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PRELIMINARY ASSESSMENT OF THE AGE OF THE PALYNOFLORA OF THE RED TANKS MEMBER, MADERA FORMATION, CARRIZO ARROYO, NEW MEXICO

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Abstract—Multiple palynological analyses of two shale samples of Red Tanks Member, Madera Formation, from Carrizo Arroyo, Valencia County, NM, show that the samples represent levels near the Pennsylvanian/Permian system boundary. Sample AR1-8 was deposited rapidly from brackish nearshore water, under conditions favoring anoxic sulfur bacteria and pyritization of the monosaccate-dominated palynoflora, which is Late Pennsylvanian in age. Sample AR1-1, about 30 m higher stratigraphically, was deposited rapidly in a deltaic channel or other freshwater environment from which oxygen was excluded. The abundant, well preserved palynoflora is dominated by bisaccate pollen, including forms such as *Platysaccus* spp. and *Limitisporites* sp., indicating an Early Permian age. Sample AR1-1 is probably the closest palynologically to the Pennsylvanian/Permian system boundary of any flora yet described from the southwestern USA.

INTRODUCTION

In this article, we assess the age of the palynoflora of the Red Tanks Member of the Madera Formation in Carrizo Arroyo in central New Mexico and discuss its bearing on the position of the Pennsylvanian/Permian system boundary in the upper Paleozoic sequence in the region. The position of this boundary has been a matter of dispute. At one time it was generally assumed to lie between the dominantly marine Upper Paleozoic strata of the Madera Formation and the overlying terrestrial Abo Formation of Permian(?) age (Darton, 1928, Moore, et al, 1944). Read and Wood (1947), however, suggested that the uppermost unit in the Madera Formation, the Red Tanks Member, might be of Permian(?) age, but others (e.g., Kottlowski, 1960) continued to correlate the Red Tanks with Late Pennsylvanian (Virgilian) strata to the south and east. More recently, Kues and Kietzke (1976) indicated that the upper one-third of the Red Tanks was possibly lowermost Permian, basing their interpretation on marine invertebrates in the unit. Studies of the plant megafossils (Tidwell and Ash,1980; Ash and Tidwell, 1982) and palynomorphs (Traverse, in Ash and Tidwell, 1986) confirmed the earlier conclusions of Kues and Kietzke. That contention is further supported by the research reported here.

BACKGROUND

In 1981, two samples (AR1-1 and AR1-8) collected by the junior author from the Red Tanks Member of the Madera Formation in Carrizo Arroyo, Valencia County, NM (Fig. 1) (Ash and Tidwell, 1982) were found to contain a generally well-preserved and abundant palynoflora of apparently Early Permian age. The palynoflora in sample AR1-8 is much less well preserved and somewhat different in composition than the one in sample AR1-1. In 1988, the palynofloras in two samples (KI1-a and KI1-b) obtained by the junior author from the Wild Cow Formation in the nearby Kinney Brick Company clay pit, Bernalillo County, NM, were studied in a reconnaissance manner and determined to be somewhat similar to those observed in the Carrizo Arroyo Red Tanks Member samples. This palynoflora was later described in detail by Willard (1992). We have restudied samples AR1-1 and AR1-8, and our results are reported here. At present, we are processing an additional 15 samples from the entire sequence exposed at the Carrizo Arroyo locality and contemplate study of material of similar age at other localities in New Mexico and Arizona to determine the position of the Pennsylvanian/Permian system boundary within these sections.

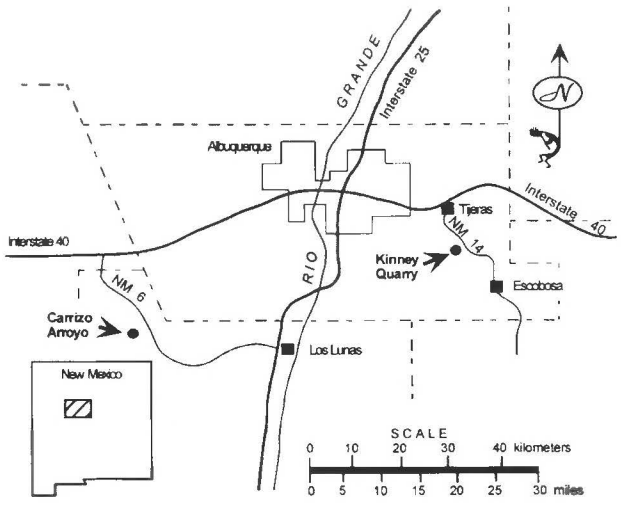


FIGURE 1. Index map showing the location of Carrizo Arroyo and the Kinney Quarry. The inset map shows the location of the study area in central New Mexico. Adapted from Kues and Kietzke (1976).

MATERIALS AND METHODS

Multiple preparations were made of two samples of shale from the Red Tanks Member, Madera Formation, Carrizo Arroyo, Valencia County, NM (Fig. 2). Sample AR1-1 comes from the principal plant megafossil horizon in unit 10 of Kues and Kietzke (1976). Sample AR1-8 was collected from an underclay about 30 m below AR1-1, directly below a thin coal bed. The samples were processed with standard palynological processing methods, basically: HCl>HF>ZnCl2 gravity separation>glycerine jelly mountant, per Traverse (1988).

DESCRIPTION OF THE PALYNOFLORA

Environment of deposition

Sporomorphs from sample AR1-1 are abundant and moderately well preserved. All specimens illustrated in Figure 3 are from this sample.

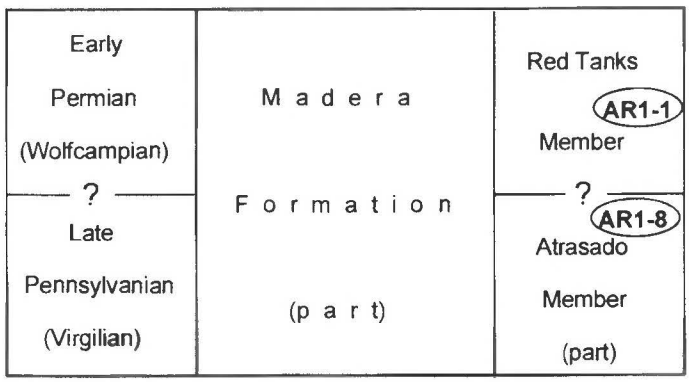


FIGURE 2. Stratigraphic chart of the upper part of the Madera Formation in Carrizo Arroyo showing the approximate positions of the samples discussed in this paper. Compiled from data in Kues and Kietzke (1976).

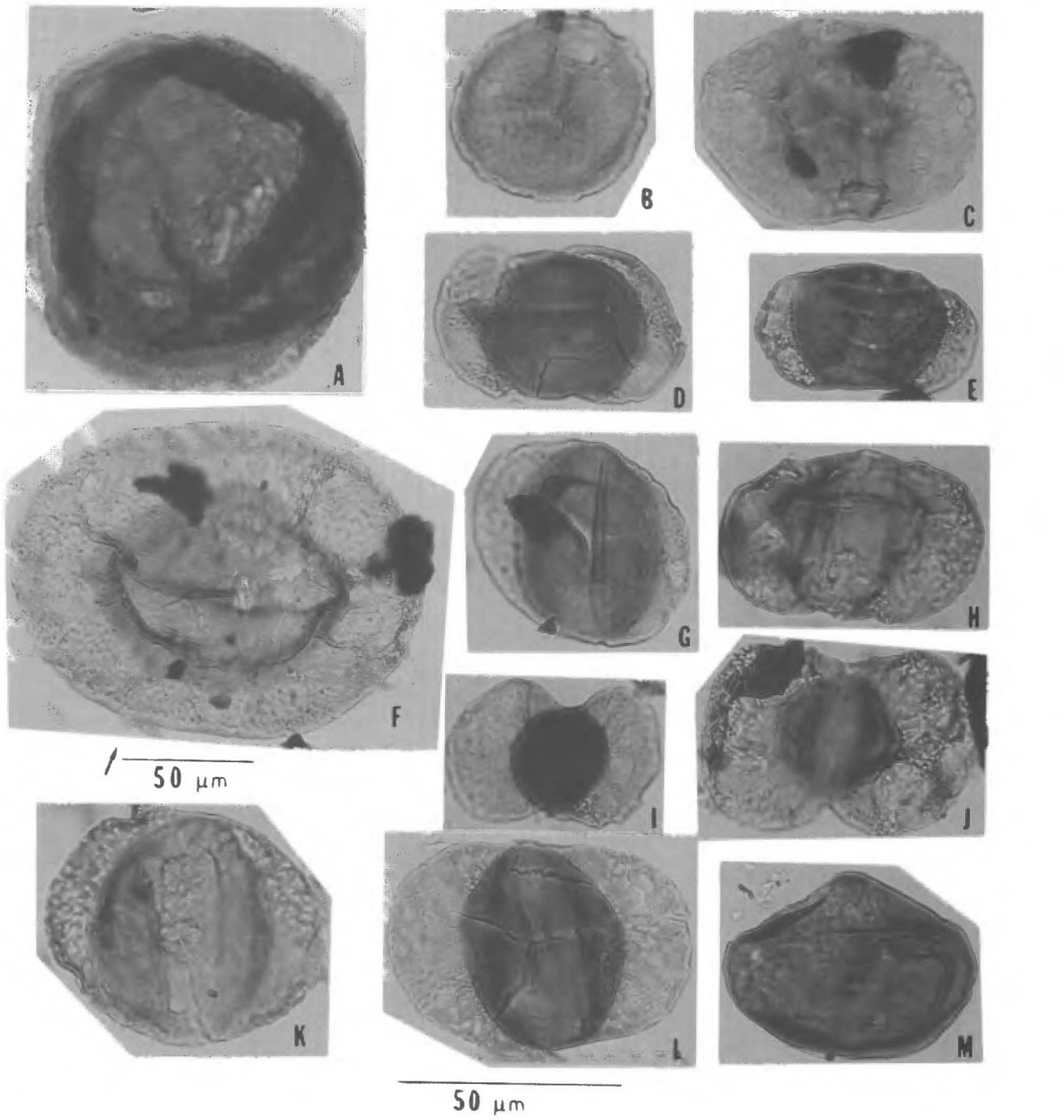


FIGURE 3. Dominant and/or significant sporomorphs from various macerations of sample AR1-1, Carrizo Arroyo. F is a collage of two photomicrographs taken with 40x objective because of the large size of the pollen grain. Its size is shown by the scale bar directly underneath the photomicrograph collage. All other forms were photographed with a 54x oil-immersion objective, and their size is indicated by the bar at the bottom of the whole figure. **A**, *Spelaeotriletes giganteus* Loboziak and Clayton. The trilete mark has been observed in other specimens. **B**, ?*Lycospora* sp. C, *Florinites* sp. The form is monosaccate, despite the appearance of a cleft at bottom of photograph, and has a somewhat vague central body with a chevron dilete mark. **D**, **E**, **G**, *Complexisporites polymorphus* Jizba. This pollen form is abundant in the sample. The bisaccate pollen grains have dense central bodies that have an unusual, more or less circular, operculate-appearing plate-like structure on the distal side. The plate sometimes is taeniate-like (D–E), or sometimes has a y-shaped cleft in the center (G). Jizba (1962) on publishing *Complexisporites*, included forms, even perhaps the holotype of the type species, in her original description that probably are referable to other genera, which have priority, e.g., *Illinites* (cf. Jansonius and Hills, card 540, 1976). However, the forms illustrated here represent a distinct generic form that may require a different generic name. **F**, *Potonieisporites* sp. This is the most abundant single taxon in both samples AR1-1 and AR1-8. All of the specimens in AR1-1 are probably the same variable species. They typically display a monolete mark but often do not. The central body varies in relative size. **H**, **K**, *Falcisporites*? sp. Bisaccate pollen of this type, with marked arcuate, dense-appearing saccus-central body overlap/attachments as seen in proximal/distal views, are common in AR1-1. Similar forms have been referred to other genera, such as *Vesicaspora*, and the group needs more study. **I**, *Platysaccus saarensis* (Bhardwaj) Jizba, 1962. This form is not common, but its occurrence is important, as it has not previously been reported in layers older than Wolfcampian. **J**, *Platysaccus* sp. This form resembles *P. papilionis* Potonié and Klaus, but the central body is slightly too large to conform. Clearly it is closely related to *P. papilionis*, which is a middle to Late Permian form. **L**, *Limitisporites rectus* Leschik. The bent laesura, approaching a dilete (chevron) mark, would put this form in *Jugasporites* according to some authors, a taxon which is clearly Permian. M, *Vittatina* sp. This taeniate ("striate") pollen genus can be either Pennsylvanian or Permian; more taxonomic work with the group is needed to determine the stratigraphic range of this particular form.

The quality of preservation and abundance indicate probable rapid deposition in a lagoonal or deltaic channel situation, with anoxic burial. Sample AR1-8 yielded very abundant but poorly preserved specimens. The spores and pollen are riddled with dozens of characteristic tetragonal crystal scars of pyrite (marcasite) deposition. Their abundance suggests relatively rapid deposition in a nearshore lagoonal situation with anoxic brackish water—an environment that encourages the sulfur bacteria responsible for marcasite deposition in organic structures.

Composition of the palynoflora

The most abundant and/or significant spores and pollen of sample AR1-1 are illustrated in Figure. 3. The flora is dominated by monosaccate and bisaccate pollen. Some of these, such as the monosaccate *Potonieisporites* and *Florinites*, are known to have been produced by conifer-related gymnosperms such as Cordaitales, Voltziales, and primitive Coniferales. Others are pollen of pteridosperms or of precursors of various Mesophytic gymnosperms. Characteristic Pennsylvanian spores such as *Triquitrites* are lacking, though there are some rather generalized trilete, psilate spores, and specimens of a very large trilete spore, *Spelaeotriletes giganteus* (Fig. 3A). There are also abundant zonate trilete spores, perhaps referable to *Lycospora* (Fig. 3B). Relatively rare specimens of the taeniate/striate pollen form *Vittatina*, also occur.

Table 1 presents results of counts of about 150 sporomorphs from samples AR1-1 and AR1-8. Sample AR1-8 is dominated by monosaccate pollen (72%), and not all of the monosaccates are *Potonieisporites*, as they are in AR1-1. Most importantly, sample ARl-1 contains a significant proportion (18%) of the bisaccates *Complexisporites*, *Limitisporites*, and *Platysaccus*, forms which are totally lacking in AR1-8. *Limitisporites* (Fig. 3L) and *Platysaccus* (Fig. 3I, J) are clear indicators of Permian age.

AGE OF THE PALYNOFLORA

The palynoflora of the stratigraphically lowest sample, AR1-8, which is dominated by Potonieisporites and other Late Pennsylvanian to Early Permian forms, would unquestionably be classified as Late Pennsylvanian (Virgilian) rather than Early Permian (Wolfcampian) because there are no strictly Permian forms. The palynoflora of sample AR1-1, from a horizon 30 m above AR1-8, on the other hand, is dominated by bisaccate pollen and has an Early Permian aspect. Although most of the flora consists of forms found on both sides of the system boundary, three forms, two species of *Platysaccus* and one species of *Limitisporites*, are clearly Permian entities. We feel confident that sample AR1-1 is Early Permian, but probably not much younger than the Lower Permian System boundary.

Table 1. Spore/pollen count percentages for Carrizo Arroyo samples AR1-1 and AR1-8.

	AR1-1 (PRC-2887)	AR1-8 (PRC-3120)
Total number of counted specimens	142	150
Taxa counted	% of total	% of total
Trilete spores:		
Lycospora	11	3
Spelaeotriletes giganteus	7	1
Indeterminable trilete spores	9	3
Monolete spores:		
Laevigatosporites	–	1
Monosaccate pollen:		
Florinites	–	13
Potonieisporites	20	50
Indeterminable monosaccate pollen	–	9
Bisaccate pollen:		
Complexisporites	14	–
Falcisporites	8	1
Limitisporites	1	–
Platysaccus	3	–
Indeterminable bisaccate pollen	15	5
Taeniate non-saccate pollen:		
Vittatina	–	1
Indeterminable other spores/pollen	11	11
Total percentages	99%	98%

COMPARISON WITH OTHER PALYNOFLORAS FROM SOUTHWESTERN USA

Willard's (1992) palynoflora from the Wild Cow Formation at the Kinney Brick Company clay pit in Bernalillo County, NM, based on multiple samples from two different sampling sections, shows saccate pollen ranging from about 12% to about 85% and variation in trilete spore abundance from about 18% to as much as 90%. Willard attributes these differences primarily to paleoecological phenomena and dates the whole assemblage as Late Pennsylvanian ("early Virgilian"). Willard notes that saccate pollen dominance is a Permian-onset phenomenon, but does not draw the conclusion that her spore-dominated "Huber Section" is older than her pollen-dominated "Mamay-Watt Section." One of our samples from the Kinney Brick Co. clay pit, has a spore-dominated flora that unquestionably dates as Pennsylvanian—Stephanian, but not latest Stephanian. Our pollen-dominated sample, and Willard's, seem younger, probably close to the end of the Stephanian.

Kremp's (1975) palynoflora from a coaly horizon in the Supai Formation, Fossil Creek Canyon, AZ, is much more diverse than the two-sample flora from Carrizo Arroyo. Monosaccates such as *Potonieisporites* and *Florinites* and monosulcate pollen such as *Cycadopites* are common, together with a great variety of trilete spores. Bisaccates, including taeniate forms such as *Protohaploxypinus*, are present, but none of the forms is apparently Permian-limited. Kremp notes the uncertain age of the flora but suggests an early Wolfcampian age. We suggest late Virgilian.

Taggart and Ghavidel-Syooki (1988) studied a channel fill in a limestone horizon of the Topeka Limestone, Shawnee Group, at Hamilton Quarry, Kansas, thought to be Virgilian, and thus close to the Pennsylvanian/Permian System boundary. However, the palynoflora is not only rich in bisaccates-monosaccates, but many of the bisaccate forms comprise a very Lower Permian-like assemblage of taeniates such as *Striatoabeites* and *Striatopodocarpites*. We agree therefore with Taggart and Ghavidel-Syooki's assignment of an Early Permian age to the Hamilton Quarry palynoflora.

CONCLUSIONS

The palynoflora of sample AR1-1 from the Red Tanks Member of the Madera Formation, Carrizo Arroyo, Valencia County, NM, is probably on the Permian side of the Pennsylvanian/Permian boundary, and closer to the boundary than any palynoflora so far reported from the southwestern USA. A more complete study of the entire section at Carrizo Arroyo, and systematic comparison with the Kinney Brick Co. clay pit flora of Bernalillo County, NM, and with floras of the Supai Formation and rocks of equivalent age in Arizona will be needed for a more certain age assignment as well as for comparison with palynofloras of the latest Carboniferous and earliest Permian in other parts of the world.

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