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STRATIGRAPHY AND FUSULINIDS OF NACO GROUP IN CHIRICAHUA AND DOS CABEZAS MOUNTAINS, ARIZONA

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INTRODUCTION

The final day of the field conference will encounter outcrops of the Naco Group which is widespread in southeast Arizona and adjacent New Mexico. The Naco Group in the Chiricahua and Dos Cabezas Mountains was originally studied as part of a Yale dissertation and subsequently published by Sabins (1957 a,b). Fusulind faunas of the upper part of the Naco Group in this area were described by Sabins and Ross (1963); the fauna of the lower part was described by Ross and Sabins (1965). The present paper is a summary of these earlier studies. A regional summary of the Pennsylvanian is given by Kottlowski (1960).

STRATIGRAPHY

General

The name "Naco Limestone" was introduced by Ransome (1904, p. 44) in the Bisbee area. In their work in the Dragoon and Little Dragoon Mountains, Gilluly and others (1954, p. 16) elevated the Naco to group status and subdivided it into the following six formations in ascending order: Horquilla Limestone, Earp Formation, Colina Limestone, Epitaph Dolomite, Scherrer Formation, and Concha Limestone. These units are widely recognizable in southeast Arizona and all save the Epitaph Dolomite occur in the Chiricahua and Dos Cabezas Mountains, as shown on the composite stratigraphic section of fig. 1. The total thickness is approximately 5,500 feet. The Naco Group ranges in age from Lower Pennsylvanian (Morrowan Series) to Middle Permian (Guadalupian Series). In this area there is a disconformity representing the Missourian and upper part of Desmoinesian Series.

Horquilla Limestone

The Horquilla consists of massive, thick-bedded, cherty, gray limestone with shale and siltstone interbeds in the lower part. The lower part forms ledge-and-slope topography, but the upper part is more resistant and forms cliffs. The field conference will examine Horquilla outcrops at Blue Mountain (Locality 8 of fig. 2) which are about 1,200 feet thick with the top concealed. Other good exposures along the route are on the crest and north face of AVA Ridge at Portal (Locality 9 of fig. 2) where the complete section is about 1,600 feet.

Most of the limestones are crinoidal or oolitic, but some are black and aphanitic with a petroliferous odor when broken. Fusulinids are abundant in many of the limestones, but were not found in the shales and siltstones. Brachiopods are abundant, particularly in the lower part where silicified shells are conspicuous on weathered surfaces. Several beds of medium thickness are composed almost wholly of colonies of the coral *Chaetetes* embedded in a calcareous shale matrix. Other colonial and horn corals are also present in the Horquilla. In the eastern sections, two marker beds are separated by about 100 feet of strata, are locally persistent near the middle of the formation (fig. 3). The lower marker bed is formed by an abundance of the algae, *Komia*. The upper one contains an abundance of *Staffella*. Bryozoans are locally abundant and several thin beds with *Prismopora* appear to be widespread.

At Blue Mountain there are at least five cyclic sequences in the lower Horquilla, each about 13 feet thick and consisting of the following units in ascending order: limestone, limestone with bedded chert, shaly limestone, limestone conglomerate, and shale. Superimposed on these cycles there seems to have been a progressive deepening of the depositional basin during early and middle Desmoinesian time. This is indicated by the relatively few beds having fusulinids and by the dominance of dark gray, fine-grained limestone in the middle part of the formation.

At Blue Mountain (Locality 8) and Portal (Locality 9) the Horquilla overlies the Paradise Formation of Late Mississippian age. The Paradise Formation is absent in the northern part of the range where the Horquilla disconformably overlies the Escabrosa Limestone of Early Mississippian age. The top of the Horquilla Limestone is a conformable gradational contact with the Earp Formation marked by the change to interbedded limestone, shale, and siltstone.

The Horquilla ranges in age from Morrowan to Virgilian, but there is a disconformity in the upper part which represents the upper Desmoinesian and much or all of the Missourian. The disconformity is

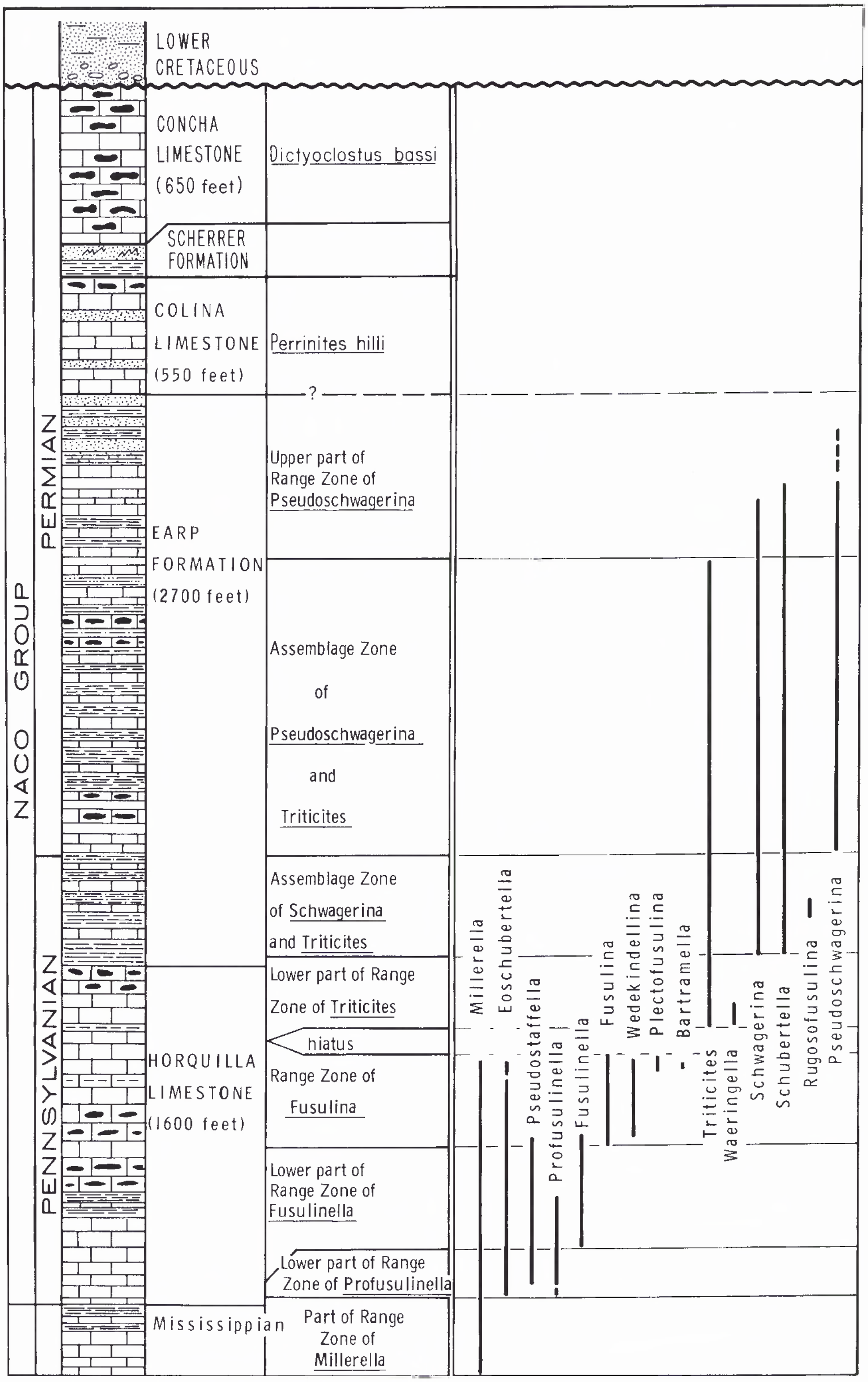


FIGURE 1

Composite stratigraphic column of Naco Group, showing fusulinid zones and other guide fossils.

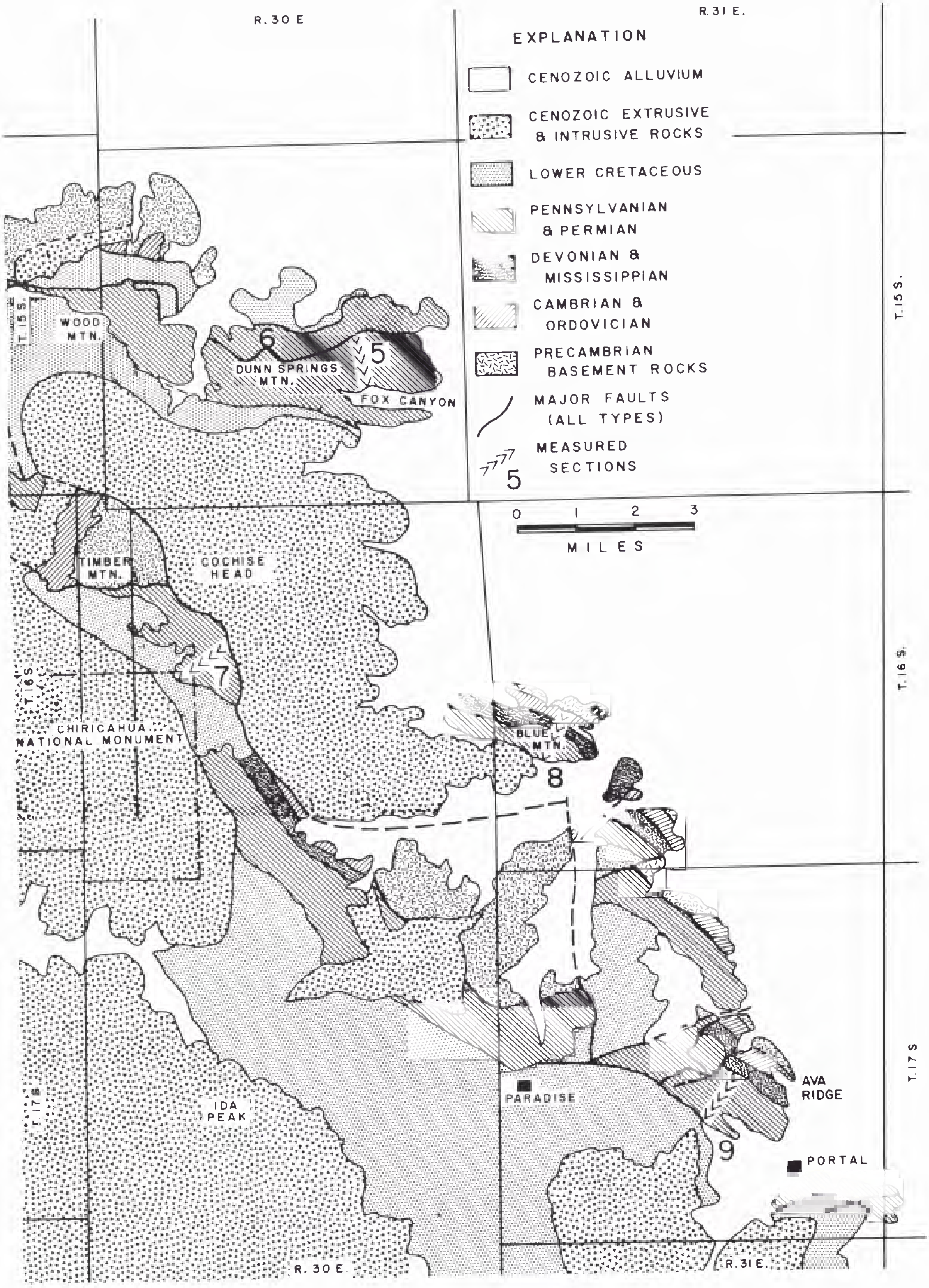
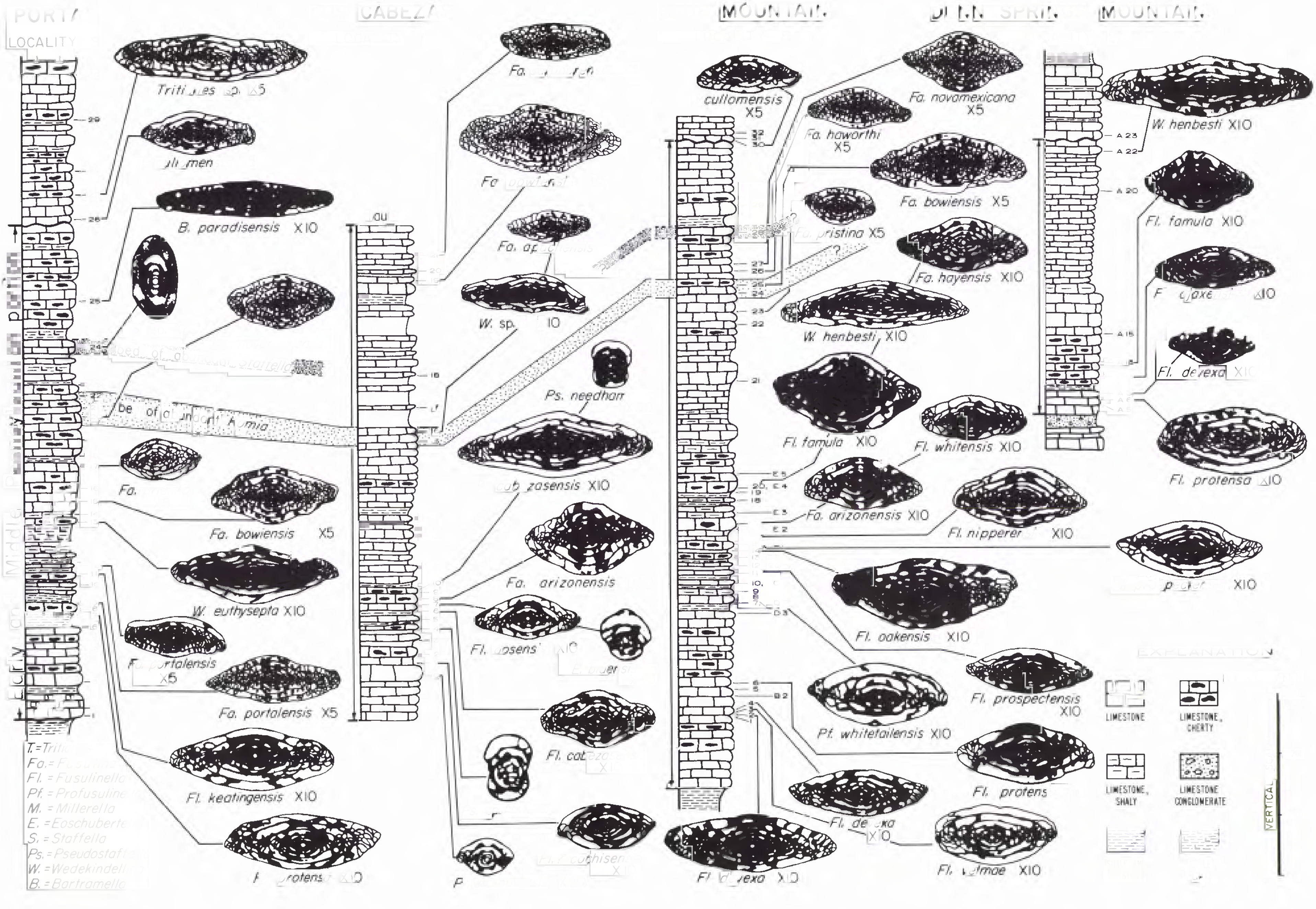


FIGURE 2

Geologic sketch map of northeastern Chiricahua Mountains showing localities mentioned in text.



Measured sections of Horquilla Limestone, showing sample localities and representative fusulinids. From Ross and Sabins (1965, f recognized on the basis of fusulinids (see fig. 3), and is not apparent on the outcrop.

EARP FORMATION

The Earp Formation consists of alternating limestones, shale, and siltstone in beds 6 to 25 feet thick that form ledge-and-slope topography (fig. 4). This contrasts with the cliffs of the underlying Horquilla Limestone. The Earp is conformably overlain by the massive black Colina Limestone. The Field Conference route will pass excellent exposures on the south flank of AVA Ridge (Locality 9 of fig. 2) where the complete section is approximately 2,700 feet thick. Other exposures will be seen from a distance on the south flank of Dunn Springs Mountain.

A wide variety of limestone types occurs in the Earp, ranging from light gray crinoidal limestone to black aphanitic types. Fusulinids, corals, and brachiopods are common in many of the limestones but are absent in the shale and siltstone interbeds. Fusulinids were not found in the upper 500 feet of the Earp, although more intensive searching might be successful.

The shale and siltstone beds are gray to buff colored in the lower two-thirds of the Earp, but red beds appear in the upper part at the Portal section.

The preceding description applies to the Earp along the northeast front of the Chiricahua Mountains. In the central part of the range the individual limestone and clastic units are much thicker as shown by the Indian Creek section (fig. 4). Also the limestones are predominantly black and aphanitic with no fusulinids except in the basal part of the exposed section.

The Earp ranges from Virgilian through Wolfcampian in age. The Pennsylvanian-Permian boundary occurs about 600 feet above the base of the Earp in the midst of alternating limestone and clastic beds. Both the stratigraphy and faunal succession are gradual across this boundary with no evidence of a break.

COLINA LIMESTONE

The Colina consists of black aphanitic limestone with distinctive scaphopods and echinoid spines that stand out on many weathered surfaces. Rare gastropods, brachiopods, and corals were found, but the fauna is sparse and restricted, in contrast to the abundant and varied faunas of the Earp and Horquilla. A complete Colina section at Timber Mountain is 535 feet thick. There are good outcrops of the ledge-forming Colina Limestone on the south side of AVA Ridge, and the ridge south of Fox Canyon.

The Colina conformably overlies the alternating limestone and clastic sequence of the Earp and is conformably overlain by the red beds and sandstone of the Scherrer Formation (fig. 1). Fusulinids are absent and the restricted Colina fauna is non-diagnostic for determining the age. The only diagnostic Colina fossil reported to date is an ammonite, *Perrinites hilli*, collected by Sabins (1957 a, p. 494), which marks the Leonardian Series.

SCHERRER FORMATION

The Scherrer Formation is a thin unit of clastic red beds and light-colored sandstones that crops out along the north face of Dunn Springs Mountain, the ridge south of Fox Canyon, and the head of Whitetail Creek. The formation is 120 to 150 feet thick. The red silty sandstone at the base forms cliffs, but where induration is not so thorough it forms slopes. The Scherrer rests with apparent conformity on the Colina Limestone.

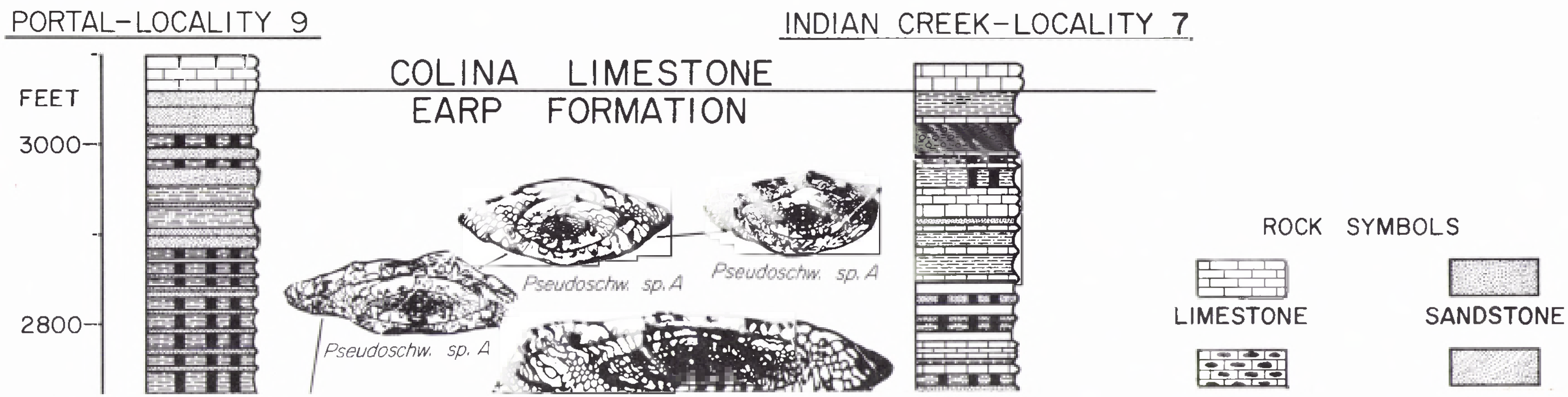
In the extreme southeastern and southern part of Arizona the Epitaph Dolomite occurs between the Colina and Scherrer. Cooper and Silver (1964, p. 67) noted that the Epitaph is apparently a wedge that is thickest in the southeast corner of Arizona and pinches out to the northwest. Sabins (1957, p. 494) inferred that the Epitaph is a dolomitized facies of the upper Colina and lower Scherrer.

CONCHA LIMESTONE

The Concha Limestone crops out on the north face of Dunn Springs Mountain, the ridge south of Fox Canyon, and at Timber Mountain. It consists of thick-bedded light-colored limestone with abundant pink chert and silicified fossils in the lower part.

The overlying Lower Cretaceous Glance Conglomerate has cut down deeply into the Concha Limestone. The maximum thickness of Concha is 730 feet at Dunn Springs Mountain. There the upper part is darker colored, lacks chert, and is nonfossiliferous except for a thin zone of *Euomphalus* sp., a large planispirally coiled gastropod. Bryant and McClymonds (1961, p. 1330 and fig. 2) assigned the upper 200 feet of the Dunn Springs Mountain section to their Rainvalley Formation. In the Chiricahua Mountains, there is so little stratigraphic change at this horizon that the present writer sees little justification for extending the term "Rainvalley Formation" into the area. Certainly it would be impractical to map the "Rainvalley Formation" separately in the Chiricahuas.

The Concha Limestone lacks fusulinids in the Chiricahua Mountains, but contains the *Peniculauris bassi* (McKee)—formerly *Dictyoclostus bassi*—fauna of Leonardian and Guadalupian (?) age. In the Empire and Whetstone Mountains where higher parts of the


PORTAL-LOCALITY 9
INDIAN CREEK-LOCALITY 7
COLINA LIMESTONE
EARP FORMATION
FEET
3000
2800
Pseudoschw. sp. A
Pseudoschw. sp. A
Pseudoschw. sp. A
ROCK SYMBOLS
LIMESTONE
SANDSTONE

Concha are preserved, it contains early Guadalupe fusulinids.

FUSULINID ZONES AND CORRELATIONS

The major fusulinid zones of the Naco Group are shown on fig. 1. Details of the Lower and Middle Pennsylvanian are shown on figs. 3 and 5. Upper Pennsylvanian and Lower Permian zones are detailed on fig. 4. The base of each fusulinid zone is determined by the first appearance of the species for which the zone is named.

Millerella ASSEMBLAGE ZONE

The *Millerella* Assemblage Zone extends downward into rocks of Mississippian age and the top of the zone is drawn at the base of the first occurrence of *Profusulinella*, although *Millerella* and closely related and associated genera, such as *Paramillerella*, extend considerably higher into Middle and Late Pennsylvanian strata. The basal part of the Horquilla Limestone is barren of fusulinids except at the Portal section (fig. 3) where the basal 80 feet contains *Millerella marblensis* Thompson, associated with species of *Staffella*.

Profusulinella ASSEMBLAGE ZONE

This is the lowest zone that contains fusiform fusulinids and was encountered only in the Dos Cabezas section where the zone is approximately 70 feet thick and is characterized by *Profusulinella walnutensis* Ross and Sabins. In the other sections, such as at Blue Mountain, the equivalent stratigraphic interval apparently is barren of fusulinids. In the Horquilla Limestone advanced species of *Profusulinella* range upward into the basal 200 feet of the *Fusulinella* Assemblage Zone where they are associated with primitive species of *Fusulinella*.

Fusulinella ASSEMBLAGE ZONE

This is the lowest zone that is represented by abundant and widely distributed fusulinid faunas in the Horquilla Limestone in the Chiricahua Mountains. This zone is thicker and has a more diverse fusulinid fauna than the lower zones. The lower limit of the *Fusulinella* Assemblage Zone is marked by the first occurrence of primitive species of *Fusulinella*, which is generally about 100 feet above the base of Horquilla Limestone. The upper limit of this zone is marked by the first appearance of *Fusulina*. The zone ranges in thickness from 70 feet at Dos Cabezas to 370 feet at Blue Mountain and can be subdivided into three subzones based on the evolutionary stage of the wall construction and the intensity of septal folding.

The lowest subzone of the *Fusulinella* Assemblage Zone, the *Fusulinella devexa* Assemblage Subzone, is characterized by species such as *Fusulinella devexa* Thompson, *F. protensa* Thompson, *F. velmae* Thompson, *Fusulinella? cochisensis* Ross and Sabins, and *Profusulinella walnutensis* Ross and Sabins. Many of these species of *Fusulinella* have a wall structure consisting of a tectum and a thin diaphanotheca that are differentiated from discontinuous inner and outer tectorial layers.

The middle subzone, the *Fusulinella prospectensis* Assemblage Subzone, is characterized by species such as *Fusulinella prospectensis* Ross and Sabins, *F. ajaxensis* Ross and Sabins, *F. oakensis* Ross and Sabins. The species in this subzone have a tectum, well-developed diaphanotheca, well-developed tectorial deposits, and septa folded only near the poles.

The highest subzone, the *Fusulinella whitensis* Assemblage Subzone, has species such as *Fusulinella cabezasensis* Ross and Sabins, *F. whitensis* Ross and Sabins, and *F. dosensis* Ross and Sabins. These species are transitional in many features with primitive species of *Fusulina*, and have a tectum, well-developed diaphanotheca, well-developed tectorial deposits, and septa that are folded near the poles and are irregularly and gently undulated across the chambers of the outer one or two volutions. Species of *Fusulinella* in this highest subzone are more diverse in size and shape than species in the lowest subzone (fig. 3). Representatives of *Fusulinella*, such as *F. dosensis* Ross and Sabins, *F. whitensis* Ross and Sabins, and *F. famula* Thompson having this advanced stage of evolution, overlap upward with early species of *Fusulina*, and many transitional species between *Fusulinella* and *Fusulina* are difficult to assign to either of these two genera.

Fusulina RANGE ZONE

The base of this zone is marked by the first appearance of *Fusulina*, which also defines the base of the Desmoinesian Series. In the Chiricahua and Dos Cabezas Mountains the *Fusulina* Range Zone is terminated by the disconformity that truncates part of the Desmoinesian Series. This zone is widespread and is about 600 feet thick, except at the Dunn Springs Mountain section where it is only 380 feet thick. The thinner section may be due to greater pre-Virgilian truncation in the Dunn Springs Mountain area because there the *Wedekindellina euthysepta* Assemblage Subzone is the highest subzone.

The lowest subzone of the *Fusulina* Range Zone in the Chiricahua Mountains is the *Fusulina hayensis* Assemblage Subzone, which contains small and primitive species of *Fusulina* that are in many aspects transitional with *Fusulinella*. These species include *F. hayensis* Ross and Sabins, *F. arizonensis* Ross and Sabins, *F. portalensis* Ross and Sabins, and *Fusulinella famula* Thompson, which is possibly a descendant of *F. iowensis* Thompson (which marks a lower and persistent subzone in the Illinois Basin). In Illinois, Dunbar and Henbest (1942, p. 30) called a similar subzone the "Subzone of *Fusulina leei*" and included species such as *F. leei* Skinner, *F. pumilla* Dunbar and Henbest, and *F. serotina* (Thompson).

The *Wedekindellina euthysepta* Assemblage Subzone is marked by the first appearance of that species, although the associated species *W. cabezasensis* Ross and Sabins and *W. henbesti* (Skinner) range downward almost to the base of the underlying Subzone of *Fusulina hayensis* (fig. 5). *Wedekindellina henbesti* also ranges well up into the overlying *Fusulina girtyi* subzone. Within the Subzone of *Wedekindellina euthysepta*, small species of *Fusulina* such as *F. pristina* Thompson and *F. cedarensis* Ross and Sabins appear to be characteristic (figs. 3, 5).

A subzone of larger species, the *Fusulina girtyi* Assemblage Subzone (Dunbar and Henbest, 1942) overlies the *Wedekindellina euthysepta* Subzone and in southeast Arizona includes such species as *Fusulina hayworthi* (Beede), *F. novamexicana* Needham, and *F. bowiensis* Ross and Sabins. These species have thickly fusiform tests and regularly folded septa.

The highest subzone of abundant *Fusulina* is the *Fusulina eximia* Assemblage Subzone designated by Dunbar and Henbest (1942, p. 30). It includes two types of *Fusulina*: those having a subcylindrical shape and those having a larger more thickly fusiform shape. The subcylindrical type is represented in southeast Arizona by *Fusulina sulphurensis* Ross and Sabins; elsewhere it is represented by *F. acme* Dunbar and Henbest, *F. eximia* Thompson, and *F. bellatula* Stewart. Thickly fusiform fusulinids were not found in the *F. eximia* Subzone in southeast Arizona, but elsewhere *F. megista* Thompson, *F. mysticensis* Thompson. *F. pseudochomata* Stewart, and *F. gordonensis* Stewart together with numerous other species, such as those described by Alexander (1954) from Oklahoma, appear in this zone.

CONTACT BETWEEN MIDDLE AND LATE PENNSYLVANIAN

In the Chiricahua Mountains, the lowest species of *Triticites*, *T. cullomensis* Dunbar and Condra and *Triticites* sp. have high, thick-walled early volutions which characterize Virgilian species of *Triticites* in contrast to the low, thin-walled early volutions of most Missourian species. In the Midcontinent region, *T. cullomensis* first appears in the Lecompton Limestone (Dunbar and Condra, 1927) of the Shawnee Group, Virgilian Series. At Dunn Springs Mountain, *T. cullomensis* is found a few feet above *Wedekindellina henbesti* (Skinner), indicating that here the upper subzones within the *Triticites* Assemblage are missing. At Blue Mountain and at Portal the top of the *F. eximia* Subzone is separated from the lowest occurrence of *T. cullomensis* by about 100 feet of nonfusulinid-bearing beds and possibly strata of Missourian age may be present but not represented by fusulinid faunas. The following fusulinid faunas are absent: (1) the highest subzone of the *Fusulina* Range Zone, the *Wedekindellina ultimata* Assemblage Subzone with *Fusulina fallensis* Thompson, Verville, and Lokke; and (2) the lower subzones within the *Triticites* Assemblage Zone including *T. ohioensis* Thompson at the base through *Triticites joensis* (Thompson). In the Midcontinent these missing *Triticites* subzones form the Missourian Series.

Triticites ASSEMBLAGE ZONE

The Virgilian part of the Horquilla Limestone (fig. 4) is dominantly dark, fine-grained calcarenite and calcilutite and contains *Triticites cullomensis* Dunbar and Condra, *Triticites* cf. *T. callosus* Dunbar and Henbest and *Waeringella chiricahuensis* Sabins and Ross as distinctive early Virgilian species.

Near the top of the Horquilla Limestone and in the lower part of the Earp Formation (fig. 4) *Triticites cuchilloensis* Needham, *T. rhodesi* Needham, *Triticites* cf. *T. plummeri* Dunbar and Condra, *T. ventricosus sacramentoensis* Needham, and *Triticites* sp. A and *Triticites* sp. B are well advanced in their morphologic features and indicate a middle to late Virgilian age. This assemblage in part shows close similarity with that from the upper part of the Magdalena Limestone of south central New Mexico (Needham, 1937), that form the Thrifty Formation of north central Texas (Myers, 1958, 1960), and it has marked similarities with fusulinids described from the higher part of the Oquirrh Formation of Utah (Thompson, Verville and Bissell, 1950). *T. cuchilloensis* Needham is closely comparable in stage of evolution to *T. comptus* Ross (1959) from the upper part of the Gaptank Formation, Glass Mountains, west Texas.

The highest occurrence of this Virgilian fusulinid assemblage (fig. 4) is found in the lower 20 feet of the Earp Formation in the section near Portal (Locality 9). However, the assemblage extends 235 feet above the base of the Earp Formation in the section at Dunn Springs Mountain (Locality 5). This suggests that the transitional lithologies of the Horquilla-Earp contact noted in the field are possibly a lateral facies change and do not necessarily mark a time plane. The association of species in the two sections differs signifi-

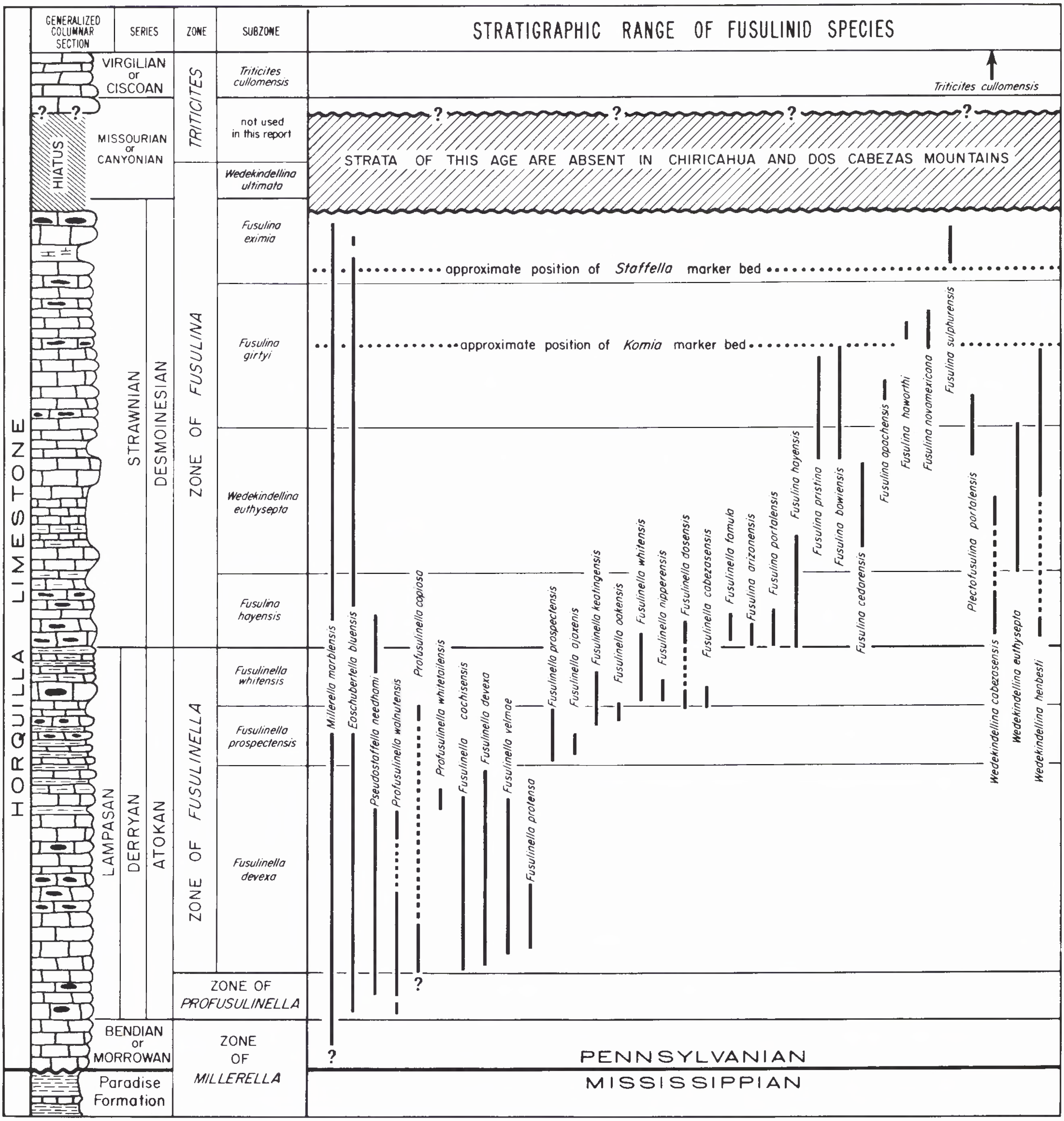


FIGURE 5

Generalized stratigraphic section of the lower and middle parts of the Horquilla Limestone divided into series, zones, and subzones, and the stratigraphic range of fusulinid species. From Ross and Sabins (1965, fig. 3).

cantly and adds support to the interpretation that there was a difference in the depositional environments in the two areas.

Triticites-Schwagerina ASSEMBLAGE ZONE

From 20 to 600 feet above its base the Earp Formation near Portal (Locality 9) has a varied assemblage of large species of *Triticites* and very primitive species of *Schwagerina*. Species, such as *T. creekensis* Thompson, *T. pinguis* Dunbar and Skinner, *S. emaciata* (Beede), and *S. silverensis* Sabins and Ross, have long stratigraphic ranges in this section and are closely similar to fusulinids common in the Bursum Formation of New Mexico (Thompson, 1954). In the section at Dunn Springs Mountain (Locality 5), this post-Virgilian sequence begins about 235 feet above the base of the Earp Formation and includes the remainder of the formation in this measured section (fig. 4). Primitive species of *Schwagerina*, such as *S. dunnensis* Sabins and Ross have well developed pseudochomata in which secondary deposits thicken the edges of the septa adjacent to the tunnel but do not form continuous ridges along the sides of the tunnel and are indicative of the early differentiation of *Schwagerina* from a lineage within *Triticites*. These species and *Triticites cellamagnus* Thompson and Bissell, add support to the placement of these beds as mainly Bursum equivalents.

These fusulinids represent the assemblage zone of *Triticites-Schwagerina* as set forth by Ross and Ross (1962) and Ross (1963) and apparently are equivalent in age to the Admire Group of Kansas, the Pueblo Formation of north central Texas, and part of the Oquirrh Formation of Utah. In the southern Ural region of the U.S.S.R. a similar assemblage of fusulinids occurs in the upper part of the Orenbergian Series at the top of the Carboniferous. In north central Texas, New Mexico and Kansas, the first appearance of *Schwagerina* is commonly used as defining the base of this assemblage zone and here in the Chiricahua Mountains the base of this zone would be placed at the first appearance of *Schwagerina silverensis* Sabins and Ross, the oldest *Schwagerina* in which the pseudochomata are small and discontinuous throughout the test (Locality 9-13). In the lower 300 feet of the Earp Formation there appears to be a complete transition from typical Virgilian species of *Triticites* into primitive species of *Schwagerina*.

Pseudoschwagerina-Triticites ASSEMBLAGE ZONE

In the Ural region of the U.S.S.R. the first occurrence of *Pseudoschwagerina* is generally used as the base of the type Permian and this criterion was followed in the type Wolfcampian region in the Glass Mountains, Texas (Ross, 1959 and 1963). In the Glass Mountains the Wolfcampian Series is divided into two formations, the Neal Ranch Formation at the base containing the fusulinid assemblage zone of *Pseudoschwagerina-Triticites* and the Lenox Hills Formation above containing the fusulinid assemblage zone of *Pseudoschwagerina-Monodiexodina*. Individual species of these genera and other genera are with few exceptions restricted to one or the other of these two zones and provide useful guides where only a small number of species are present.

In the Chiricahua Mountains the Zone of *Pseudoschwagerina-Triticites* includes most of the upper fusulinid-bearing limestones of the Earp Formation, from just above Locality 9-14 as high as Locality 9-23 in the measured section near Portal (fig. 4). The species of fusulinids from the Zone of *Pseudoschwagerina-Triticites* show a close similarity with those from the Council Grove Group in Kansas, the Neal Ranch Formation, Glass Mountains, Texas (Ross, 1959, 1963) and from the upper part of the Bird Springs Limestone, southern California (Thompson, Wheeler and Hazzard, 1946).

Pseudoschwagerina-Monodiexodina ASSEMBLAGE ZONE

The youngest Wolfcampian zone, the Zone of *Pseudoschwagerina-Monodiexodina*, is believed to be represented in the Chiricahua Mountains only by *Schwagerina loringi* (Thompson), *Pseudoschwagerina* sp. A, and the upper part of the range of *Schubertella kingi* Dunbar and Skinner. In the section near Portal this zone includes the upper 300 to 400 feet of limestones, and here *S. loringi* occurs at about the same position beneath the red shales as it does in the Swisshelm Mountains to the southwest (Thompson, 1954, p. 26), although it occurs considerably lower in the section near Indian Creek (Locality 7).

Parafusulina RANGE ZONE

The upper part of the Concha Limestone has been removed by pre-Cretaceous erosion in the Chiricahua Mountains, and no fusulinids have been found from the top of the Earp Formation to the top of the Concha Limestone in this area. Higher beds of the Concha are preserved in Whetstone Mountains, from which Ross and Tyrrell (1965) report *Parafusulina sullivanensis* Ross and *P. boesei* Dunbar and Skinner, and in the Empire Mountains, from which Sabins and Ross (1963) report *P. empirensis*. *P. sullivanensis* and *P. boesei* are indicative of an early Guadalupian age and, as P. *empirensis* occurs stratigraphically higher, it also is of Guadalupian age.

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