					X
	JS-2	2					X
	JS-3	2					X
Cerro Gordo pit	CG-2	12		X			
	CG-3	11		X			
	CG-5	9		X			X
	CG-6	8					X
	CG-7	7	X				
	CG-8	4					X
	CG-9	3	X				
Aztec Springs	AS-1	4					X
	AS-2	4					X
	AS-3	4					X
	AS-4	4					X
	AS-5	3					X
	AS-6	2					X
	AS-7	2					X
	AS-8	3					X
	AS-9	2					X
	AS-10	3					X
	AS-11	3				X	
	AS-12	3					X

G-Good, F-Fair, P-Poor, VP-Very Poor, A-Absent

Figure 3.--Tabulation of spore frequency by locality, sample, and lithologic unit.

SANTA FE COAL MINE B FLORA

LOCALITY AND STRATIGRAPHIC RELATIONSHIPS

The Santa Fe coal mine B flora was selected for detailed study because of the abundance of material, the excellent preservation of the flora, and the variety of forms. The entire flora studied came from a single sample of Santa Fe coal from mine B, the location of which is given on page 9. Most of the exposed section at Santa Fe coal mine B is continental and no marine fossils were found in the immediate vicinity. However, a late Atokan or early Desmoinesian age is suggested by Kottlowski (1959), who states:

> * * * the coal bed merely was mapped as a part of the upper clastic member of the Sandia formation. Megafossils collected from various beds near Elisa Ranch, were identified by some unknown paleontologist of the Survey [U. S. Geological Survey] * * * The brachiopods are a rather mixed assemblage of Atokan and Desmoinesian types, similar to those from Brill's (G. S. A., v. 63, p. 851) units 61 and 51 of the Pecos River section. Fusulinids from the upper Sandia formation in the Santa Fe area suggest upper Atokan age, but the vertical and lateral variations of the Sandia and lower Madera units strongly indicate that the gradational boundary between the formations varied in time from place to place. All this adds up to * * * the coal bed is near the Derry [Atokan]--Desmoinesian boundary.

In support of this age, Read and Wood (1947, p. 230) make the same age determination in the area of the Pecos River coal bed discussed on page 10. The flora found in the roof shale of the Pecos River coal is quite similar to that of the Santa Fe mine B.

MOUNTING OF SPECIMENS

The single-mounting technique for microfossils, as described by Anderson (1958), was used in preparing the flora for individual specimen study. Specifications for building and operating the micromanipulator are set forth in Anderson's paper and will not be repeated here.

The residue was placed in xylene after maceration. One drop of residue was placed on a glass slide, covered with 3 or 4 drops of Crown immersion oil and mixed together. Single specimens were picked with the micromanipulator, discharged onto individual glass slides, covered with a drop of Canada balsam, and a cover slip was applied. The rapid mounting procedure made it possible to study most of the specimens as single mounts in addition to preparing holotype and paratype material. All descriptions were based on single-mounted specimens. The position of the specimens on the slides was marked with a diamond scribe and the specimen numbers recorded in the systematic descriptions.

SYSTEMATIC RELATIONSHIPS

The Santa Fe coal mine B flora includes 17 genera, 9 previously described species, 5 new species, and 12 non-referred species. The following genera and species are described from the Santa Fe coal mine B flora.

Superdivision SPORITES

Division TRILETES

Subdivision AZONOTRILETES

Suite LAEVIGATI

Punctatisporites sp. A

P. sp. B

Punctatasporites sp. A

P. sp. B

P. sp. C

Calamospora sp.

Granulatisporites cf. *G. granulatus* Ibrahim 1933

G. granularis Kosanke 1950

G. sp. A

G. sp. B

Cyclogranisporites sp.

Suite APICULATI

Anapiculatisporites sp.

Acanthotriletes spinosus (Kosanke 1950)

Raistrickia cf. *R. solaria* Wilson and Hoffmeister 1956

R. spinosa, n. sp.

Suite MURONATI

Camptotriletes ? sp.

Cristatisporites sulcatus (Kosanke 1950)

Microreticulatisporites tenuimuri, n. sp.

Division ZONALES

Subdivision AURITOTRILETES

Suite AURICULATI

Triquitrites complanatus, n. sp.

T. punctatus, n. sp.

T. sp.

Subdivision ZONOTRILETES

Suite CINGULATI

Lycospora cf. L. granulata Kosanke 1950

L. novamexicana, n. sp.

Division MONOLETES

Subdivision AZONOMONOLETES

Laevigatosporites cf. L. desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall 1944

L. globosus Schemel 1951

Latosporites sp.

Superdivision POLLENITES

Division SACCITES

Subdivision MONOSACCITES

Endosporites pallidus Schemel 1950

Florinites antiquus Schopf 1944

Lycospora, Florinites, and Triquitrites constitute over 60 percent of the total flora with Lycospora being most abundant and making up 28 percent of the flora. Granulatisporites, Raistrickia, and Laevigatosporites are common and the remaining 11 genera are uncommon or rare. The relative frequency of the different genera is shown in Figure 4. This spore diagram is based upon a count of 300 specimens.

The age of the coal bed as suggested by the flora is late Atokan or more probably early Desmoinesian (Fig. 5). This early Desmoinesian age is supported by the presence of four Desmoinesian genera (Fig. 5) previously unrecorded in the Atokan (Kosanke, 1950, pl. 17; Potonié and Kremp, 1954, p. 182-184; and Hoffmeister and others, 1955, p. 14-17). Further evidence of this age is the total absence of the dominant Atokan genus Densosporites (Kosanke, 1950, pl. 17), and the presence of Triquitrites with spinose auriculae, found typically in Desmoinesian coals (Hoffmeister and others, 1955, p. 18). Although the coal bed could be either late Atokan or early Desmoinesian, the early Desmoinesian age is most likely correct in light of the above.

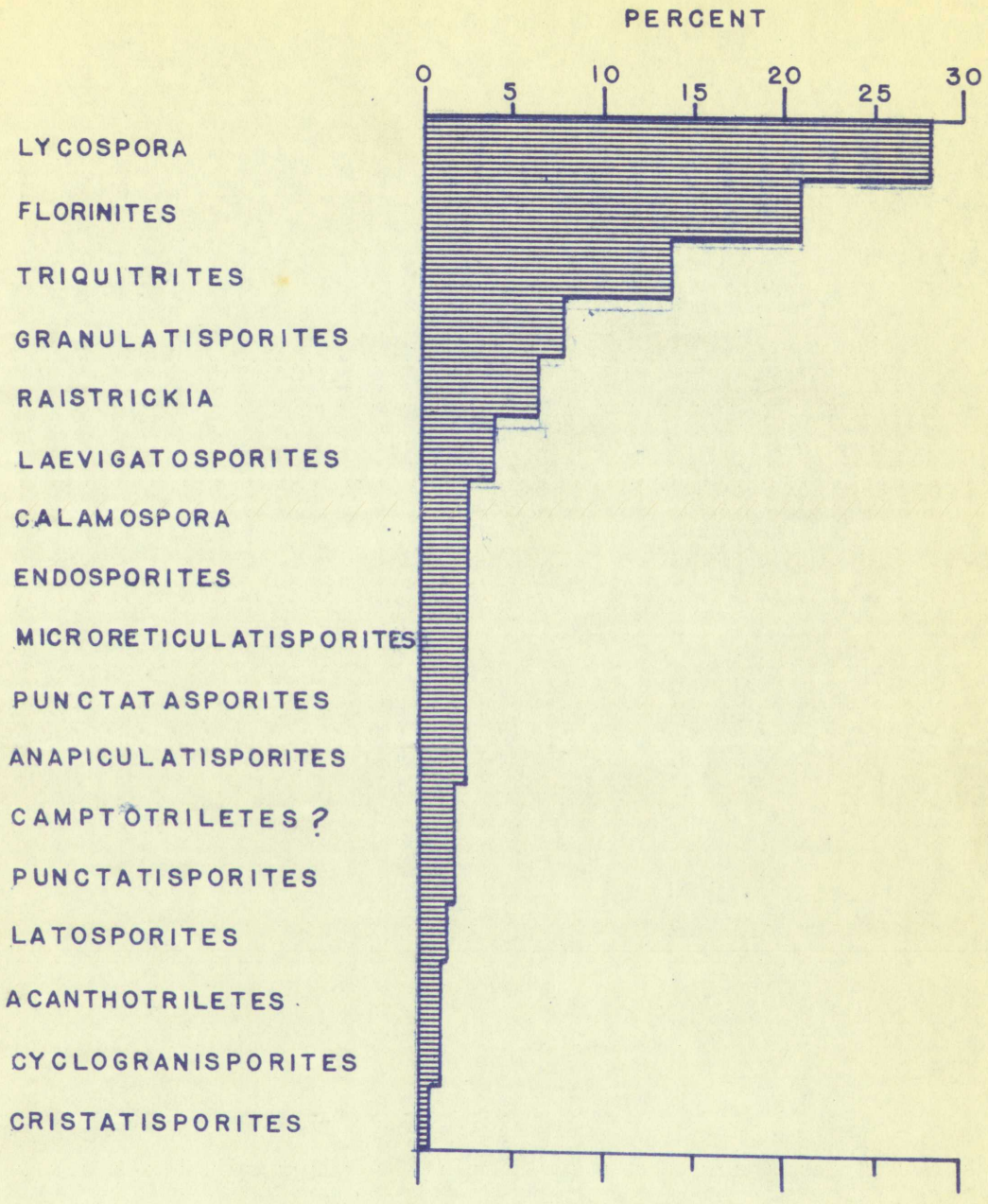


Figure 4.—Composite generic spore diagram of the Santa Fe mine B coal flora.

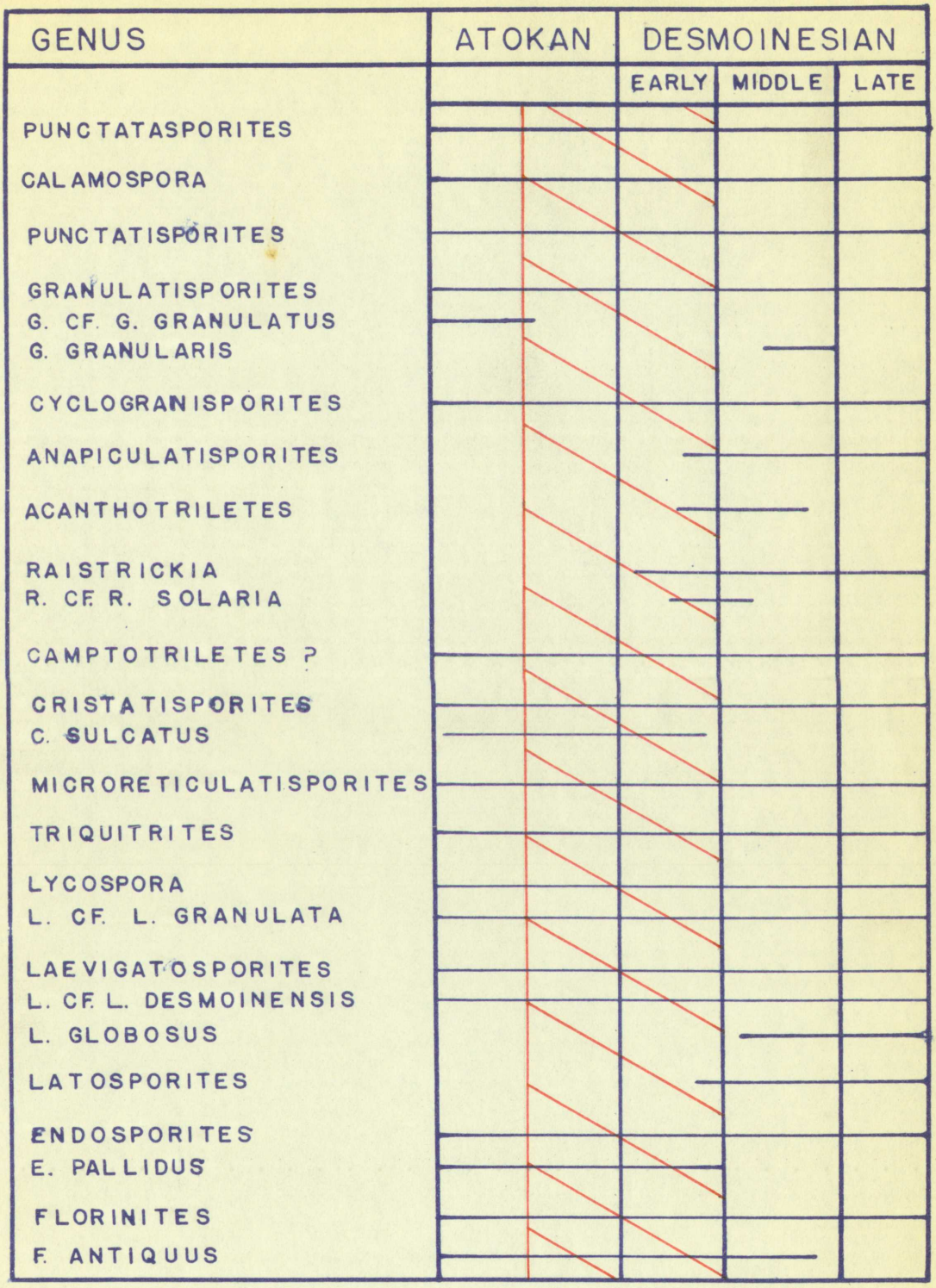


Figure 5.—Range chart of fossil spores in the Santa Fe mine B coal flora. The hachured zone indicates the probable age of the flora.

SYSTEMATIC DESCRIPTIONS

Superdivision SPORITES

Division TRILETES

Subdivision AZONOTRILETES

Suite LAEVIGATI

Genus Punctatisporites (Ibrahim 1933)

Schopf, Wilson, and Bentall 1944

Punctatisporites sp. A

Plate 1, figure 1

Description.--Spore is radial, trilete, and circular in transverse plane. Spore coat near margin is somewhat irregularly thickened with the trilete mark present but exhibiting a characteristic double-fold parallel to the periphery. The ornamentation is finely and regularly granulose throughout.

Dimensions.--Spore measures 52 x 48 microns. Spore coat is approximately 1.5 to 2 microns thick.

Discussion.--This species is rare in the sample. Specimen Nos. SF-1, 2.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Punctatisporites sp. B

Plate 1, figure 2

Description.--Spore is radial, trilete, and circular

in transverse plane. Spore is finely but regularly punctate. The lips are well defined with narrow laesurae.

Dimensions.--Spore measures 49 microns in diameter. The spore coat is about 1 micron thick.

Discussion.--This species is rare in sample, closely resembles P. obliquus Kosanke, 1950, but is significantly larger. Specimen No. SF-3.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages10 and 20).

Genus Punctatasporites Ibrahim 1933

Punctatasporites sp. A

Plate 1, figure 3

Description.--Spore is radial, trilete mark not visible, roughly circular in transverse plane. The trilete rays may be present but are indistinct. The spore coat is very finely granulose.

Dimensions.--Spore is relatively small, measuring 51 X 49 microns. The spore coat is less than 2 microns thick.

Discussion.--This species is rare in the sample. Specimen No. SF-4.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Punctatasporites sp. B

Plate 1, figure 4

Description.--Spore is radial, circular in transverse plane, and shows small plications. The trilete rays are absent or not visible. The ornamentation of the spore coat is finely granulose to rugulate.

Dimensions.--Spore measures 34 microns in diameter and is thus relatively small for the genus. Spore coat is approximately 2 microns thick.

Discussion.--This species is rarely found in the sample and is distinctive due to its small size. Specimen No. SF-5.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Punctatasporites ? sp. C

Plate 1, figure 5

Description.--Spores are radial, trilete, subcircular in transverse outline, exhibiting many tapered folds roughly parallel to the margin of the spore. In some specimens the trilete mark may be present but obscured by folding. The ornamentation of the spore coat is laevigate.

Dimensions.--Spores range from 75 to 110 microns in diameter. The spore coat ranges from 2 to 3 microns in thickness.

Discussion.--This species is uncommon in the sample and is characterized by the extreme size. Specimen Nos. SF-6, 7.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Genus Calamospora

Schopf, Wilson, and Bentall 1944

Calamospora sp.

Plate 1, figure 6

Description.--Spore is radial, trilete, and oval in transverse plane. Folds are frequent, tapered, and lenticular in outline. The spore coat ornamentation is laevigate or weakly granulose. The trilete mark is distinct, lips are raised but not well developed, and the laesurae are narrow.

Dimensions.--Spore measures 61 X 49 microns and the spore coat is approximately 1 micron thick. The trilete rays average 14 microns in length.

Discussion.--This species is rare in the sample. Specimen No. SF-8.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Genus Granulatisporites Ibrahim 1933

Granulatisporites cf. G. granulatus

Ibrahim 1933

Plate 1, figures 7, 8

Description.--Spores are radial, trilete, triangular in outline; margin of the spore between radii is concave, corners opposite the radii are rounded. Folding is present. The spore coat is granulose to finely punctate and the granulations are closely spaced. The trilete mark is distinct and extends at least three-fourths the distance to the edge of the spore. The lips are moderately developed but broken in part by granulations.

Dimensions.--Spores are relatively small, ranging from 22 to 27 microns in diameter. The spore coat averages 1.5 microns thick.

Discussion.--Specimens of this species are commonly found in the sample and are quite similar to those described by Schemel (1950, p. 237). Specimen Nos. SF-9, 10.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Granulatisporites granularis Kosanke 1950

Plate 1, figure 9

Description.--Spore is radial, trilete, subtriangular in outline; margin of the spore wall between radii is

concave, corners opposite radii are broadly rounded. The ornamentation of the spore coat is granulose with the granulations being closely spaced. A broad area around the laesurae is slightly thickened. The trilete mark is distinct, laesurae narrow, and the lips are somewhat raised. The rays extend approximately two-thirds the distance to the spore wall.

Dimensions.--Spore measures 27 X 27 microns and is relatively small for the species. The spore coat is 1.5 microns thick.

Discussion.--This species is rare in the sample, but it appears to be conspecific with G. granularis except for its smaller size. Specimen No. SF-11.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Granulatisporites sp. A

Plate 1, figure 10

Description.--Spore is radial, trilete, and triangular in transverse plane; margin of the spore wall between radii is concave, corners opposite radii are broadly rounded. The trilete mark is distinct, laesurae are narrow, lips are well developed and raised, radii extend one-half to two-thirds the distance to the spore wall. The spore coat is distinctly but very finely granulose. The granulations are closely spaced.

Dimensions.--Specimen measures 41 X 41 microns. Spore coat is about 1.5 microns thick.

Discussion.--This species is rarely found in the sample but is similar to G. sp. A Schemel (1950, p. 238). Specimen No. SF-12.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Granulatisporites sp. B

Plate 1, figure 11

Description.--Spore is radial, trilete, and triangular in transverse plane; margin of the spore wall between radii is concave, corners opposite radii are broadly rounded. The spore coat is very finely and uniformly granulose to punctate. There is a slight but distinct folding in the contact area. The trilete mark is distinct, and the lips are well developed. The rays of the trilete mark extend one-half the distance to the spore wall.

Dimensions.--The diameter is 40 microns and the thickness of the spore coat is about 1.5 microns.

Discussion.--This species is rare in the sample and is quite similar to Schemel's (1950, p. 238) G. sp. B. Specimen No. SF-13.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Genus Cyclogranisporites

Potonié and Kremp 1954

Cyclogranisporites sp.

Plate 1, figure 12

Description.--Spore is radial, trilete, and circular in transverse plane. The trilete mark is present but indistinct. Ornamentation consists of spherical granules of equal size uniformly distributed on the surface of the spore.

Dimensions.--Spore measures 52 X 48 microns. The thickness of the spore coat is approximately 2 microns.

Discussion.--This species is rare in the sample. Specimen No. SF-14.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Suite APICULATI

Genus Anapiculatisporites

Potonié and Kremp 1954

Anapiculatisporites sp.

Plate 2, figure 1

Description.--Spore is radial, trilete, triangular in transverse outline, and folding is absent. Spore exhibits a peculiar ornamentation with an internal proximal punctate or granulose area and minute conical projections widely separated on the external distal surface.

The trilete mark is long, well developed, lips raised, and the laesurae are wide.

Dimensions.--Spore measures 55 X 48 microns. The trilete mark measures 20.5 microns while the spore wall measures 2.5 to 3.5 microns thick.

Dicussion.--This species is rare in the sample and is characterized by the peculiar ornamentation. Specimen No. SF-15.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Genus Acanthotriletes Naumova 1937

Acanthotriletes spinosus (Kosanke 1950)

Plate 2, figures 2, 3

Granulatisporites spinosus Kosanke, 1950, Illinois Geol. Survey Bull. 74, p. 22, pl. 3, fig. 7.

Description.--Spores are radial, trilete, triangular in transverse plane; margin of spore wall is either slightly concave or convex between rays, corners opposite radii are roundly pointed. The spore coat has numerous regularly spaced blunt to pointed setae. The trilete mark is distinct and split widely open. Rays extend about two-thirds the distance to the edge of the spore wall.

Dimensions.-- Specimens are relatively variable in size, ranging from 24 to 31 microns in diameter. The setae are up to 3 microns long and about 1 to 1.5 microns wide at the base.

Discussion.--This species is uncommon in the sample and is placed in the genus Acanthotriletes instead of Granulatisporites on the basis of the very long spines or setae. Specimen Nos. SF-16, 17.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Genus Raistrickia

Schopf, Wilson, and Bentall 1944

Raistrickia cf. R. solaria

Wilson and Hoffmeister 1956

Plate 2, figures 4, 5

Description.--Spores are radial, trilete, circular in outline and are characterized by numerous crowded processes. Processes are simple to tripartite, cylindrical, and occasionally tapered. Spores are definitely trilete but the mark may be obscured in some specimens. The laesurae are narrow and the lips are slightly raised in some specimens.

Dimensions.--The known size range is 51 to 63 microns (Wilson and Hoffmeister, 1956, p. 22) but is here extended to 42 to 64 microns. The processes measure 2.8 to

8 microns long and about 1 to 5 microns wide at the base. The trilete rays measure 19 to 24.5 microns long.

Discussion.--The specimens found in the Santa Fe coal fit the description for R. solaria Wilson and Hoffmeister, 1956, except for having consistently smaller measurements. This species is common in the sample. Specimen Nos. SF-18, 19, 20, 21, 22.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Raistrickia spinosa, n. sp.

Plate 2, figures 6 (holotype), 7

Description.--Spores are radial, trilete, subtriangular in transverse plane and have numerous conical, rounded or occasionally blunt spines. The lips are distinct and slightly raised, and the laesurae are relatively narrow. The spore coat is covered on both the proximal and distal sides by spine-like projections.

Dimensions.--Spores are relatively small, measuring 41 to 48 microns. The rays of the trilete mark average 16 to 18 microns long. The spine-like projections average 3 to 6 microns at the base and average 2 to 6 microns long. The spore coat is quite thick, being approximately 4 microns.

Discussion.--R. spinosa, n. sp. is quite similar to R. prisca Kosanke, 1950, but differs in having the spines more

regularly spaced. Specimen Nos. SF-23 (holotype), 24.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Raistrickia sp.

Plate 2, figure 8

Description.--Spore is radial, trilete, and circular in outline. The spore coat exhibits many irregularly spaced processes which are constricted at the base; processes are bi- to polypartite. The trilete mark is distinct, laesurae relatively narrow, and the lips are raised and moderately developed. The spore coat is finely granulose between processes.

Dimensions.--Specimen has a diameter of 37 microns. Processes measure 2.5 to 4.5 microns long and 1 to 2 microns wide at the base. The spore coat is approximately 1.5 microns thick. Trilete rays average 20.6 microns long.

Discussion.--This species is rare in the sample and is characterized by the small, polypartite processes and small size. Specimen No. SF-25.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Suite MURONATI

Genus Camptotriletes Naumova 1937

Camptotriletes?sp.

Plate 2, figure 9

Description.--Spore is radial, trilete with moderately long rays. The proximal surface in the area of the trilete mark is laevigate. The distal surface is ornamented by knobby cristae or ridges. There is no folding of the spore coat. The trilete ray is plainly visible with the lips being slightly raised and having very narrow laesurae.

Dimensions.--Spore measures 52 X 44 microns. Ridges or cristae commonly measure 5 microns. Spore coat is approximately 3 microns thick.

Discussion.--The specimens found in the Santa Fe mine B coal closely resemble Schopfites Kosanke, 1950, but have a more cristae-like ornamentation which closely resembles Camptotriletes Naumova, 1937. Specimen No. SF-26.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Genus Cristatisporites

Potonié and Kremp 1954

Cristatisporites sulcatus

(Wilson and Kosanke 1944)

Plate 2, figure 10

Punctatisporites sulcatus Wilson and Kosanke, 1944, Iowa Acad. Sci. Proc., v. 51, p. 331, pl. 1, fig. 4.

Description.--Spore is radial, trilete, and subtriangular in transverse plane. Spore coat is characterized by dense, heavy irregular reticulations which extend into conical or verrucose processes. The trilete mark is present but obscured by reticulations.

Dimensions.--Spore measures 33 X 33 microns in diameter and the spore coat is approximately 2 to 3 microns thick.

Discussion.--Rare in the sample. The fused cristae form the reticulate pattern typical of the C. sulcatus described by Wilson and Kosanke (1944). Specimen No. SF-27.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Genus Microreticulatisporites Knox 1950

Microreticulatisporites tenuimuri, n. sp.

Plate 2, figures 11 (holotype), 12

Description.--Spores are radial, trilete, and circular in outline. Folding is absent. The rays of the trilete mark are long but indistinct. The surface is covered with a faint reticulum of broad lumina and narrow muri which are poorly developed in some specimens. Floors of the lumina are punctate-granulose.

Dimensions.--The known size range is 41 to 74 microns. The spore coat is about 2.5 to 3 microns thick. The rays

of the trilete mark extend two-thirds the distance to the spore wall when present. Lumina measure 2.5 to 3.5 microns in diameter and the muri are less than 0.5 micron wide.

Discussion.--This species is uncommon in the sample. This species resembles Punctatisporites sp. A which could be the same species with an undeveloped reticulum. Specimen Nos. SF-28 (holotype), 29.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Division ZONALES

Subdivision AURITOTRILETES

Suite AURICULATI

Genus Triquitrites Wilson and Coe 1940

Triquitrites complanatus, n. sp.

Plate 3, figures 1 (holotype), 2, 3

Description.--Spores are radial, trilete, and triangular in transverse plane. Interradial margins are essentially straight although slight variations between concave and convex may be seen in some specimens. Corners are round, truncate, or combined. Arrangement of auriculae is irregular. The trilete rays are distinct, lips slightly raised, and the laesurae are narrow. An inner granulose area containing the trilete mark is characteristic of this species. This inner area is separated by a laevigate band

outside the pyramic area and is sometimes bordered by granulose ornamentation near the periphery.

Dimensions.--The known size range is from 35 to 43 microns. The holotype measures 42.5 microns. The spore coat averages 2 microns thick.

Discussion.--T. complanatus, n. sp. is common in the sample and is characterized by the laevigate band encircling the pyramic area. Specimen Nos. SF-30 (holotype), 31, 32.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Triquitrites punctatus, n. sp.

Plate 3, figures 4 (holotype), 5, 6

Description.--Spores are radial, trilete, and triangular in transverse plane. The interradial margins are essentially straight but in some specimens folding makes the margin appear concave. The auriculae are typically spinose and ornamentation of the spore coat is uniformly punctate. The rays of the trilete mark extend to the margin of the spore wall, the lips are simple, and the laesurae are narrow.

Dimensions.--The size range is from 32 to 42 microns and the holotype measures 32 microns. The average length of the trilete rays is 18 microns. The spore coat averages less than 2 microns thick.

Discussion.--T. punctatus, n. sp. is common in the sample and is characterized by the uniformly punctate ornamentation. Specimen Nos. SF-33 (holotype), 34, 35, 36.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Subdivision ZONOTRILETES

Suite CINGULATI

Genus Lycospora Schopf, Wilson, and Bentall 1944

Lycospora cf. L. granulata Kosanke 1950

Plate 3, figures 7, 8, 9

Description.--Spores are radial, trilete, triangular to subtriangular in transverse plane. Spores are laterally compressed, showing a small equatorial ridge and good proximal-distal orientation. The trilete rays are distinct, lips are pronounced and slightly raised, and the laesurae are narrow. The rays extend through the thickened periphery but not into the equatorial rim. The spore coat has a granulose ornamentation and the granulations are closely spaced.

Dimensions.--Spores are relatively small, ranging from 23 to 28 microns. The equatorial rim averages about 2 microns wide while the thickened periphery of the spore wall averages about 1.5 microns.

Discussion.--This species is abundant in the sample. The specimens are smaller and more finely granulose than L. granulata Kosanke, 1950, but this difference is not significant enough to warrant a new species. Specimen Nos. SF-36, 37, 38, 39, 40.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Lycospora novamexicana, n. sp.

Plate 3, figures 11 (holotype), 10, 12

Description.--Spores are radial, trilete, and triangular to subtriangular in transverse plane. The proximal-distal orientation is good. The trilete mark is indistinct although it can usually be traced to the margin of the spore wall. Spores exhibit a wide equatorial ridge which is irregular, widened at the corners, and not well defined. The surface of the spore coat is coarsely granulose and in some cases the sculpturing elements appear rugose.

Dimensions.--Spores are relatively small and range from 23 to 35 microns. The holotype measures 35 microns. The width of the equatorial rim averages about 2.7 microns while the thickness of the spore coat averages 1 to 1.5 microns.

Discussion.--L. novamexicana, n. sp. is characterized by a weak trilete mark, coarse granulose ornamentation,

and a relatively wide rim. This species is abundant in the sample. Specimen Nos. SF-41 (holotype), 42, 43, 44, 45, 46.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Division MONOLETES

Subdivision AZONOMONOLETES

Genus Laevigatosporites (Ibrahim 1933)

emend. Schopf, Wilson, and Bentall 1944

Laevigatosporites cf. L. desmoinensis

(Wilson and Coe) Schopf, Wilson, and Bentall 1944

Plate 4, figure 1

Phaseolites desmoinensis Wilson and Coe, 1940, Am. Midland Naturalist, v. 23, p. 182-183, pl. 1, fig. 4.

Description.--Spore is bilateral, monolete, and elongate. The monolete mark is long, lips are slightly developed, and the laesura is narrow. The spore coat is laevigate to minutely punctate or granulose.

Dimensions.--Spore measures 56 X 38 microns and the monolete mark is over half the length of the spore. The spore coat is approximately 2 microns thick.

Discussion.--This species is uncommon in the sample. It is similar to L. desmoinensis (Wilson and Coe) Schopf, Wilson, and Bentall, 1944, but is somewhat smaller. Specimen No. SF-47.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Laevigatosporites globosus Schemel 1951

Plate 4, figure 2

Description.--Spore is bilateral, monolete, and oval-circular in outline. The spore coat is punctate with the punctations obscuring the monolete mark. The punctations are uniformly and closely spaced.

Dimensions.--Spore measures 22 X 26 microns. The punctate ornamentation prevents a measurement of the monolete mark but is appears to be at least half the length of the spore body. The spore coat is about 1.5 microns thick.

Discussion.--This species is uncommon in the sample. Specimen No. SF-48.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Genus Latosporites Potonié and Kremp 1954

Latosporites sp.

Plate 4, figure 3

Description.--Spore is bilateral, monolete, and oval in outline. The spore coat ornamentation is finely punctate. The monolete mark is long, gaping and boat shaped, and bordered by a moderate thickening.

Dimensions.--Spore measures 59 microns long and 36 microns wide. The thickening about the monolete mark is approximately 2.7 microns wide. Thickness of the spore coat is about 1.5 microns.

Discussion.--This species is uncommon in the sample. Specimen No. SF-49.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Superdivision POLLENITES

Division SACCITES

Subdivision MONOSACCITES

Genus Endosporites Wilson and Coe 1940

Endosporites pallidus Schemel 1950

Plate 4, figures 4, 5

Description.--Spore is radial, trilete (?), and subtriangular in transverse plane. Both the central body and the bladder show granulose ornamentation but the ornamentation on the bladder may be coarser and somewhat granulose-rugulate. The centermost part of the central body is sometimes absent, making it difficult to observe the trilete mark.

Dimensions.--The isolated specimen is 47 microns in diameter including the bladder. The central body is 26 microns in diameter and both bladder and central body appear to be approximately 1 micron thick.

Discussion.--This species is uncommon in the sample. Specimen No. SF-50, 51.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

Genus Florinites

Schopf, Wilson, and Bentall 1944

Florinites antiquus Schopf 1944

Plate 4, figures 6, 7, 8, 9

Description.--Pollen grains are bilateral and elliptical in transverse plane. The originally sperical body is usually folded. Folding of the bladder is slight and rarely occurs. A trilete mark was not observed in any of the specimens. Ornamentation of the bladder is usually infrareticulate near the outer margin, becoming granulose near the body. The ornamentation of the central body is granulose.

Dimensions.--Over-all measurements for the observed specimens range from 60 X 48 to 82 X 72 microns. Average diameter of the central body is 30 microns. The wall is usually about 1 micron thick.

Discussion.--This species is abundant in the sample. Specimen Nos. SF-52, 53, 54, 55, 56, 57, 58, 59.

Occurrence.--Santa Fe mine B, Atokan-Desmoinesian boundary (see pages 10 and 20).

REFERENCES CITED

Anderson, R. Y., 1958, A micromanipulator for single-mounting microfossils: Micropaleontology, v. 4, p. 205-206.

Brill, K. G., Jr., 1952, Stratigraphy in the Permo-Pennsylvanian zeugogeosyncline of Colorado and northern New Mexico: Geol. Soc. America Bull., v. 63, p. 809-880.

Gardner, J. H., 1910, Carboniferous coal in New Mexico: Mines and Mineral, v. 30, p. 570-571.

Henbest, L. G., and Read, C. B., 1944, Stratigraphic distribution of the Pennsylvanian Fusulinidae in a part of the Sierra Nacimiento of Sandoval and Rio Arriba Counties, New Mexico: U. S. Geol. Survey Oil and Gas Inv. Prelim. Chart 2.

Herrick, C. L., and Bendrat, T. A., 1898, Identification of an Ohio Coal Measures horizon in New Mexico: Univ. New Mexico Bull. 27, Geol. ser., v. 2, Fasciculus 2, 10 p.

Hoffmeister, W. S., Staplin, F. L., and Malloy, R. E., 1955, Geologic range of Paleozoic plant spores in North America: Micropaleontology, v. 1, p. 9-27.

Ibrahim, A. C., 1933, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Dissertation, Berlin; privately pub. 1933, by Konrad Triltsch, Würzburg, 47 p.

Kelley, V. C., and Wood, G. H., Jr., 1946, Lucero uplift, Valencia, Socorro, and Bernalillo Counties, New Mexico: U. S. Geol. Survey Oil and Gas Inv. Prelim. Map 47.

Knox, E. M., 1950, The spores of Lycopodium, Phylloglossum, Selaginella, and Isoetes: Botanical Soc. Edinburgh Trans., v. 30, p. 209-357.

Kosanke, R. M, 1950, Pennsylvanian spores of Illinois and their use in correlation: Illinois Geol. Survey Bull. 74, 128 p.

Kottlowski, F. E., 1959, Written communication.

Lee, W. T., and Girty, G. H., 1909, The Manzano group of the Rio Grande Valley, New Mexico: U. S. Geol. Survey Bull. 389, 141 p.

Morgan, J. L., 1955, Spores of McAlester coal: Oklahoma Geol. Survey Circ. 36, 54 p.

Naumova, S. N., 1937, The spores and pollens of the coals of the U. S. S. R.: Rept. 17th Sess. Intern. Geol. Congr. 1937, Moscow, v. 1, p. 353-364.

Potonié, Robert, and Kremp, Gerhard, 1954, Die Gattungen der paläozoischen Sporae dispersae und ihre Stratigraphie: Landesanstalt fur Bodenforschung, Geol. Jahrb., v. 69, p. 111-194.

Read, C. B., 1958, Oral communication.

Read, C. B., Duffner, R. T., Wood, G. H., Jr., and Zapp, A. D., 1950, Coal resources of New Mexico: U. S. Geol. Survey Circ. 89, 24 p.

Read, C. B., and Wood, G. H., Jr., 1947, Distribution and correlation of Pennsylvanian rocks in late Paleozoic sedimentary basins of northern New Mexico: Jour. Geology, v. 55, p. 220-236.

Schemel, M. P., 1950, Carboniferous plant spores from Daggett County, Utah: Jour. Paleontology, v. 24, p. 232-244.

Schopf, J. M., Wilson, L. R., and Bentall, Ray, 1944, An annotated synopsis of Paleozoic fossil spores and the definition of generic groups: Illinois Geol. Survey Rept. Inv. 91, 73 p.

Thompson, M. L., 1942, Pennsylvanian system in New Mexico: New Mexico Bureau of Mines and Mineral Resources Bull. 17, 90 p.

Wilson, L. R., and Coe, E. A., 1940, Descriptions of some unassigned plant microfossils from the Des Moines series of Iowa: Am. Midland Naturalist, v. 23, p.182-186.

Wilson, L. R., and Hoffmeister, W. S., 1956, Plant microfossils of the Croweburg coal: Oklahoma Geol. Survey Circ. 32, 57 p.

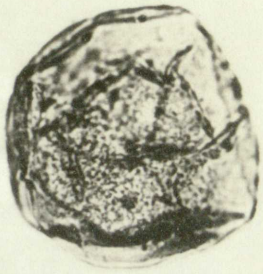
Wilson, L. R., and Kosanke, R. M., 1944, Seven new species of unassigned plant microfossils from the Des Moines series of Iowa: Iowa Acad. Sci. Proc. 1944, v. 51, p. 329-332 [1945] .

PLATE 1.--SPORES FROM THE SANTA FE MINE B COAL

PLATE I

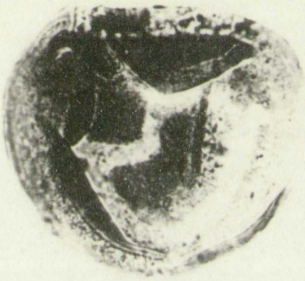
1

2

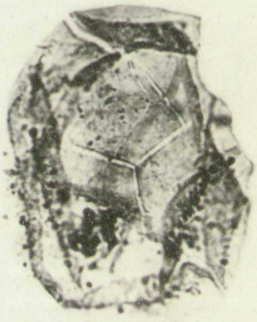


3

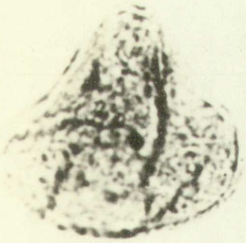
4



5

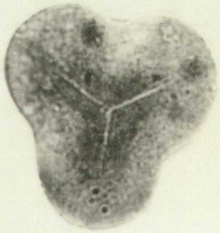


6



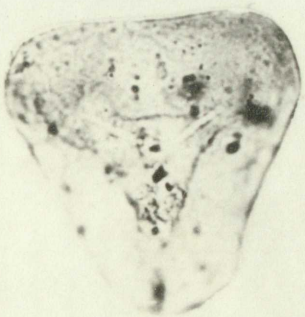
7

8

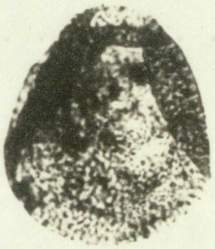


9

10



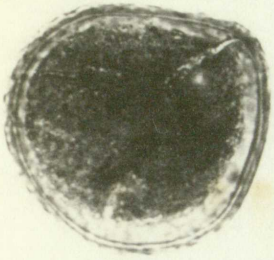
11



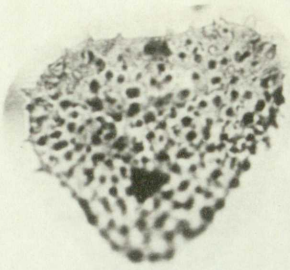
12

PLATE 2.--SPORES FROM THE SANTA FE MINE B COAL

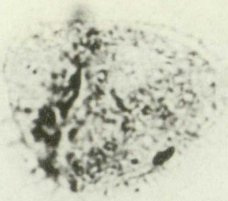
PLATE 2



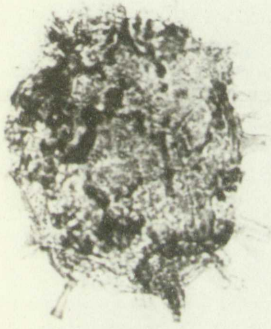
1



2

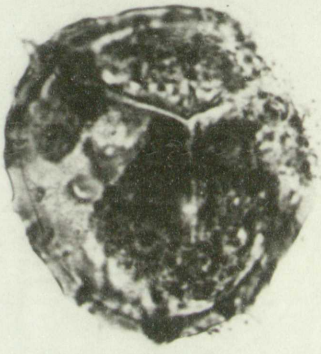


3

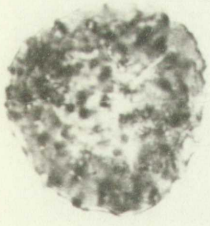


4

5

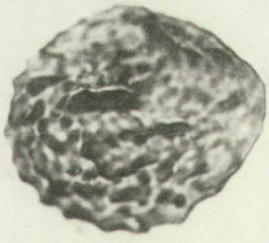


6

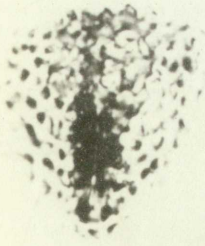


7

8

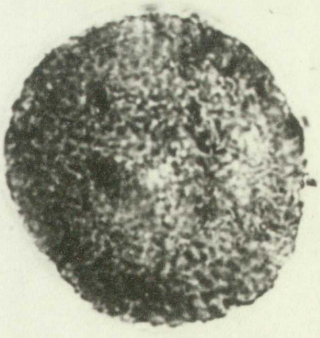


9



10

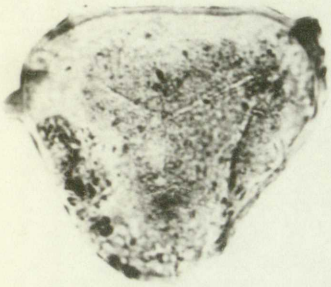
11



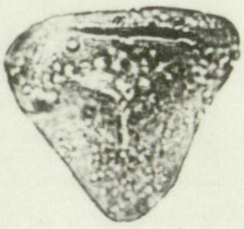
12

PLATE 3.--SPORES FROM THE SANTA FE MINE BOCOAL

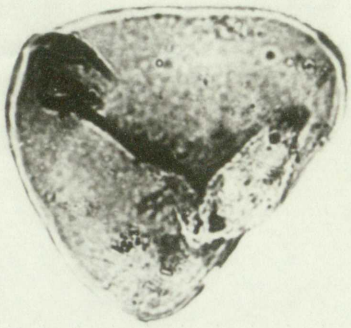
PLATE 3



1

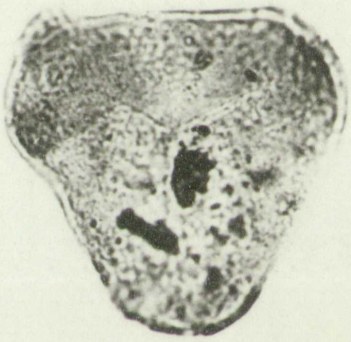


2



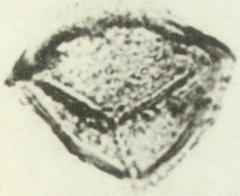
3

4

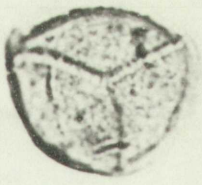


5

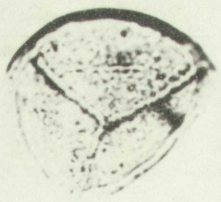
6



7

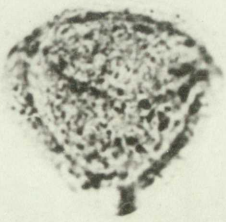


8

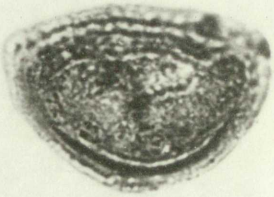


9

10



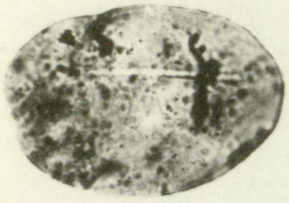
11



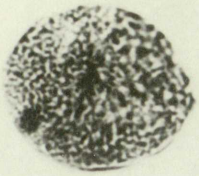
12

PLATE 4.--SPORES FROM THE SANTA FE MINE B COAL

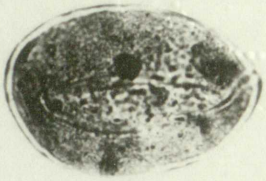
PLATE 4



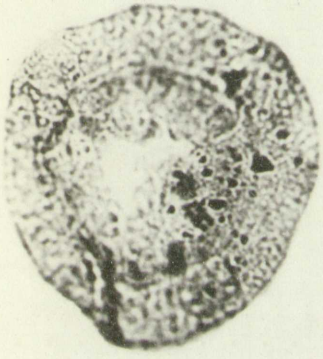
1



2



3

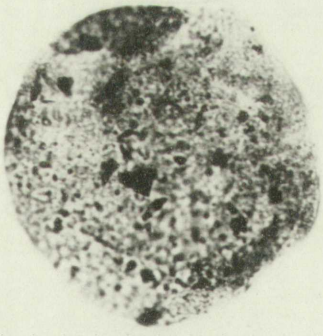


4

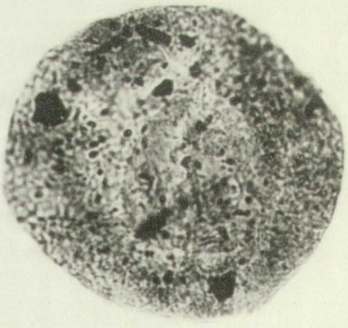
5

6

7



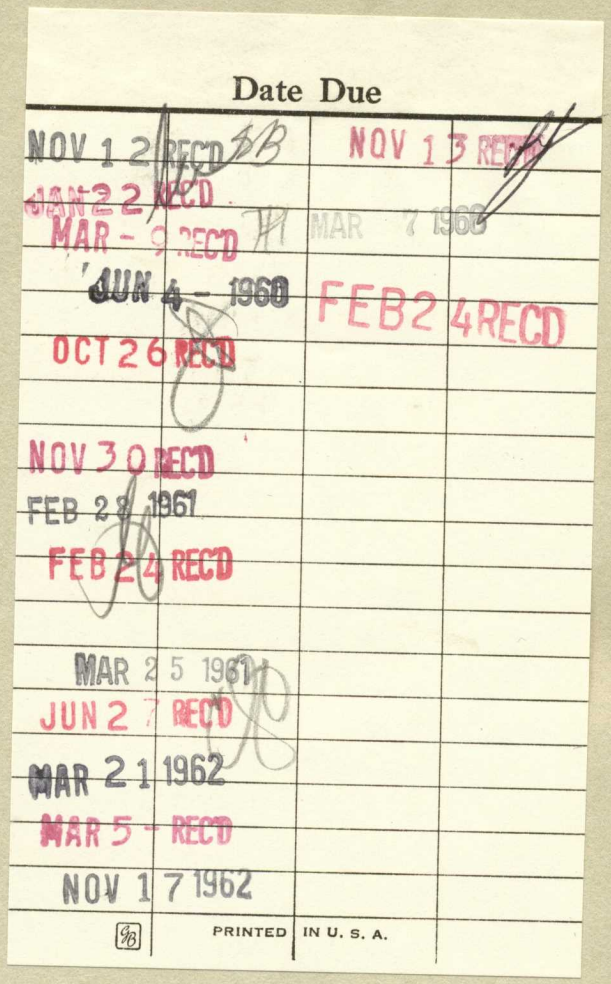
8



9

IMPORTANT!

Special care should be taken to prevent loss or damage of this volume. If lost or damaged, it must be paid for at the current rate of typing.



Date Due

NOV 12 RECD

NOV 13 RECD

JAN 22 RECD

MAR - 9 RECD

MAR 7 1960

JUN 4 - 1960

FEB 24 RECD

OCT 26 RECD

NOV 30 RECD

FEB 28 1961

FEB 24 RECD

MAR 25 1961

JUN 27 RECD

MAR 21 1962

MAR 5 - RECD

NOV 17 1962

PRINTED IN U. S. A.