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PENNSYLVANIAN AND LOWER MARINE PERMIAN STRATIGRAPHY OF SOUTH-CENTRAL NEW MEXICO

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AREAL SUMMARY

Pennsylvanian and early marine Permian rocks crop out in most of the mountain ranges of south-central New Mexico. A thick Derryan to Wolfcampian section is exposed in the west-facing escarpment of the Sacramento Mountains and in the Hueco Mountains. Lower to Middle Pennsylvanian beds crop out on the west side of the Franklin Mountains, on Bishop Cap, and in the southern Organ Mountains--in the Franklin Mountains they are in fault contact with limestone of Wolfcampian age. A thick Pennsylvanian and early marine Permian sequence of rocks occurs in the San Andres, Caballo, and Mud Springs Mountains, while thinner sections crop out in the Oscura, Fra Cristobal, Robledo, Animas, Cuchillo, and Black Ranges.

Rocks of Pennsylvanian age are 2500 to 3100 feet thick in the Sacramento Mountains and range in age from possible Morrowan to Virgilian. The basal beds, which are chiefly of Derryan age, are clastics--conglomerates, sandstones, shales, and silty limestones--which in places fill channels which were cut into Mississippian rocks. Overlying the Derryan rock are almost 1000 feet of cherty limestones below and sandstones above of Desmoinesian age which in the central part of the range interfinger with a shaly clastic deltaic facies (Pray, 1954). The Missourian rocks are chiefly thin-bedded argillaceous limestones and calcareous shales 500 to 900 feet thick. Virgilian beds, 800 to 1000 feet thick, are dark shales and interbedded argillaceous limestones which grade up into the interbedded nodular to massive limestones, conglomerates, arkosic sandstones, and pale reddish-brown to gray shales of the Fresnal group (Thompson, 1942). Within the lower part of the Virgilian occur the massive reef-like limestones seen on the 1954 field trip (Fifth Field Conference) of the New Mexico Geological Society.

The Bursum formation occurs only in the northwestern part of the Sacramento Mountains and is lithologically and faunally similar to the type Bursum of the Oscura Mountains except that in the Sacramento area the formation contains a much greater amount of gray shales and sandstones. Southward, the Bursum pinches out beneath the Abo redbeds, although remnants have been found by Thompson (1954) in the Hueco Mountains. In the southern Sacramento Mountains, basal Permian rocks rest unconformably on Virgilian beds and consist of a lower conglomerate and redbeds similar to the Powwow conglomerate, a medial limestone and marine shale series, and an upper Abo redbed series. Thompson (1954) and Pray and Otte (1954) have traced this sequence southward to the Hueco Mountains and believe the lower redbeds correlate with the Powwow conglomerate of the Hueco formation, the medial series thickens into the Hueco limestones, and the upper redbeds form the Deer Mountain red shale member of the Hueco formation.

The Pennsylvanian rocks in the Hueco Mountains range from possible Morrowan age up to Virgilian and are more than 1700 feet thick where not eroded away by early Wolfcampian erosion. The Morrowan (?) beds, thick-bedded coralline limestone with cherty units are about 500 feet thick. The Derryan strata consist of a lower cherty coralline limestone sequence, about 240 feet thick, overlain by about 130 feet of marly limestone and shale. Beds of Desmoinesian age contain a basal light-gray cherty limestone about 30 feet thick, a medial shale and marly limestone sequence about 300 feet thick, and an upper sequence about 300 feet thick of massive light-gray cherty limestone overlain by interbedded cherty limestones and calcareous shales and cherty phosphatic limestones with lenses of limestone-pebble conglomerate. Reef-like masses occur at the top of the Missourian or in the lower Virgilian equivalent. Virgilian beds occur only to the north of Powwow Canyon in the Hueco Mountains, where they are thick-bedded limestones, coarse conglomerates, and sandstones (King, King, and Knight, 1945; Thompson, 1954). To the south they have been removed by pre-Powwow erosion.

Thompson (1954) found about 20 feet of Bursum equivalent locally present in the Hueco Mountains north of Powwow Canyon. The Hueco limestone lies with marked angular and erosional unconformity on all of the older rocks in the Hueco Mountains, from the Bursum down to the El Paso limestone. The Hueco limestone is about 1500 feet thick and was subdivided

by King, King, and Knight (1945) into three mappable divisions with two additional members. Redbeds and conglomerates locally form the basal deposits and are called the Powwow conglomerate member. The lower and upper mapping divisions consist of light-gray thick-bedded limestones, cherty in part, while the middle division consists of thin-bedded argillaceous marly limestones. In the upper division is a sequence of red shales, about 175 feet thick, called the Deer Mountain red shale member. This is the unit which Thompson (1942, 1954) and Pray and Otte (1954) correlate with the upper part of the Abo of the Sacramento Mountains.

In the Franklin Mountains, at Bishop Cap, and in the southern Organ Mountains only the lower part of the Pennsylvanian is exposed. Beds of Morrowan (?) and Derryan age are massive cherty limestones about 800 feet thick. Desmoinesian rocks, more than 600 feet thick, are thin-bedded limestones, cherty in part, with fossiliferous shale lenses. Higher Pennsylvanian beds are concealed by alluvium. In isolated fault blocks west of the Franklin Mountains about 650 feet of the Hueco limestone is exposed, with both upper and lower beds concealed by alluvium. The Hueco here, in part at least, is upper Hueco in age.

A relatively thin Pennsylvanian section occurs in the Robledo Mountains. Beds of Derryan age overlie the thick (Tertiary) Lookout Peak rhyolite sill and may have been in part assimilated in the sill. Exposed Derryan rocks are carbonaceous shales and argillaceous limestones up to about 20 feet thick. Rocks of Desmoinesian age are about 220 feet thick and are chiefly thin- to thick-bedded cherty limestones. The Missourian rocks are interbedded shales and medium-bedded limestones about 215 feet thick. The Virgilian equivalent is about 210 feet thick and consists of lower and upper shaly beds with medial massive limestones.

Rocks referred to the Bursum formation may range from 100 to possibly 300 feet thick in the Robledo Mountains and consist of interbedded massive limestones, cherty limestones, argillaceous nodular limestones, red shales, and conglomeratic lenses. The Hueco limestone is about 1700 feet thick, unconformably overlain by Tertiary volcanic rocks, and is divisible into three lithologic units; lower limestones about 890 feet thick; medial interbedded red siltstones, yellowish-brown shales and sandstones, and thin-bedded limestones, about 475 feet thick; upper cherty limestones about 350 feet thick. Gastropod, brachiopod and fusulinid faunas are similar to those of the type Hueco limestone. The red siltstones are petrographically identical to red siltstones of the Abo redbeds to the east and are considered to be tongues of the Abo.

Pennsylvanian rocks in the San Andres Mountains range from about 3000 feet thick in the southern part in Ash Canyon to about 2000 feet near Mockingbird Gap at the north end. McKee (1951) reported from Wanless that 2992 feet of Pennsylvanian rocks crop out in Rhodes Canyon. The combined thicknesses of the Derryan, Desmoinesian, and Missourian, however, thin southward, being about 1300 feet thick near Mockingbird Gap and 400 feet in Ash Canyon, while Virgilian equivalents thicken southward, being about 800 feet thick near Mockingbird Gap and almost 2600 feet thick in Ash Canyon. The lower series are generally of massive limestone with some interbedded clastics especially in the Derryan and Missourian. Virgilian rocks consist of interbedded sandstones and thick limestones near Mockingbird Gap, but of interbedded sandstones, dark-gray shales, dark-gray argillaceous limestones, and gypsum beds near Ash Canyon.

Thompson (1954) reported about 100 feet of the Bursum formation (?) in Rhodes Canyon consisting of a lower sequence of interbedded sandstones, red shales, and nodular limestones overlain by a massive cliff-forming biostromal limestone- a lithology similar to that of the type Bursum formation. North of Rhodes Spring the Bursum formation is overlain by a unit similar to the Powwow conglomerate, a thick lenticular conglomerate that fills deep channels cut into the upper Bursum reef limestone. Above the conglomerate are several hundred feet of typical Hueco limestone that grades up into the Abo redbeds. About 200 feet of interbedded argillaceous and fossiliferous limestones, shales, and sandstones in Mockingbird Gap occur above 100 feet of conglomerate which contains reworked Bursum-type fusulinids. The upper unit is tentatively referred to the lower Hueco and the conglomerate is considered basal Hueco. The Bursum was probably removed by pre-Hueco erosion. To the south, near Ash Canyon, Thomson (1954) measured more than 350 feet of the basal part of the Hueco limestone resting unconformably on Virgilian beds; probably a total of more than 1000 feet of the Hueco limestone crops out below and interfingers with the Abo redbeds.

Only about 910 feet of Pennsylvanian rocks occur in the northern Oscura Mountains, but the section includes beds from Derryan to Virgilian in age. Beds of Derryan age consist of lower conglomerates, sandstones, and black shales, of variable thickness, and upper dark-gray, cherty, nodular limestones; total thickness ranges from about 100 to 150 feet. Desmoi-

nesian beds are about 320 feet thick and are typically cherty limestones. Missourian rocks are thin- to thick-bedded limestones with lenses of red shales and arkosic sandstones, total about 240 feet thick. Virgilian rocks are about 200 feet thick and consist of a lower series of interbedded light-gray limestones, arkosic sandstones, and red shales; a medial massive limestone; and an upper series of red shales with interbedded nodular limestones, gray shales, and arkosic sandstones.

The Bursum formation, here at its type locality near Bursum Ranch, overlies the Virgilian rocks, is about 140 feet thick, and consists of a lower series of purplish-red and greenish-gray shales interbedded with arkosic sandstones and nodular limestones; the upper beds are a thick massive light-gray limestone. In most places the Bursum is overlain by an arkosic conglomeratic sandstone of the basal Abo, which may be the equivalent of the Powwow conglomerate.

In the Mud Springs Mountains, northwest of Truth or Consequences, about 1640 feet of Pennsylvanian is exposed. Rocks of Derryan age are about 220 feet thick and are chiefly marine limestone, cherty in part, with interbedded shales and conglomeratic sandstones. These Derryan beds are only 130 feet thick in the Derry Hills, 25 miles to the south. The Desmoinesian series is about 700 feet thick in the Mud Springs Mountains and consists of highly cherty limestones with thin beds of nodular argillaceous limestones, gray and red shales, and arkosic sandstones. Rocks of Missourian age are about 270 feet thick and are chiefly cherty algal limestones below and interbedded limestones and shales above. The Virgilian beds are about 450 feet thick and are of nodular to massive limestones with interbedded red, green, and gray shales and arkosic sandstones. Below conglomerates and conglomeratic sandstones of the basal Abo is about 60 feet of interbedded purplish to light-gray nodular limestones and purplish-red shales lithologically similar to the Bursum formation.

Kelley and Silver (1952) measured about 1120 feet of the Magdalena group in the Caballo Mountains a few miles south of Palomas Gap. They noted that the unit varies considerably in thickness ranging from about 1000 feet to 1700 feet. Their lower stratigraphic subdivision, the Red House formation, is tentatively (Kelley and Silver, 1952, Figure 2) correoated with the Derryan and lower Desmoinesian; the middle subdivision, the Nakaye formation, is upper Desmoinesian and lower Missourian: and the upper subdivision, the Bar B formation, is upper Missourian, Virgilian, and possibly lower Wolfcampian. The upper 50 feet of the Bar B formation is of intercalated limestones, reddish-brown siltstones, limestone conglomerate, and calcareous sandstone, which may be an equivalent of the Bursum formation.

In the Sun Oil Company No. 1 Victorio Land and Cattle Company oil test on the Jornada del Muerto (sec. 25, T. 10 S., R. 1 W.), about 1800 feet of Pennsylvanian rocks were encountered. The basal 250 to 300 feet is predominantly black shale with interbedded light-gray and greenish-gray sandstones and argillaceous limestones. At the top is about 50 feet of interbedded limestones and red shales which may be the Bursum equivalent. A similar section occurs in the Fra Cristobal Mountains (Eugene Cserna, personal communication).

In the northern part of Sierra Cuchillo, Jahns (1944) reported about 1400 feet of Pennsylvanian rocks. At the base is 120 feet of feldspathic quartzite and quartz-pebble conglomerate, overlain by about 120 feet thick of dark-brown shaly beds. The upper beds are chiefly thin- to thick-bedded cherty limestone with lenses of quartzite and calcareous shale. A similar section, not previously reported, is exposed in an inlier about two miles northeast of Monticello. Derryan to Virgilian fusulinids were collected from this outcrop; the upper beds are unconformably overlain by Tertiary volcanic rocks.

In the Black Range near Kingston, Kuellmer (1954) reported more than 650 feet of Pennsylvanian rocks probably of Derryan to Virgilian age, conformably overlain by Abo redbeds. Farther south, just north of Cooks Peak, Jicha (1954) measured 180 feet of Pennsylvanian sediments which contain an upper Desmoinesian and lower Missourian fauna. East and south of Cooks Peak, however, only 40 to 80 feet of Pennsylvanian is present. In the Cooks Peak and Dwyer (quadrangle west of Cooks Peak--Lake Valley) areas the Pennsylvanian is unconformably overlain by 80 to 150 feet of limestone-chert conglomerate and redbeds which have been called Lobo and/or Abo. The lower part of this clastic unit is lithologically similar to the Powwow conglomerate. In the Dwyer quadrangle, northwest of Cooks Peak and on the southeast margin of Santa Rita area, Elston (1953) reported about 1000 feet of Pennsylvanian strata beneath the Abo conglomerate and redbeds, a sequence similar to that near Santa Rita where about 820 feet of Derryan to Virgilian equivalents occur.

THICKNESS AND LITHOLOGY

Rocks of Pennsylvanian age thicken southward and eastward from the northern Oscura Mountains and eastward from the Cuchillo Mountains reaching

maximum thicknesses of over 3000 feet in the southern San Andres Mountains near Ash Canyon and in the northern Sacramento Mountains near Alamogordo. The thinnest relatively complete Pennsylvanian section in south-central New Mexico is on Robledo Mountain which with the fragmental section at Cooks Peak may be an expression of the Florida landmass. The thinning south from Ash Canyon to the Franklin and Hueco Mountains is in part due to early Wolfcampian erosion of the upper Pennsylvanian rocks.

The thickness and lithology of the early Pennsylvanian beds, the Morrowan (?) and Derryan equivalents, reflect their overlap onto pre-Pennsylvanian rocks from the Hueco Mountains northward (Thompson, 1948). Desmoinesian beds are relatively thick in the Sacramento, Mud Springs, and Franklin Mountains and relatively thin in the Oscura, Robledo, and Hueco Mountains. Typically cherty limestones, they are argillaceous and contain interbedded fine-grained clastics where thicker. Rocks of Missourian age are relatively uniform in thickness and lithology but do thicken toward the northern Sacramento Mountains. Virgilian rocks thicken southward from the Oscura Mountains, eastward from the Mud Springs and Robledo Mountains, and westward from the Sacramento Mountains, attaining a probable maximum of 2600 feet near Ash Canyon. The deposits in the thicker sections are typical deltaic to brackish water clastics and precipitates that indicate a narrow north-south Virgilian basinal area, extending from about Rhodes Pass south to the New Mexico-Texas line near Newman. Unfortunately, Virgilian beds were almost entirely removed by erosion during early Wolfcampian time in the Hueco Mountains so that the original extent of the basin to the southeast is not known. Biohermal and biostromal reefs occur within these basinal Virgilian deposits in the northern and central San Andres Mountains, and in the Sacramento and Hueco Mountains. Virgilian limestones to the east, north, and west of the basin contain significant amounts of interbedded redbeds, arkosic sandstones, and gray calcareous siltstones.

The maximum thickness of the Bursum formation is east of Tularosa in the northern Sacramento Mountains where Otte (1954) reported about 400 feet of interbedded redbeds and fossiliferous marine limestones. Southward the formation thins until only remnants are found, such as the 20 feet locally present in the Hueco Mountains. Westward and northwestward from Tularosa the formation thins, except for the possibly relatively thick marine Bursum equivalent in the Robledo Mountains. The lower limits of the Bursum in the Robledo area have not been established exactly.

The Hueco limestone with its basal Powwow conglomerate and middle upper Deer Mountain red shale is about 1500 feet thick at the type locality in the Hueco Mountains. Northward into the Sacramento Mountains the Hueco interfingers with Abo redbeds (Thompson, 1942, 1954; Pray and Otte, 1954), the limestone facies forming a medial tongue in the Abo of the southern Sacramento Mountains. North northwestward from the Hueco Mountains the Hueco limestone is a northward-thinning lower limestone wedge intertonguing with an upper northward-thickening Abo redbed wedge; this is shown in the San Andres Mountains--near the south end the Hueco is over 1000 feet thick and is overlain by several hundred feet of Abo while at Rhodes Pass only a few hundred feet of Hueco limestone occur, grading up into 800 feet of Abo redbeds.

Northwestward from the type locality to the Robledo Mountains the Hueco limestone equivalent is about 1700 feet thick and includes a lower thick limestone, a middle-upper interbedded limestone and Abo redbeds, and an upper limestone, which has lenses of reddish shales near the top. Northward from the Robledo Mountains to the Caballo Mountains there appears to be an abrupt change, with the upper Hueco limestone pinching out northward, or intertonguing downward into Abo redbeds; a thickening of and a complete transition into redbeds of the middle-upper clastic unit, and wedging out of the lower Hueco limestones. Kelley and Silver (1952) noted a southward increase in thickness of the Magdalena group in the Caballo Mountains; perhaps some of the upper beds of the Magdalena in the southern Caballo Mountains are equivalent to the lower Hueco of the Robledo Mountains.

TERMINOLOGY

Names applied to units of the Pennsylvanian and lower Permian rocks by the geologists working in south-central New Mexico have been suited to their individual purposes. Common practice is to lump the predominant carbonate sequence as the Magdalena group, including in places beds of Devonian (?), Mississippian (N.M. Geol. Soc., 1952, p. 106-107), Pennsylvanian, and Permian age, and to subdivide the sequence on lithologic-topographic-photographic differences; then name the subdivisions formations or divisions (King and King, 1945) which are satisfactory mappable units and, in most cases, so used. Correlation from range to range, from one group of terms to another, from one type of facies definition to a slightly different facies type makes comparative

stratigraphic studies difficult. Projecting predominantly topographic units into the subsurface on the basis of cutting studies is also quite difficult.

Thompson (1942, 1948) has subdivided the Pennsylvanian in central and southern New Mexico into series, groups, formations, and members based on widespread detailed faunal and lithologic studies. The lower case units are difficult to use in small-scale (1:62,500) areal mapping because of cartographic limitations in depicting thin units, because Pennsylvanian outcrops are usually on steep slopes which form very thin bands when projected onto a map, and because most field geologists lack the time and paleontologic knowledge to map such detailed units. The lower case units are useful for large-scale (1:1200) mapping such as that of mining districts (Kottlowski, 1952).

Use of subsystem time-lithologic units in stratigraphic studies of the Pennsylvanian has its value in depicting geologic history in more detail than when only broad lithologic units are examined. There has been criticism of the use of "midcontinent" age terms in New Mexico; while it is realized that many formations change names at a state line, most fossils do not. The Des Moines River Valley is, of course, a long distance from Truth or Consequences, but so is Dakota, or for that matter Pennsylvania or the Province of Perm in Russia. Exact contemporaneity is not suggested.

The term Bursum formation is applied to rocks that are lithologically and faunally similar to the type Bursum (Wilpolt, MacAlpin, Bates, and Vorbe, 1946) as redefined by Thompson (1954). The type locality is in the Hansonburg Hills just west of the northern Oscura Mountains. Fusulinids are of early Wolfcampian age; the rocks are interbedded fossiliferous marine limestones and purplish-red clastics.

Rocks of the Hueco limestone are lithologically and faunally similar to those of the type Hueco limestone in the Hueco Mountains. Fusulinids are those of middle and upper Wolfcampian age.

FAUNAL SUMMARY

The marine Pennsylvanian and lower Permian rocks of southern New Mexico are highly fossiliferous and contain large faunas of calcareous algae, foraminifers, brachiopods, conodonts, bryozoans, crinoids, gastropods, pelecypods, and corals, with less abundant faunas of echinoids, cephalopods, and trilobites in approximately this relative order of abundance. Very few parts of the Pennsylvanian faunas have been studied in detail and not many more of the Permian faunas have been studied. Fusulinid foraminifers from many regions of the world have been found to be excellent index fossils for rather close correlation of Pennsylvanian and Permian rocks both locally and over great distances. The exceedingly abundant and widespread fusulinid faunas of New Mexico are particularly helpful in correlating the variable and interfingering lithologies of the Pennsylvanian and lower Permian among the different exposures in the mountains of this region. Without the aid of these index guide fossils, or others of equal value, it would be quite difficult to determine the history of sedimentation of this region.

All major marine units of the Pennsylvanian as well as the Wolfcampian part of the Permian contain fusulinid foraminifers in considerable numbers. Their evolutionary trends as well as their general stratigraphic distribution have become well enough understood that they can be used for zonation of the Pennsylvanian and lower Permian rocks either on the limits of the stratigraphic ranges of certain fusulinid genera or on the predominance of certain other genera or species.

ZONE OF *Millerella*: — The Lower Pennsylvanian of America has been referred to as the Zone of *Millerella,* not because the genus *Millerella* is restricted to this part of the section but because representatives of this genus are abundant there almost to the exclusion of other fusulinids. The basal Pennsylvanian limestone, La Tuna limestone, of the Franklin and Hueco Mountains contains prolific faunas of *Millerella* and rare, if any, fusulinids of other types. The genus *Millerella* is known to have a range from Mississippian to upper Pennsylvanian and few if any species of the genus have been recognized to have any great value for correlation. *Millerella* may be somewhat of a facies fusulinid and its value for even general correlation is open to question. We consider it probable that the lower Zone of *Profusulinella* in the Hueco Mountains is equivalent to the Arrey formation in the Mud Springs Mountains where *Profusulinella* is very scarce among many *Millerella.*

ZONE OF *Profusulinella*:—The lower part of the Derryan of the Hueco Mountains contains a prolific *Profusulinella* fauna from such primitive species at its base as *P. copiosa* up to the advanced species *P. spicata.* The genus seems limited to rocks of lower Derryan age, and that part of the section is referred to the Zone of *Profusulinella.* Although the Arrey formation contains principally *Millerella,* it is considered to be lower Zone of *Profusulinella* in age. A definite evolutionary trend has been recognized among species of *Profusulinella* and major parts of this zone can be recognized. It is considered almost certain that *Fusu-*

linella was derived from *Profusulinella,* and it is somewhat surprising that the two genera have not been found in association.

ZONE OF *Fusulinella*:—The genus *Fusulinella* ranges in age in New Mexico from Middle Derryan to lower Desmoinesian. Its range in other parts of central United States seems to be about the same. However, the fusulinid faunas in upper Derryan rocks are dominated by this genus and this part of the stratigraphic section is termed the Zone of *Fusulinella.* In extreme western America *Fusulinella* is known to range throughout upper Derryan and Desmoinesian rocks.

ZONE OF *Fusulina*:—For a long time *Fusulina* has been considered confined to rocks of Desmoinesian age and that part of the stratigraphic section has been designated as the Zone of *Fusulina.* Associated with *Fusulina,* however, are many other fusulinid genera, such as *Pseudostaffella, Wedekindellina, Oketaella, Staffella,* and others. The Desmoinesian of New Mexico contains faunas of *Fusulina* which show its almost complete evolutionary development in prolific abundance from such forms as *Fusulina? isolita* in the top of the Derryan to *F. eximia* near the top of the Armendaris group. More recent studies do show, however, that greatly advanced *Fusulina* range into lower Missourian rocks of other areas.

SUBZONE OF *Wedekindellina*:—The genus *Wedekindellina* has a stratigraphic range from near the base of the Desmoinesian to the lower Missourian from such lower Desmoinesian forms as *W. matura* in the Youghall formation and equivalent rocks of Arizona and Utah to *W. ultimata* in the Bethany Falls limestone of Missouri, Kansas, and Iowa and the Coane limestone of New Mexico. Therefore, this subzone bridges a series boundary. The species *W. ultimata* occurs abundantly over wide areas of central and western United States and could be designated as a subdivision of the subzone of *Wedekindellina.*

ZONE OF *Triticites*:—The genus *Triticites* has its first appearance above the Coane limestone of New Mexico and equivalent rocks in other areas. It ranges into the Permian Wolfcampian. Although this fusulinid genus is not restricted to the upper Pennsylvanian, *Triticites* dominates the fusulinid faunas of that part of the section to the exclusion of any other major zone genus and the Upper Pennsylvanian is referred to as the Zone of *Triticites.* Evolutionary trends among *Triticites* are rather clearly understood but there are many elements of the genus which must be used with caution for detail correlation. Some species of *Triticites* and major trends of the genus are very helpful in correlation of Upper Pennsylvanian rocks, and they constitute some of the more valuable Pennsylvanian index fossils.

ZONE OF *Pseudoschwagerina*:—The genus *Pseudoschwagerina* first appears in New Mexico in the Hueco limestone and ranges to the top of the Hueco. The genus seems world-wide in distribution in approximately the same part of the stratigraphic secton that has been designated as the Zone of *Pseudoschwagerina.* More recent studies by Dunbar (1953), however, seem to indicate that *Pseudoschwagerina* may range above the Wolfcampian in western Texas. That part of the Wolfcampian below the Hueco limestone, the Bursum formation, contains species of *Triticites, Schwagerina, Psuedofusulina,* and other genera. The long-range Zone of *Schwagerina* has been proposed to include this part of the stratigraphic section, although the genus *Schwagerina* ranges in America from near the base of the Wolfcampian to Leonardian. In many other parts of the world *Schwagerina* ranges up into some of the highest fusulinid-bearing Permian. It is of importance, however, that *Schwagerina* does not occur below the Wolfcampian.

REFERENCES

Dunbar, C. O., (1953) A zone of **Pseudoschwagerina** low in the Leonard series in the Sierra Diablo, Trans-Pecos, Texas: Am. Jour. Sci., v. 251, p. 798-813.

Elston, W. F. (1953) Geology and mineral deposits of the Dwyer quadrangle, Grant, Luna, and Sierra Counties, New Mexico: Unpublished Ph. D. thesis, Columbia University.

Jahns, R. H. (1944) Beryllium and tungsten deposits of the Iron Mountain district, Sierra and Socorro Counties, New Mexico: U. S. Geol. Survey Bull. 945-C.

Jicha, H. L. (1954) Geology and mineral deposits of Lake Valley quadrangle, Grant, Luna, and Sierra Counties New Mexico: New Mexico Bur. Mines and Mineral Res. Bull. 37.

King, P. B., King, R. E., and Knight, J. B. (1945) Geology of Hueco Mountains, El Paso and Hudspeth Counties, Texas: U. S. Geol. Survey Oil and Gas Inv. Prelim. Map 36.

Kottlowski, F. E. (1952) Geology and ore deposits of a part of the Hansonburg mining district, Socorro County, New Mexico: New Mexico Bur. Mines and Mineral Res. Cir. 23.

Kuellmer, F. J. (1954) Geologic section of the Black Range at Kingston, New Mexico: New Mexico Bur. Mines and Mineral Res. Bull. 33.

McKee, E. D. (1951) Sedimentary basins of Arizona and adjoining areas: Geol. Soc. America Bull., v. 62, p. 481-506.

N. M. Geol. Soc. (1952) Stratigraphy of Paleozoic, Mesozoic rocks in parts of central New Mexico: N. M. Geol. Soc., Third Field Conference, p. 106-126.

Otte, Carel, Jr. (1954) Upper Pennsylvanian and Lower Permain stratigraphy of the northernmost Sacramento Mountains, New Mexico: Unpublished Ph. D. thesis, California Institute of Technology.

Pray, L. C. (1954) Outline of the stratigraphy and structure of the Sacramento Mountains escarpment: N. M. Geol. Soc., Fifth Field Conference, p. 92-107.

·····, and Otte, Carel, Jr. (1954) Correlation of the Abo formation of south-central New Mexico: Geol. Soc. America Bull., v. 65, p. 1296 (abst.).

Thompson, M. L. (1942) Pennsylvanian system in New Mexico: New Mexico Bur. Mines and Mineral Res. Bull. 17.

····· (1948) Studies of American fusulinids: Univ. Kan., Paleont. Contrib. No. 4, Protozoa, Art. 1.

····· (1954) American Wolfcampian fusulinids: Univ. Kan., Paleont. Contrib. No. 14, Protozoa, Art. 5.

Wilpolt, R. H., MacAlpin, A. J., Bates, R. L., and Vorbe, George (1946) Geologic map and stratigraphic sections of Paleozoic rocks of Joyita Hills, Los Pinos Mountains, and northern Chupadera Mesa, Valencia, Torrance, and Socorro Counties, New Mexico: U. S. Geol. Survey Oil and Gas Inv. Prelim. Map 61.