Palynology of Part of the Paradox and Honaker Trail Formations, Paradox Basin, Utah

U.S. GEOLOGICAL SURVEY BULLETIN 2000–L

Cover. View south toward the La Sal Mountains along the Colorado River between Cisco and Moab, Utah. Fisher Towers in center is composed of Permian Cutler Formation and capped by Triassic Moenkopi Formation. The prominent mesa at left center is capped by Jurassic Kayenta Formation and Wingate Sandstone and underlain by slope-forming Triassic Chinle and Moenkopi Formations. The Chinle-Moenkopi contact is marked by a thin white ledge-forming gritstone. The valley between Fisher Towers and Fisher Mesa in the background is part of Richardson Mesa, part of Professor Valley. Photograph by Omer B. Raup, U.S. Geological Survey.

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By Robert M. Kosanke

EVOLUTION OF SEDIMENTARY BASINS—PARADOX BASIN
A.C. Huffman, Jr., Project Coordinator

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A multidisciplinary approach to research studies of sedimentary rocks and their constituents and the evolution of sedimentary basins, both ancient and modern

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PALYNOLOGY OF PART OF THE PARADOX AND HONAKER TRAIL FORMATIONS, PARADOX BASIN, UTAH

By Robert M. Kosanke

ABSTRACT

Palynomorphs from the upper part of the Paradox Formation, cycles 1–5, contain representatives of both arborescent and herbaceous plants. Elsewhere in the United States a major floral change is present in close proximity to the Middle-Upper Pennsylvanian boundary based on palynomorph occurrence. This floral change is marked by the extinction of several taxa including *Lycospora* spp., *Densosporites* spp., and *Thymospora pseudothiessenii*. In the Paradox Formation, *Lycospora* is present in cycles 3 and 5. *Densosporites* is present in cycle 1, but *Thymospora* was not identified from any of the samples studied. Although only a single specimen of *Laevigatosporites* was identified, this taxon is abundant and a major element of Middle and Upper Pennsylvanian strata throughout the United States and the world. Such bilateral, monolete spores are also present in younger geologic strata and in some modern plants.

Initially, it was thought that *Lycospora* was not present above the Paradox Formation in the Honaker Trail Formation. A concerted effort to examine additional preparations resulted in the finding of two extremely poor specimens that might be related to this genus. If this relation is true, it is likely that these specimens, occurring more than 500 ft above the Paradox Formation, are reworked.

INTRODUCTION

The Pennsylvanian System of the Paradox Basin of Utah and Colorado includes the Molas Formation in contact with the Mississippian Leadville Limestone below and the Hermosa Group above. The Hermosa Group contains three formations, in ascending order, the Pinkerton Trail, Paradox, and Honaker Trail, and it is overlain by Permian strata.

The Paradox Formation contains 33 halite cycles (Williams-Stroud, 1994). These cycles, numbered from the top down (Hite, 1960), are composed of transgressive and regressive phases. Halite is the endmember of the regressive phase, and black shale commonly marks the end of the transgressive phase and the onset of regression. Anhydrite and dolomite are present in both phases. Baars and others (1967), utilizing fusulinids and black shale marker beds, placed the Paradox Formation in the Desmoinesian Series. The overlying Honaker Trail Formation is generally thought to be mostly within the Missourian Series.

In general terms the most abundant palynomorphs in the upper part of the Paradox Formation are those conventionally associated with gymnosperms and pteridosperms, which produce saccate pollen grains. Such taxa as *Potonieisporites, Striatites, Pityosporites, Florinites,* and others commonly are present, whereas other palynomorphs are in the minority. The abundance of saccate taxa in these samples is similar to that commonly in younger Pennsylvanian and Permian strata. Plants producing saccate pollen grains can generally be associated with a drier climate.

Kosanke (1947, 1950) reported major palynomorph extinctions occurring in the Illinois Basin between the Middle and Upper Pennsylvanian. The Upper Pennsylvanian assemblage of palynomorphs is significantly different from that in the Paradox Basin in that tree ferns and sphenopsids (*Laevigatosporites*) are very abundant.

For this investigation, samples were obtained from three coreholes (fig. 1): (1) U.S. Department of Energy Gibson Dome No. 1 (GD–1), sec. 21, T. 30 S., R. 21 E., San Juan County, Utah, Honaker Trail Formation; (2) Delhi Taylor Oil, Cane Creek No. 1 (CC–1), sec. 25, T. 26 S., R. 20 E., Grand County, Utah, Paradox Formation; and (3) Delhi-Taylor Oil, Shafer No. 1 (S–1), sec. 5, T. 27 S., R. 20 E., San Juan County, Utah, Paradox Formation. Raup and Hite (1991a, b, 1992) described the lithology, mineralogy, and evaporite cycles of the Cane Creek and Shafer coreholes.

Samples of the Honaker Trail Formation from the Gibson Dome No. 1 corehole were assigned to macerations 1001–A–E as shown in figure 2. Samples from cycles 1 and 2 of the Paradox Formation were obtained from the Cane Creek No. 1 corehole and assigned to macerations 984–A–D

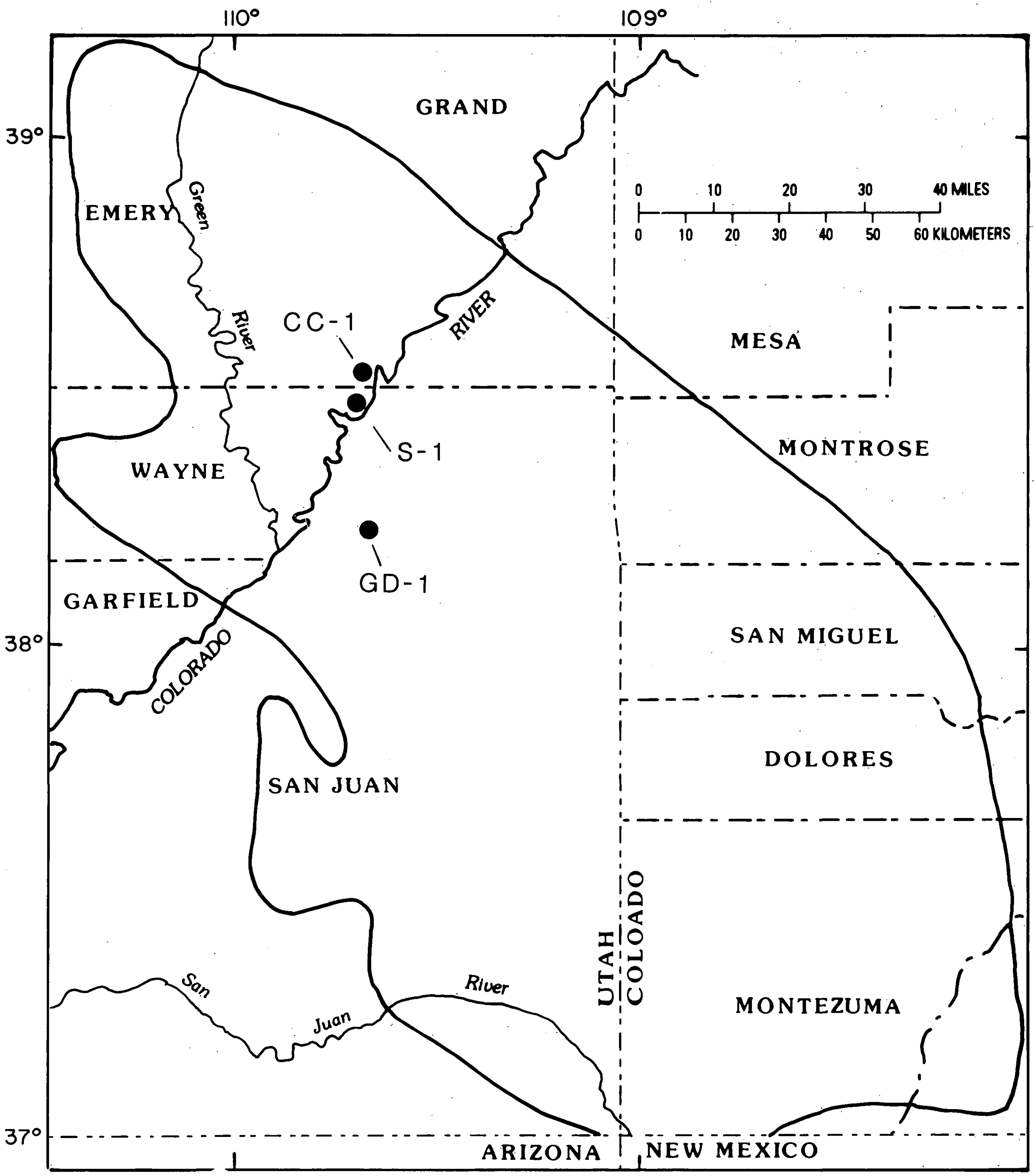

Figure 1. Map of the Paradox Basin, Utah and Colorado, showing the location of coreholes used in this study. CC–1, Cane Creek No. 1 corehole; S–1, Shafer No. 1 corehole; GD–1, Gibson Dome No. 1 corehole. Heavy line shows the approximate extent of halite faceies in the Paradox Formation, the common delineator of the boundary of the Paradox Basin. Modified from Raup and Hite (1991).

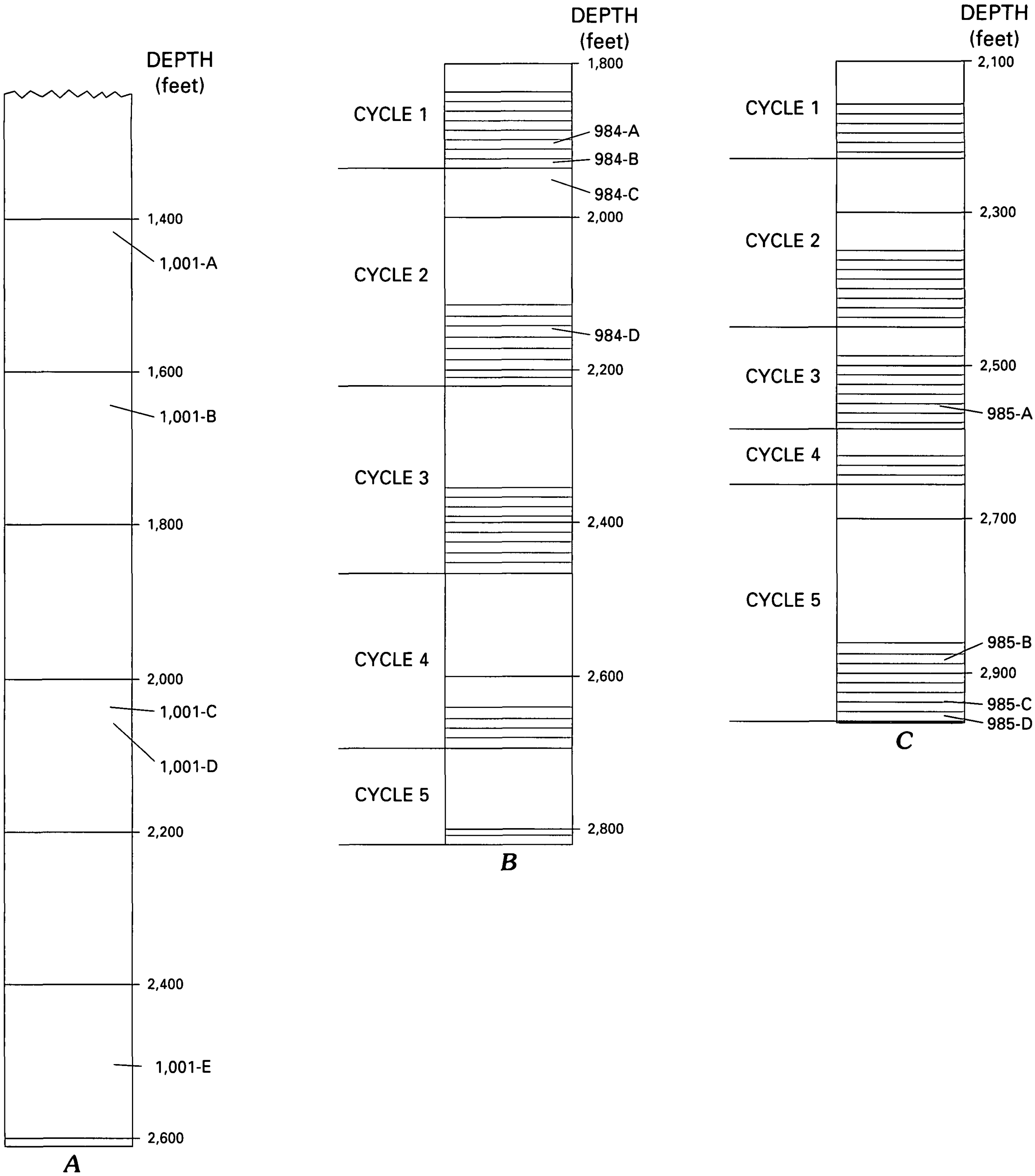

Figure 2. Diagrams showing location of samples collected for this study. *A*, Honaker Trail Formation, Gibson Dome No. 1 corehole, paleobotanical locality D8153. Position of samples assigned to macerations 1001–A through and including 1001–E is shown. *B*, Upper part of the Paradox Formation, cycles 1–5, Cane Creek No. 1 corehole, paleobotanical locality D8154. Lined area indicates position of black shale; position of samples assigned to macerations 984–A–D is also shown; maceration 984–C is a halite sample. *C*, Upper part of the Paradox Formation, cycles 1–5, Shafer No. 1 corehole, paleobotanical locality D8155. Samples from black shale are indicated by maceration numbers 985–A–D.

as shown in figure 2. Samples from cycles 3 and 5 of the Paradox Formation were obtained from the Shafer No. 1 corehole and assigned to macerations 985–A–D as shown in figure 2.

PREPARATION OF SAMPLES

The black shale samples basically were treated as described by Doher (1980). Bodine and Fernalld (1973) outlined the use of EDTA in the dissolution of gypsum, anhydrite, and calcium-magnesium carbonates. The use of EDTA, as described by Rueger (1984), was helpful in the preparation of halite samples. All maceration residues were mounted in balsam.

PALYNOMORPHS FROM CYCLES 1 AND 2, CANE CREEK NO. 1 COREHOLE

In general, preservation of palynomorphs is poor in cycles 1 and 2 of the Paradox Formation and somewhat better in cycles 3 and 5. The position of samples in the Cane Creek No. 1 corehole is shown in figure 2. Samples from cycle 1, 1,912 ft, 3-3/4–4 in., maceration 984–A, contained abundant opaque matter, and the palynomorphs were dark yellow. The following palynomorphs were identified.

Calamospora straminea Wilson and Kosanke
Cirratriradites sp.
Cyclogranisporites microgranus Bharadwaj
Densosporites cf. *D. triangularis* Kosanke
Florinites sp.
Knoxisporites cf. *K. stephanephorus* Love
Leiotriletes sphaerotriangularis (Loose) Potonié and Kremp
Pityosporites westphalensis Williams
Potonieisporites sp.
Punctatisporites cf. *glaber* (Naumova) Playford
Striatites sp.
Vesicaspora sp.

The sample from cycle 1, 1,937 ft, 8½–9½ in., maceration 984–B, was barren of palynomorphs.

The sample from cycle 2, 1,939 ft, 0–1½ in., a halite sample, maceration 984–C, contained a few variously folded and poorly preserved palynomorphs.

Pityosporites sp.
Potonieisporites (?)
Calamospora (?)
Other monosaccate and bisaccate forms

The sample from cycle 2, 2,164 ft, maceration 984–D, a black shale, yielded only the following palynomorphs:

Cirratriradites sp.
Potonieisporites (?)
Punctatisporites (?)

PALYNOMORPHS FROM CYCLES 3 AND 5, SHAFER NO. 1 COREHOLE

The position of samples in the Shafer No. 1 corehole is shown in figure 2. The sample from cycle 3, 2,548 ft, 10–10½ in., maceration 985–A, contained very dark brown organic matter and a limited number of palynomorphs including:

Calamospora (?)
Florinites sp.
Lycospora pellucida (Wicher) Schopf, Wilson, and Bentall
Pityosporites westphalensis Williams
Potonieisporites sp.
Reticulatisporites sp.
Vesicaspora wilsonii (Schemel) Wilson and Venkatachala

The sample from cycle 5, 2,881 ft, 4¼–6¼ in., maceration 985–B, contained abundant fine opaque matter and much better preserved palynomorphs.

Calamospora breviradiata Kosanke
Cirratriradites cf. *C. annuliformis* Kosanke
Convolutispora sp.
Florinites antiquus Schopf in Schopf, Wilson, and Bentall
Laevigatosporites cf. *L. globosus* Schemel
Lycospora granulata Kosanke (pl. 1, fig. 3)
L. pellucida (Wicher) Schopf, Wilson, and Bentall
L. sp.
Parasaccites (?)
Pityosporites westphalensis Williams
Platysaccus saarensis (Bharadwaj) Jizba
Punctatisporites cf. *P. glaber* (Naumova) Playford (pl. 1, fig. 4)
P. sp. (pl. 1, fig. 6)
Triquitrites additus Wilson and Hoffmeister (pl. 1, fig. 1)
Vesicaspora wilsonii (Schemel) Wilson and Venkatachala

The sample from cycle 5, 2,940 ft, 6–7 in., maceration 985–C, contained medium- to dark-brown organic matter. Palynomorphs were not as abundant as in maceration and 985–B, and the following were identified.

Cirratriradites annulatus Kosanke
Complexisporites (?) (pl. 1, fig. 8)
Florinites sp.
Illinites unicus (Kosanke) Helby (pl. 1, fig. 9)
I. sp.
Lycospora micropapillata (Wilson and Coe) Schopf, Wilson, and Bentall
L. pellucida (Wicher) Schopf, Wilson, and Bentall (pl. 1, fig. 2)
Pityosporites cf. *P. westphalensis* Williams (see pl. 1, fig. 5)

Potonieisporites cf. *P. elegans* (Wilson and Kosanke) Wilson and Venkatachala (pl. 1, fig. 7)

Stenozonotriletes cf. *S. occulus* Ravn

Striatites (sp.) (see pl. 1, fig. 10)

The sample from cycle 5, 2,960 ft, 4–5 in., maceration 984–D, was barren of palynomorphs.

PALYNOMORPHS FROM SAMPLES OF THE HONAKER TRAIL FORMATION

Samples from the Honaker Trail Formation, above the Paradox Formation, were collected from the Gibson Dome No. 1 corehole. Five shale or siltstone samples were collected and assigned to macerations 1001–A–E (fig. 2).

Maceration 1001–A, 1,428 ft, black shale with vitrinite lenses

Maceration 1001–B, 1,647 ft, dark gray shale

Maceration 1001–C, 2,035 ft, siltstone

Maceration 1001–D, 2,047 ft, dark-gray to black shale

Maceration 1001–E, 2,509 ft, siltstone

Preservation of palynomorphs is very poor, and, as a matter of fact, macerations 1001–B and 1001–C were barren of palynomorphs.

Maceration 1001–A contained abundant small pieces of light-yellow organic matter. Only one palynomorph was identified, *Calamospora* cf. *C. flexilis* Kosanke.

Maceration 1001–D contained abundant fine opaque matter, and the few palynomorphs were brownish in color. One was *Leiotriletes* cf. *L. parvus* Guennel. Two pieces of palynomorphs suggestive of *Lycospora* (?) were observed. This probably is reworked material.

Maceration 1001–E contained black and gray lenses. Only the black lenses were prepared, and dark-brown organic matter and a few palynomorphs were found.

Endosporites (?)

Potonieisporites sp.

Punctatisporites cf. *P.* glaber (Naumova) Playford

Striatites sp.

Wilsonites vesicatus (Kosanke) Kosanke

Some other very poorly preserved monosaccate and bisaccate palynomorphs

DISCUSSION

Evidence for in situ growth of plants was not found in the black shales examined, cycles 1–5, nor were stigmarian rootlets and other plant megafossils found in place. Arnold (1940) described *Lepidodendron johnsonii* from the "Weber (?) shale" of eastern Chaffee County in central Colorado. Arnold's reconstruction (fig. 3) shows an Early Pennsylvanian landscape with a *Lepidodendron* forest in a swampy environment.

Arnold (1941) described Paleozoic plants from several Colorado formations that were "Permian" in appearance and affinities. These plants grew, however, under conditions of aridity, and the presence of desiccation features in the rocks is obvious. Arnold stated, "The plants are therefore not proof of Permian or even late Pennsylvanian age, but may be an early appearance due to conditions of the environment."

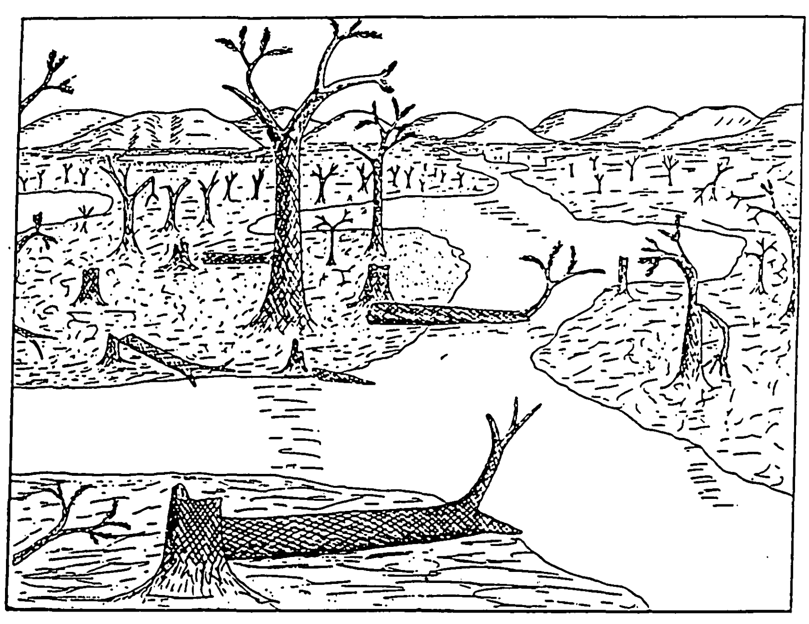

Figure 3. Schematic drawing showing environment during the Lower Pennsylvanian in central Colorado. Numerous *Lepidodendron* trees are in situ in a swampy lowland comprising mud and sluggish streams. From Arnold (1940).

Arnold (1956) reported on the occurrence of a new species of large calamite stem from the eastern side of the Sangre de Cristo range, Huerfano County, Colorado. Burbank and Goddard (1937) assigned a Pennsylvanian age to the strata from which Arnold's *Calamites huerfanoensis* was collected. During the Pennsylvanian, plants were present in Colorado east of the Paradox Basin, and they were present along the eastern margin of the basin, according to G.L. Geanniny (personal commun., 1994).

SUMMARY

Palynomorphs have been extracted from cycles 1–3 and 5 of the Pennsylvanian Paradox Formation and from the overlying Pennsylvanian Honaker Trail Formation. Preservation of palynomorphs from the Honaker Trail Formation is very poor, and, to some extent, the same is true of palynomorphs from cycles 1 and 2 of the Paradox Formation. The samples examined were primarily from black shale.

The most abundant palynomorphs observed in the upper part of the Paradox Formation are those traditionally associated with gymnosperms and pteridosperms that produced saccate pollen grains. These plants are found in younger Pennsylvanian and Permian strata and are indicative of arid to semiarid conditions. The climate in the area under consideration was arid during much of the Desmoinesian.

Palynomorphs that indicate selected growth forms such as herbaceous and arborescent plants were also recognized. *Cirratriradites, Densosporites,* and *Endosporites* are associated with herbaceous lycopsid plants. *Convolutispora, Cyclogranisporites, Leiotriletes*, and others are related to ferns. Palynomorphs associated with arborescent plants are *Lycospora, Calamites, Florinites, Pityosporites, Potonieisporites*, and others.

On the basis of the cores examined it was not possible to determine whether plants grew in situ within the basin in the black shale environment. If the plants did not grow in the basin, the palynomorphs were either blown or washed into the basin from the margins of the basin.

Within the Paradox Basin, *Lycospora*, the palynomorph of arborescent lycopsids, apparently became extinct between cycles 3 and 2, below the Middle-Upper Pennsylvanian boundary. This extinction would be somewhat similar to the known extinction of this taxon in the Illinois and Appalachian Basins; however, because recovery and preservation of palynomorphs were very poor, especially for samples of cycle 2, additional samples should be collected, prepared, and examined to further evaluate the extinction of *Lycospora*.

The palynoflora of the upper part of the Paradox Formation should be compared with that from other areas of United States. The Paradox Formation is considered to be Desmoinesian, based on the work of Baars and others (1967). Selected taxa are present in the Paradox Formation such as *Lycospora pellucida* (pl. 1, fig. 2), *L. granulata* (pl. 1, fig. 3), *Densosporites* cf. *D. triangularis*, *Calamospora breviradiata*, and others that are present in Desmoinesian strata elsewhere. Thus, these selected taxa agree with a Middle Pennsylvanian Desmoinesian age assignment for the Paradox Formation. Some important palynomorphs in the Illinois and Appalachian Basins are absent, however, from the upper Paradox Formation samples examined. Some of these taxa include *Thymospora pseudothiessenii, Torispora securis, Radiizonates* sp., and *Zosterosporites triangularis.* Also, only a single specimen of *Laevigatosporites* was identified from these samples, and this genus is an abundant element of Middle Pennsylvanian palynoflora elsewhere in the United States.

The differences in the palynoflora between the Paradox Basin and the typical coal swamp coal are the result of prevailing environmental conditions. The typical upper Middle Pennsylvanian palynomorphs that are present in the Paradox Basin were capable of surviving under these drier conditions. Further evidence that plants respond to their environmental conditions is provided by the abundance of saccate pollen grains. Many of the plants that produce saccate pollen grains are present in environmental conditions drier than those of coal swamps.

One of the purposes of this investigation was to determine if selected taxa became extinct within the upper part of the Paradox Formation. Although evidence suggests that *Lycospora* spp. became extinct above cycle 3, in either cycle 2 or 1, it was decided to explore the Honaker Trail Formation above the Paradox Formation for any possible reoccurrence of species of *Lycospora*. Unfortunately, the occurrence of palynomorphs in the Honaker Trail Formation was limited and the palynomorphs very poorly preserved. Two poorly preserved specimens somewhat resembling *Lycospora* were found some 500 ft above the Middle-Upper Pennsylvanian boundary. The corroded condition of these specimens suggests that they were reworked and that the extinction of this genus occurred within the upper part of the Paradox Formation.

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PLATE

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PLATE 1

Palynomorphs extracted from transgressive strata, the black shale of the Paradox Formation, are commonly very poorly preserved. It is possible, however, to obtain some significant information on range zones of selected taxa for comparison with other areas of the United States.

Figure 1. *Triquitrites additus* Wilson and Hoffmeister, D8155–B, maceration 985–B, slide 7, 111.3×9.0, maximum diameter 39.6 microns, negative numbers 7253–7256.

2. *Lycospora pellucida* (Wicher) Schopf, Wilson, and Bentall, D8155–C, maceration 985–C, slide 7, 119.0×14.2, maximum diameter 27 microns, negative numbers 7289–7294.

3. *Lycospora granulata* Kosanke, D8155–B, maceration 985–B, 118.8×4.0, maximum diameter 37 microns, negative numbers 7240–7242.

4. *Punctatisporites* cf. *P. glaber* (Naumova) Playford, D8255–B, maceration 985–B, slide 6, 106.5×8.2, maximum diameter 38.4 microns, negative numbers 7298–7299.

5. Oblique lateral view of a bisaccate pollen grain similar to *Pityosporites westphalensis* Williams, D8155–C, maceration 985–C, slide 2, 107.8×13.4, maximum diameter 84.56 microns, negative numbers 7276–7279.

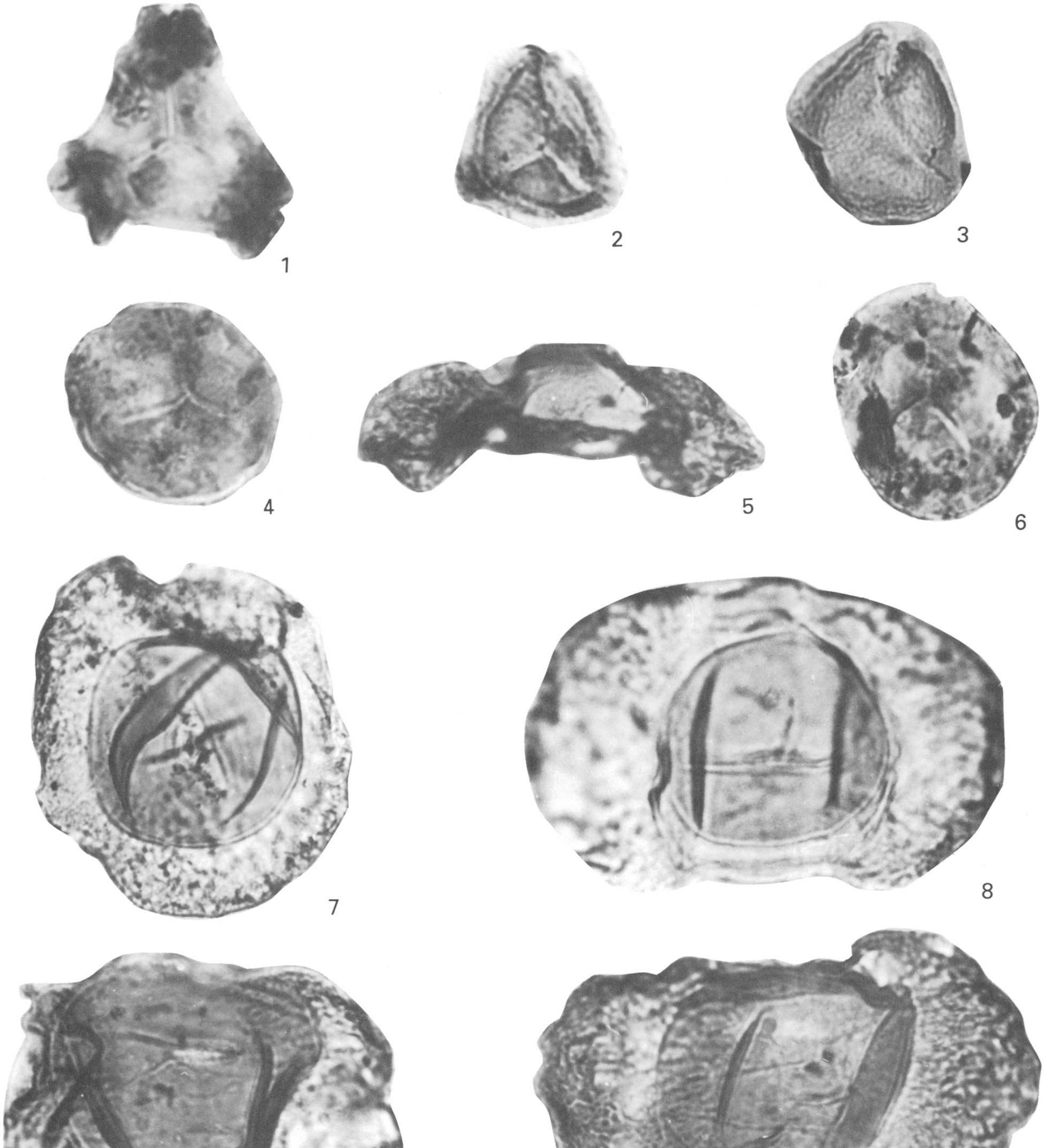
6. *Punctatisporites* sp. D8155–B, maceration 985–B, slide 6, 106.5×8.2, maximum diameter 38.4 microns, negative numbers 7237–7238.

7. *Potonieisporites* cf. *P. elegans*, (Wilson and Kosanke), Wilson and Venkatachala, D8155, maceration 985–C, slide 1, 108.7×3.2, maximum diameter 130.5 microns, negative numbers 7224–7227.

8. *Complexisporites* (?), D8155–C, maceration 985–C, slide 5, 116.8×20.0, maximum diameter 71 microns, negative numbers 7204–7207.

9. Oblique view of *Illinites unicus* (Kosanke) Helby, D8155–C, slide 2, 110.3×17.3, maximum diameter 64 microns, negative numbers 7276–7279.

10. *Striatites* sp., similar to *S. richteri* (Potonié) Jizba but lacks pronounced striations and slit of the cap, D8155–C, maceration 985–C, slide 4, 110.9×8.6, maximum diameter 87 microns, negative numbers 7261–7263.



PALYNOMORPHS FROM THE PENNSYLVANIAN PARADOX FORMATION,
PARADOX BASIN, UTAH

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