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Paleoenvironments of the South Hospah coal deposits, McKinley County, New Mexico

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Abstract

Coal-bearing deposits in the South Hospah area were sampled from four core sections for palynological analysis. The palynomorph assemblages indicate a Late Cretaceous (early Campanian) age for these deposits. According to palynological evidence, it is appropriate to assign these strata to the Menefee Formation. Palynological, paleobotanical, and sedimentological data indicate that the sediments were deposited in a lowland, fresh-water swamp complex under a maritime, warm-temperate climatic regime of high equability. A major shift in the sedimentological and palynological composition of the samples above the "blue" coal suggests an alluvium-dominated upper-deltaic facies representing progradation of the Menefee delta into the area studied.

Introduction

Microscopic, organic-walled, acid-resistant entities, or palynomorphs, are abundantly present in a great variety of both terrestrial and marine sediments. Palynological analyses of rocks provide valuable information about the ecological and environmental conditions in the geologic past. Palynology is a useful tool in biostratigraphic correlation and in understanding the maturation history of source rocks, which is evidenced by the extensive application of this discipline in oil and coal exploration.

This is a preliminary report on an extensive palynological study of the coal-bearing deposits in the South Hospah area. The palynoflora documented in this study will be used as the baseline for future biostratigraphic investigations that are vital to a better understanding of the geology of this region.

Geographic and stratigraphic position of the study area

The study area is located on the South Hospah lease, about 19 road mi northeast of Crownpoint, in the east-central part of McKinley County (Fig. 1). It includes sec. 1 of T16N, R10W and secs. 25–27 and 34–36 of

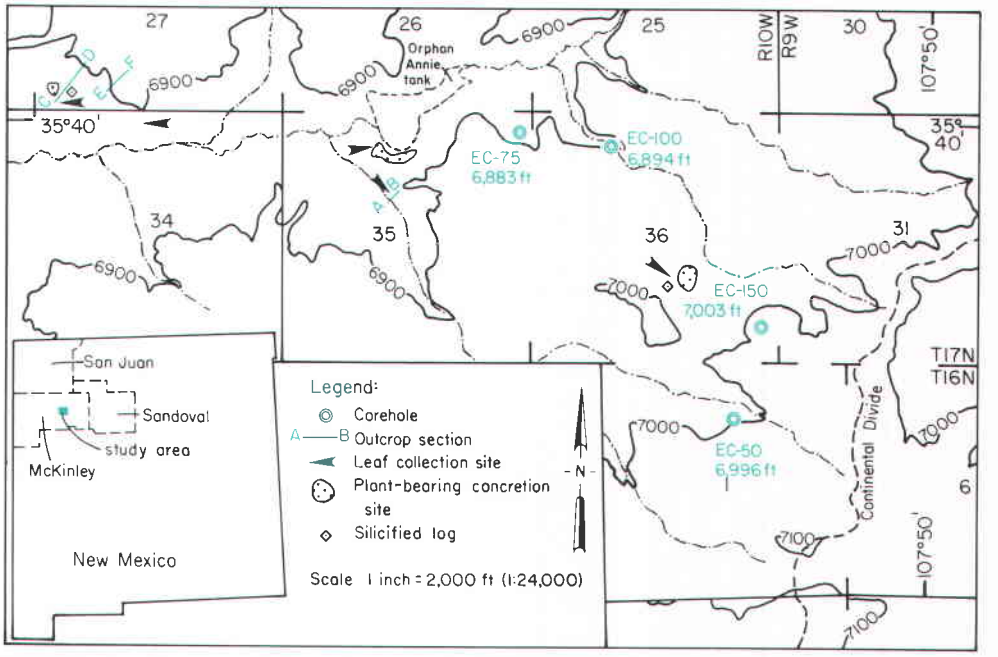

FIGURE 1—Location map of the study area in the South Hospah area, McKinley County. The four core sections are highlighted in blue and the elevations given were determined at the surface; see Fig. 3 for profiles and exact locations of the cores.

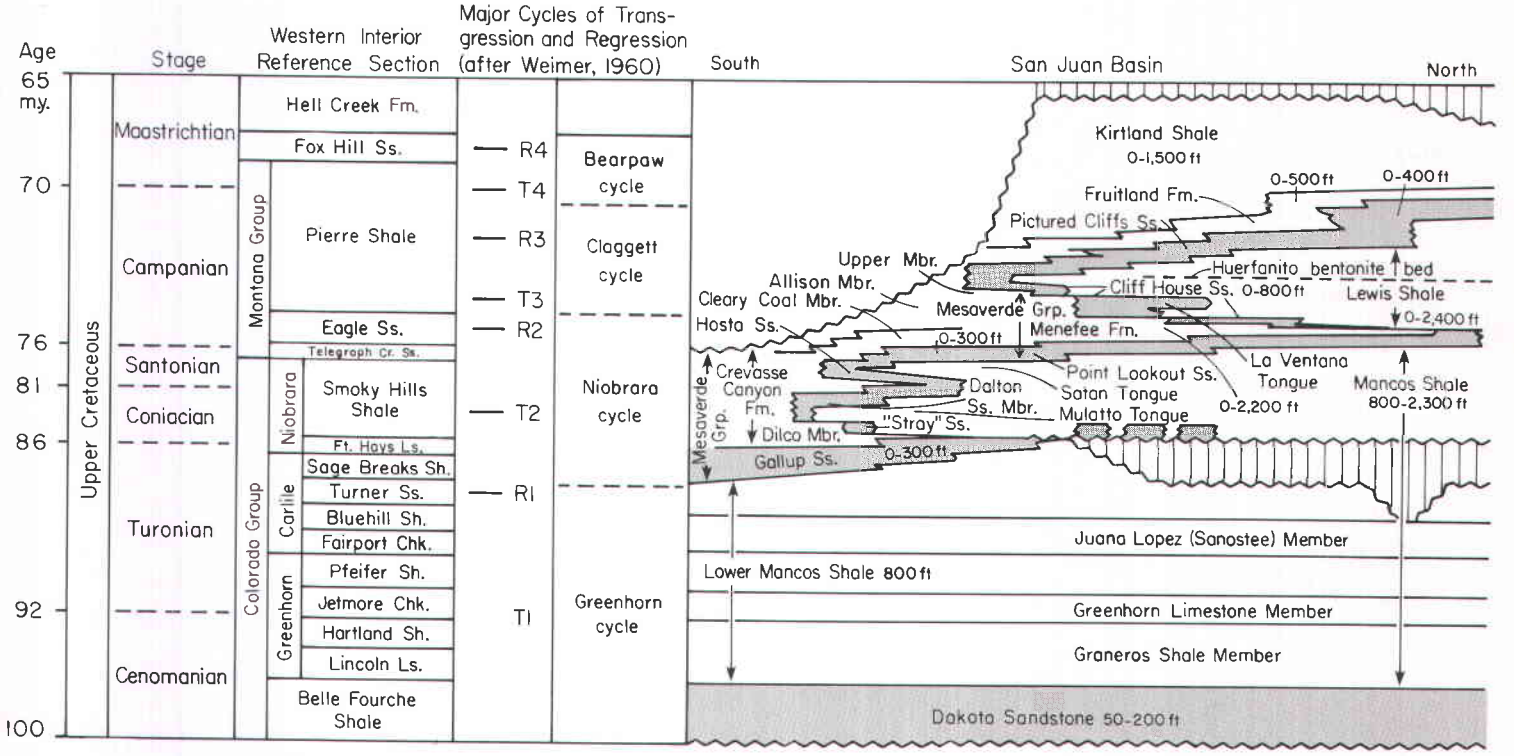

FIGURE 2—Stratigraphic setting of the Upper Cretaceous deposits in the San Juan Basin (from Jameossanaie, 1983).

T17N, R10W in Orphan Annie Rock quadrangle and Laguna Castillo quadrangle. The area is bounded between 107° 50′ to 107° 54′ west long. and 35° 52′ to 35° 40′ north lat.

The rocks exposed in the area are mainly shale beds and crossbedded sandstones associated with coal deposits that are assigned to the Cleary Coal Member of the Menefee Formation (King and Wengerd, 1957). The strata dip about 2–3° to the northeast towards the center of the San Juan Basin. Coal seams are exposed locally at the surface.

Major coal-bearing formations in New Mexico

The Mesaverde Group is the oldest coal-bearing terrestrial rock unit in New Mexico. It consists of the Crevasse Canyon Formation with two coal-bearing members, the Dilco and the Gibson, and the Menefee Formation with a lower coal-bearing member, the Cleary Coal Member, and an upper unnamed coal-bearing member (Fig. 2). The most economically significant coal in the basin is in the stratigraphically higher Fruitland Formation (Beaumont, 1968).

Methods of Study

The locations of the four cored sections that were sampled for this study are shown in Fig. 1. The cored sections include a total of 233 ft of subsurface rocks (Fig. 3).

One hundred seventy-six samples of coal and associated rocks were prepared for palynological analysis. Samples were treated with hydrofluoric acid to remove the silica and partially dissolve the clay material. The residues were then bleached by cold sodium hypochlorite (trade name Clorox) and stained red with 0.1% Safranin–O for microscopic study. Some coal samples that did not respond to the Clorox treatment were treated with a standard Schulze solution (one part saturated potassium chlorate solution and nine parts commercial strength nitric acid) on a steam table for 15 minutes followed by a quick wash with 5% potassium hydroxide.

Discussion

Acid-resistant marine phytoplankton such as dinoflagellates and acritarchs were not found in the South Hospah palynological assemblages. The absence of other marine microfossils and marine invertebrate remains in the rock samples, and the presence of fresh-water algal bodies (*Palambages* and *Schizosporis*) in the maceration residues (Fig. 4, nos. 19–21) indicate that the sediments were deposited in terrestrial fresh-water environments.

The presence of *Pseudoplicapollis newmanii* (Fig. 4, nos. 3 and 4), *Schizosporis scabratus* (Fig. 4, no. 20), *Cingulatisporites dakotaensis* (Fig. 4, no. 18), *Triporoletes novomexicanus* (Fig. 4, no. 13), *Schizaea reticulata* (Fig. 4, no. 14), and *Kuylisporites scutatus* (Fig. 4, no. 17) in the South Hospah palynoflora indicates that the deposits are early Campanian in age. They are younger than the Santonian assemblage described by Tschudy (1976) from the Gibson Coal Member of the Crevasse Canyon Formation in McKinley County and the basal Menefee Formation in San Juan County. They are older than the assemblage described by Delfel (1979) from the La Ventana Sandstone in Sandoval County. Delfel reported the ocurrence of *Aquilapollenites* in the La Ventana Sandstone samples, which is absent from the South Hospah assemblages and indicates a younger age. Palynological data presented by Delfel (1979) suggest that the La Ventana Sandstone is not younger than Campanian (Jameossanaie, 1983). Thus, the name Menefee Formation assigned to the terrestrial coal-bearing rock unit exposed in the South Hospah area is appropriate (see Fig. 2).

Gymnospermous bisaccate pollen grains were rarely encountered in the South Hospah assemblage. The relative percentage of these palynomorphs, where present, rarely exceeded 0.3% of the total. Bisaccate pollen grains occur more regularly in other terrestrial Late Cretaceous sections in New Mexico such as the Crevasse Canyon Formation (Tschudy, 1976). The scarcity or absence of the bisaccate pollen from the South Hospah assemblages indicates that the number of coastal-plain, delta-plain, or swampland conifers producing this pollen type must have been extremely low in or near the depositional site. It also suggests that any upland conifers of this type must have been located at a considerable distance from the site.

Members of taxodiaceous plants are represented in the South Hospah assemblages by *Sequoiapollenites*, *Taxodiaceaepollenites*, and *Inaperturopollenites* (Fig. 4, nos. 9–11), which support the lowland habitat of the plants contributing to the palynoflora of this site. Of four living species in this family that are native to North America three are adapted to moist or wet lowland habitats.

Members of the palm family are also represented in the South Hospah assemblages ☞

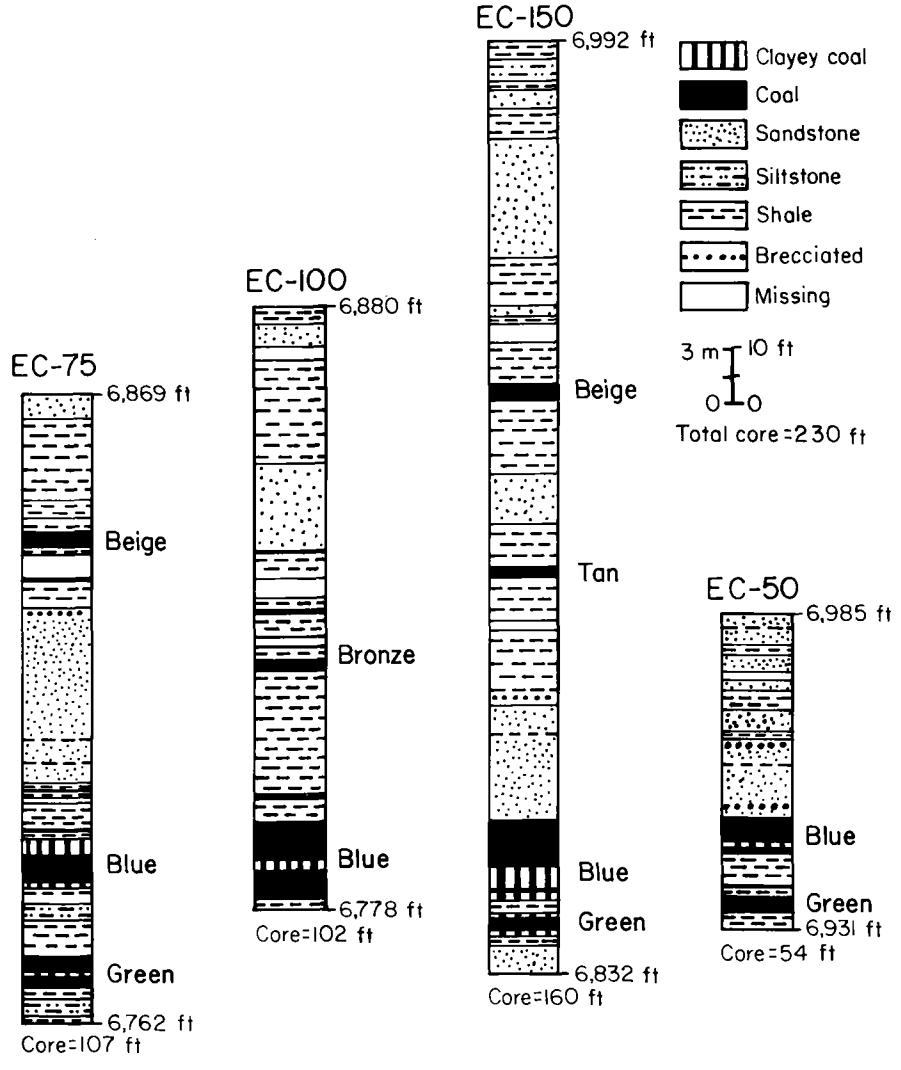

FIGURE 3—Stratigraphic profiles of the four South Hospah core sections. The exact locations are as follows: **EC–75,** SE¼NE¼, sec. 35, T17N, R10W; **EC–100,** NW¼NE¼, sec. 36, T17N, R10W; **EC–150,** SE¼SE¼, sec. 36, T17N, R10W; **EC–50,** SW¼NE¼, sec. 1, T16N, R10W. The elevations given were determined from the top of the cores. Surface elevations and approximate locations are given in Fig. 1.

by both pollen and leaf impressions. All nine extant genera of palms native to North America occur in lowland and coastal areas of Florida and the southern coastal plains except for the California Washingtonia (*Washingtonia filifera*), which is native to the southern United States at 150–1,000 m elevations (Elias, 1980).

The association of taxodiaceous and araucarian pollen with pollen assignable to the gum tree family (Nyssaceae; Fig. 4, nos. 5 and 6) and palm family (Fig. 4, nos. 7 and 8), along with a high relative frequency of gleicheniaceous fern spores (Fig. 4, nos. 15 and 16) is an indication of lowland depositional environments and a wet, warm-temperate climatic regime. An abundance of araucarian twigs, *Sequoia*-type needles, and palm leaves in outcrops of the study area (Fig. 1) supports the palynological interpretation (Cross, et al., 1983). It seems that the maritime climate moderated by the interior seaway, which prevailed in the area for most of the Late Cretaceous, provided a high level of equability in which a wide range of plant populations could flourish simultaneously. The moderating effect of the Cretaceous seaway is apparent by the occurrence of pollen grains representing families with the present-day tropical or subtropical distribution in the Late Cretaceous deposits of areas as far north as Alberta, Canada (Srivastava, 1970; Norris et al., 1975). Paleontological studies on the Cretaceous foraminifers (Bergquist, 1971) and gastropods (Sohl, 1971) of the western hemisphere also indicate a warm-temperate condition for the southern part of the Western Interior region.

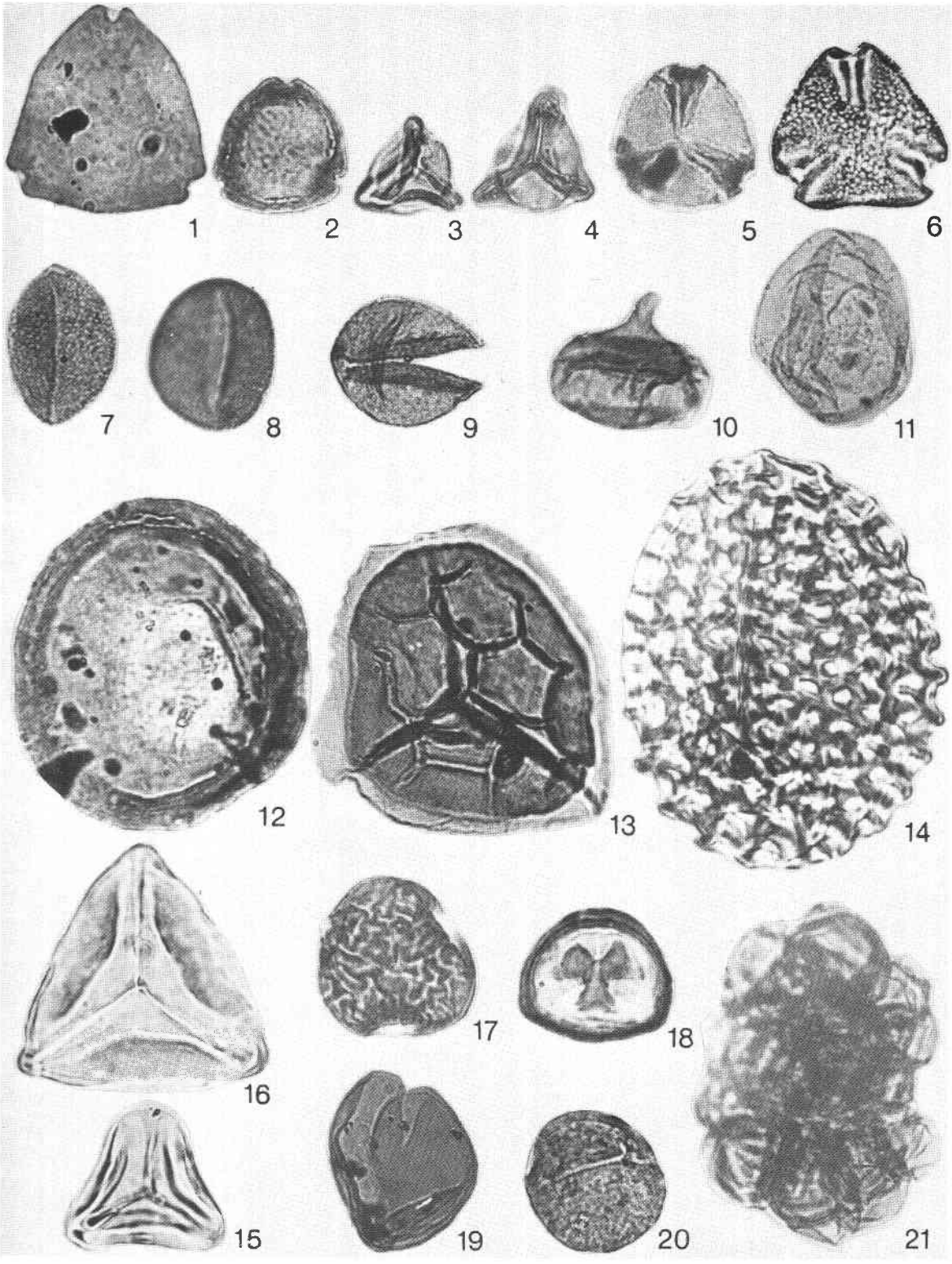

FIGURE 4—Some significant palynomorphs from the South Hospah area (all illustrations X 1,000). **1, 2,** *Triporpollenites* spp.; **3, 4,** *Pseudoplicapollis newmanii* Nichols and Jacobson, 1982; **5, 6,** *Margocolporites* spp.; **7, 8,** *Monocolpopollenites reticulatus* Nichols, Ames, and Traverse, 1973; **9,** *Taxodiaceaepollenites hiatus* Potonié, 1958; **10,** *Sequoiapollenites* sp.; **11,** *Inaperturopollenites dubius* (Potonié and Venitz) Thomson and Pflug, 1953; **12,** *Balmeiopsis limbatus* (Balme) Archangelsky, 1977; **13,** *Triporoletes novomexicanus* (Anderson) Srivastava, 1975; **14,** *Schizaea reticulata* Cookson, 1957; **15,** *Gleicheniidites senonicus* Ross, 1949; **16,** *Gleicheniidites* sp.; **17,** *Kuylisporites scutatus* Newman, 1965; **18,** *Cingulatisporites dakotaensis* Stanley, 1965; **19,** *Schizosporis cooksoni* Pocock, 1962; **20,** *Schizosporis scabratus* Stanley, 1965; **21,** *Palambages* sp.

Pollen spectra of the main coal seams, "blue" and "green" coals (Fig. 5), are distinguished by exceptionally high relative frequencies of gleicheniaceous fern spores (Fig. 4, nos. 15 and 16) and triporate angiospermous pollen of the type comparable to those produced by the families Myricaceae and Corylaceae (Fig. 4, nos. 1 and 2). The type of vegetation represented by the pollen flora in the "blue" and "green" coals may be characterized by shrubby and arborescent angiosperms and gleicheniaceous ferns. This type of plant community may indicate a marsh environment. The term marsh is used here to refer to the unforested wetland habitats as opposed to forested swamp environments supporting mainly arborescent vegetation. Fern-dominated marshes are one of the major peat-forming

environments in the Okefenokee marsh–swamp complex of southern Georgia and northern Florida. Dense stands of Virginia chain fern (*Woodwardia virginica*) grow around the edges of the swamps in the Okefenokee. The pollen signature of the *Woodwardia* peat is distinguished from other marsh types by its higher average percentage of *Woodwardia* spores (Spackman et al., 1974). In the absence of grasses, sedges, and several other herbaceous dicotyledonous angiosperms that had not yet evolved by early Campanian time, the gleicheniaceous ferns and shrubby angiosperms could have occupied the available ecological niches of these modern taxa in marsh environments. This is evidenced by the pollen signature in a considerable portion of main coal seams (Fig. 5). The minor coal beds above the main seams have a different pollen signature. They contain an abundance of *Nyssa*-type tricolporate pollen (Fig. 4, nos. 5 and 6) and tricolpate pollen grains. The frequencies of gleicheniaceous spores and taxodiaceous pollen are not significant in these coals (Fig. 5). The peat for these minor coals seems to have accumulated in forested swamps composed of *Nyssa*-type vegetation as a major component.

The relative percentage of taxodiaceous pollen is 4% or less in the "pure" coal beds. This pollen is abundant in some noncoal-producing organic shales at a few points along the section, indicating that taxodiaceous gymnosperms, although abundant at some levels in the South Hospah section, did not contribute significantly to the peat. The clayey coals and clay shales that contain high relative frequencies of taxodiaceous pollen in this area are also dominated by cuticular tissues, but they are very low in fusinite and vitrinite particles. This seems to be in contrast with modern taxodiaceous peat in which the wood and the pollen are both abundant (Spackman et al., 1974).

The "blue/green" coal complex is overlain by a generally coarsening-upward sequence characterized by relatively thick deposits of fine- to medium-grained, grayish to white, arkosic sandstone and light-gray silty shale. This sequence is interrupted by a few thin coal beds and associated black shales. The crossbedding in these sandstones indicates an increase in the energy of the depositional environment. A sharp contact was noted between the "blue" coal and the overlying white sandstone in EC–50, which indicates partial erosion of the coal and subsequent deposition of sandstone at this level (Fig. 3).

This trend corresponds to the progradation of the South Hospah delta, which resulted in migration of the peat swamps from the study area along with the regression of the sea (Fig. 2). Subsequently, the area was occupied by the fluvial-dominated upper-delta environments on which sandstones were deposited over the previously accumulated peat.

Conclusions

The South Hospah deposits are estimated to be early Campanian. They correlate with the Menefee Formation according to palynological data. The environment of deposition was a lowland, freshwater swamp complex. An equable, moist warm-temperate climatic regime probably prevailed during the deposition of these sediments. The gradual progradation of the South Hospah delta resulted in development of a coarsening-upward sequence and migration of the coal swamps out of this area.

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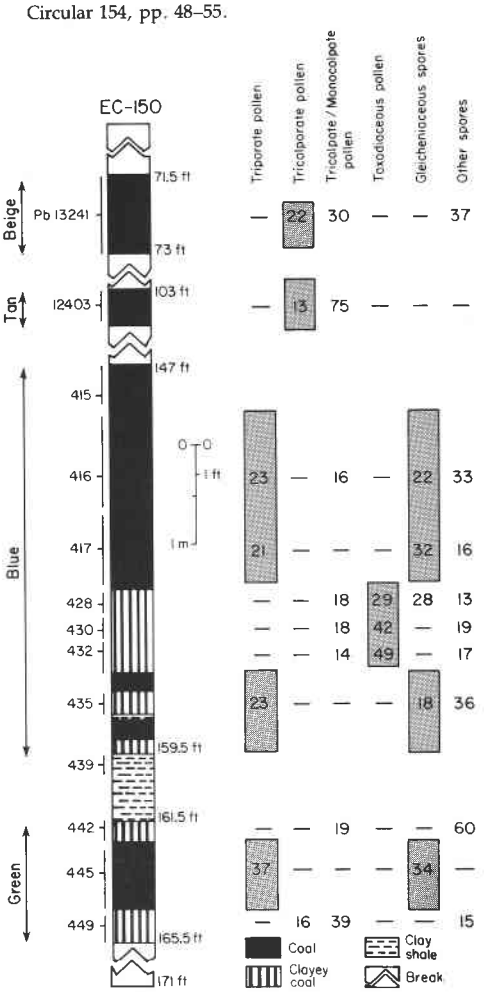

FIGURE 5—Relative frequencies of major palynomorph groups in core section EC–150. The frequencies for key palynomorphs at each level of the section have been highlighted in gray.