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by

Thomas Ellis Williams

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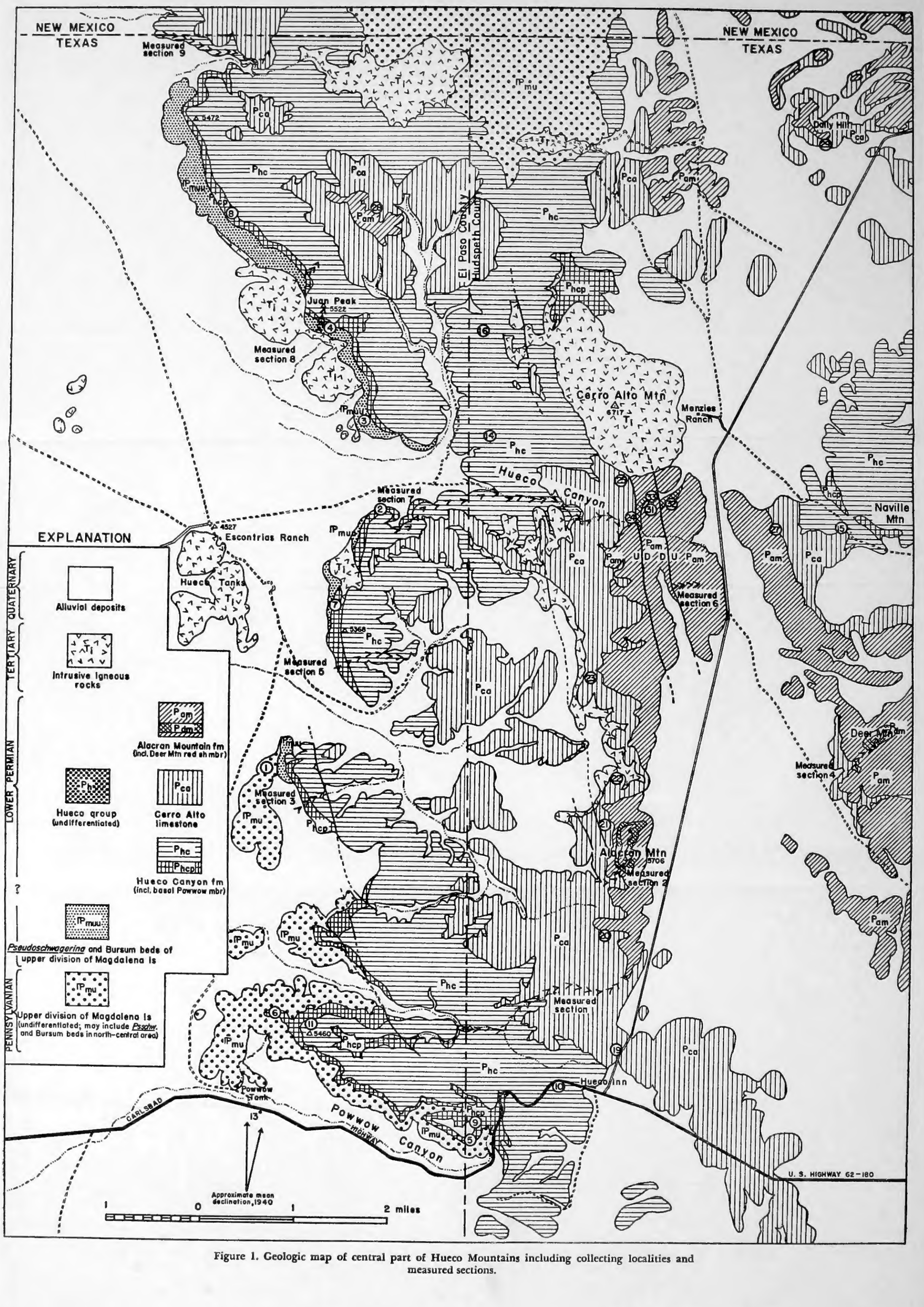

Figure 1. Geologic map of central part of Hueco Mountains including collecting localities and measured sections.

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FUSULINIDAE OF THE HUECO GROUP (LOWER PERMIAN), HUECO MOUNTAINS, TEXAS

BY THOMAS E. WILLIAMS

ABSTRACT

On the geologic map of the Hueco Mountains, Texas, King, *et al.* (1945) recognized three "divisions" of the Hueco limestone: a lower light gray limestone, 500 feet thick (including a Powwow member); a middle dark gray limestone, about 250 feet thick; and an upper light gray limestone, 800 feet thick including 180 feet of red beds (Deer Mountain red shale member). These divisions have been mapped throughout the range; each is lithologically distinctive and amazingly uniform. The lower, middle, and upper divisions are considered formations and called the Hueco Canyon formation, the Cerro Alto limestone, and the Alacran Mountain formation respectively; the Powwow and Deer Mountain units are retained as members of the Hueco Canyon and Alacran Mountain formations. Accordingly the Hueco limestone is renamed the Hueco group.

The formations of the Hueco group contain distinctly different assemblages of fusulinid species. The Hueco Canyon, the Cerro Alto, and most of the Alacran Mountain are within the "zone of Pseudoschwagerina" (Wolfcampian Series). The Wolfcamp-Leonard boundary, marked by the appearance of a *Schwagerina crassitectoria-S. franklinensis* fauna, falls within the Alacran Mountain formation some 80 feet above the last appearance of *Pseudoschwagerina.* The composition of the fusulinid faunas of the Hueco group is as follows (in ascending order) : Hueco Canyon formation—*Monodiexodina bispatulata* n. sp., *Paraschwagerina shuleri* n. sp., *Pseudoschwagerina beedei, P. geiseri* n. sp., *P. texana, P. uddeni, Schubertella kingi, Schwagerina bellula, S. davisi* n. sp., *S. emaciata, S. huecoensis, S. knighti, S. thompsoni*? and *Triticites powwowensis;* Cerro Alto limestone—*Schwagerina eolata, S. neolata;* Alacran Mountain formation—*Pseudoschwagerina convexa, P. gerontica, P. texana, P. uddeni, Schwagerina diversiformis,* and *S. nelsoni; Schwagerina crassitectoria, S. menziesi* n. sp. and *S. franklinensis.* Facies control of fauna is strikingly demonstrated in the occurrence of a typical Wolfcampian assemblage in the Hueco Canyon formation, its replacement by the specialized *Schwagerina eolata-S. neolata* assemblage in the Cerro Alto limestone and its reappearance in the Alacran Mountain formation.

FUSULINIDAE OF THE HUECO GROUP (LOWER PERMIAN), HUECO MOUNTAINS, TEXAS

By Thomas E. Williams

INTRODUCTION

Location and Accessibility

The Hueco Mountains are a north-trending range which occupy an area of about 584 square miles in El Paso and Hudspeth counties, Texas, and in southern Otero County, New Mexico. They are bounded approximately by the meridians 105° 50′ W. and 106° 10′ W. and the parallels 31° 40′ N. and 32° 05′ N. The mapped area extends the length of the range but includes only those portions of the range displaying Permian age rocks.

The range is traversed by one paved road, U. S. Highway 62-180. Two loose surfaced, graded and drained roads extend north from the highway, roughly paralleling the escarpment on both the east and west sides; one leading to the Hueco Tanks and the other to New Mexico (see fig. 2). A network of dirt roads covers the area, but these are not passable to ordinary vehicles. Such roads follow the contours of the land, and the excessive steepness of some of the grades plus the frequency of washouts make the use of four-wheel-drive vehicles imperative.

Previous Investigations

The geology of the Hueco Mountains was first treated by C. B. Richardson in 1904 as part of a report of a reconnaissance of that part of trans-Pecos, Texas, north of the Texas and Pacific railway. He included a geologic map of that portion of the range west of meridian 106° 00′ W. in the El Paso folio of the U. S. Geological Survey Atlas, issued in 1909.

J. W. Beede (1920) presented the first description of the stratigraphic sequence in the Hueco Mountains accompanied by the first complete geologic map of the range south of the New Mexico-Texas State line. He recognized the major subdivisions employed today although several of the names have been changed. Further refinements in the stratigraphy appeared in the papers of King and King (1929), R. E. King (1931), and P. B. King (1934; 1942). P. B. King, R. E. King, and J. B. Knight (1945) mapped the Hueco Mountains in greater detail, incorporating the stratigraphic subdivisions proposed since the work of Beede in 1920. A summary treatment of the stratigraphy accompanied the map. The map, however, did not include that portion of the range north of the New Mexico-Texas State line, and it remained for Hardie (1958) to complete the task.

Additional reports containing significant stratigraphic and paleontologic information pertaining to the Hueco Mountains have been those of Dunbar and Skinner (1937), Miller and Furnish (1940), Thompson (1942; 1948; 1954), Miller and Parizek (1948), Laudon and Bowsher (1949), Yochelson (1956), Batten (1958), Stewart (1958), and Howe (1959).

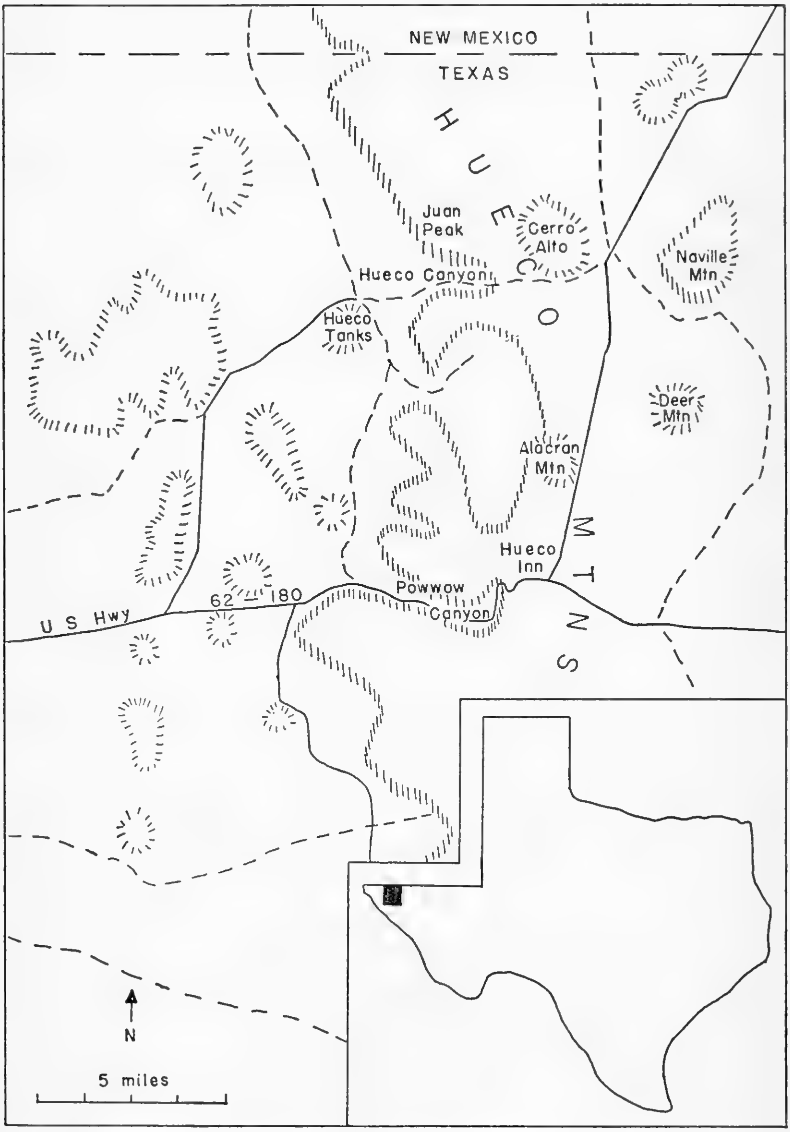

Figure 2. Index map of Hueco Mountains, El Paso and Hudspeth counties, Texas.

Method of Investigation

The geologic map (fig. 1, frontispiece; plate 1, Williams, 1962) of the area was prepared with the aid of the U. S. Department of Agriculture aerial photographs. The geologic contacts were located in the field and plotted on 7-inch by 9-inch, 1:30,000 scale, stereo-paired aerial photographs. A composite base map was conconstructed from the following U. S. Geological Survey 15-minute quadrangle maps: Desert (1943) and Bassett Lake (1943), New Mexico-Texas; Hueco Tanks (1944), Hueco Mountains (1943), Clint (1945), and Borrego (1942), Texas. This map was photographed, enlarged to same scale as the aerial photographs, and reproduced on a transparent Mylar base; the geologic contacts were transferred from the photographs to the map by tracing. The works of King *et al.* (1945) and Hardie (1958) were consulted freely in the placement of the geologic contacts.

Stratigraphic sections were measured both directly by tape, and by Jacob staff and Brunton compass. The classification of bedding according to thickness is that of McKee and Weir (1953) modified by Ingram (1954). Colors were determined by use of the National Research Council Rock Color Chart.

Fossils (principally fusuline Foraminifera) were collected from each formation at numerous localities throughout the area and at each horizon where present within the measured sections. A list of the fusulinid species and their ranges is given in fig. 3. New species of Fusulinidae from the area are described in the section on systematic paleontology. Both holotypes and hypotypes are deposited in the Yale University Peabody Museum.

The investigation was suggested and directed by Dr. Carl O. Dunbar, Professor Emeritus of Paleontology and Stratigraphy, Yale University. Grants from the Schuchert Fund of the Yale Peabody Museum and from Sigma Xi helped defray the expenses of the field work. The Graduate School of Southern Methodist University and the Graduate Research Center of Dallas provided additional funds to hire laboratory assistants. I am further indebted to Dr. Karl M. Waage and Dr. Elwyn L. Simons for their critical reading of the manuscript.

This study was submitted in May 1962, as a dissertation for the degree of Doctor of Philosophy at Yale University.

Geologic Setting

The Hueco Mountains are situated in trans-Pecos, Texas, that part of the state, west of the Pecos River that differs distinctly from other parts of Texas in topography, climate and geology. A major physiographic feature within trans-Pecos, Texas, is the Diablo Plateau, a large uplifted block of nearly flat-lying sedimentary rocks, structurally higher at the west, east, and southeast margins. It is flanked on the east and west by Salt Flat and the Hueco Bolson respectively; these are structural valleys of the type so common throughout the Basin and Range Province. Fault scarps and abrupt dips separate the plateau from the sunken valleys at its edge. The dissected fault scarps on both sides of the plateau appear as mountains when viewed from the basins. Such are the Hueco Mountains on the west margin and the Sierra Diablo on the east. To the north into New Mexico the plateau merges imperceptibly into a low escarpment, Otero Mesa. From its west margin the Diablo Plateau slopes gently eastward and the strata are likewise inclined to the east, with an angle of dip comparable to the topographic slope. Thus, the Hueco Mountains are essentially a cuesta with a west-facing escarpment and a relief of approximately 1,000 feet. Exposed along this relatively steep western escarpment is a thick section of sedimentary rocks that range in age from Precambrian to Cretaceous. A variety of structural features resulting from small scale intrusive igneous activity and minor faulting serve to complicate this simple picture.

Beede (1920, p. 7) noted that the major influence upon the structure of the region as a whole appeared to have been from the southwest, giving a gentle northeast dip to the whole northern part of the Diablo Plateau and bringing up the older Paleozoic rocks at the south end of the Hueco Mountains. This was probably part of a general doming in the vicinity of the southern end of the range in early Permian time (post-Bursum, pre-Middle Wolfcamp), which produced the regional unconformity at the base of the Hueco group. The broad structural configuration within the area of investigation is that of a monocline having a low eastward dip with structural disturbances developed on its western border (Richardson, 1909). According to King, *et al.* (1945), the major structural feature of the Hueco Mountains is an arch trending northwestward, whose axis lies near or a little west of the crest of the range. A variety of minor structural features are superposed on the arch, principally as a result of intrusive igneous activity during Tertiary time. Intrusion was accompanied by uplift in the neighborhood of two of the larger intrusions, Cerro Alto and Red Mountain, producing an anticlinal distribution of strata peripheral to those bodies. Gentle domes, lacking exposures of igneous rocks at their centers but displaying a comparable peripheral distribution of strata (e.g. Naville Mountain and a similar structure northwest of Red Mountain), suggest the presence of laccoliths.

With the exception of the faulting which accompanied the subsidence of the Hueco Bolson and the uplift of the Diablo Plateau, faults within the Hueco Mountains are relatively subordinate features of limited magnitude and variable trend. Doubtless they originated as adjustments to the displacements resulting from igneous intrusions inasmuch as many of them are distinctly related to such features.

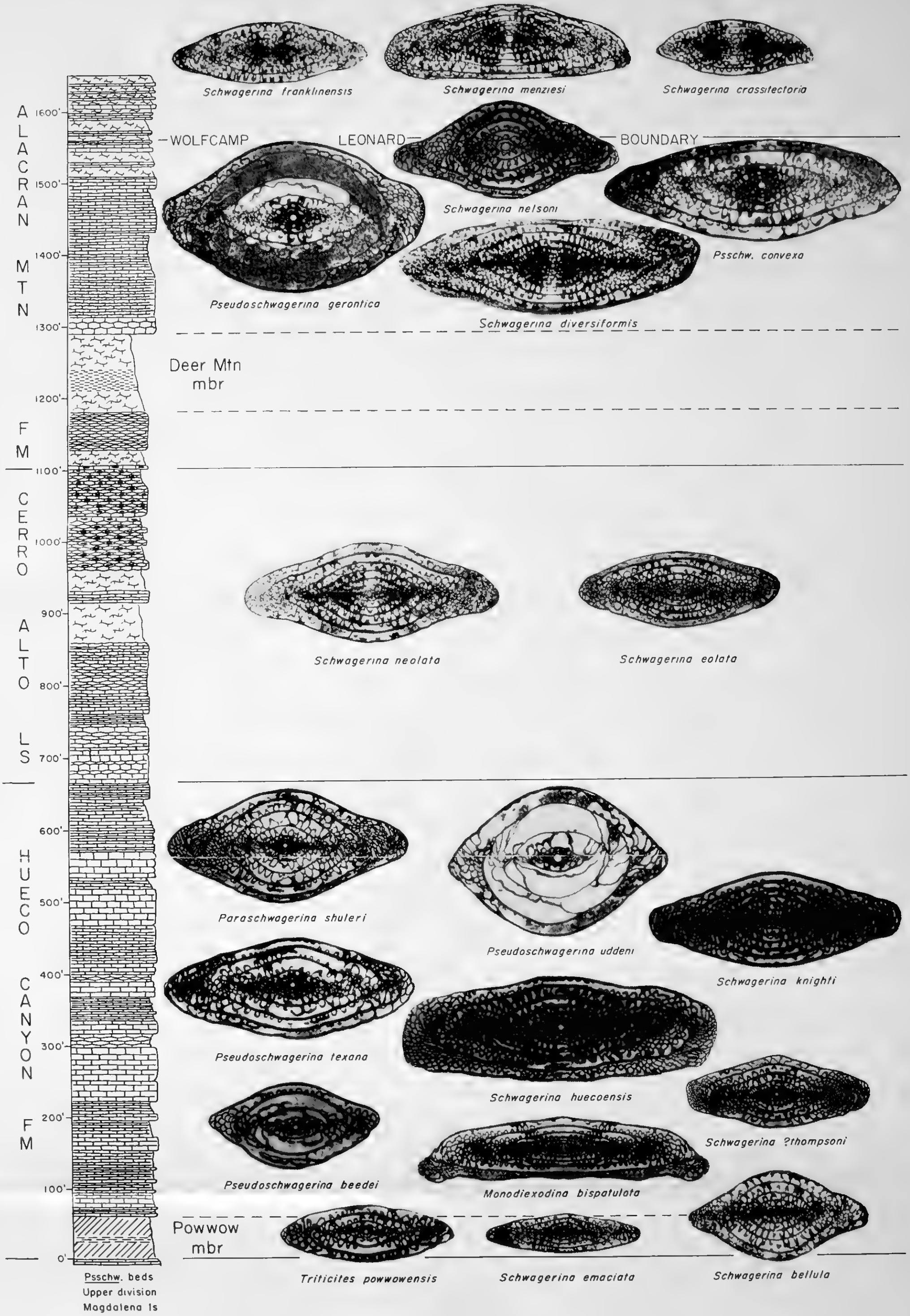

Figure 3. Generalized columnar section of Permian formations in Hueco Mountains, Texas showing stratigraphic distribution of fusulines (all ×5)

STRATIGRAPHY

Pre-Hueco Formations

The base of the Hueco group in the vicinity of Powwow Canyon (El Paso-Carlsbad highway) is marked by a major unconformity which increases in magnitude southward, where the group rests with marked angular unconformity on underlying rocks ranging from the Magdalena limestone (Pennsylvanian) downward to the El Paso limestone (Ordovician) (King, King, and Knight, 1945). To the north the magnitude of the unconformity decreases; there the gap between the Pennsylvanian and Permian is approximately equal to the time represented by the lower part of the Wolfcampian Series (of Ross, 1959). Thus, the Hueco group rests unconformably on a variety of units. Detailed discussion of the stratigraphy of each of the pre-Hueco formations is beyond the scope of this paper and, moreover, several of these units have been the subject of recent studies (Thompson, 1942, 1948; Laudon and Bowsher, 1949; Hardie, 1958b; Howe, 1959). While investigating the nature of the contact at the base of the Hueco group north of the El Paso-Carlsbad highway, I made several collections of fusulinids from subjacent rocks mapped by King, *et al.* (1945) as Pennsylvanian. The descriptions of these faunas are included in this paper. Consequently at least summary discussion of the stratigraphy of the underlying Magdalena limestone is in order.

Magdalena Limestone

The term Magdalena was proposed by C. H. Gordon (1907) for the Pennsylvanian rocks of the Magdalena Mountains, Socorro County, New Mexico. It was applied to the Pennsylvanian of the Hueco Mountains by Beede (1920). King and King (1929) noted the presence of Strawn, Canyon, and Cisco equivalents within the Magdalena of this area and Thompson (1942; 1948) arrived at a similar conclusion, using instead the mid-continent terms, Desmoinesian, Missourian, and Virgilian, plus his proposed Derry series. In their map of the Hueco Mountains, King, *et al.* (1945) recognized a lower division (Morrowan and Lampasan) about 500 feet thick and consisting of heavy-bedded, coralline limestone, with some very cherty members; a middle division (Lampasan and Desmoinesian) 300 feet thick and consisting of marl, marly limestone, and shale, with some limestone ledges near the middle; and an upper division (Desmoinesian, Missourian, and Virgilian) at least 500 feet thick consisting of thick to thin ledges of limestone, interbedded with marl. Collections from the subjacent Pennsylvanian units are limited to the upper division of the Magdalena limestone, and observations are restricted to that unit. The term "upper division of the Magdalena limestone" as discussed herein is that of King, *et al.*

UPPER DIVISION OF THE MAGDALENA LIMESTONE

King, *et al.* (1945) describe the upper division as consisting of thin to thick ledges of limestone, interbedded with marl. The following distinctive lithologic features were cited as characteristic of the higher part of the unit (i.e. about 150 feet above the base); (a) "pepper and salt" appearance of many of the thinner limestones, owing to a heavy concentration of black, phosphatic flecks; (b) limestone pebbles, in some instances forming coarse conglomerates, in the thicker limestone units; (c) marl slopes with considerable orange chert; and (d) the presence of a large limestone reef. The observations of King, *et al.* (1945) are limited to exposures south of the New Mexico-Texas State line, more specifically the area between the El Paso-Carlsbad highway and the mouth of Hueco Canyon, whereas the range extends some distance to the north into New Mexico. This northern portion was mapped by Hardie (1958), who noted that the Pennsylvanian rocks there differed markedly from those described to the south. He reported that portion of the Pennsylvanian along the escarpment to consist of regularly cyclical deposits of alternating shales, limestone, and limestone-and-chert-pebble conglomerates in the lower two-thirds and a predominance of massive limestone with a few shales and conglomerates in the upper third. Since the Magdalena is situated beneath an unconformity which decreases in magnitude to the north, the Pennsylvanian rocks north of Hueco Canyon are probably younger than those described by King, *et al.* to the south (see fig. 4).

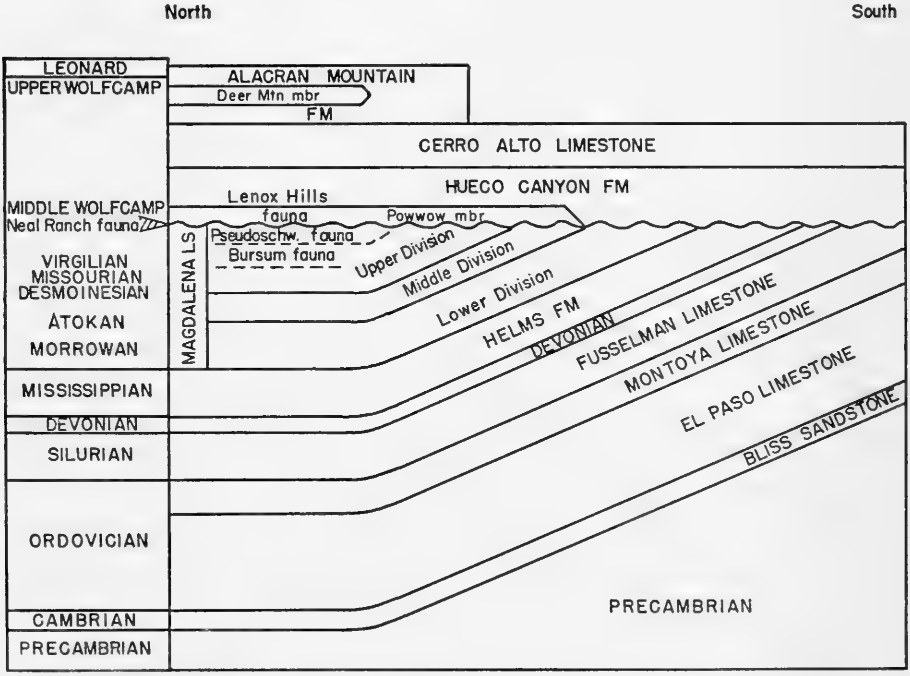

Figure 4. Schematic diagram of regional unconformity at base of Hueco group.

Beds of the upper division of the Magdalena limestone begin to appear beneath the unconformity at the base of the Hueco group in the vicinity of Powwow Canyon, on the east wall of the canyon below the airway beacon. At this point they are exposed at the head of the canyon, whereas farther to the north they crop out at the base of the escarpment and in outliers immediately west of the escarpment. Additional exposures occur peripheral to the Red Mountain intrusion in the northern Hueco Mountains a few miles east of the escarpment. By virtue of a gentle northern regional dip of the Pennsylvanian rocks and their truncation by erosion preceding deposition of the Hueco group, progressively younger beds of the upper division are exposed to the north until it appears that beds of earliest Permian age may be included in this interval.

The lower portion of the upper division of the Magdalena limestone is best exposed in the walls on the north side of Powwow Canyon. King, *et al.* (1945) considered it to be a Des Moines equivalent on the basis of a brachiopod assemblage of *Mesolubus* sp. and *Muricatina muricatina.* Stewart (1958) reported the fusulinid *Fusulina mysticensis* from this part of the section and called it upper Strawn. Stewart did not, however, define upper Strawn in reference to a stratigraphic unit of rocks but rather as that section occurring above the zone of *Wedekindellina* and within the zone of *Fusulina;* this would presumably be correlative with the Desmoinesian.

Additional exposures of stratigraphically higher portions of the upper division occur farther north along the escarpment. The northernmost Pennsylvanian section of King, *et al.* (1945), measured section J, is found in an outlier immediately west of the escarpment and three miles due south of the Hueco Tanks. In its lower beds, this section contains rather primitive species of *Triticites,* similar in stage of evolution to those in the middle or upper Canyon [Missourian]; in the uppermost beds are two advanced species of *Triticites,* resembling forms in the lower Cisco [Virgilian] (personal communication from C. O. Dunbar to King, *et al.*). Fusulinids were not reported from beds mapped as Magdalena north of this point and it is fair to assume that King, *et al.* considered the remainder of the Magdalena to be equivalent to the beds of measured section J or younger (upper Virgilian).

It is noteworthy however that beds immediately northeast of measured section J and stratigraphically higher (Locality 1) have yielded a Bursum fusulinid fauna (lowest Permian). Thompson (1954, p. 18) recognized the Bursum in the Hueco Mountains, "just north of Powwow Canyon," by the presence of *Schwagerina* sp. and *Triticites cellamagnus.* I am uncertain whether that portion of the section exposed at Locality 1 is identical with Thompson's Bursum, but it is the only locality in the Hueco Mountains where I have found Bursum fusulinids.

It appears then that the upper division is at least partially Permian in age, and this conclusion is reinforced by the presence of a primitive *Pseudoschwagerina* fauna above the "Bursum" portion of the Magdalena. Beds containing this fauna lie immediately below the unconformity at the base of the Hueco group and compose the upper division of the Magdalena exposed in the base of the escarpment from the mouth of Hueco Canyon northward. They crop out as a distinct unit, consisting of approximately 200 feet of 5-10 foot beds of medium- and thick-bedded, light gray limestones alternating with covered intervals of a comparable thickness. This unit is informally referred to herein as the *Pseudoschwagerina* beds of the Magdalena limestone. Future work may indicate the desirability of treating this unit as a separate formation, especially in light of its probable Permian age. I hesitate to propose formation rank because of insufficient stratigraphic data and consequent uncertainty as to its qualifications as a mappable unit. The *Pseudoschwagerina* beds are exposed continuously from the southern side of the mouth of Hueco Canyon northward along the escarpment, finally disappearing under the alluvium at the north end of the range. They are probably also present in the exposures mapped as Pennsylvanian surrounding the Red Mountain intrusion but have not been differentiated from the Magdalena in that area. Observations were limited to the exposures along the western escarpment south of the New Mexico-Texas State line. The northern part of the Hueco

Mountains currently is part of a U. S. Army missile range and access to the area is severely restricted.

The contact between the *Pseudoschwagerina* beds and the underlying Bursum beds is everywhere covered. In the absence of evidence to the contrary, it is assumed to be conformable. Evidence as to the nature of the upper contact is also rare. Situated at the base of a slope-forming unit, the Powwow member of the Hueco Canyon limestone, it too is invariably obscured. The possibility of a faunal break between the *Pseudoschwagerina* beds and the overlying Powwow member is difficult to assess. My collections from the upper member of the Magdalena are neither as plentiful nor as widely distributed as might be desired. Comparison with the North American standard in the Glass Mountains contributes little, the contact between the Pennsylvanian and the Permian there being one of disconformity (Ross, 1959b, p. 299). Existing data indicate, however, that there is a minor but nonetheless discernible break in the evolutionary continuity of the fusulinid faunas between the *Pseudoschwagerina* beds and the overlying Powwow member. This conclusion is only tentative and further studies of the fusulinid faunas of these units, both along the escarpment and in the area peripheral to the Red Mountain intrusion, are prerequisite to a more positive inference of the existence of a hiatus.

HUECO GROUP

TERMINOLOGY AND SUBDIVISION

In 1904, Richardson (p. 32) proposed the name Hueco for the Carboniferous of trans-Pecos, Texas, after the excellent exposures in the Hueco Mountains. The formation was described as consisting mainly of massive gray limestone with a total thickness of 3,000 feet with no indication of its upper limit, more or less of the top having been covered or removed by erosion (Richardson, 1909, p. 4). Faunal studies by G. H. Girty accorded a Pennsylvanian age to the unit. Gordon (1907) and Lee and Girty (1909) divided the rocks of the upper Carboniferous of the Rio Grande valley of New Mexico into the Magdalena and Manzano groups, separated by a local unconformity. Shortly thereafter Richardson (1910) reported that the Magdalena group could be traced into the Hueco limestone on the western flank of the Franklin Mountains in Texas, although it could not there be separated from the Manzano group owing to the disappearance of the unconformity. Richardson thus concluded that the Hueco formation embraced both the Magdalena and Manzano groups. A somewhat more detailed study of the type section by Beede (1920, p. 7) revealed that "the Hueco formation contains both the Magdalena and Manzano groups of rocks, and in addition a considerable thickness of the Mississippian." He further noted that the upper of the three groups rested with marked unconformity on the Magdalena group. On the basis of Richardson's conclusions as to the equivalence of the Magdalena-Manzano groups and the Hueco limestone, and the priority of the term Manzano (Herrick, 1900), Beede chose to drop the term Hueco and use Helms group, Magdalena group, and Manzano group for the Mississippian, Pennsylvanian, and Permian respectively.

King and King (1929, p. 910, 922) retained the term Helms (although they suspected that only the upper portion was Mississippian), but recognized three subdivisions—Bend, Strawn, Canyon-Cisco—in place of Magdalena. They sub-

RICHARDSON 1909	BEEDE 1920	KING & KING 1929		KING & KNIGHT 1945		HARDIE 1958		WILLIAMS THIS PAPER		
HUECO LIMESTONE	MANZANO GROUP	GYM FORMATION		HUECO LS	UPPER DIVISION	HUECO LS	UPPER DIVISION	HUECO LS	ALACRAN MTN FM	PERMIAN
					MIDDLE DIVISION		MIDDLE DIVISION		CERRO ALTO LS	
					LOWER DIVISION		LOWER DIVISION		HUECO CANYON FM	
	MAGDALENA GROUP	CISCO-CANYON		MAGDALENA LIMESTONE	UPPER DIVISION	MAGDALENA LIMESTONE	UPPER DIVISION	MAGDALENA LIMESTONE	U. DIV. "PSSCHW. BEDS" "BURSUM BEDS"	
					MIDDLE DIVISION		NOT APPLICABLE		NOT APPLICABLE	PENNSYLVANIAN
		STRAWN			LOWER DIVISION					
		BEND								
	HELMS GROUP	HELMS GROUP	CHESTER	HELMS FM	UPPER MEMBER					MISSISSIPPIAN
			LAKE VALLEY		LOWER MEMBER					
			PERCHA?	BEDS OF DEVONIAN AGE						DEV

Figure 5. Comparison of names used in this report with names used in previous reports.

stituted the name Gym formation for Manzano group because of the similarity lithologically and faunally to the Gym formation (Darton, 1916) of the Florida Mountains of southwestern New Mexico. King and King (1929, p. 910, 923 and fig. 7) also proposed the name Powwow for a member composed of conglomerate and red beds at the top of the Cisco, and the name Deer Mountain red shale for a red bed member in the upper part of the Gym. P. B. King (1934, p. 743) later acknowledged that the Powwow had been erroneously grouped with the Pennsylvanian strata below the unconformity rather than above with the overlying Permian rocks. R. E. King (1931, p. 16) recognized three additional members of the Gym formation: a lower light gray limestone, 500 feet thick (including the Powwow conglomerate member) containing a great abundance of *Schwagerina* (*Pseudoschwagerina* of modern authors); a middle dark gray limestone, 250 feet thick, characterized by a great abundance of gastropods and pelecypods; and upper light gray limestone, 800 feet thick including 180 feet of red beds (Deer Mountain red shale member), characterized by the abundant brachiopods *Composita mexicana* and *Wellerella texana.*

P. B. King (1934, p. 742), in the first of his excellent summaries of the Permian stratigraphy of trans-Pecos, Texas, restored the name Hueco limestone in a restricted sense, i.e. to exclude all of the Magdalena, citing Keyte (1929, p. 904) as a precedent and noting that the previous use of Manzano and Gym involved the introduction of names from other areas without clear demonstration of equivalency or reasonable correspondence of lithologies. The wisdom of this move was borne out by a restudy of the Gym formation (Kelley and Bogart, 1952; Bogart, 1953) which revealed that Darton's Gym included Silurian, Devonian, Mississippian, Pennsylvanian and Cretaceous (?) rocks in addition to some strata of Permian age. R. E. King's (1931) subdivisions were retained. However on their geologic map of the Hueco Mountains, King, King and Knight (1945) employed the terms "lower, middle, and upper divisions" of the Hueco limestone in place of the lower, middle and upper members. The Powwow conglomerate and Deer Mountain red shale were treated as members of the lower and upper divisions. In his map of the northern part of the Hueco Mountains in Otero County, New Mexico, Hardie (1958a; 1958b) treated the Hueco as a formation but used the "divisions" of King, *et al.* (1945) in mapping. Hardie observed that the Powwow conglomerate member appeared to be a rather local feature more or less restricted to the type locality but admitted the possibility that it might be represented by the uppermost red shale of his Magdalena group.

The term "division" has no standing in the stratigraphic code (Am. Comm. Strat. Nomenclature, 1961), yet the divisions of King, *et al.* (1945) cannot simply revert to member status; members may not contain members. Therefore it is proposed herein to raise the lower, middle, and upper divisions to formation rank, calling them the Hueco Canyon formation, Cerro Alto limestone and Alacran Mountain formation respectively. They have been mapped throughout the range (King, *et al.,* 1945; Hardie, 1958; Williams, 1962); each is lithologically distinctive and amazingly uniform in thickness, in color, and in gross bedding characteristics. Gradual transition between units renders difficult the consistent placement of contacts; nevertheless, the distinction can be made, particularly with the aid of aerial photographs. The generally thick-bedded nature of the Hueco Canyon formation produces an alternating light and dark "zebra-stripe" pattern on the photographs, and contrasts with the dark pattern of the typically medium- and thin-bedded Cerro Alto limestones. A similar contrast appears at the contact between the Cerro Alto limestone and the overlying thick-bedded Alacran Mountain formation, which also exhibits an alternating light and dark "zebra-stripe" pattern. This is a reflection of the basic similarity between the lower and upper formations of the Hueco group, a resemblance which is repeated in the similarity of their fusuline faunas.

Recognition of these units on lithologic characters away from the contacts is not difficult and the observer is rarely in doubt as to his position in the stratigraphic section. The choice of contacts may in some places be arbitrary, but indefinite contacts are still contacts and each of the formations proposed herein is none the less lithologically distinctive. The Powwow conglomerate and Deer Mountain red shale are retained as members in the sense of King, *et al.* (1945). Accordingly, the Hueco limestone (restricted) of King (1934) is here renamed the Hueco group. A comparison of names used in this report with names used by previous workers is given in fig. 5, and a generalized columnar section of both the Pennsylvanian and Permian rocks of the area appears in fig. 6.

HUECO CANYON FORMATION

Name and type section. The Hueco Canyon formation is named for Hueco Canyon in the central part of the Hueco Mountains, Texas, where the unit, with the exception of the basal Powwow member, is well exposed at its maximum thickness. The type stratigraphic section, exposed in the south side of Hueco Canyon, is described below and is illustrated graphically in measured section 7 of fig. 7.

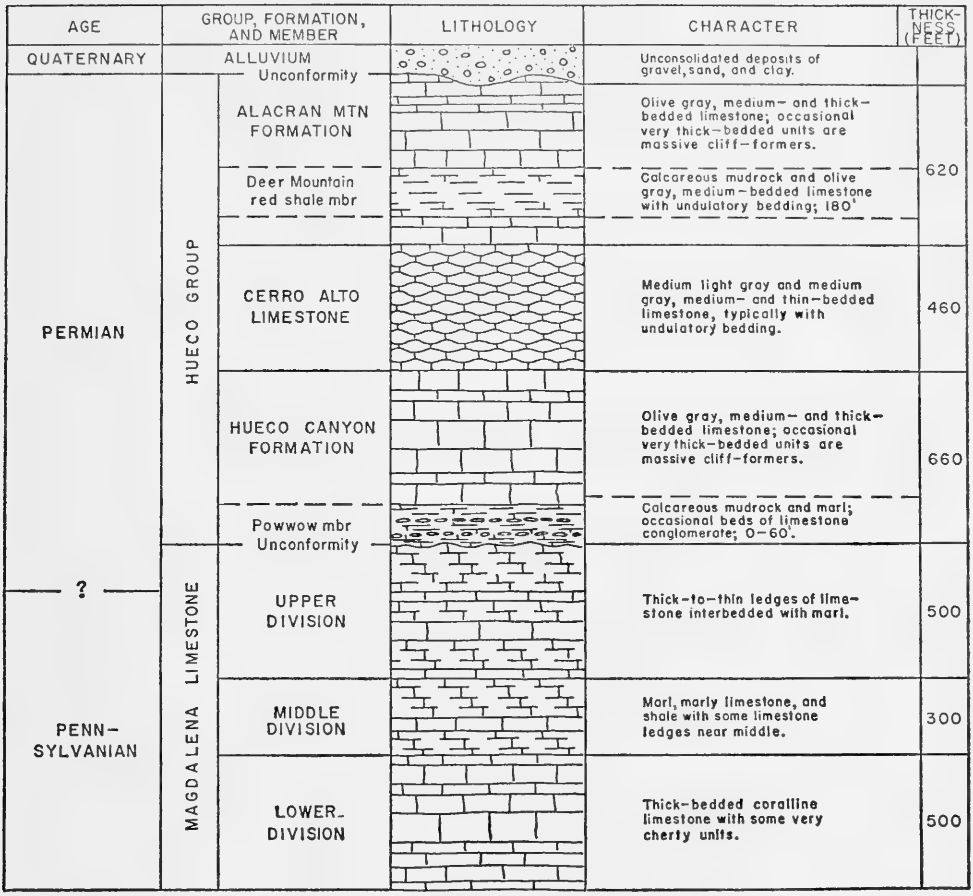

Figure 6. Generalized columnar section for Pennsylvanian-Permian rocks of the Hueco Mountains, Texas.

Section of Hueco Canyon formation in Hueco Canyon, central part of Hueco Mountains, Texas

Permian

Cerro Alto limestone

Hueco Canyon formation:

	Ft
Limestone, light olive gray, thin- and medium-bedded	22
Covered; probably limestone, thin-bedded	29
Limestone, light olive gray, medium- and thick-bedded; stylolites	43
Limestone, medium light gray to medium gray, medium- and thick-bedded	36
Covered; probably limestone, thin-bedded	15
Limestone, light olive gray to olive gray, very thick-bedded; stylolites	50
Limestone, light olive gray; medium- and thick-bedded	68
Limestone, medium dark, medium- and thick-bedded; undulatory bedding	10
Limestone, medium gray, thick-bedded; stylolites	22

Section of Hueco Canyon Formation in Hueco Canyon, (*Continued*)

	Ft
Covered; occasional ledges of limestone, medium light gray to medium gray, medium-bedded	32
Limestone, light olive gray to olive gray; thick-bedded; stylolites	20
Limestone, medium gray, thin-bedded; undulatory bedding; conspicuously indented weathered profile; abundant free fusulinids	18
Limestone, light olive gray, thick-bedded; stylolites; fusulinids in matrix in lower 5 feet	47
Limestone, light olive gray, very thick-bedded; cliff-former; stylolites; fusulinids in matrix at base	30
Covered; upper 5 feet has limestone, olive gray to light olive gray, medium-bedded, undulatory bedding; considerable medium gray chert which weathers medium gray and moderate brown; fusulinids in matrix at base	16.5
Limestone, light olive gray, thick-bedded; some chert nodules; fusulinids in matrix at base	10
Covered	25
Limestone, light olive gray, thick-bedded	18
Covered; occasional resistant beds of limestone, light olive gray and olive gray, medium-bedded; 5 foot thick fusulinid coquina near base (free specimens)	95
Thickness Hueco Canyon formation above Powwow member	606.5
Powwow member of Hueco Canyon formation:	
Covered; outcrop of reddish-brown soil about midway up covered slope	60
Total thickness Hueco Canyon formation	666.5
Pseudoschwagerina beds of Magdalena limestone.	

Lithology and thickness. At the type locality, the Hueco Canyon limestone consists of a basal conglomerate and red bed sequence followed by 600 feet of olive gray, medium- and thick-bedded limestones, with occasional very thick-bedded units; the latter are generally massive cliff-formers. Stylolites are common, as is an abundance of chert nodules at various levels. The thickness of the Hueco Canyon formation, excluding the Powwow member, decreases from north to south in the area of investigation from 635 feet at the New Mexico-Texas State line to 470 feet in the canyon north of Powwow Canyon, a loss of 165 feet as a result of southward thinning.

The basal conglomerates and red shales of the Hueco Canyon formation were first described by Beede (1920, p. 15). They were included in his Permian Manzano group. The name Powwow conglomerate was given to these beds by King and King (1929, p. 910) for exposures in Powwow Canyon, the route of the El Paso-Carlsbad highway. The Powwow was erroneously placed below the Pennsylvanian-Permian unconformity, but this mistake was recognized and rectified by P. B. King (1934, p. 743). A measured section including the Powwow appeared in a later publication (King, *et al.*, 1945, measured section N) in the form of a graphic section. It was measured by Knight on the ridge north of Powwow Tank. There the Powwow is poorly exposed but provides the best outcrops of the unit in the entire range. Re-examination of measured section N reveals little room for improvement in light of the nature of the exposures, and the Powwow portion of graphic section 1 (fig. 7) is after Knight. The lithologic description of the unit is given below.

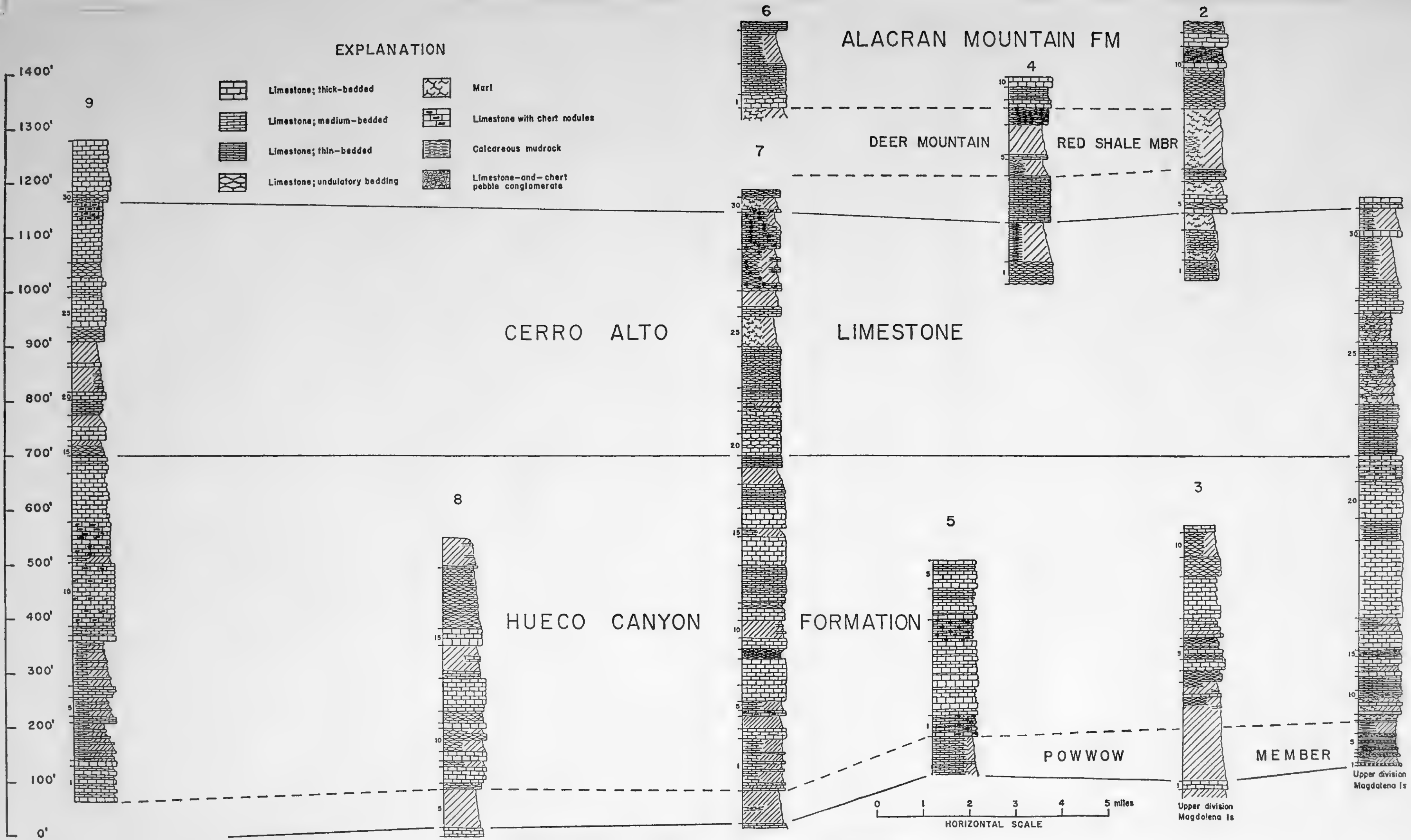

Figure 7. Correlation of stratigraphic sections of Hueco group in Hueco Mountains, Texas.

Section of Powwow member of Hueco Canyon formation in canyon north of Powwow Canyon, southern part of Hueco Mountains, Texas.

Permian

Top of member:	Ft
Marl, light gray, medium-bedded; undulatory bedding nodules of dark-gray chert	11
Limestone, olive gray, medium-bedded	4
Covered; probably calcareous mudrock, dark reddish-brown changing to light gray, medium-bedded marl with undulatory bedding at top	21
Conglomerate, pebble- and cobble-size fragments of limestone and chert, interbedded with calcareous mudrock, dark reddish-brown	29
Covered; probably calcareous mudrock, dark reddish-brown	6
Conglomerate, pebble- and cobble-size fragments of limestone and chert; overlain by thin layer of sandy limestone	6
Covered; probably calcareous mudrock, dark reddish-brown	11
Conglomerate, pebble-size fragments of limestone and chert	6
Total thickness Powwow member	94
Upper division of Magdalena limestone (in part)	
Limestone, light gray, medium-bedded	4+

The choice of the term conglomerate in naming this unit was no doubt influenced by the predominance of that lithology among the exposed portions of rocks of the Powwow interval. However the member is for the most part covered and is probably dominantly calcareous mudrock which weathers to a reddish-brown clay, and light gray, medium-bedded marl possessing undulatory bedding. The conglomerates consist of pebble- and cobble-size fragments of limestone and chert. Inasmuch as the conglomeratic aspect of the unit is confined to the vicinity of Powwow Canyon, I propose that the name be shortened to Powwow member.

Measurements of the thickness of the Powwow member are available only for the section north of Powwow Canyon (95 feet) and the section at the mouth of Hueco Canyon (70 feet). It is not exposed in the canyon immediately south of the New Mexico-Texas State line. Hardie (1958a, p. 29-30) gives a figure of 97 feet for the combined thickness of two covered intervals at the top of his Magdalena group, measured in the escarpment two and one-half miles north of the state line. These intervals are separated by a four foot unit of limestone and chert conglomerate and are herein mapped as the Powwow member. Thus, the thickness of the Powwow is nearly constant from the north end of the range to Powwow Canyon where it thins rapidly by onlap and disappears (see fig. 8).

Distribution. From the El Paso-Carlsbad highway northward into New Mexico, the Hueco Canyon formation produces the Hueco escarpment by virtue of the resistant nature of its massive and very thick-bedded units, forming nearly vertical cliffs exceeding 100 feet in height. Southeast of the highway it crops out along the edge of the Diablo Plateau, serving as a zone of transition from the highly dissected lower Paleozoic, Mississippian, and Pennsylvanian terrains of the southern part of the Hueco Mountains on the west to the gently-sloping lands of the plateau on the east. East of the escarpment it is peripheral to several of the local uplifts caused by igneous activity, e.g. Cerro Alto, Red Mountain,

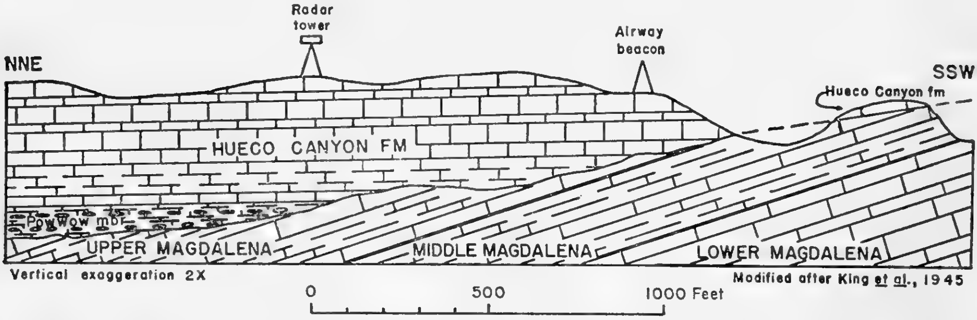

Figure 8. Sketch showing unconformity between Hueco Canyon formation and Magdalena limestone on southeast wall of Powwow Canyon

and Naville Mountain. The smaller ranges subsidiary to, and immediately west of, the Hueco Mountains proper consist largely of the Hueco Canyon formation, in some instances capped by the Cerro Alto limestone.

The Powwow member crops out at the base of the Hueco escarpment almost continuously from Powwow Canyon to the northern end of the escarpment in Otero County, New Mexico. King, *et al.* (1945) did not carry the Powwow member any further north from the type locality than the mouth of the canyon immediately southwest of the Hueco Tanks. Nor did Hardie (1958a; 1958b) recognize the Powwow member in his map of the northern part of the Hueco Mountains, although he conceded that it might be represented by the uppermost red shale of his Magdalena group (1958a, p. 9). As noted previously, the Powwow is for the most part covered, but is readily recognized in the field and on aerial photographs as a slope-forming unit. It has been mapped northward from its type locality, the length of the escarpment (fig. 1, pl. 1, Williams, 1962) and includes portions of what had been previously considered upper Magdalena by King, *et al.* (1945) and Hardie (1958a; 1958b). Justification for the extension of the Powwow to the north is to be found in the existence of a covered interval at a comparable stratigraphic level, and the presence within this interval of a distinctive assemblage of fusulinids identical with the assemblage which characterizes the Hueco Canyon formation. Additional outcrops of the Powwow are to be found in the area immediately north-northwest of Cerro Alto and at the foot of the cliff on the southwest side of Naville Mountain; it probably also crops out at the base of the Hueco Canyon formation on the periphery of the Red Mountain intrusion, although it has not been differentiated in that area.

CONTACTS. South of Powwow Canyon, the Hueco Canyon formation overlies with marked angular unconformity all the underlying rocks of the Hueco Mountains, from the upper Magdalena to the El Paso limestone (upper Pennsylvanian to Ordovician). From Powwow Canyon northward to where the range disappears beneath the alluvium in southern Otero County, New Mexico, the Powwow member is the basal unit of the Hueco Canyon formation. It successively overlies middle Magdalena (Missourian), upper Magdalena (Virgilian), and in the escarpment due east of the Hueco Tanks, the Bursum beds and the *Pseudoschwagerina* beds of the upper Magdalena (lower Permian). There is no evidence of angular unconformity between the Powwow member and the *Pseudoschwagerina* beds of the Magdalena; the contact is apparently conformable. Thus, the magnitude of the unconformity from the vicinity of the Hueco Tanks northward is considerably reduced. Hardie (1958a, p. 23) reached a similar conclusion: "Northward in the Hueco Mountains in New Mexico, the angularity of the unconformity is much less pronounced and the emergence [post-Virgilian emergence] may be represented only by a red shale deposit and a few scattered conglomerates." The Hueco Canyon formation is everywhere overlain conformably by the Cerro Alto limestone in the central and northern Hueco Mountains. The contact is one of gradual transition, making it difficult to delimit closely the units in the field.

FAUNAL LIST. With the exception of the Fusulinidae, the following list was compiled from published sources, using only those localities from within the area of investigation which could be determined with reasonable certainty as belonging to the stratigraphic units outlined herein. The identification of the Fusulinidae are, however, those of the author. Those species marked with an asterisk have their type locality in the Hueco Mountains.

HUECO CANYON FORMATION

PROTOZOA
  Foraminifera
    FUSULINIDAE
      *_Monodiexodina bispatulata,_ n. sp.
      *_Paraschwagerina shuleri,_ n. sp.
      Pseudoschwagerina beedei Dunbar and Skinner
      *_P. geiseri,_ n. sp.
      *_P. texana_ Dunbar and Skinner
      *_P. uddeni_ (Beede and Kniker)
      Schubertella kingi Dunbar and Skinner
      Schwagerina bellula Dunbar and Skinner
      *_S. davisi,_ n. sp.
      S. emaciata (Beede)
      S. huecoensis (Dunbar and Skinner)
      S. knighti Dunbar and Skinner
      *_S. thompsoni_? Needham
      Staffella lacunosa Dunbar and Skinner

BRACHIOPODA
  Buxtonia peruviana (d'Orbigny)
  *_Camarophoria hueconiana_ Girty
  C. theveneni Kozlowski
  Composita mexicana (Hall)
  C. subtilita (Hall)
  Derbya cf. _D. buchi_ (d'Orbigny)
  Dictyoclostus dartoni (King)
  D. hessensis (King)
  *_D. huecoensis_ (King)
  D. semistriatus (Meek)
  D. wolfcampensis (King)
  Dielasma bovidens (Morton)
  _D._ cf. _D. bovidens_ (Morton)
  Enteletes dumblei Girty
  E. liumbonus King
  Horridonia boulei (Kozlowski)

- *Hustedia mormoni* (Marcou)
- *Kozlowskia capaci* (d'Orbigny)
- *Linoproductus cora* (d'Orbigny)
- *Neospirifer condor* (d'Orbigny)
- *Orthotichia hueconiana* (Girty)
- *Rhipidomella*
- *Spiriferellina*
- *Waagenoconcha* cf. *W. montpelierensis* (Girty)
- *Wellerella texana* (Shumard)

MOLLUSCA

Gastropoda

- *Glyptotomaria (Glyptotomaria) marginata* Batten
- *Omphalotrochus obtusispira* (Shumard)
- *Straparollus (Euomphalus) cornudanus* (Shumard)

Cephalopoda

AMMONOIDS

- *Agathiceras girtyi* Bose
- *Eoasianites deciensis* (Plummer and Scott)
- *E. modestus* (Bose)
- *E. ruzencevi* Miller and Furnish
- *Metalegoceras* cf. *M. colemanense* [Miller and Furnish]
- *Neopronorites bakeri* Miller and Furnish
- *Peritrochia sellardsi* (Plummer and Scott)
- **Properrinites bosei denhami* Miller and Furnish
- **Synartinskia huecoensis* (Miller and Furnish)

POWWOW MEMBER

PROTOZOA

Foraminifera

FUSULINIDAE

- **Pseudoschwagerina beedei* Dunbar and Skinner
- **Schubertella kingi* Dunbar and Skinner
- **Schwagerina bellula* Dunbar and Skinner
- *S. emaciata* (Beede)
- **S. huecoensis* (Dunbar and Skinner)
- *S. thompsoni*? Needham
- **Triticites powwowensis* Dunbar and Skinner

AGE AND CORRELATION. Recognition of a three-fold division of the Hueco limestone first appeared in R. E. King's (1931) monograph of the brachiopods of trans-Pecos, Texas. King presented an analysis of the brachiopod fauna of the lower light gray limestone member, herein called the Hueco Canyon formation, and assigned it to the upper part of the Wolfcamp (Lenox Hills formation of Ross, 1959). Dunbar and Skinner (1937) in their monograph on the Permian Fusulinidae of Texas concluded "the lower Hueco [Hueco Canyon formation] . . . carries abundant fusulines and correlates beyond question with the Wolfcamp formation of the Glass Mountains." The common possession of a typical *Pseudoschwagerina uddeni* fauna was cited as the proof of the correlation. The work of Miller and Furnish on the ammonoids of the Hueco Canyon formation in the southern part of the Hueco Mountains gave added weight to the correlation. "The ammonoid fauna is essentially identical with that of the Wolfcamp formation [Lenox Hills formation] of the Glass Mountains and that of the Admiral formation of north-central Texas." (Miller and Furnish, 1940, p. 15)

On the basis of fusulinids, Ross (1959a, p. 100) believed the Hueco Canyon formation was probably only slightly older than the basal conglomerate of his Lenox Hills formation. The fusulinid faunal sequence of the Hueco Canyon formation is consistent with Ross's interpretation. The Hueco Canyon formation and the Lenox Hills formation possess the following fusulinid species in common: *Pseudoschwagerina beedei, P. texana (P. texana* and *P. tumidosus* of Ross), *P. uddeni (P. uddeni* and *P. robusta* of Ross), *Schwagerina bellula, S. knighti,* and *Monodiexodina linearis* [*M. bispatulata,* n. sp.]. The absence of such species as *Schwagerina extumida, S. crebrisepta, S. lineanoda, S. dispansa, S. laxissima, S. nelsoni, S. hessensis, S. diversiformis, S. compacta, S. hawkinsi, S. tersa,* species found in the upper shales and limestones of the Lenox Hills formation, indicates that the Lenox Hills and Hueco Canyon formations are not exact equivalents. The absence of any of the Glass Mountains species of *Triticites* and the scarcity of *Paraschwagerina* suggest lack of equivalence of any part of the Hueco Canyon formation with the underlying Neal Ranch formation. Lloyd (1949, p. 31) reached a similar conclusion on the basis of unpublished data. According to Lloyd, the limestones above the Powwow conglomerate (i.e., the Hueco Canyon formation) do not contain the lowermost Wolfcampian fusulinids; and the Hueco limestone is late Wolfcampian, or possibly middle and late Wolfcampian. The fusulinid fauna of the Hueco Canyon formation is restricted to the basal Powwow member and approximately 400 feet of the overlying limestone. It is concluded herein that the lower part of the Hueco Canyon formation is correlative with at least part of the time represented by the Neal Ranch-Lenox Hills unconformity and with the lower part of the Lenox Hills formation.

Correlation with the standard section is, of course, important and has received primary consideration. However the Hueco group extends some 40 miles to the north into the Sacramento Mountains of New Mexico where it interfingers with the continental beds of the Abo sandstone. The latter are devoid of marine fossils and their mutual time relations with the marine strata of the standard Wolfcampian Series can only be determined indirectly through their connections with members of the Hueco group. Tracing the well-defined faunal zones of the Hueco group into the Abo sandstone should prove helpful in this respect, but this has not yet been done. Several authors have made attempts at correlation on a purely homotaxial basis. Assuming essential equivalence of the Hueco group and the Abo sandstone, Thompson (1954, fig. 5B), Pray (1954), Pray and Otte (1954), Otte, (1959), and especially Pray (1961, p. 99-106) would treat the Powwow as a southern extension of a lower red bed tongue of the Abo; consider the middle Abo sequence of thin-bedded limestone, dolomitic limestone, and non-red shales as the northern extension of the upper Hueco Canyon-Cerro Alto-lower Alacran Mountain formations; and the Deer Mountain red shale member as the southern extension of an upper tongue of Abo red beds (see fig. 9). Bachman and Hayes (1958), who mapped a portion of the area between the southern Sacramento Mountains and the northern Hueco Mountains, dispute this interpretation, demonstrating that appreciable area of alluvial cover prevents establishment of positive correlations by lithologic continuity. The results of this investigation add little to the resolution of this controversy because of a lack of published information on the fusulinid content of the various subdivisions of the Hueco

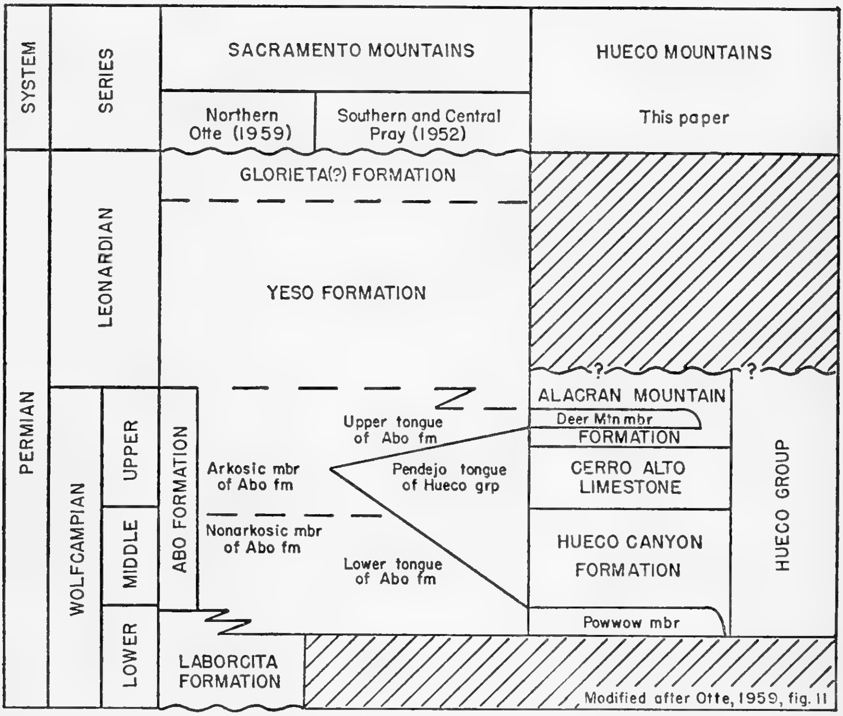

Figure 9. Age and regional correlation of the Abo formation between Sacramento and Hueco Mountains.

group north of the New Mexico-Texas State line. Work on the fusulinid faunas of this area would seem to be a promising subject for a future investigation.

Otte (1959, p. 68-69) correlates the Powwow member with the uppermost 200 feet of the Laborcita formation of the northern Sacramento Mountains on the basis of: (1) the presence of *Schwagerina* cf. *S. huecoensis* in a limestone that forms the top of the Laborcita formation; (2) the presence of *S. huecoensis* in that portion of the lower division of the Hueco limestone [Hueco Canyon formation] immediately overlying the Powwow conglomerate. It should be noted however that *S. huecoensis* occurs not only in that portion of the Hueco Canyon formation directly atop the Powwow member, but also within the Powwow; in fact, *S. huecoensis* was originally described from the Powwow. Since *S. huecoensis* first appears at the top of the Laborcita formation, the Powwow is probably younger than that portion of the Laborcita below the limestone unit bearing the *S. huecoensis* fauna.

CERRO ALTO LIMESTONE

NAME AND TYPE SECTION. The Cerro Alto limestone is named for the excellent exposures in the upper reaches of Hueco Canyon, south-southwest of Cerro Alto in the central part of the Hueco Mountains, Texas. The type stratigraphic section, exposed in the south walls of Hueco Canyon, is described below and is illustrated graphically in measured section 7 of fig. 7.

Section of Cerro Alto limestone in Hueco Canyon,
central part of Hueco Mountains, Texas.

Permian

Alacran Mountain formation

Cerro Alto limestone:	Ft
Covered except for 6 feet of medium light gray to medium gray, medium-bedded limestone at base; probably a medium gray, medium-bedded marl	28
Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding; chert nodules; fusulinids in matrix at base; poorly preserved productid brachiopods about 30 feet above base	68
Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding; scattered chert nodules	74
Covered	28
Limestone, light olive gray to olive gray, medium-bedded	17
Covered; scattered outcrops indicate medium-bedded marl with undulatory bedding	54
Limestone, medium gray, medium-bedded with thin interbedded layers of marl; undulatory bedding; poorly preserved omphalotrochid gastropods	74
Limestone, medium light gray and medium gray, medium-bedded; occasional interbeds of laminated marl	25
Covered; occasional ledges of thin-bedded limestone; probably interbedded medium light gray limestone and light olive gray marl, both medium-bedded; poorly preserved omphalotrochid and bellerophontid gastropods; somewhat prominent ledges of thin-bedded, fusulinid-bearing limestone about 8 feet above base	16
Limestone, light olive gray to olive gray, thick-bedded; undulatory bedding	40
Limestone, medium light gray to medium gray, medium- and thick-bedded; undulatory bedding; poorly preserved gastropods and pelecypods	40
Total thickness Cerro Alto limestone	464

Hueco Canyon formation.

Lithology and thickness. At the type locality, the Cerro Alto limestone consists of slightly more than 460 feet of medium light gray and medium gray, medium- and thin-bedded limestone, typically possessing undulatory bedding. Stylolites are not common and chert nodules are only locally abundant. The thickness of the Cerro Alto limestone is remarkably uniform throughout the area of investigation, showing a decrease of only 20 feet in ten miles, from a thickness of 465 feet at the New Mexico-Texas State line to a thickness of 445 feet in the canyon north of Powwow Canyon.

Distribution. The distribution of the Cerro Alto limestone parallels that of the Hueco Canyon formation on the east side of the escarpment; this is a function of its superior stratigraphic position and the gentle eastward regional dip of the Permian rocks in this area. Immediately to the east of the crest of the northern part of the Hueco Mountains, it is repeated on the east limb of a north-plunging syncline produced by the intrusion of the Red Mountain stock. A similar situation prevails northwest of Cerro Alto where strata of the Cerro Alto limestone are preserved in a doubly-plunging syncline, a consequence of the intrusion of the Cerro Alto stock.

The Cerro Alto limestone characteristically weathers to gently rounded hills. However, it crops out atop a minor escarpment trending north-northwest between Alacran Mountain and Hueco Canyon. There it is underlain by the Alacran sill and the beds are essentially flat-lying, serving, along with the lower portion of the overlying Alacran Mountain formation, as a caprock over the less resistant igneous material. The edge of the outcrop belt is migrating eastward as a consequence of slope retreat.

On the Diablo Plateau proper the Cerro Alto limestone is peripheral to Naville Mountain, an uplift presumably due to a laccolithic intrusion (King, *et al.,* 1945). It crops out at the base of Daily Hill and the Deer Mountain mesa, and underlies the edge of the plateau for some distance southeastward from the El Paso-Carlsbad highway. It also survives as remnants on some of the smaller ranges subsidiary to and immediately west of the Hueco Mountains.

The Cerro Alto formation is underlain and overlain conformably by the Hueco Canyon formation and the Alacran Mountain formation respectively. The contacts are gradually transitional.

FAUNAL LIST. With the exception of the Fusulinidae, the following list was compiled from published sources, using only localities from within the area of investigation which could be placed with reasonable certainty within the stratigraphic units as outlined herein. The identifications of the Fusulinidae are those of the author. Those species marked with an asterisk have their type locality in the Hueco Mountains.

PROTOZOA

- **Foraminifera**
  - FUSULINIDAE
    - **Schwagerina eolata* Thompson
    - **S. neolata* Thompson

BRACHIOPODA

- *Composita mexicana* (Hall)
- *Derbya buchi* (d'Orbigny)
- *Dictyoclostus inca* d'Orbigny
- *Linoproductus cora* (d'Orbigny)
- *L. villiersi* (d'Orbigny)
- *Meekella mexicana* Girty
- *Wellerella texana* (Shumard)

MOLLUSCA

- **Gastropoda**
  - *Amphiscapha (Amphiscapha) dextrata* Yochelson
  - *Glyptotomaria (Glyptotomaria) marginata* Batten
  - *Omphalotrochus obtusispira* (Shumard)
  - *Sallya bicincta* Yochelson
  - *Shansiella conica* Batten
  - *Straparollus (Euomphalus) cornudanus* (Shumard)
  - *Discotomaria nodosa* Batten
- **Pelecypoda**
  - *Astartella*
  - *Myalina*
  - *Pinna*

Age and correlation. R. E. King (1931, p. 16) recognized a middle dark gray limestone member, herein called the Cerro Alto limestone, of the Gym (Hueco) limestone, about 250 feet thick, characterized by a great abundance of gastropods and pelecypods, with a more or less impoverished brachiopod assemblage. Following analysis of this limited brachipod fauna, King correlated the Cerro Alto limestone with the Hess formation (now Hess member of the Leonard formation) of the Glass Mountains. In a graphic presentation of the evidence for this correlation, P. B. King (1934, p. 104) noted that five of the nine species of the brachiopods characteristic of the Cerro Alto limestone, were restricted to the Leonard formation in the Glass Mountains. Careful examination of King's chart reveals that three of the Leonard species of the Cerro Alto limestone brachiopod fauna *(Enteletes dumblei, Marginifera cristobalensis, Crurithyris* [*Ambocoelia*] *guadalupensis)* have only been questionably identified from the Cerro Alto limestone, and two are long-ranging forms *(Composita mexicana* and *Wellerella texana* [*Pugnoides texanus*]*)* which also occur in the underlying Hueco Canyon formation of undoubted Wolfcampian age. Thus the correlation of the Cerro Alto limestone with the Hess member of the Leonard formation on the basis of contained brachiopods is at least debatable.

In their treatment of the fusulines of the Cerro Alto limestone, Dunbar and Skinner (1937) were restricted to one collection of reasonably certain stratigraphic position. From this collection they identified *Schwagerina hessensis* and *S. hawkinsi*, forms which characterize the lower Leonard formation in the Glass Mountains. Although I was unable to relocate satisfactorily the station from which this collection was made, I did have the opportunity to restudy the original collection and to make comparisons with the type material of Dunbar and Skinner. In my opinion the specimens identified as *Schwagerina hessensis* and *S. hawkinsi* are better interpreted as falling within the range of variation exhibited by *Schwagerina neolata*, one of the two species composing the peculiar fusulinid facies fauna of the Cerro Alto limestone. It would then appear that the suggestions of a Leonard age for the Cerro Alto limestone are worthy of reconsideration.

In this regard it is unfortunate that ammonoids have not been found in the middle and upper portions of the Hueco group in the Hueco Mountains. However, northward into the Sacramento Mountains of New Mexico, the Hueco interfingers with the Abo red beds (Thompson, 1942, 1954; Lloyd, 1949; Pray, 1954, 1961; Pray and Otte, 1954; Bachman and Hayes, 1956, 1958; Otte, 1959), and the limestone forms a medial tongue in the Abo of the southern Sacramento Mountains (the Pendejo tongue of Pray, 1961, p. 104). Miller and Parizek (1948) have reported an ammonoid fauna from the Pendejo tongue a few miles south of the Sacramento Mountains in the Otero Mesa, Otero County, New Mexico. By virtue of stratigraphic position, the Pendejo tongue can be considered equivalent to the upper part of the Hueco Canyon formation and/or the Cerro Alto limestone; and such is implied in the interpretative diagram of Thompson (1954, fig. 5B) showing the relationships of Wolfcampian equivalents from the Hueco Mountains to the Sacramento Mountains. Miller and Parizek (p. 351) reached the following conclusions as to the age of these strata: "Therefore, from a study of the cephalopods alone, it can be said that although the evidence is not very conclusive, the available data seem to suggest that the ammonoid-bearing beds of the Hueco in New Mexico are slightly younger than those of the same formation [Miller and Furnish, 1940, p. 15], the lower Wolfcamp [Neal Ranch formation], and Admiral of Texas, and are probably of about the same age as the upper Wolfcamp [Lenox Hills formation] of west Texas and the Clyde formation of north-central Texas." This find is particularly significant in that the fusulinid fauna of the Cerro Alto limestone appears to be a rather specialized facies fauna, dominated by the species *Schwagerina eolata* and *S. neolata*. These species have no recognizable counterparts in the Glass Mountains section. Ross (1959a, p. 100) assigned the middle Hueco limestone (Cerro Alto formation) to some part of the Lenox Hills formation above the basal conglomerate, apparently on the basis of position in sequence. Thus, despite a lack of diagnostic fusulinids, it would seem more logical to correlate the Cerro Alto limestone with the Lenox Hills formation rather than with the overlying Leonard.

ALACRAN MOUNTAIN FORMATION

Name and type section. The Alacran Mountain formation is named for Alacran Mountain, a small mesa in the central part of the Hueco Mountains, where, except for the upper 220 feet, the unit is well exposed. The type stratigraphic section was measured on the southwest side of Alacran Mountain. The lithologic description is given below and is illustrated graphically in measured section 2 of fig. 7.

Section of Alacran Mountain formation at Alacran Mountain, central part of Hueco Mountains, Texas.

	Ft
Permian	
Alacran Mountain formation:	
Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding; fusulinids in matrix 60 feet above base	75+
Limestone, light gray to medium light gray, very thick-bedded	25
Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding; chert nodules; fusulinids in matrix at top	29
Limestone, light gray to medium light gray, very thick-bedded	10
Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding	75
Thickness of Alacran Mountain formation above Deer Mountain member	214
Deer Mountain red shale member:	
Covered; indications of reddish-brown calcareous mudrock from 30 to 65 feet above base overlain by scattered outcrops of brown marl	109
Thickness Deer Mountain red shale member	109
Alacran Mountain formation below Deer Mountain member:	
Limestone, light olive gray, thick-bedded at base becoming thin-bedded toward top	22
Covered; probably marl, light olive gray to olive gray, thick-bedded; undulatory bedding	23
Algal limestone, light olive gray, bedding not discernible; 10 feet of light olive gray to olive gray, thin-bedded limestone in middle of unit	33
Thickness Alacran Mountain formation below Deer Mountain member	78
Total thickness Alacran Mountain formation	401

Cerro Alto limestone:	
Covered; probably marl, light olive gray to olive gray, medium-bedded; bedding somewhat undulatory	31
Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding	40
Covered; probably marl, light olive gray to olive gray, medium-bedded; undulatory bedding	14
Limestone, light olive gray to olive gray, medium-bedded; silicified *Composita, Wellerella,* omphalotrochid gastropods	37+

A reference section is herein designated to supplement the type section insofar as upwards of 220 feet are missing at the type locality. The reference section is selected from one of the fault block exposures south of the Menzies Ranch headquarters, also in the central part of the Hueco Mountains. The lithologic description of the reference section is given below and is illustrated graphically in measured section 6 of fig. 7.

SECTION OF ALACRAN MOUNTAIN FORMATION SOUTH OF MENZIES RANCH HEADQUARTERS, CENTRAL PART OF HUECO MOUNTAINS, TEXAS.

Permian	
Alacran Mountain formation:	Ft
Covered; occasional ledges of olive gray, medium-bedded limestone; probably largely marl	40
Limestone, olive gray, thick-bedded	6
Interbedded light olive gray to olive gray, thin-bedded limestone, and covered intervals, probably marl, grayish orange; fusulinids in matrix 20 feet above base	54
Limestone, light olive gray, medium-bedded; fusulinids in matrix	6
Covered except for a medial 10 feet thick ledge of light olive gray to olive gray, medium-bedded limestone; probably marl, grayish orange	36
Limestone, light olive gray, medium-bedded	16
Limestone, light olive gray to olive gray, medium-bedded, undulatory bedding	27
Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding	35
Covered; probably limestone, light brownish gray to brownish gray; medium-bedded; undulatory bedding	60
Limestone, light olive gray to yellowish gray; medium-bedded; undulatory bedding	56
Limestone, light olive gray and olive gray, thick-bedded; undulatory bedding	24
Thickness Alacran Mountain formation above Deer Mountain member	360
Deer Mountain red shale member	

LITHOLOGY AND THICKNESS. The Alacran Mountain formation is very similar, both lithologically and faunally, to the Hueco Canyon formation. It has a composite thickness of approximately 622 feet. Except for the 122-foot Deer Mountain red shale member, it consists of light olive gray and olive gray, medium- and thick-bedded limestone; occasional very thick-bedded units are massive cliff-formers.

The red bed member of the Alacran Mountain formation was first described by King and King (1929, p. 923) as a tongue of the Chupadera formation extending south from New Mexico into Texas, and the name "Deer Mountain red beds" was used in a diagram illustrating correlations of Permian sections in trans-Pecos, Texas. In a later publication by R. E. King (1931, p. 16), this member was described as consisting of 150 feet of red beds in the lower part of the "upper division of the Gym limestone," exposed in the vicinity of Deer Mountain. P. B. King (1934, p. 742) recognized exposures of a bed of dark-red shale, 200 feet in thickness, in the upper member of the Hueco limestone and applied the term Deer Mountain red shale member from exposures on the mountain of that name four miles southeast of Cerro Alto. Two measured sections including the Deer Mountain member appeared (King, *et al.,* 1945) in the form of graphic sections; they were based on the exposures at Alacran Mountain and the fault block south of the Menzies Ranch headquarters.

The Deer Mountain red shale member crops out in only three places in the Hueco Mountains—Deer Mountain mesa (type locality), Alacran Mountain mesa, and in the fault blocks south of the Menzies Ranch headquarters. It is exposed in its entirety only at the mesas. Nevertheless this member represents a significant episode in the geologic history of the area, although it is defined and recognized by observable physical features rather than inferred geologic history. The exposure might lead one to believe that it is defined and recognized by *lack* of observable features. Its most salient characteristic is that it generally appears as a covered interval. At such outcrops as permit observations of its lithology, the Deer Mountain member appears to consist predominantly of a middle unit of calcareous mudrock which invariably crops out as reddish-brown soil. Light olive gray to olive gray, medium-bedded limestones, displaying undulatory bedding, compose the upper and lower portions. The lithologic description of the unit, based on exposures at the type locality, is given below.

Section of Deer Mountain red shale member of Alacran Mountain formation at Deer Mountain, central part of Hueco Mountains, Texas.

Permian	
Alacran Mountain formation:	Ft
Limestone, light olive gray, very thick-bedded	18
Limestone, light olive gray, medium-bedded; chert nodules	24
Limestone, light olive gray, very thick-bedded	15
Thickness Alacran Mountain formation above Deer Mountain member	57
Deer Mountain red shale member:	
Limestone, medium light gray, medium-bedded; undulatory bedding; chert nodules	29
Covered	55
Limestone, light olive gray to olive gray, medium-bedded; discontinuously exposed	8
Covered; probably a reddish-brown calcareous mudrock	30
Thickness Deer Mountain red shale member	122
Alacran Mountain formation below Deer Mountain member:	
Limestone, medium light gray to medium gray, medium-bedded	85
Thickness Alacran Mountain formation below Deer Mountain member	85
Total thickness Alacran Mountain formation	264

Cerro Alto limestone:

Covered; probably limestone, light olive gray, thin-bedded	70
Limestone, light olive gray, medium-bedded; undulatory bedding	40+

Distribution. Except for such localities as Alacran Mountain, Deer Mountain, and the fault blocks south of the Menzies Ranch headquarters, exposures of the Alacran Mountain formation are limited to the limestones below the Deer Mountain red shale member. For the most part these beds crop out some distance to the east of the escarpment. Some exceptions to this are: the exposures just east of the crest of the escarpment of the northern part of the Hueco Mountains in the north-plunging syncline produced by the intrusion of the Red Mountain stock; those preserved in the similarly produced doubly-plunging syncline to the northwest of the Cerro Alto stock; and the beds which, in conjunction with the Cerro Alto limestone, serve as a caprock on a minor escarpment trending north-northwest between Alacran Mountain and Hueco Canyon. The strata to the east and southeast in the Diablo Plateau are herein treated as the Hueco group—undifferentiated. Complications by faulting render untenable simple extrapolations to the east on the basis of regional strike and dip. These strata may in fact be the equivalent of the limestones above the Deer Mountain red shale member or younger (Leonardian), but I could find no evidence to bear on the matter; they are barren of fusulines.

Contacts. The Alacran Mountain formation is underlain conformably by the Cerro Alto limestone. The contact is one of gradual transition, but one which can be placed consistently in the field. The upper contact is everywhere one of disconformity, the upper beds of Alacran Mountain limestone having been removed by erosion. They are overlain by unconsolidated sediments, evidently of Quaternary age (King, *et al.,* 1945).

Faunal list. With the exception of the Fusulinidae, the following list was compiled from published sources, using only localities from within the area of investigation which could be placed with reasonable certainty within the stratigraphic units as outlined herein. The identifications of the Fusulinidae are those of the author. Those species marked with an asterisk have their type locality in the Hueco Mountains.

PROTOZA

Foraminifera

FUSULINIDAE

**Pseudoschwagerina convexa* Thompson
P. gerontica Dunbar and Skinner
P. texana Dunbar and Skinner
P. uddeni (Beede and Kniker)
Schwagerina crassitectoria Dunbar and Skinner
S. franklinensis Dunbar and Skinner
S. diversiformis Dunbar and Skinner
**S. menziesi,* n. sp.
S. nelsoni Dunbar and Skinner

BRACHIOPODA

Camarophoria hueconiana Girty
Composita mexicana (Hall)
Derbya buchi (d'Orbigny)
Dictyoclostus dartoni King
D. inca d'Orbigny
D. semistriatus (Meek)
Horridonia subhorrida rugatula (Girty)
Hustedia huecoensis King
Kozlowskia capaci (d'Orbigny)
Marginifera whitei? King
Meekella mexicana Girty
Orthotichia hueconiana (Girty)
Rhynchopora taylori Girty
Streptorynchus pygmaeum Girty
Wellerella texana (Shumard)

MOLLUSCA

Cephalopoda

NAUTILOIDS

Stenopoceras sp.

Age and correlation. Prior to formal recognition of the upper member of the Gym (Hueco limestone), P. B. and R. E. King (1929, p. 925) observed that the Gym limestone of the Diablo Plateau interfingered with red beds and gypsum of the Chupadera formation (Yeso, Glorieta, and San Andres formations) near the New Mexico-Texas State line, and that a few tongues of the red bed facies extended south of the boundary into Texas; the Deer Mountain red shale member was considered to be one such tongue. Thus even before the proposal of a threefold subdivision of the Hueco limestone, the possibility of a Leonard age for the upper Hueco was under active consideration. Coincident with its recognition as a member, R. E. King (1931, p. 16) correlated the upper light gray limestone (herein called the Alacran Mountain formation) with the Hess formation (now Hess member of the Leonard formation). The evidence for this correlation consisted mainly of the common association of the abundant and characteristic brachiopods *Composita mexicana* and *Wellerella texana,* a widespread faunal facies of the Chupadera formation (Yeso, Glorieta, and San Andres), Bone Canyon member of the Delaware Mountain formation (Bone Spring limestone), and upper Hess formation (Hess member of Leonard formation).

Dunbar and Skinner (1937) did not have access to collections from the Alacran Mountain formation and no published fusulinid studies of this unit appeared until the work of Thompson in 1954. However during that interval P. B. King (1942, p. 677) reported that the Wolfcampian genus *Pseudoschwagerina* had been collected in the limestones above the Deer Mountain red shale member. Thompson (1954, p. 19) described a fusulinid fauna from these upper limestones both at Alacran Mountain and Deer Mountain, but he noted that most of the fauna was not present in the type section of the Wolfcampian of the Glass Mountains. Its rather highly advanced aspect suggested that the upper Hueco was younger than the type Wolfcampian, although still much more similar to the subjacent Hueco faunas than to younger Permian (i.e. Leonard) faunas. For this reason and because "upper Wolfcampian rocks were removed by pre-Leonardian erosion" he proposed that the Wolfcampian Series be redefined to include the upper part of the Hueco limestone in the Hueco Mountains.

Ross (1959a, p. 100-101) concluded that the middle Hueco limestone and the lower part of the upper Hueco limestone (Cerro Alto limestone and lower Alacran Mountain formation respectively) were equivalent to that portion of the Lenox Hills formation above the basal conglomerate. He agreed that the upper part of the upper Hueco limestone above the Deer Mountain red shale member was probably younger than the fossiliferous parts of the Lenox Hills formation and admitted that it might not be represented in the Glass Mountains succession. However, he suggested the possibility of equivalence with the lower part of the Bone Spring formation (i.e. Leonard age) on the basis of: (1) the presence of *Pseudoschwagerina gerontica* in the upper part of the upper Hueco limestone in the Hueco Mountains; (2) the association of *Pseudoschwagerina gerontica* and *Schwagerina franklinensis* in the Hueco limestone of the Franklin Mountains; (3) the restriction of *Schwagerina franklinensis* to the Leonard formation in the Glass Mountains; and (4) the presence of a highly specialized *Pseudoschwagerina, P. stanislavi* (Dunbar, 1953, p. 799), in the Bone Springs formation (Leonard) of the Sierra Diablo.

The results of this investigation corroborate the findings of Thompson as to the existence of *Pseudoschwagerina gerontica, P. convexa, Schwagerina diversiformis,* and *S. nelsoni* (plus *Pseudoschwagerina texana* and *P. uddeni*) in the upper Alacran Mountain formation above the Deer Mountain member. Moreover other beds containing this fauna were discovered in a downfaulted block of the Alacran Mountain formation south of Cerro Alto (Locality 33). This assemblage is a straightforward Wolfcampian fauna, albeit slightly younger than the youngest beds of the standard section. However, a fauna consisting of *Schwagerina crassitectoria* and *S. franklinensis* (forms characteristic of the Leonard in the Glass Mountains), occurs approximately 80 feet above the *Pseudoschwagerina gerontica* fauna. Thus, it appears that the Wolfcamp-Leonard boundary lies somewhere within the upper part of the Alacran Mountain formation and is herein placed arbitrarily at the base of the unit containing the *Schwagerina crassitectoria-S. franklinensis* fauna.

The Deer Mountain red shale member has been variously interpreted as a red bed sequence of the Yeso formation (P. B. King, 1934, p. 746; Bachman and Hayes, 1956, p. 1796 and 1958, p. 698) and as a southern tongue of the Abo sandstone (P. B. and R. E. King, 1929, p. 923; P. B. King, 1942, p. 677; Pray, 1954, p. 101 and 1961, p. 105; Pray and Otte, 1954, p. 1296; Thompson, 1954, fig. 5B; Otte, 1959, fig. 11). Consequently the age assigned to the limestones above the Deer Mountain member should agree with the age of the Yeso or Abo (or vice versa). The Leonard age of the Yeso is generally accepted, but the age of the Abo has been the subject of considerable controversy. Although considered wholly Wolfcampian in the Permian correlation chart (Dunbar, *et al.,* 1960), the literature abounds with alternative proposals of an early Leonard age, in whole or in part (P. B. King, 1942, p. 674-677; R. E. King, 1945, p. 16-17; Bates, *et al.,* 1947, p. 28; Lloyd, 1949, p. 31 and *in* Jones, 1953, fig. 9). It was noted by P. B. King (1942, p. 674-677) that the assignment of a Wolfcampian age to the Abo was based on: (1) the correlation of the upper Abo of the southern Sacramento Mountains with the Deer Mountain red beds of the Hueco Mountains to the south, and (2) the premise that the limestones above those red beds contained a Wolfcampian fusulinid fauna. R. E. King (1945, p. 17) urged reconsideration of the Wolfcampian age of the Abo on the basis of well log correlations with the Leonard of the subsurface of southeastern New Mexico. Bachman and Hayes (1958, p. 696-697) quoted paleobotanical evidence for an uppermost Wolfcampian or lower Leonardian age for the upper tongue of the Abo sandstone in the southern Sacramento Mountains, preferably the latter. However, if in fact the Deer Mountain red shale member is equivalent to the upper tongue of the Abo, an uppermost Wolfcampian age would be more consistent with the regional relations of the Abo, inasmuch as the Deer Mountain member is overlain by a *Pseudoschwagerina* fauna of undoubted Wolfcampian affinities in the Hueco Mountains. In summary, the age of the upper Abo is dependent on the age of that portion of the Alacran Mountain formation which contains the Deer Mountain red shale member. The latter is overlain by a *Pseudoschwagerina* fauna and is herein interpreted as Wolfcampian, accepting Thompson's proposal to expand the limits of the Wolfcampian Series.

Correlation with the Type Wolfcampian Series

The type Wolfcampian crops out in the face of the Glass Mountains, Texas, where it was deposited in conjunction with late Pennsylvanian strata on the northern margin of the Marathon orogenic belt. Deposition along the flank of the rising Marathon Mountains produced beds which thicken and thin abruptly along strike and contain numerous facies changes and unconformities. In contrast to these conditions, the sediments of the Hueco group appear to have been deposited as an uninterrupted succession on a stable platform. Comparison of two such dissimilar environments is difficult at best, and it is not surprising that our understanding of the stratigraphic relations between the Hueco group in its type area and the standard sequence in the Glass Mountains is not one of simple equivalence. My correlations are based on comparison of the fusulinid faunas and are summarized in fig. 10.

It appears virtually certain that there are no temporal equivalents of the Neal Ranch formation in the Hueco group. Examination of the fusulinid faunal list of the Neal Ranch formation (Ross, 1959b, p. 300) disclosed only four species which are present in the Hueco Canyon formation; *Pseudoschwagerina beedei, P. texana, P. uddeni,* and *Schwagerina emaciata.* Two of these (*Pseudoschwagerina uddeni* and *Schwagerina emaciata*) are restricted to the Neal Ranch formation and the remaining two (*Pseudoschwagerina beedi* and *P. texana*) range into the overlying Lenox Hills formation. The Neal Ranch formation also includes various species of *Triticites* as important elements of its fauna whereas the Hueco Canyon fauna contains only one species of *Triticites* (*T. powwowensis*), a form transitional to the genus *Schwagerina* and quite different from those found in the Neal Ranch formation. The base of the Hueco Canyon formation is marked by a widespread regional unconformity (see figs. 4, 8), and it is probable that the site of the present Hueco Mountains was one of uplift and erosion during Neal Ranch time. Consequently the lowermost formation of the Wolfcampian Series is represented by a hiatus in the Hueco Mountains section.

The greatest measure of faunal similarity between the Hueco group and the standard section is to be found in the Lenox Hills and Hueco Canyon formations. *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula,* and *S. knighti* are common to both units (see fig. 3). Correlation of the two units is further supported by the presence of several Hueco Canyon forms (e.g. *Pseudoschwagerina uddeni* and *Monodiexodina bispatulata*) which, although not specifically identical with the remaining elements of the Lenox Hills fauna, can certainly be said to represent a comparable stage of evolution. It is true that several of the minor components of the Lenox Hills fauna are not present in the Hueco Canyon formation; this is more attributable to the diversity of the Wolfcampian fauna than to any real lack of equivalence between the two formations. According to Ross (1959a, p. 90-93), many Wolfcampian fusulinids follow definite lithotopes, and there is unquestionably a greater variety of depositional environments in the Glass Mountains section.

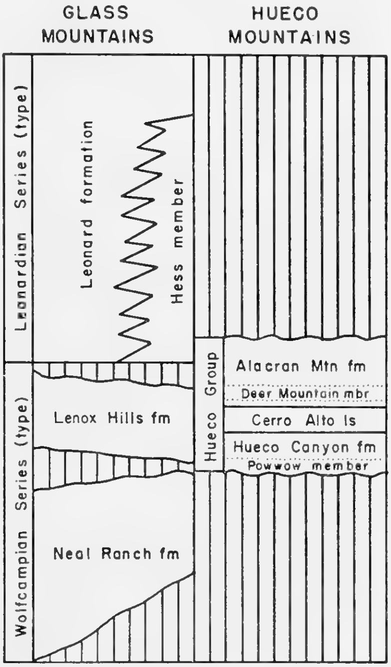

Figure 10. Correlation of Hueco group with the type Wolfcampian Series.

Correlation of the Cerro Alto limestone with the standard section is based largely on position in sequence. The fusulinid fauna of the Cerro Alto is dominated by and restricted to the species *Schwagerina eolata* and *S. neolata,* forms which have not been reported from the type Wolfcampian, nor in fact from any other areas of the North American Permian outside of the Hueco Mountains. Yet they do not represent isolated occurrences, for they are both abundant and widespread within the Cerro Alto limestone. Rather *Schwagerina eolata* and *S. neolata* appear to constitute a restricted facies fauna whose corresponding lithotope was not present in the Glass Mountains. This view is supported by the nature of their distribution within the Hueco group. It is noteworthy in this regard that the limestones of the Hueco Canyon and Alacran Mountain formations are very similar, and this similarity extends to their fusulinid faunas. The Alacran Mountain formation contains nearly all the same basic types of fusulines which are found in the Hueco Canyon formation; the fusulinid fauna of the Alacran Mountain formation differs only in having attained a higher degree of development. During deposition of the Cerro Alto limestone, the typical Wolfcampian fusulinid fauna of the Hueco Canyon formation was replaced by the

Schwagerina eolata-S. neolata fauna. This fauna persisted through Cerro Alto time, but was replaced by a younger fauna with strong Wolfcampian affinities upon the return of conditions which permitted deposition of limestone of the kind found in the Alacran Mountain formation. Thus, the Cerro Alto limestone is probably contemporaneous with the upper part of the Lenox Hills formation but does not contain any of the characteristic Lenox Hills fusuline Foraminifera because of facies control of faunas.

The fusulinids of the Alacran Mountain formation in the limestones above the Deer Mountain red shale member indicate that these strata are younger than the highest beds of the Lenox Hills formation. However, they are more closely related to the Wolfcampian than to the Leonardian Series. The presence of *Pseudoschwagerina texana, P. uddeni, Schwagerina diversiformis,* and *S. nelsoni* amply demonstrates the Wolfcampian affinities of the fauna. Moreover *Pseudoschwagerina gerontica* and *P. convexa* are obvious descendants of *Pseudoschwagerina uddeni* and *P. texana.* Both are characteristic of the Alacran Mountain formation but neither are found in the Lenox Hills formation. This suggests that the Alacran Mountain beds are slightly younger than the highest beds of the Lenox Hills formation and were no doubt deposited during the interval represented by the unconformity at the top of the Lenox Hills formation in the western Glass Mountains.

The Wolfcamp-Leonard boundary is recognized as falling within the upper part of the Alacran Mountain formation, approximately 280 feet above the Deer Mountain red shale member. Unfortunately most of the upper part of the Alacran Mountain formation has been removed by erosion; only a small portion remains preserved in a graben south of Cerro Alto (measured section 6). In beds some 80 feet above the last appearance of *Pseudoschwagerina,* one finds a fauna consisting of *Schwagerina crassitectoria* and *S. franklinensis;* both forms have been reported from the lower part of the Leonard formation (Ross, 1959a; 1960). Therefore that portion of the Alacran Mountain formation above the *Schwagerina crassitectoria-S. franklinensis* fauna is correlated with the zone of *Schwagerina crassitectoria* and is considered to be Leonardian in age.

SYSTEMATIC PALEONTOLOGY

ORDER FORAMINIFERA

FAMILY FUSULINIDAE

GENUS MONODIEXODINA Sosnina, 1956

Monodiexodina bispatulata, n. sp.

(Plate 1, figures 1-5)

DESCRIPTION. This is a slender, elongate and subcylindrical species of 8 or 9 volutions; it normally attains a length of 14 or 15 mm and a diameter of 3.0 mm. The form ratio increases steadily and rapidly with growth from about 1.5 in the first whorl to as much as 6.0 in the last. The shell is scarcely at all inflated in the middle and the polar extremities are bluntly rounded.

The proloculus normally measures between 200 and 240 microns in diameter, is very thin-walled, and is commonly somewhat distorted in shape. The early whorls also have thin walls; they increase gradually from a thickness of about 20 microns in the first whorl to about 80 microns in the seventh, maintaining a rather constant thickness from the seventh to the final whorl. The wall consists of a thin tectum and a well-defined keriotheca.

Septal folding is rather weak except near the basal margin where regular folds of adjacent septa touch, forming a pattern of cell-like chamberlets. Cuniculi are present in the outer two volutions but cannot be recognized in the earlier volutions. The restriction of the folding to near the base of the septa produces a distinctive appearance in axial section; a regularly spaced succession of low septal loops extending from each side of the tunnel to the poles. The spacing of the septa is moderately close with a total of 10 septa in the first chamber, increasing to 20 in the third, and displaying an average of 28 in the succeeding whorls. Septal pores are obscured by secondary deposits in the inner whorls but are abundant in the outer whorls. Phrenothecae were conspicuously absent in all specimens which I examined.

One of the most diagnostic features of this species is the large amount of axial filling and the striking appearance it presents in axial section. The secondary deposits are laid down irregularly along the axial zone, completely filling the chambers in this region; with increasing size of chambers the deposits are correspondingly more massive, producing a "propeller-shaped" profile, not unlike two spatulas, hence the name "bispatulata."

The tunnel is low and wide; lack of chomata renders difficult the determination of its limits and the possession of septa simple enough to be cut away at the sides of the tunnel is a further complicating factor. Thus the tunnel measurements are somewhat irregular and fail to show any noticeable trend other than a general increase in tunnel width from youth to maturity.

DISCUSSION. *Monodiexodina bispatulata* is characterized by: its size and slender, subcylindrical profile; thin walls particularly in the early whorls; regular basal septal folding; heavy and peculiarly distributed axial deposits. It most closely resembles *Monodiexodina linearis* (Dunbar and Skinner) but is larger and less cylindrical. It can be distinguished from *Schwagerina franklinensis* Dunbar and Skinner by its greater size, larger form ratio, restriction of folding to the basal margin of the septa, and possession of secondary axial deposits; from *Monodiexodina steinmanni* (Dunbar and Newell) by its less cylindrical shape, larger size, lack of chomata, and more consistent possession of axial deposits; from *Monodiexodina paralinearis* (Thorsteinsson) by its larger size, lack of chomata, and heavier and more regularly distributed axial fillings.

TABLE 1

MEASUREMENTS OF *MONODIEXODINA BISPATULATA*

	Volution	YPM 22460	YPM 22462	YPM 22463	YPM 22464
Radius vector (mm)	0	.08	.12	.09	.09
	1	.18	.26	.21	.15
	2	.26	.34	.24	.23
	3	.45	.45	.44	.35
	4	.65	.60	.65	.50
	5	.85	.80	.85	.70
	6	1.05	1.00	1.15	.90
	7	1.30	1.20	1.40	1.20
	8	1.60	1.60	—	—
Half length (mm)	0	.11	.11	.10	.10
	1	.24	.36	.44	.18
	2	.53	.64	.70	.42
	3	.80	1.10	1.25	.80
	4	1.20	1.40	2.30	1.30
	5	1.90	2.20	3.40	1.95
	6	3.00	3.30	5.40	2.90
	7	4.40	4.70	6.40	4.35
	8	6.30	—	—	—
Form ratio	1	1.3	1.4	2.1	1.2
	2	2.0	1.9	2.9	1.8
	3	1.8	2.4	2.8	2.3
	4	1.8	2.3	3.5	2.6
	5	2.2	2.7	4.0	2.8
	6	2.9	3.0	4.7	3.2
	7	3.4	3.9	4.6	3.6
	8	3.9	—	—	—
Tunnel angle (°)	1	33	21	28	26
	2	40	27	32	33
	3	58	27	47	39
	4	48	35	45	38
	5	60	40	73	38
	6	65	—	—	50
Wall thickness (mm)	0	.016	.024	.016	.008
	1	.024	.008	.024	.008
	2	.016	.016	.048	.016
	3	.032	.016	.056	.032
	4	.048	.040	.064	.040
	5	.048	.064	.072	.048
	6	.056	.072	.080	.064
	7	.080	.072	.080	.080
	8	.080	.072	—	.080
	9	.080	—	—	—

Occurrence. *Monodiexodina bispatulata* is restricted to the Hueco Canyon formation in the Hueco Mountains, Texas, where, however, it is not overly abundant (Locality 9; sec. 1, bed 19).

Genus PARASCHWAGERINA Dunbar and Skinner, 1936

Paraschwagerina shuleri, n. sp.

(Plate 2, figures 1-5)

Description. A rather large, highly ventricose species of 7 volutions, attaining a length of about 11 mm and a thickness of 5 mm. The poles are acutely pointed and the lateral slopes are convex. It displays a thick fusiform profile as a consequence of rapid inflation during growth.

The proloculus is the largest of any of the known species of *Paraschwagerina,* with a diameter of 200 to 240 microns. The juvenarium consists of 2 to 3½ rather tightly coiled, elongate volutions, followed by rapid inflation; this change in the rate of expansion produces chambers more than twice as high as those of the preceding whorls. The chamber height of the final volution is about 100 microns less than that of the penultimate. The chambers are nearly uniform in height from pole to pole. The form ratio increases from about 1.5 to 2.5 within the juvenarium and decreases to a more or less constant value thereafter.

The walls of the juvenarium are uniformly thin, ranging from 24 to 32 microns. However, the wall thickness of the remaining whorls increases steadily to a maximum of 136 microns. The wall consists of a tectum and a well-defined keriotheca. The septa in the juvenarium are intensely folded from pole to pole; the septa in the outer whorls are also marked by strong, high folds, which subdivide the chambers into rounded chamberlets. The septa appear as high loops in axial sections. Septal pores are abundant but rather fine; intense folding causes the septa to cross the slice at high angles and renders the septal pores inconspicuous in axial sections. Phrenothecae appear to be a diagnostic feature; they are present in all the specimens of the sample.

The tunnel is a moderately narrow low slit of somewhat irregular width. The absence of chomata (both in the juvenarium and succeeding whorls) renders difficult the choice of tunnel limits, but this only partially explains the lack of consistent tunnel angle values. Determination of tunnel angles from polished half-sections reveals a similar spread of values.

This species is named in honor of Dr. Ellis W. Shuler, former Professor of Geology at Southern Methodist University, in recognition of his many contributions to the paleontology of Dallas County, Texas.

Discussion. *Paraschwagerina shuleri* is characterized by its moderately large proloculus, compact and slender juvenarium, exceptional height of volutions in the outer whorls, intensity of septal folding, rudimentary chomata restricted to the outside of the proloculus, and consistent possession of phrenothecae. It can be distinguished from *P. gigantea* (White) by its larger proloculus, smaller number of volutions, more inflated form, less uniform septal fluting, and lack of chomata; from *P. kansasensis* (Beede and Kniker) by its larger proloculus, smaller number of volutions, elliptical rather than subspherical profile, lack of chomata, and consistent possession of phrenothecae; from *P. acuminata* Dunbar and Skinner by its greater size, larger proloculus, lack of chomata, and consistent possession of phrenothecae; and from *P. plena* Ross by its larger size, less abrupt change in rate of expansion, more evenly elliptical profile, possession of phrenothecae, and greater regularity of septal folding.

Occurence. *Paraschwagerina shuleri* is restricted to the Hueco Canyon formation and to date has only been found in measured section 8, bed 17. However, there are indications that it may be more widely distributed in the northern part of the Hueco Mountains.

TABLE 2

MEASUREMENTS OF *PARASCHWAGERINA SHULERI*

	Volution	YPM 22465	YPM 22466	YPM 22469	YPM 22468
Radius vector (mm)	0	.11	.09	.10	.13
	1	.18	.15	.15	.27
	2	.30	.26	.22	.39
	3	.46	.38	.39	.70
	4	.90	.75	.80	1.25
	5	1.55	1.40	1.30	1.75
	6	2.10	2.05	1.80	2.15
	7	2.50	2.45	2.20	—
Half length (mm)	0	.12	.10	.11	.12
	1	.28	.28	.24	.44
	2	.52	.52	.52	.72
	3	.90	1.00	1.05	1.30
	4	1.60	1.65	1.70	2.40
	5	2.30	2.60	2.80	3.30
	6	3.20	3.30	4.10	4.40
	7	5.10	4.80	5.10	—
Form ratio	1	1.6	1.9	1.6	1.6
	2	1.7	2.0	2.4	1.8
	3	2.0	2.6	2.7	1.9
	4	1.8	2.2	2.1	1.9
	5	1.5	1.9	2.2	1.9
	6	1.5	1.6	2.3	2.0
	7	2.0	2.0	2.3	—
Tunnel angle (°)	1	19	19	19	15
	2	21	30	44	19
	3	24	34	30	21
	4	28	23	21	17
	5	25	33	24	—
	6	—	40	—	—
Wall thickness (mm)	0	.024	.016	.016	.032
	1	.032	.024	.016	.024
	2	.032	.024	.024	.024
	3	.032	.024	.032	.040
	4	.040	.032	.032	.080
	5	.064	.064	.064	.112
	6	.096	.120	.104	.096
	7	.104	.080	.136	—

Genus PSEUDOSCHWAGERINA Dunbar and Skinner, 1936

Pseudoschwagerina beedei Dunbar and Skinner
(Plate 3, figures 1-8)

Pseudoschwagerina uddeni Needham, N. Mex. School Mines Bull. 14, pl. 10, fig. 3, 1937.
Pseudoschwagerina beedei Dunbar and Skinner, Texas Univ. Bull. 3701, p. 656-658, pl. 49, figs. 1-14, 1937.

Description. A rather small, thickly fusiform species of 5 to 6 volutions, attaining a length of 5.4 to 7.8 mm and a diameter of 3.0 to 3.8 mm. The poles are subacutely rounded. The axial profile is evenly elliptical throughout most of growth with the lateral slopes becoming slightly concave in the penultimate and final volutions. The proloculus

TABLE 3

MEASUREMENTS OF *PSEUDOSCHWAGERINA BEEDEI*

	Volution	YPM 22471	YPM 22474	YPM 22473	YPM 22477
Radius vector (mm)	0	.10	.11	.07	.10
	1	.15	.20	.10	.15
	2	.20	.30	.20	.25
	3	.50	.50	.35	.40
	4	.70	1.20	.65	.60
	5	1.60	1.85	1.20	1.10
	6	1.90	—	1.60	1.45
Half length (mm)	0	.11	.11	.08	.10
	1	.30	.30	.15	.20
	2	.60	.70	.40	.40
	3	1.00	1.40	.70	.70
	4	1.60	2.30	1.20	1.25
	5	2.70	3.70	2.20	2.10
	6	3.90	—	3.20	2.70
Form ratio	1	2.0	1.5	1.5	1.3
	2	3.0	2.3	2.0	1.6
	3	2.0	2.8	2.0	1.8
	4	2.3	1.2	1.8	2.4
	5	1.7	2.0	1.8	1.9
	6	2.0	—	2.0	1.9
Tunnel angle (°)	1	27	27	36	39
	2	30	36	33	31
	3	—	—	44	32
	4	—	—	45	—
Wall thickness (mm)	0	.016	.024	.016	.016
	1	.024	.016	.016	.008
	2	.032	.032	.032	.041
	3	.073	.057	.049	.049
	4	.073	.057	.073	.065
	5	.089	.089	.081	.073
	6	.065	—	.065	.049

is of medium size with a more or less constant diameter of about 200 microns. A well-defined juvenarium of 3 or 4 tightly coiled volutions is followed by rapid inflation in the next one-fourth volution. The next two volutions are high but the last volution declines appreciably. The chamber height is nearly uniform from pole to pole in all but the last volution where it increases somewhat toward the poles. The wall is rather thin, increasing gradually from about 30 microns in the early whorls to about 90 microns in the penultimate whorl and decreasing slightly in the final whorl. It consists of a tectum and a well-developed keriotheca. The septa are nearly plane except near the base and near the poles where they are feebly folded. The folding is more regular in the final volution but still confined to the base of the septa; this produces a regular pole-to-pole sequence of septal loops, which in conjunction with the decline in the height of the final volution (Dunbar and Skinner, 1937, p. 658), constitute criteria for the recognition of mature forms. Septal pores are abundant in the outer volutions. Chomata are present in, and confined to, the whorls of the juvenarium.

Discussion. *Pseudoschwagerina beedei* is the smallest and structurally the most primitive of the pseudoschwagerines in the trans-Pecos Texas-New Mexico Permian, and is the earliest member of a lineage composed of *Pseudoschwagerina beedei-P. uddeni-P. gerontica.* The differences between these three species are differences of degree and there exists within the Hueco limestone an almost complete sequence of transitional forms. Thus *P. beedei* is similar to *P. uddeni* (Beede and Kniker); it is distinguished by its smaller size and the presence of 3 or 4 volutions in the juvenarium versus the 1½-2 volutions in the juvenarium of *P. uddeni* (Beede and Kniker). Forms at the extremes of the range of variation in populations of these two species are not easily distinguished. *P. kozlowskii* Dunbar and Newell from the Lower Permian of Bolivia is very similar in size and shape to *P. beedei;* the authors of *P. kozlowskii* state that it is constantly somewhat more slender in the juvenile whorls. *P. needhami* Thompson also resembles this species in size and shape but is characterized by more massive chomata and more slowly expanding shell. *P. rhodesi* Thompson can be more readily differentiated from this species by its shorter, more tightly coiled juvenarium, lack of basal folding of the septa, and failure of the chamber to decline in height in the last whorl. *P. morsei* Needham differs in being consistently larger and more elongate, and in possessing a somewhat better defined juvenarium with sharply pointed poles.

Distribution. *Pseudoschwagerina beedei* was originally described from, is characteristic of, and restricted to, the Hueco Canyon formation in the Hueco Mountains; it is most abundant in the basal part of this unit. It has been reported from the upper part of the Neal Ranch formation in the Wolf Camp Hills and in the lower part of the Lenox Hills formation in the western Glass Mountains (Ross, 1959a, p. 404).

Pseudoschwagerina convexa Thompson

(Plate 4, figures 1-4)

Pseudoschwagerina convexa Thompson, 1954, Kans. Univ. Paleont. Contr., Protozoa, art. 5, p. 75-76, pl. 44, figs. 1-4; pl. 51, figs. 1-8, 1954.

Description. A rather large and evenly fusiform species of 6 or 7 volutions, commonly attaining a length of 10 or 11 mm, and a diameter of 4.5 to 5.5 mm. It has sharply pointed poles in the inner volutions of the juvenarium, but the poles of the succeeding whorls are bluntly rounded to pointed. The lateral slopes taper rather regularly but are slightly concave in the outer volutions of some specimens.

The proloculus is large with an outside diameter of 300 to 360 microns. The juvenarium consists of 3 volutions coiled rather closely. Following the juvenarium there is usually a great increase in the height of the whorls. The change is not quite so abrupt or so extreme as in *Pseudoschwagerina uddeni* and there are several forms in which the juvenaria are so indistinct that they are distinguishable only by the chomata. The last volution declines somewhat in height.

TABLE 4

MEASUREMENTS OF *PSEUDOSCHWAGERINA CONVEXA*

	Volution	YPM 22481	YPM 22480	YPM 22479	YPM 22478
Radius vector (mm)	0	.17	.18	.15	.14
	1	.30	.30	.40	.25
	2	.45	.45	.80	.50
	3	.65	.60	.55	.75
	4	1.05	.85	1.20	1.10
	5	1.80	1.15	1.70	1.70
	6	2.45	1.55	2.00	2.15
	7	—	2.00	—	—
Half length (mm)	0	.19	.19	.15	.16
	1	.30	.40	.60	.30
	2	.60	.80	1.00	.75
	3	1.10	1.20	1.60	1.20
	4	2.00	1.65	2.50	2.20
	5	3.10	2.80	3.30	4.20
	6	4.60	4.20	4.55	5.00
	7	—	5.00	—	—
Form ratio	1	1.0	1.3	1.5	1.2
	2	1.3	1.8	1.3	1.5
	3	1.7	2.0	2.9	1.6
	4	1.9	1.9	2.1	2.0
	5	1.7	2.4	1.9	2.5
	6	1.9	2.7	2.3	2.3
	7	—	2.5	—	—
Tunnel angle (°)	1	23	27	22	25
	2	20	23	22	24
	3	—	24	39	34
	4	—	23	32	29
	5	—	29	—	49
	6	—	32	—	—
Wall thickness (mm)	0	.040	.024	.024	.032
	1	.032	.032	.032	.032
	2	.032	.056	.032	.040
	3	.064	.056	.048	.032
	4	.064	.056	.080	.064
	5	.072	.072	.080	.104
	6	.104	.104	.088	.080
	7	—	.144	—	—

The wall is thicker than that of the generotype, measuring 80 to 140 microns in the outer whorls. The septa are generally strongly and somewhat regularly folded near their basal margin. Septal loops are common except in the more inflated forms (where the abundance of septal loops is more strongly influenced by the position of the slice in the chambers). Septal pores are abundant. The tunnel angle increases steadily and gradually from 20° in the first whorl to 35° in the intermediate whorls. However it is impossible to distinguish the tunnel in the outer whorls owing to restriction of chomata to the juvenarium; this difficulty is also encountered in the use of polished half sections.

Discussion. This species is distinguished by many of the same features as *P. texana* Dunbar and Skinner—size, shape, possession of a juvenarium, and restriction of chomata to the juvenarium; it also resembles *P. texana* Dunbar and Skinner in the variation in distinctness with which the juvenarium is set off by inflation of later whorls. It is distinguished from *P. texana* Dunbar and Skinner by its slightly larger size and generally better developed chomata in the juvenarium. General similarity in form and stratigraphic position indicate direct descent from *P. texana* but the apparent trend toward more massive chomata is puzzling. *P. convexa* differs from *P. montanensis* Frenzel and Mundorff in its thicker wall and more massive chomata in the inner three to four volutions, and in its shorter and inflated outer volutions. *P. convexa* differs from *P. uber* Thompson and Hazzard in its more loosely coiled outer volutions, shorter and more inflated shell, narrower tunnel and considerably larger proloculus.

Occurrence. *Pseudoschwagerina convexa* is characteristic of, and restricted to, the Alacran Mountain formation (excluding the Deer Mountain member) in the Hueco Mountains, Texas.

Pseudoschwagerina geiseri, n. sp.

(Plate 5, figures 1-3)

Description. This extremely large species attains a length of 20 mm and a diameter of 5 mm in 6 volutions. The lateral slopes are gently convex becoming somewhat concave toward the poles at maturity. The growth is commonly somewhat irregular and the poles may appear rather blunt or unsymmetrically pointed.

The proloculus is moderately large, commonly between 250 and 300 microns in diameter. The juvenarium consists of two whorls which are relatively short and thickly fusiform. There is a rapid inflation of the whorls following the juvenarium but the change is not as abrupt or as extreme as in *P. uddeni* (Beede and Kniker); it is more like that in *P. texana* Dunbar and Skinner. The last volution declines somewhat in height. Chamber height is fairly constant from the middle third of the shell to the poles. The form ratio increases gradually and regularly from 2.0-2.5 in the early whorls to as much as 3.9 at maturity.

The wall is thick, increasing from 32 microns in the first volution to a maximum of 128 microns in the later whorls. The septa are irregularly folded with only a slight concentration of folding at the base. The abundance of septal loops varies with the orientation of the thin section. Septal pores are abundant in all the inflated whorls.

The septal count varies from 16 chambers in the first volution to 24 in the fourth. Chomata are restricted to the juvenarium, becoming obsolete in the inflated whorls. The tunnel is difficult to measure in the absence of chomata but appears to range between 40° and 50°.

The species is named in honor of Dr. S. W. Geiser, Professor Emeritus of Biology at Southern Methodist University, to whom the writer is indebted for many helpful suggestions with regard to matters of zoological nomenclature.

Discussion. This species is readily distinguished from most species by virtue of its great size, particularly its extreme length. Additional distinctive characteristics include an abbreviated juvenarium and an abrupt change in rate of coiling from the latter to the inflated whorls. It is larger than *P. gerontica* Dunbar and Skinner and may be further distinguished from that species by its more slender proportions, less elevated whorls, and more strongly fluted septa. It is most like *P. texana* var. *ultima* Dunbar and Skinner but differs in being larger, more loosely coiled, with less highly fluted septa, and having a juvenarium more distinctly set off by inflation of the post-nepionic whorls. *P. montanensis* Frenzel and Mundorff is not as large and does not display the abbreviated juvenarium distinctly set off from the succeeding volutions by an abrupt change in rate of coiling.

Occurrence. *Pseudoschwagerina geiseri* is restricted to the Hueco Canyon formation and to date has only been found at Locality 8. However, there are indications that it may be more widely distributed in the northern part of the Hueco Mountains.

TABLE 5

MEASUREMENTS OF *PSEUDOSCHWAGERINA GEISERI*

	Volution	YPM 22482	YPM 22484	YPM 22587	YPM 22588
Radius vector (mm)	0	.12	.13	.10	.15
	1	.34	.38	.36	.32
	2	.50	.80	.64	.56
	3	.95	1.70	1.20	1.10
	4	1.65	2.25	1.75	1.70
	5	2.25	2.50	2.15	2.20
	6	2.60	—	—	—
Half length (mm)	0	.16	.14	.10	.18
	1	.48	.80	.90	.36
	2	1.20	1.75	1.70	1.20
	3	3.30	4.40	3.40	3.30
	4	6.60	6.30	5.90	5.15
	5	9.30	8.20	7.30	7.00
	6	9.90	—	—	—
Form ratio	1	1.3	2.1	2.5	1.1
	2	2.4	2.2	2.8	2.1
	3	3.5	2.6	2.8	3.0
	4	4.0	2.8	3.4	3.0
	5	4.1	3.3	3.4	3.2
	6	3.9	—	—	—
Tunnel angle (°)	1	22	41	—	28
	2	53	—	50	51
	3	56	55	47	35
	4	—	—	56	46
Wall thickness (mm)	0	.024	.024	.024	.024
	1	.032	.048	.032	.040
	2	.040	.056	.048	.048
	3	.064	.064	.048	.064
	4	.088	.104	.104	.104
	5	.128	.104	.088	.128
	6	.088	—	—	—

Pseudoschwagerina gerontica Dunbar and Skinner
(Plate 6, figures 1-3)

Pseudoschwagerina gerontica Dunbar and Skinner, Texas Univ. Bull. 3701, p. 660-662, pl. 51, figs. 1-6, 1937.

Thompson, Kansas Univ. Paleont. Contr., Protozoa, art. 5, p. 76-77, pl. 50, fig. 7; pl. 52, figs. 7-10, 1954.

DESCRIPTION. This species commonly attains a length of 11-12 mm and a diameter of 6 to 6.5 mm within 6 volutions, making it the largest of the American species of *Pseudoschwagerina*. In external form it is thickly fusiform, inflated in the middle, and produced into stubby nubs at the poles.

The proloculus may be described as medium to large with, however, some variation in size, ranging from 240 to 380 microns. There are generally 3 and sometimes 4 whorls in the juvenarium. The whorls of the juvenarium are rather closely coiled with moderately thick walls and well-developed chomata; the chomata are restricted to the whorls of the juvenarium. There is a very rapid inflation of the whorls following the juvenarium, such that the change to a fully inflated form takes place in less than half a volution. The two post-juvenarium volutions are very high resulting in a subglobular profile; the last volution declines notably in height and is usually disproportionately extended at the poles.

The septa are closely spaced in the juvenarium, becoming more widely spaced in the succeeding two volutions and then more closely spaced again in the final volution. The amount of septal folding is similarly distributed; close folding in the juvenarium, loose folding in the succeeding two volutions, and close folding at the base again in the final

TABLE 6

MEASUREMENTS OF *PSEUDOSCHWAGERINA GERONTICA*

	Volution	YPM 22485	YPM 22487	YPM 22486	YPM 22589
Radius vector (mm)	0	.19	.12	.13	.18
	1	.30	.25	.25	.30
	2	.55	.40	.50	.45
	3	.80	.75	.70	1.10
	4	2.10	1.70	1.75	2.30
	5	3.00	2.55	2.75	3.00
	6	—	3.25	3.40	3.30
Half length (mm)	0	.20	.13	.13	.19
	1	.40	.40	.40	.40
	2	.80	.80	.60	.70
	3	1.50	1.30	1.20	1.35
	4	3.70	2.70	3.80	2.60
	5	5.10	3.90	4.00	3.75
	6	—	5.40	5.10	4.60
Form ratio	1	1.3	1.6	1.6	1.3
	2	1.5	2.0	1.2	1.6
	3	1.9	1.7	1.7	1.2
	4	1.8	1.6	2.2	1.1
	5	1.7	1.6	1.5	1.3
	6	—	1.7	1.5	1.4
Tunnel angle (°)	1	25	—	19	16
	2	29	18	22	32
	3	41	19	—	—
	4	—	21	—	—
Wall thickness (mm)	0	.041	.024	.041	.032
	1	.024	.040	.049	.032
	2	.032	.065	.049	.041
	3	.065	.065	.041	.024
	4	.065	.065	.049	.057
	5	.130	.113	.089	.097
	6	—	.138	.105	.097

volution where septal loops are present in a rather primitive form. Comparison of the Hueco Mountain material with a sample prepared from type material reveals that the latter rather persistently displays close folding in both the penultimate and ultimate volution. Septal pores are abundant throughout the inflated whorls. The wall is moderately thick, 40-65 microns, in the juvenarium, increasing to 90-100 microns in the inflated whorls, reaching in the last whorl a thickness as great as 138 microns.

Discussion. This species is distinguished by many of the same features as *P. uddeni* (Beede and Kniker)—size, small number and extreme height of volutions, abbreviated juvenarium, and the abrupt change from the latter to the inflated whorls. It is distinguished from *P. uddeni* solely by its larger size, and in fact there are within the Hueco limestone several intermediate forms, whose assignment to either of the two species is completely arbitrary. It is a direct descendant of *P. uddeni* as shown by the similarity in form and by stratigraphic position; *P. uddeni* is characteristic of the Hueco Canyon formation and reappears in considerably fewer numbers in the Alacran Mountain formation, whereas *P. gerontica* is restricted to the latter.

Occurrence. *Pseudoschwagerina gerontica* is characteristic of, and restricted to, the Alacran Mountain formation (excluding the Deer Mountain member) in the Hueco Mountains, Texas. It is also present (type locality) in the Hueco limestone of the Franklin Mountains, Texas.

Pseudoschwagerina texana Dunbar and Skinner
(Plate 7, figures 1-4)

Schwagerina fusulinoides Beede and Kniker [not Schellwien], Texas Univ. Bull. 2433, p. 19, pl. 1, fig. 4; pl. 7, figs. 1-3, 1924.

Dunbar and Condra, Nebr. Geol. Survey Bull. 2, p. 121, pl. 14, figs. 2-5, 1927 [1928].

White, Texas Univ. Bull. 3211, p. 81, pl. 8, figs. 10-12, 1932.

Pseudoschwagerina fusulinoides Needham, N. Mex. School Mines Bull. 14, p. 51-53, pl. 8, fig. 11; pl. 9, figs. 1-4, 1937.

Pseudoschwagerina texana Dunbar and Skinner, Texas Univ. Bull. 3701, p. 662-665, pl. 52, figs. 1-8; pl. 53, fig. 9, 1937.

Thompson, Kans. Univ. Paleont. Contr., Protozoa, art. 1, p. 74-75, pl. 47, figs. 1-6, 9-10; pl. 48, figs. 1, 3-7, 9-10; pl. 50, figs. 8-9, 1954.

Pseudoschwagerina texana var. *ultima* Dunbar and Skinner, Texas Univ. Bull. 3701, p. 665-666, pl. 53, figs. 6-7, 10, 1937.

Description. Commonly a somewhat evenly fusiform species of 5 or 6 volutions with some individuals having as many as 7; length ranges from 9 to 13 mm with an average of 10 mm; diameter ranges from 3.5 to 5.0 mm with an average of 4.0 mm. The lateral slopes taper regularly to rather sharp poles.

The proloculus is commonly large with a fairly uniform diameter of 250 to 300 microns with extremes of 200 to 400 microns. The juvenarium consists of 2 to 3½ volutions coiled rather closely as in *Triticites*. Generally there is an abrupt change in the rate of increase of radius of curvature in the spiral curve of growth upon completion of the juvenarium. This is followed by volutions of fairly constant height with a slight decline in the height of the last volution. The change, however, is not quite so abrupt or so extreme as in *P. uddeni* (Beede and Kniker) and in fact within a suite of 25 axial sections of topotype material, there exists a gradational series of forms with distinct juvenaria to those in which the juvenaria can be distinguished only by the chomata. The antetheca increases in height from the middle to the ends and the ratio of length to diameter as well as axial profile change only slightly during growth, with a form ratio of 2.5 to 3.0 at maturity.

The wall is somewhat thicker than in *P. uddeni* (Beede and Kniker), showing a consistent increase from 80 to 140 microns in the outer whorls with the last whorl decreasing to 110 microns. The septa are rather strongly folded near their basal margin although

TABLE 7

MEASUREMENTS OF *PSEUDOSCHWAGERINA TEXANA*

	Volution	YPM 22491	YPM 22490	YPM 22489	YPM 22488
Radius vector (mm)	0	.14	.13	.12	.14
	1	.25	.40	.25	.40
	2	.40	.60	.45	.65
	3	.70	.85	.70	1.00
	4	1.10	1.35	1.20	1.60
	5	1.60	1.80	1.80	2.10
	6	2.00	2.25	2.15	2.40
Half length (mm)	0	.16	.14	.12	.15
	1	.50	.40	.40	.50
	2	.90	.90	.80	1.10
	3	1.70	1.45	1.50	2.50
	4	2.60	2.80	2.20	4.00
	5	3.60	3.80	3.10	5.20
	6	4.60	4.50	4.90	5.80
Form ratio	1	2.0	1.0	1.6	1.2
	2	2.2	1.5	1.8	1.7
	3	2.4	1.7	2.1	2.5
	4	2.4	2.2	1.8	2.5
	5	2.2	2.1	1.7	2.5
	6	2.3	2.0	2.3	2.4
Tunnel angle (°)	1	19	31	19	22
	2	27	19	28	23
Wall thickness (mm)	0	.032	.016	.032	.024
	1	.024	.040	.032	.040
	2	.032	.056	.064	.072
	3	.056	.072	.080	.088
	4	.088	.096	.088	.120
	5	.096	.128	.136	.144
	6	.120	.128	.112	.112

not always regularly so; opposed folds do not commonly meet. Septal loops are common in axial sections but their abundance is influenced by the position of the slice in the chambers. Septal pores are abundant in all the inflated whorls. The tunnel is very difficult to distinguish in thin sections because chomata are limited to the juvenarium.

Discussion. Intensive examination of this species, through restudy of topotype material and study of samples widespread both laterally and vertically within the Hueco limestone of the Hueco Mountains has served only to reaffirm the observations of the authors of the species: "This species displays considerable variation in its proportions and in the distinctness with which its juvenarium is set off by the inflation of the post-nepionic whorls. On the one hand there are shells relatively shorter and thicker than the types, which grade toward *P. uddeni,* and on the other hand there are some that are not easily separated from *Schwagerina huecoensis.*" It is herein distinguished from *Pseudoschwagerina uddeni* (Beede and Kniker), *P. tumidosus* Ross, *P. roeseleri* Thompson and Hazzard, *P. robusta* (Meek), *P. morsei* Needham, and *P. arta* Thompson by virtue of being more slender and elongate and in the possession of more strongly folded septa;

from *Schwagerina huecoensis* (Dunbar and Skinner) by the possession of well developed chomata in the juvenarium and, generally, an abrupt increase in the height of the whorls after about 2 to 3½ volutions. It differs from *P. beedei* Dunbar and Skinner and *P. uber* Thompson and Hazzard by its more elongate, larger shell and more intensely folded septa.

Occurrence. *Pseudoschwagerina texana* is found in both the Hueco Canyon and Alacran Mountain formations of the Hueco Mountains. It has been reported from the upper part of the Neal Ranch formation in the Wolf Camp Hills and in the Lenox Hills formation in the western Glass Mountains (Ross, 1959a, p. 413). Additional reports of the occurrence of *P. texana* include the Hueco limestone of the Franklin Mountains and the Sierra Diablo, Texas (Dunbar and Skinner, 1937); the Hueco limestone of Ash Canyon and Robledo Mountains, New Mexico (Thompson, 1954); the Gouldbusk limestone of north-central Texas and the Florence limestone of Kansas (Thompson, 1954).

Pseudoschwagerina uddeni (Beede and Kniker)

(Plate 8, figures 1-3)

Schwagerina uddeni Beede and Kniker, Texas Univ. Bull. 2433, p. 27, pl. 1, figs. 1-2, 4-7, 1924.

Dunbar and Condra, Nebr. Geol. Survey Bull. 2, p. 119, pl. 8, figs. 1-3, 1927 [1928].

[not] White, Texas Univ. Bull. 3211, p. 83, pl. 8, figs. 16-18, 1932.

Pseudoschwagerina uddeni Dunbar and Skinner, Jour. Paleontology, v. 10, p. 89, pl. 11, figs. 6-7, 1936.

Needham, N. Mex. School Mines Bull. 14, p. 54-56, pl. 9, fig. 5, [not pl. 10, figs. 1-4], 1937.

Dunbar and Skinner, Texas Univ. Bull. 3701, p. 658-660, pl. 50, figs. 1-10; pl. 53, fig. 8, 1937.

Dunbar and Newell, Am. Jour. Sci., v. 244, p. 475, pl. 7, figs. 1-5; pl. 12, fig. 8, 1946.

Thompson, Kans. Univ. Paleont. Contr., Protozoa, art. 1, pl. 11, figs. 7, 10, 1948.

Roberts, Geol. Soc. Am. Mem. 58, p. 208, pl. 40, figs. 1-2, 1953.

Thompson, Kans. Univ. Paleont. Contr., Protozoa, art. 5, pl. 43, figs. 11-15; pl. 50, fig. 6, 1954.

Description. A very large and extremely ventricose species of 5 to 6 volutions, reaching a length of 10.0 mm and a thickness of 6.5 mm at maturity. The average of specimens collected is slightly smaller. The form is not truly subspherical at any stage of growth for the poles are normally extended slightly to subacutely rounded apices.

The size of the proloculus varies from 260 to 360 microns. The juvenarium consists normally of about 2¼ relatively closely coiled volutions; it is rather thickly fusiform, with a length of about 1½ times the diameter. At the close of the juvenile stage the volution increases very rapidly in height and the change to the fully inflated form takes place in less than half a volution. The next two volutions are very high, but the height of the last volution declines again. The wall is rather thin in all but the final whorl where it thickens suddenly to about 115 microns.

The septa show very little folding except for those of the final whorl. In the penultimate and earlier whorls, the septa are frequently cut in axial sections but not as septal loops. Septal loops are present in a rather primitive form in the last whorl; the folding is confined to the base of the septa. Septal pores are abundant throughout the inflated whorls.

Narrow but well-developed chomata are present in the whorls of the juvenarium where they define a narrow tunnel. However, the chomata are completely lacking in the inflated whorls and the tunnel cannot be distinguished in axial sections. It was equally difficult to discern tunnel limits in polished half sections. Such measurements as were made suggested tunnel angles of 65° for the outer volutions.

Discussion. The type material for this species came from Hueco Canyon, Hueco

TABLE 8

MEASUREMENTS OF *PSEUDOSCHWAGERINA UDDENI*

	Volution	YPM 22492	YPM 22494	YPM 22493	YPM 22590
Radius vector (mm)	0	.17	.13	.18	.18
	1	.36	.25	.45	.30
	2	.50	.40	1.10	.50
	3	1.65	1.10	2.55	1.70
	4	2.80	2.20	3.40	2.95
	5	3.25	3.10	—	3.40
	6	—	3.60	—	—
Half length (mm)	0	.17	—	.19	.17
	1	.40	.30	.50	.35
	2	1.20	.55	1.30	.85
	3	2.30	1.90	2.30	2.30
	4	3.30	3.00	3.50	3.55
	5	4.40	4.25	—	5.05
Form ratio	1	1.1	1.2	1.3	1.2
	2	2.4	1.4	1.2	1.7
	3	1.4	1.7	.9	1.4
	4	1.2	1.4	1.0	1.2
	5	1.4	1.4	—	1.5
Tunnel angle (°)	1	26	23	46	31
	2	—	49	—	52
	3	—	—	—	—
	4	—	—	—	—
Wall thickness (mm)	0	.032	.032	.040	.024
	1	.032	.032	.048	.056
	2	.048	.048	.032	.056
	3	.040	.032	.032	.032
	4	.080	.048	.104	.048
	5	.114	.088	—	.112
	6	—	.120	—	—

Mountains, Texas. I am satisfied that I accurately relocated the stratum from which Beede and Kniker's specimens were collected, and my description of the species is based on a sample of 20 axial sections of specimens from that unit. As diagnosed by Dunbar and Skinner (1937, p. 659) this species is distinguished by its size, the small number and extreme height of its volutions, the abbreviated juvenarium, and the abrupt change from the latter to the inflated whorls. *Pseudoschwagerina uddeni* is similar to and gradationally intermediate between *P. beedei* Dunbar and Skinner and *P. gerontica* Dunbar and Skinner; it is distinguished from these species largely on size and the possession of stubby knobs at the poles; forms at the extremes of the range of variation in populations of these two species cannot be clearly differentiated. Other species resembling *P. uddeni* are: *P. texana* Dunbar and Skinner—more slender and elongate, and the septa are more strongly folded; *P. robusta* (Meek) emend. Thompson and Wheeler—possess a greater number of volutions at maturity, and with a corresponding number of volutions is slightly smaller; *P. roesleri* Thompson and Hazzard—larger juvenarium, different septal count, and large form ratio.

Occurrence. In the Hueco Mountains, Texas, this species is found through most of the Hueco Canyon formation except for the basal Powwow member; it is absent in the Cerro Alto limestone but reappears in the overlying Alacran Mountain formation in greatly reduced numbers. It has been reported from the Neal Ranch formation in the Wolf Camp Hills and at the base of Lenox Hills in the Glass Mountains, Texas (Ross, 1959a, p. 421). Additional occurrences include the Permian in eastern Sutton County, central Texas, and from the lower part of the Florence flint near Silverdale, Kansas (Dunbar and Skinner, 1937); the Permian of the central Andes (Dunbar and Newell, 1946); the Copacabana group of Peru (Roberts, 1953).

Genus SCHUBERTELLA Staff and Wedekind, 1910

Schubertella kingi Dunbar and Skinner

(Plate 9, figures 1-5)

Schubertella kingi Dunbar and Skinner, Texas Univ. Bull. 3701, p. 610-611, pl. 45, figs. 10-15, 1937.

Thompson and Wheeler, Geol. Soc. Am. Mem. 17, p. 24-25, pl. 8, figs. 6-10, 1946.

Thompson and Hazzard, Geol. Soc. Am. Mem. 17, p. 40-46, pl. 10, figs. 1-9, 1946.

Description. This is a very small species with a maximum length of only 1.4 mm at maturity. Adult specimens consist of 5 or 6 volutions and are elongate to thickly fusiform with bluntly rounded poles.

The proloculus is extremely small, ranging from 20 to 30 microns in diameter, with a maximum of 35 microns. The endothyroid juvenarium consists of 1 to 2 volutions and is rather well defined. The whorls in the juvenarium are narrow and coiled at right angles to the adult whorls.

Narrow, prominent chomata are characteristic of the outer whorls but appear to be completely lacking in the first volution. The well-developed chomata serve to delimit sharply the tunnel, and the tunnel angle increases from 20° to 30° in the second volution to 50° at maturity.

The wall is quite thin and consists of a tectum and diaphanotheca. It is 3 to 4 microns thick in the early whorls and rarely exceeds 20 microns at maturity. The septa are extremely plane and consequently no septal loops appear in axial sections.

Discussion. *Schubertella kingi* is characterized by its extremely small size, thin walls, and endothyroid juvenarium. It differs from *S. melonica* Dunbar and Skinner in being larger and thinner, and in having a more fully developed juvenarium; from *S. muellerriedi* Thompson and Miller in being smaller, with a less ellipsoidal outline.

Occurrence. *Schubertella kingi* was originally described from the Hueco Canyon formation in the Hueco Mountains, specifically from the Juan Peak section. The species is widespread both geographically and stratigraphically in the Wolfcampian of North America, having been recognized from rocks of this age in California, New Mexico, Kansas, Nebraska, Utah and north-central Texas (Thompson, 1954, p. 33).

TABLE 9

MEASUREMENTS OF *SCHUBERTELLA KINGI*

	Volution	YPM 22495	YPM 22496	YPM 22497	YPM 22498
Radius vector (mm)	0	.017	.009	—	.013
	1	.037	.037	.028	.024
	2	.063	.064	.055	.037
	3	.096	.100	.083	.064
	4	.147	.156	.138	.103
	5	.250	.193	.276	.164
	6	—	—	—	.200
Half length (mm)	0	.013	.013	—	.018
	1	.046	.055	.028	.033
	2	.083	.092	.064	.061
	3	.193	.147	.120	.100
	4	.350	.330	.248	.220
	5	.690	.710	.460	.405
	6	—	—	—	.520
Form ratio	1	1.2	1.5	1.0	1.4
	2	1.3	1.4	1.2	1.6
	3	2.0	1.5	1.4	1.6
	4	2.4	2.1	1.8	1.7
	5	2.8	3.7	1.7	2.5
	6	—	—	—	2.6
Tunnel angle (°)	1	—	—	—	—
	2	22	26	20	30
	3	32	27	35	35
	4	60	53	52	40
	5	—	—	—	42
Wall thickness (mm)	0	.004	.003	—	.003
	1	—	.003	.004	—
	2	.007	.003	.008	—
	3	.014	.005	.009	.009
	4	.016	.007	.011	.014
	5	.018	.009	.018	.018
	6	—	—	—	.018

GENUS SCHWAGERINA Möller, 1877

Schwagerina bellula Dunbar and Skinner

(Plate 10, figures 1-6)

Schwagerina bellula Dunbar and Skinner, Texas Univ. Bull. 3701, p. 643-644, pl. 63, figs. 8-18, 1937.

DESCRIPTION. This species was originally described as "a small fusiform species with neatly pointed ends and evenly convex lateral slopes attaining a length of 6 to 7.5 mm and a diameter of about 3 mm." However, a sample based on about 25 thin sections disclosed a somewhat greater range in size for a comparable number of volutions; it has a length of 7 to 9.5 mm and a diameter of 3 to 4 mm at a size of 7 to 8 volutions.

The proloculus is extremely small, seldom exceeding 140 microns in diameter. The inner whorls are low, tightly-coiled, and very thin-walled (generally about 16 microns); following this there is a rapid but gradual increase in the height of the succeeding volutions, producing rather high chambers at maturity. The height of the chambers is relatively constant from the middle of the shell to the poles, resulting in a fairly stable form ratio in the mature portion of the shell. The inner whorls are slightly more tumid

TABLE 10

MEASUREMENTS OF *SCHWAGERINA BELLULA*

	Volution	YPM 22501	YPM 22503	YPM 22502	YPM 22504
Radius vector (mm)	0	.06	.06	.02	.07
	1	.10	.10	.07	.15
	2	.15	.20	.09	.20
	3	.25	.35	.16	.35
	4	.45	.60	.25	.60
	5	.75	1.00	.50	.95
	6	1.20	1.30	.85	1.40
	7	1.70	1.70	1.20	—
Half length (mm)	0	.06	.07	.03	.07
	1	.15	.15	.06	.20
	2	.30	.30	.15	.40
	3	.55	.70	.35	.70
	4	.95	1.60	.55	1.10
	5	1.65	2.20	1.25	1.80
	6	2.50	3.30	1.95	3.00
	7	4.10	—	3.00	—
Form ratio	1	1.5	1.5	0.8	1.3
	2	2.0	1.5	1.7	2.0
	3	2.2	2.0	2.2	2.0
	4	2.1	2.7	2.2	1.8
	5	2.2	2.2	2.5	1.9
	6	2.1	2.5	2.3	2.1
	7	2.4	—	2.5	—
Tunnel angle (°)	1	23	27	21	23
	2	19	31	22	28
	3	20	—	35	24
	4	30	—	30	24
	5	22	—	33	29
	6	35	—	31	24
	7	—	—	52	—
Wall thickness (mm)	0	.016	.016	.008	.024
	1	.016	.016	.008	.016
	2	.016	.016	.008	.016
	3	.024	.040	.016	.040
	4	.036	.056	.040	.040
	5	.064	.072	.048	.096
	6	.080	.096	.080	.120
	7	.088	—	.112	—

with a form ratio of 1.5 which increases to about 2.5 at maturity. The wall thickness increases gradually from 16 microns in the first volution to 110 to 120 microns in the last. The tectum and keriotheca are well defined.

The septal folds are strong, regular and high, showing in axial section as septal loops which are high, narrow and closely crowded. Chomata are completely lacking.

DISCUSSION. This species is characterized by its small proloculus, evenly elliptical profile, low and thin-walled early whorls contrasting with thicker evenly convex outer volutions, and intense high folding of the septa. It can be distinguished from *Paraschwagerina gigantea* (White) by its smaller size and more gradual expansion; from *S. diversiformis* Dunbar and Skinner by its smaller proloculus, less pronounced development of axial filling, blunter polar extremities, and somewhat different profile; from *S. emaciata* (Beede) by its larger size, tightly coiled inner whorls, evenly elliptical profile, and stronger, higher and more regular septal loops; from *S. compacta* (White) by its less marked development of axial filling and less pronouncedly spindle-shaped profile; from *S. aculeata* Thompson and Hazzard by more tightly coiled inner whorls and a consistently smaller proloculus; from *S. munaniensis* Dunbar and Newell by its larger size, thicker wall and limited development of axial filling. It differs from *S. fax* Thompson and Wheeler only in being somewhat less inflated; I suspect that *S. fax* is but a geographic subspecies.

In a supplementary note appended to the paper containing the original description of the species, Skinner (*in* Dunbar and Skinner, 1937, p. 699), one of the authors of *S. bellula,* wrote that *S. bellula* was a synonym of a recently described species, *S. thompsoni* Needham. Comparison of a sample prepared from topotype material of *S. thompsoni* with a similar sample of *S. bellula* indicates that Skinner was in error. *S. bellula* can be readily distinguished from *S. thompsoni* by its evenly elliptical profile, smaller proloculus, high and intense septal folding, and moderate amounts of axial filling.

OCCURRENCE. *Schwagerina bellula* was originally described from, is characteristic of, and restricted to the Hueco Canyon formation in the Hueco Mountains of Texas and New Mexico. It is reported from the lower Lenox Hills formation at Leonard Mountain and in the Hess ranch horst (Ross, 1959a, p. 328).

Schwagerina crassitectoria Dunbar and Skinner
(Plate 11, figures 1-7)

Schwagerina crassitectoria Dunbar and Skinner, Texas Univ. Bull. 3701, p. 641, pl. 65, figs. 1-15, 1937.

Ross, Cushman Lab. Foram. Research Contr., v. 11, pt. 4, p. 123, pl. 17, figs. 1-9, 1960.

DESCRIPTION. This fusiform species is generally small. The largest specimen in my collections attains a length of 8.5 mm and a diameter of 3.0 mm in seven volutions and the average size is 6.0-7.0 mm in length, 2.0-2.5 mm in diameter and consists of six volutions.

The proloculus is of small to moderate size, ranging from 14 to 26 microns. The first volution is low and thin-walled, followed by progressive expansion in the succeeding whorls. The form ratio is generally near 2.5 and fails to change appreciably during growth following the second volution. The axial profile as seen in thin section approximates that of an ellipse although the arcs are usually slightly flattened in the central region; the poles are nearly rounded. The authors of the species noted a rough and irregular surface on many of the cotypes, attributing it to inequalities in the height and size of successive meridional chambers. Such irregularities could have been produced by minor crushing of the outer volutions. Thin sections of material from the Hueco Mountains, which were all prepared from fusulinids in a solid limestone matrix, failed to display this irregularity.

The septa are strongly folded and the folds extend across the entire chamber. These high and regular folds, closely spaced and displaying rounded crests in axial sections, touch at the basal margins of the septa to subdivide the lower part of the meridional chambers into cell-like chamberlets. In the lateral portions of the shell the folds overlap each other.

The wall is thin in the proloculus (8 microns) and in the first two volutions (16 microns). It increases in the succeeding whorls to a maximum of 64 microns at maturity. It consists of a tectum and well-defined keriotheca.

TABLE 11

MEASUREMENTS OF *SCHWAGERINA CRASSITECTORIA*

	Volution	YPM 22507	YPM 22508	YPM 22509	YPM 22510
Radius vector (mm)	0	.13	.09	.07	.09
	1	.22	.22	.14	.17
	2	.35	.30	.24	.29
	3	.50	.50	.40	.45
	4	.70	.75	.65	.65
	5	.95	1.00	.90	.90
	6	1.30	1.30	1.20	1.15
	7	1.50	—	—	—
Half length (mm)	0	.14	.10	.08	.09
	1	.29	.52	.29	.32
	2	.60	.90	.60	.70
	3	1.00	1.30	.90	1.00
	4	1.60	2.30	1.40	1.80
	5	2.20	2.70	1.90	2.90
	6	3.30	3.40	2.90	3.70
	7	4.10	—	—	—
Form ratio	1	1.3	2.4	2.1	1.9
	2	1.7	3.0	2.5	2.4
	3	2.0	2.6	2.3	2.2
	4	2.3	3.1	2.2	2.8
	5	2.3	2.7	2.1	3.2
	6	2.5	2.6	2.4	3.2
	7	2.7	—	—	—
Tunnel angle (°)	1	30	50	35	38
	2	23	42	40	34
	3	20	29	40	37
	4	21	32	42	40
	5	39	50	—	—
	6	45	—	—	—
Wall thickness (mm)	0	.024	.008	.016	.016
	1	.016	.016	.008	.016
	2	.016	.016	.016	.024
	3	.032	.024	.016	.032
	4	.032	.032	.032	.040
	5	.040	.064	.040	.056
	6	.048	.064	.056	.064
	7	.056	—	—	—

The tunnel angle is about 30° in the early whorls and increases irregularly in succeeding volutions to reach 50° at maturity. Chomata are not present but there is a conspicuous secondary deposit in a broad zone bordering the tunnel. This filling occupies the axial zone to the poles and is concentrated in the middle half of the shell. False inner walls (phrenothecae of Thompson, 1948, p. 15) appear sporadically among specimens from the Hueco Mountains.

Discussion. *Schwagerina crassitectoria* is characterized by a thick fusiform shape, thin walls in the early whorls, high and regular septal folds, and the possession of limited axial deposits distributed in a more or less distinctive pattern. Ross (1959a, p. 335) noted that *S. crassitectoria* and *S. guembeli* Dunbar and Skinner are closely related and that gradational forms are commonly found in the lower part of the Leonard formation; he separated *S. crassitectoria* arbitrarily on the basis of a larger form ratio and less pronounced axial fillings.

Occurrence. *Schwagerina crassitectoria* has only been found at one locality (measured section 6, bed 9) in the upper Alacran Mountain formation in the Hueco Mountains, Texas, where it is associated with *S. franklinensis* Dunbar and Skinner. According to Ross (1959a; 1960) it occurs in the lower part of the Leonard formation (where, in conjunction with *S. guembeli,* it composes the lowest zone of the Hess member) and in the upper Lenox Hills formation throughout the eastern Glass Mountains.

Schwagerina davisi, n. sp.

(Plate 12, figures 1-5)

Description. This elongate species consists of 7 volutions, with a length of 11 mm and a diameter of 3.5 mm. The lateral slopes are usually gently convex but are occasionally concave; the ends are only slightly pointed.

The proloculus is thin-walled and small, with an average diameter of 200 microns. The early whorls are thin-walled, ranging in thickness from 16 to 24 microns. Beginning with the fourth whorl, wall thickness increases steadily to maximum of 80 to 100 microns in the late volutions. The wall consists of a tectum and well-defined keriotheca.

The shell expands gradually through the first three volutions and rapidly thereafter. The form ratio increases irregularly from about 2.0 to a maximum of 3.0 at maturity. The task of measuring the half length is complicated by the presence of axial filling; it is difficult to recognize consistently the ends of the volutions. This probably explains the lack of regularity in the increase in form ratios. The height of the chambers is rather constant across the middle third of the shell but increases somewhat toward the ends.

The septal folds are strong, high and slightly irregular. The spacing of the septa is moderately close with a total of 10 chambers in the first volution increasing to 37 in the seventh volution. Phrenothecae are common in all whorls. A moderate amount of axial filling is common, although the quantity is variable.

The tunnel is narrow, the tunnel angle commonly measuring between 25° and 30°. No trace of chomata can be seen.

This species is named in honor of Mr. J. R. Davis, owner of the Davis Ranch (formerly Escontrias Ranch) in appreciation of the many courtesies extended to the writer.

Discussion. *Schwagerina davisi* is characterized by its size, sub-elliptical profile and irregular septal folds. It most closely resembles *S. aculeata* Thompson and Hazzard but has a less uniform profile, blunter ends and more loosely coiled volutions at maturity. It can be distinguished from *S. eolata* Thompson by its larger size, smaller proloculus, more rapid expansion after the first three volutions and greater irregularity of septal folds; from *S. pugunculus* Ross by a less evenly elliptical profile, blunter ends and greater irregularity of septal folds; from *S. andresensis* Thompson by a more elongate shape, basal septal folding and heavier axial filling; and from *S. bellula* Dunbar and Skinner by a less evenly elliptical profile, blunter ends, weaker and less regular septal folding, and thinner walls.

TABLE 12

MEASUREMENTS OF *SCHWAGERINA DAVISI*

	Volution	YPM 22514	YPM 22515	YPM 22516	YPM 22518
Radius vector (mm)	0	.09	.05	.08	.07
	1	.14	.09	.16	.11
	2	.21	.15	.26	.18
	3	.34	.24	.45	.26
	4	.57	.47	.65	.44
	5	.95	.75	1.00	.70
	6	1.35	1.05	1.50	1.10
	7	1.70	1.50	1.75	1.40
Half length (mm)	0	.10	.06	.10	.08
	1	.20	.18	.40	.20
	2	.56	.38	.80	.44
	3	.90	.64	1.20	.80
	4	1.40	1.30	1.80	1.30
	5	2.20	1.90	2.70	1.80
	6	3.40	3.30	4.20	2.60
	7	4.80	4.20	5.70	3.80
Form ratio	1	1.4	2.0	2.5	1.8
	2	2.7	2.5	3.1	2.4
	3	2.6	2.8	2.7	3.1
	4	2.5	2.8	2.8	3.0
	5	2.3	2.5	2.7	2.6
	6	2.5	3.1	2.8	2.3
	7	2.8	2.8	3.3	2.7
Tunnel angle (°)	1	30	24	38	30
	2	32	24	25	25
	3	25	31	25	27
	4	26	31	27	26
	5	24	25	24	25
	6	26	25	34	21
Wall thickness (mm)	0	.016	.016	.024	.016
	1	.016	.024	.024	.008
	2	.016	.024	.024	.016
	3	.024	.024	.032	.024
	4	.064	.048	.048	.040
	5	.080	.056	.080	.064
	6	.120	.072	.096	.072
	7	.080	.080	.080	.080

Schwagerina diversiformis Dunbar and Skinner

(Plate 13, figures 1-4)

Schwagerina diversiformis Dunbar and Skinner, Texas Univ. Bull. 3701, p. 647-648, pl. 60, figs. 1-7, 1937.

Thompson, Kans. Univ. Paleont. Contr., Protozoa, art. 5, p. 66-67, pl. 37, figs. 1-5, 1954.

Description. The shell is large, fusiform, and consists of from 8 to 9 volutions. It attains a length of 15-16 mm and a diameter of 4.5 mm. This species is characterized by a very distinctive profile in axial section—a straight axis of coiling with sharply pointed poles in the inner volutions and bluntly rounded poles at maturity. The central part is essentially cylindrical but the end regions have steep lateral slopes, giving a profile which Dunbar and Skinner (1937) have aptly compared to a "short, thick, sharply pointed shuttle." Whereas in the early whorls the antetheca is nearly uniform in height from pole to pole, in the later volutions the ends of the shell are rapidly elongated and the form ratio increases to anywhere from 3.1 to 3.8. The trivial name alludes to the difference in form in successive growth stages produced by this pronounced ontogenetic change. Moderate to heavy amounts of axial fillings are common and constitute one of the most distinctive features of this species; frequently the distribution of axial deposits conforms to the "shuttle" formed by the inner whorls.

The proloculus is moderately large, ranging commonly between 240 and 380 microns; it is subspherical and has a relatively thick wall. The shell expands slowly and essentially uniformly. The wall increases gradually in thickness from about 25 microns in the first volution to 120 in the penultimate whorl, decreasing to about 100 microns in the last whorl. It consists of a well-defined tectum and keriotheca.

The septa are narrowly and highly folded throughout the length of the shell; folds reach to the top of the chamber and opposed folds of adjacent septa meet to subdivide the meridional chambers into cell-like chamberlets. However cuniculi are absent. The tunnel is narrow, the tunnel angle commonly measuring between 25° and 35°. Chomata are missing. False inner walls (phrenothecae of Thompson, 1948, p. 15) appear sporadically among specimens from the Hueco Mountains.

Discussion. *Schwagerina diversiformis,* one of the largest forms of the genus, is characterized by its large size, intensely folded septa, secondary deposits in the end zone of the immature whorls, and a remarkable change in shape during development, i.e. a strong, thick, shuttle-shaped profile in the inner whorls followed by whorls which are disproportionately elongated at the poles, developing bluntly rounded and extended ends. It can be distinguished from *S. youngquisti* Thompson and Hansen by its more inflated shell, small proloculus, more tightly coiled inner volutions, more nearly cylindrical central regions, narrower tunnel and more bluntly pointed poles in the outer volutions; from *S. knighti* Dunbar and Skinner by its generally larger proloculus, distribution of secondary deposits and distinctive profile in axial section; from *S. eolata* Thompson and *S. neolata* Thompson again by its distinctive profile in axial section and also by its larger size.

Occurrence. *Schwagerina diversiformis* was originally described from the Hueco limestone of the Franklin Mountains, Texas. It is characteristic of and restricted to the Alacran Mountain formation in the Hueco Mountains, Texas. It has also been reported from upper Neal Ranch strata at Gap Tank, the Lenox Hills formation, and the lower part of the Leonard limestone in the western Glass Mountains, Texas (Ross, 1959a, p. 347).

TABLE 13

MEASUREMENTS OF *SCHWAGERINA DIVERSIFORMIS*

	Volution	YPM 22519	YPM 22520	YPM 22521	YPM 22522
Radius vector (mm)	0	.10	.14	.17	.16
	1	.17	.18	.30	.22
	2	.28	.30	.45	.45
	3	.45	.50	.70	.70
	4	.65	.80	.90	1.00
	5	.95	1.10	1.20	1.35
	6	1.30	1.40	1.60	1.75
	7	1.70	1.80	2.00	2.10
	8	2.05	2.20	2.20	2.30
Half length (mm)	0	.12	.14	.19	.18
	1	.32	.48	.60	.48
	2	.60	.75	.90	.60
	3	1.00	1.10	1.30	1.10
	4	1.20	1.50	2.00	1.90
	5	1.70	2.00	3.00	2.60
	6	2.80	2.60	3.90	3.70
	7	4.20	3.50	5.40	5.90
	8	6.30	5.30	6.80	8.80
Form ratio	1	1.9	2.7	2.0	2.2
	2	2.1	2.5	2.0	1.3
	3	2.2	2.2	1.9	1.6
	4	1.8	1.9	2.2	1.9
	5	1.8	1.8	2.5	1.9
	6	2.2	1.9	2.4	2.1
	7	2.5	1.9	2.7	2.8
	8	3.1	2.4	3.1	3.8
Tunnel angle (°)	1	39	26	—	31
	2	45	29	26	30
	3	—	28	25	25
	4	32	27	21	25
	5	24	20	23	27
	6	27	22	34	21
	7	31	34	—	—
Wall thickness (mm)	0	.016	.032	.024	.040
	1	.016	.008	.024	.024
	2	.024	.024	.024	.032
	3	.032	.048	.032	.040
	4	.032	.040	.032	.048
	5	.056	.048	.080	.088
	6	.008	.096	.096	.112
	7	.104	.120	.096	.120
	8	.072	.096	.048	.088

Schwagerina emaciata (Beede)

(Plate 14, figures 1-6)

Fusulina emaciata Beede, Ind. Univ. Studies, v. 3, no. 29, p. 14, 1916.

Dunbar and Condra, Nebr. Geol. Survey Bull. 2, 2nd ser., p. 116-117, pl. 10, figs. 1-3, 1927 [1928].

Triticites emaciata White, Texas Univ. Bull. 3211, p. 44-45, pl. 3, figs. 4-6, 1932.

Schwagerina emaciata Dunbar and Skinner, Texas Univ. Bull. 3701, p. 633-635, figs. 1-12, 1937.

[part] Thompson, Kans. Univ. Paleont. Contr., Protozoa, art. 5, p. 55-56, 1954.

[part] *Schwagerina emaciata jarillaensis* Needham, N. Mex. School Mines Bull. 14, p. 47-49, pl. 7, fig. 10; pl. 8, figs. 1-4, 1937.

[not] *Schwagerina emaciata* Needham, N. Mex. School Mines Bull. 14, p. 46-47, pl. 7, figs. 7-9, 1937.

Description. A small elongate species of 6 or 7 volutions, ranging in length from 6 to 7 mm and in thickness from 1.5 to 1.9 mm. The ends are neatly pointed in the early whorls; in some forms they are blunter in the later whorls whereas in others they are more or less pointed at maturity.

The proloculus is small, normally between 100 and 120 microns; and the whorls are rather closely coiled. The shell increases in size uniformly; form ratios generally increase steadily, averaging less than 2.0 in the early volutions and generally exceeding 3.0 at maturity. Each chamber is about uniform in height across the middle of the shell but increases in height irregularly toward the poles. The wall is thin, attaining a maximum of 55 or 65 microns in the sixth or seventh whorls. It consists of a thin tectum and a well-defined keriotheca.

The septa are strongly and more or less regularly folded; septal loops are common but are not always regularly distributed especially toward the poles. Chomata are lacking, making the tunnel difficult to delimit in the outer whorls. The tunnel angle is between 20° and 30° in the early whorls and gradually increases to about 45°.

Discussion. *Schwagerina emaciata* is one of the earliest and most primitive forms of the genus, and is distinguished by its small size, elongate fusiform shape, small proloculus, thin walls, strongly but slightly irregularly folded septa, lack of chomata, and regular rate of coiling. It is similar to *S. gracilitatis* Dunbar and Skinner but is much smaller both at corresponding whorls and at maturity; the lateral slopes are also more evenly elliptical. *S. emaciata* differs from *S. grandensis* Thompson in the possession of a smaller proloculus, absence of chomata and lack of an inflated central region; from *S. colemani* Thompson in that it has a less inflated shell, thinner walls, and gentler, less uniform lateral slopes; from *S. providens* Thompson and Hazzard by its smaller and more tightly coiled shell; and from *S. thompsoni* Needham by its larger size for a given number of volutions and thinner walls.

Occurrence. *Schwagerina emaciata* is characteristic of and restricted to the Hueco Canyon formation in the Hueco Mountains of Texas and New Mexico. It is reported from the Neal Ranch formation in the Wolf Camp Hills and at the base of the Lenox Hills formation in the Glass Mountains, Texas (Ross, 1959a, p. 351). Additional occurrences include the Hueco limestone of the Sierra Diablo, Texas (Dunbar and Skinner, 1937); the Bursum formation, Oscura Mountains, New Mexico (Thompson, 1954); the Florena shale and Cottonwood limestone throughout Nebraska, Kansas, and northern Oklahoma (Thompson, 1954); and the Coleman Junction limestone of north-central Texas (Dunbar and Skinner, 1937). This species is frequently associated with *Schubertella kingi;* the combination occurs in the Hueco limestone of both the Hueco Mountains and Sierra Diablo, the Florena and Cottonwood, and the Coleman Junction.

TABLE 14

MEASUREMENTS OF *SCHWAGERINA EMACIATA*

	Volution	YPM 22525	YPM 22523	YPM 22526	YPM 22527
Radius vector (mm)	0	.04	.05	.05	.06
	1	.07	.09	.06	.14
	2	.10	.15	.11	.24
	3	.20	.26	.16	.37
	4	.30	.41	.25	.59
	5	.50	.51	.45	.80
	6	.75	.78	.65	—
	7	—	—	.80	—
Half length (mm)	0	.05	.06	.06	.06
	1	.07	.14	.11	.18
	2	.15	.40	.18	.56
	3	.25	.68	.30	.90
	4	.60	1.00	.60	1.80
	5	1.15	1.70	1.00	2.80
	6	2.65	2.30	1.60	—
	7	—	—	2.60	—
Form ratio	1	1.0	1.6	1.8	1.3
	2	1.5	2.7	1.6	2.3
	3	1.3	2.6	1.9	2.4
	4	1.5	2.4	2.4	3.0
	5	2.3	3.3	2.2	3.5
	6	3.5	3.0	2.5	—
	7	—	—	3.2	—
Tunnel angle (°)	1	25	18	22	25
	2	27	27	24	29
	3	29	29	20	37
	4	42	44	30	46
	5	44	34	40	—
	6	—	—	40	—
Wall thickness (mm)	0	.008	.008	.008	.016
	1	.008	.016	.008	.008
	2	.008	.016	.008	.016
	3	.024	.024	.024	.032
	4	.032	.040	.032	.048
	5	.040	.048	.032	.056
	6	.056	.064	.048	—
	7	—	—	.056	—

Schwagerina eolata Thompson
(Plate 15, figures 1-6)

Schwagerina eolata Thompson, Kans. Univ. Paleont. Contr., Protozoa, art 5, pl. 36, figs. 1-8, 1954.

Description. A somewhat elongate, fusiform species of 6 to 7 volutions, attaining a length of 8 to 9.5 mm and a diameter of 2.8 to 3.5 mm. The slopes are convex to slightly concave and the ends are almost pointed.

TABLE 15

MEASUREMENTS OF *SCHWAGERINA EOLATA*

	Volution	YPM 22529	YPM 22531	YPM 22533	YPM 22534
Radius vector (mm)	0	.12	.11	.10	.15
	1	.20	.15	.20	.25
	2	.30	.25	.35	.35
	3	.55	.40	.55	.60
	4	.80	.65	.80	.85
	5	1.15	1.00	1.10	1.20
	6	1.50	1.30	1.40	1.45
	7	—	1.60	—	—
Half length (mm)	0	.14	.11	.12	.16
	1	.30	.20	.40	.50
	2	.50	.40	.70	.80
	3	1.40	1.00	1.30	1.30
	4	1.80	1.50	1.90	1.90
	5	2.70	2.20	2.60	2.60
	6	3.90	2.80	3.30	3.70
	7	4.80	4.60	—	—
Form ratio	1	1.5	1.3	2.0	2.0
	2	1.7	1.6	2.0	2.3
	3	2.5	2.5	2.4	2.2
	4	2.3	2.3	2.4	2.2
	5	2.3	2.2	2.4	2.2
	6	2.6	2.2	2.4	2.5
	7	—	2.9	—	—
Tunnel angle (°)	1	37	33	18	22
	2	30	30	44	33
	3	22	39	40	30
	4	23	31	40	32
	5	38	28	26	40
	6	—	39	37	—
Wall thickness (mm)	0	.024	.016	.024	.032
	1	.016	.016	.016	.024
	2	.016	.024	.016	.032
	3	.032	.032	.040	.048
	4	.056	.048	.056	.056
	5	.072	.104	.072	.088
	6	.056	.104	.088	.072
	7	.056	.064	.080	—

The proloculus is thin-walled and small, ranging from 200 to 300 microns in diameter. The first and second volutions are very thin-walled; the walls of succeeding volutions increase to a maximum of 104 microns in the penultimate volution followed by a slight decrease in the last volution. The wall consists of a tectum and well-defined keriothica.

The shell expands gradually and uniformly. The chambers are of constant height across the middle third of the shell but increase in height toward the ends. The form ratio increases with growth from 1.5 to 3.0 at maturity.

The septal folds are strong, somewhat regular and high, forming closed chamberlets of a height at least two-thirds of the chamber height; in axial sections the septal loops are high, narrow and rather closely crowded. The septa are thin and closely spaced. Phrenothecae are common in all but the final whorl. A moderate amount of axial filling is common, although the quantity is variable.

The tunnel is moderately wide when it can be distinguished. However, owing to a lack of chomata the limits of the tunnel are not always obvious. The measurements indicate considerable irregularity in the tunnel angle, and this is substantiated by supplementary measurements of polished axial surfaces. The tunnel angle varies between 30° and 40° with a gradual increase from youth to maturity.

Discussion. This species is distinguished by its medium-to-large size, more or less evenly elliptical profile, small proloculus, moderately thin walls and its strong, high septal folds. It resembles rather closely *Schwagerina neolata* Thompson with which it is commonly associated; however, it can be distinguished by its more elongate and slender shell, thinner wall and smaller proloculus.

Occurrence. *Schwagerina eolata* was originally described from, is characteristic of, and restricted to the Cerro Alto limestone. It has been reported only from the Hueco Mountains, Texas, where, however, it is quite abundant.

Schwagerina franklinensis Dunbar and Skinner
(Plate 16, figures 1-6)

Schwagerina franklinensis Dunbar and Skinner, Texas Univ. Bull. 3701, p. 628, pl. 66, figs. 1-11, 1937.

Description. This elongate, fusiform to subcylindrical species attains a length of 9 mm and a diameter of 3 mm in six or seven volutions. The ends are normally bluntly rounded.

The proloculus is thin-walled and quite small, generally from 80 to 100 microns in diameter. The thin-walled character of the proloculus continues through the early whorls, which seldom exceed 24 microns before the third volution. The early whorls are closely coiled, but succeeding volutions show a gradual and progressive increase in the height of the chambers with a concomitant increase in form ratio from 1.5-2.5 in the early whorls to 3.5 at maturity. The profile in axial section is reminiscent of that of *Schwagerina diversiformis* but on a smaller scale and less pronouncedly developed. Following the closely coiled inner whorls, the central part is essentially cylindrical with moderately steep lateral slopes on the end regions (i.e. shuttle-shaped). Not infrequently the spiral wall is lightly bent inward at the midplane.

The wall thickness ranges from 8 to 16 microns in the early whorls, generally increasing to 48 microns in the fourth volution, and thickening to as much as 64 microns in the final volution. It consists of a tectum and a well-developed keriotheca.

The septal folds are strong but irregular in size. However, the folding is not consistently developed in the upper portions of the septum and the septal loops of axial sections vary in size and height. The concentration of septal loops diminishes from the pole to the center, indicating that the septum does not parallel the axis of coiling but instead is somewhat concave in the direction of growth.

Lack of chomata renders the tunnel rather inconspicuous in axial sections. Its limits are difficult to recognize but measurements from polished axial surfaces suggest an average

TABLE 16

MEASUREMENTS OF *SCHWAGERINA FRANKLINENSIS*

	Volution	YPM 22535	YPM 22536	YPM 22537	YPM 22538
Radius vector (mm)	0	.05	.08	.08	.09
	1	.14	.13	.16	.14
	2	.20	.21	.25	.24
	3	.35	.35	.40	.40
	4	.50	.60	.65	.60
	5	.75	.90	.85	.80
	6	1.05	1.15	1.15	—
	7	1.40	—	—	—
Half length (mm)	0	.06	.09	.09	.10
	1	.20	.16	.29	.35
	2	.50	.64	.70	.90
	3	.60	1.20	1.30	1.35
	4	1.40	1.70	2.00	2.00
	5	2.20	2.50	2.80	3.20
	6	3.00	3.90	—	—
	7	4.30	—	—	—
Form ratio	1	1.4	1.2	1.8	2.5
	2	2.5	3.0	2.8	3.7
	3	1.7	3.4	3.2	3.4
	4	2.8	2.8	3.1	3.3
	5	2.9	2.8	3.3	4.0
	6	2.9	3.4	—	—
	7	3.0	—	—	—
Tunnel angle (°)	1	51	63	46	51
	2	41	44	63	45
	3	40	45	38	40
	4	26	28	50	49
	5	29	40	—	31
	6	44	—	—	—
Wall thickness (mm)	0	.008	.008	.008	.016
	1	.016	.008	.008	.016
	2	.016	.016	.016	.016
	3	.016	.024	.024	.008
	4	.024	.048	.048	.032
	5	.032	.048	.042	.048
	6	.048	.064	.042	.048
	7	.056	—	—	—

tunnel angle of 40°. There is no clearly discernible change in tunnel angle from youth to maturity. The axial zone is commonly faintly clouded by secondary shell material but the deposit is never strong and is irregular and inconstant.

Discussion. This species is characterized by a small proloculus, low and thin-walled early volutions, a somewhat "shuttle-shaped" axial profile, and walls of medium thickness in the outer volutions. It can be distinguished from *Schwagerina huecoensis* (Dunbar and Skinner) by the smaller proloculus, the low and thin-walled early volutions which appear more slender and less inflated, and by spiral walls which are thinner at all stages of growth; from *Schwagerina diversiformis* Dunbar and Skinner by its small proloculus, small size, thinner walls, less regularly folded septa and smaller volume of axial fillings; from the larger forms of *Schwagerina emaciata* (Beede) by its distinctive axial profile and possession of limited axial deposits; and from *Schwagerina gracilitatis* Dunbar and Skinner by higher and more closely spaced septal folds.

Occurrence. *Schwagerina franklinensis* has been found only at one locality (measured section 6, bed 9) in the upper Alacran Mountain formation in the Hueco Mountains, Texas, where it is associated with *S. crassitectoria*. It was originally described from the Hueco limestone of the Franklin Mountains, Texas. According to Ross (1959a, p. 358) it occurs in the lower part of the Leonard formation in the central and eastern Glass Mountains, Texas, and in the uppermost part of the Lenox Hills formation at Dugout Mountain (western Glass Mountains).

Schwagerina aff. *S. grandensis* Thompson

(Plate 17, figures 1-4)

Description. An elongate-fusiform species of about 6 volutions, attaining a length of 9 mm and a diameter of 4 mm. The central area is somewhat inflated and the lateral slopes are slightly concave, terminating in pointed poles.

The proloculus is of medium size with a fairly constant diameter of 200 microns. The shell increases in size uniformly; form ratios generally increase steadily from 1.5 in the early volutions to 3.2 at maturity. The chambers are lowest in the middle third of the shell, increasing in height toward the poles. The wall is thin in the early whorls but thickens with growth to a maximum of 104 microns. The wall consists of a tectum and a well-defined keriotheca.

The septa are strongly and more or less regularly folded; the folding extends nearly to the top of the chamber. The tunnel is well defined despite the absence of chomata. It is narrow in the early whorls but gradually widens.

Discussion. Lack of an adequate sample precludes the description of this form as a new species. It most closely resembles *Schwagerina grandensis* Thompson especially in general size, diameter of proloculus, and degree of septal folding, but it has a significantly different profile in that the central region is not as inflated nor are the lateral slopes as pronouncedly concave.

Occurrence. *Schwagerina* aff. *S. grandensis* is found in the Hueco Mountains at Locality 1 in association with *Triticites* cf. *T. cellamagnus* Thompson and Bissell in the upper member of the Magdalena limestone, in what are referred to herein as the Bursum beds.

TABLE 17

MEASUREMENTS OF *SCHWAGERINA* aff. *S. GRANDENSIS*

	Volution	YPM 22541	YPM 22542	YPM 22543	YPM 22544
Radius vector (mm)	0	.10	.10	.10	.11
	1	.16	.15	.16	.29
	2	.27	.25	.26	.43
	3	.45	.45	.45	.75
	4	.70	.75	.75	1.10
	5	.95	1.10	1.05	1.30
	6	1.25	1.40	—	—
Half length (mm)	0	.10	.10	.10	.10
	1	.20	.24	.24	.48
	2	.65	.48	.48	1.30
	3	1.20	1.00	.95	2.40
	4	1.70	1.80	1.95	3.60
	5	3.50	2.80	3.30	4.10
	6	4.00	3.70	—	—
Form ratio	1	1.3	1.6	1.5	1.7
	2	2.4	1.9	1.8	3.0
	3	2.7	2.2	2.1	3.2
	4	2.4	2.4	2.6	3.3
	5	3.7	2.5	3.1	3.2
	6	3.2	2.6	—	—
Tunnel angle (°)	1	15	16	23	32
	2	22	21	28	34
	3	30	23	36	42
	4	44	44	50	—
	5	54	45	—	—
Wall thickness (mm)	0	.008	.016	.016	.016
	1	.016	.008	.016	.016
	2	.032	.024	.032	.024
	3	.048	.056	.048	.056
	4	.064	.080	.064	.072
	5	.088	.104	.080	.096
	6	.104	.080	—	—

Schwagerina huecoensis (Dunbar and Skinner)

(Plate 18, figures 1-4)

Pseudofusulina huecoensis Dunbar and Skinner, Am. Jour. Sci., v. 222, p. 257-258, pl. 1, figs. 4-6b, 1931.

Thompson, Kans. Univ. Paleont. Contr., Protozoa, art. 1, pl. 12, figs 5-7, 1948.

Schwagerina huecoensis, Dunbar and Skinner, Texas Univ. Bull. 3701, p. 627-628, pl. 57, figs. 1-9, 1937.

[not] Needham, N. Mex. School Mines Bull. 14, p. 49-50, pl. 8, figs. 5-6, 1937.

Description. An elongate-fusiform species of 6 or 7 volutions, attaining a length of 13

TABLE 18

MEASUREMENTS OF *SCHWAGERINA HUECOENSIS*

	Volution	YPM 22549	YPM 22550	YPM 22551	YPM 22552
Radius vector (mm)	0	.16	.13	.14	.15
	1	.44	.34	.37	.32
	2	.70	.60	.60	.50
	3	1.00	.90	.90	.75
	4	1.40	1.20	1.25	1.05
	5	1.90	1.55	1.60	1.40
	6	2.20	1.95	1.90	1.80
	7	—	2.30	—	2.00
Half length (mm)	0	.16	.15	.13	.16
	1	.60	.46	.64	.52
	2	1.20	1.00	1.10	.90
	3	1.80	1.50	2.20	1.60
	4	3.00	2.40	3.70	2.50
	5	5.20	3.30	5.20	3.80
	6	6.90	5.50	7.40	5.80
	7	—	6.90	—	6.60
Form ratio	1	1.5	1.4	1.7	1.6
	2	1.7	1.7	1.8	1.8
	3	1.8	1.7	2.4	2.1
	4	2.1	2.0	2.9	2.4
	5	2.7	2.1	3.2	2.7
	6	3.1	2.8	3.9	3.2
	7	—	3.0	—	3.3
Tunnel angle (°)	1	—	23	20	16
	2	18	22	26	20
	3	32	23	41	33
	4	25	35	33	42
	5	61	34	42	47
Wall thickness (mm)	0	.016	.016	.016	.032
	1	.048	.040	.032	.040
	2	.064	.064	.080	.064
	3	.080	.088	.080	.072
	4	.096	.088	.136	.104
	5	.104	.120	.136	.112
	6	.088	.120	.072	.112
	7	—	.072	—	.096

to 15 mm and diameter of 4.0 to 4.5 mm. The axial profile is one of a slender ellipse in the inner whorls; the height of each chamber is uniform from the center to the poles. In the outer whorls the height of each chamber increases toward the poles, thus the axial profile is blunter at the ends.

The proloculus is fairly large, commonly measuring 280 to 320 microns; it is rather thick-walled and slightly subspherical. The early whorls are short and thickly fusiform; they become increasingly elongate with growth. Expansion of the whorls is gradual and moderately rapid. The form ratio increases steadily from about 1.5 in youth to anywhere from 3.0 to 3.9 at maturity. Wall thickness also increases gradually with growth from 40 microns in the first volution to a maximum of 140 microns in the fifth and sixth volutions; the final volution is generally somewhat thinner.

The septal folds are high and strong; they meet basally in adjacent septa to form regular cell-like chamberlets. Abundant high septal loops appear in axial sections. Septal pores are coarse and abundant. Very feeble chomata are recognizable only on the outside of the proloculus and are absent in the remainder of the shell.

The tunnel is of moderate width and the tunnel angle does not increase appreciably in successive whorls (from about 20° in youth to 40° at maturity). Lack of chomata renders difficult the delimitation of the tunnel in the outer whorls. Variable but slight amounts of axial filling are common. Phrenothecae were persistently present to some degree in all specimens which I examined.

Discussion. *Schwagerina huecoensis* is characterized by its size, ontogenetic change in shape, strong and high septal folds, gradual and moderately rapid expansion, and persistent presence of phrenothecae. It can be distinguished from *S. franklinensis* Dunbar and Skinner by its large size, large proloculus, thicker walls, and short, thickly fusiform shape of early whorls. Although normally it is readily distinguishable from *Pseudoschwagerina texana* Dunbar and Skinner by its gradual and moderately rapid expansion, there are forms of the latter in which the juvenarium is very indistinctly set off by inflation of the post-nepionic whorls; such forms are not easily separated from *Schwagerina huecoensis.*

Occurrence. *Schwagerina huecoensis* was originally described from, and is restricted to, the Hueco Canyon formation in the Hueco Mountains, Texas; however, it is by no means common within that unit.

Schwagerina knighti Dunbar and Skinner

(Plate 19, figures 1-4)

Schwagerina knighti Dunbar and Skinner, Texas Univ. Bull. 3701, p. 648-650, pl. 81, figs. 11-14, 1937.

Description. The shell consists of 9 to 10 volutions, attains a length of 12 mm and a diameter of 4.5 to 5 mm. It is strongly inflated at the middle with somewhat acutely extended poles. The lateral slopes may be slightly convex.

The proloculus is small but displays considerable variation in size, ranging from 80 to 240 microns. The early whorls are low, tightly coiled and thin-walled; these are followed by the development of an evenly elliptical profile among the intermediate whorls as shown by the abrupt reduction in the form ratio; the form ratio then increases to about 2.5 reflecting the elongate profile which characterizes the outer whorls. The height of the chambers is more or less constant from pole to pole in the intermediate whorls; however, the height of the chambers increases toward the poles in the outer whorls. Wall thickness increases gradually from a minimum of 8 microns in the inner volutions to a maximum of 152 microns in the penultimate volution; the wall of the last volution is invariably somewhat thinner.

Septal folds are strong, regular and high as evidenced by the high, narrow and closely crowded septal loops in axial sections. Chomata are completely lacking but a limited amount of axial filling is not infrequent. The tunnel angle is narrow, ranging from 20° to 30° and showing no systematic increase with growth; this may be in part due to the difficulty in measuring the tunnel angle in the absence of chomata. Phrenothecae appear sporadically among the specimens from the Hueco Mountains.

Discussion. This species is characterized by its small-to-medium proloculus, large size, ontogenetic change in shape, limited amount of axial filling and intense, high septal folding. It can be distinguished from *S. bellula* Dunbar and Skinner only by its larger size; such close morphologic similarity plus its stratigraphic position (appears in the Hueco Mountains section after *S. bellula*) suggests direct descent. *S. knighti* differs

TABLE 19

MEASUREMENTS OF *SCHWAGERINA KNIGHTI*

	Volution	YPM 22553	YPM 22554	YPM 22555	YPM 22556
Radius vector (mm)	0	.11	.12	.04	.04
	1	.18	.21	.07	.09
	2	.30	.30	.11	.14
	3	.60	.70	.20	.20
	4	1.05	1.20	.35	.35
	5	1.50	1.60	.70	.60
	6	1.90	2.00	1.00	.90
	7	2.30	2.45	1.40	1.30
	8	—	—	1.70	1.75
	9	—	—	2.10	2.20
	10	—	—	—	2.50
Half length (mm)	0	.13	.13	.05	.05
	1	.30	.28	.06	.12
	2	.60	.60	.25	.28
	3	1.20	1.10	.50	.40
	4	1.70	1.80	.80	.70
	5	2.50	2.90	1.30	.90
	6	4.30	3.90	1.80	1.40
	7	6.00	5.50	3.00	2.30
	8	—	—	4.10	3.40
	9	—	—	5.10	4.70
Form ratio	1	1.7	1.3	.9	1.3
	2	2.0	2.0	2.3	2.0
	3	2.0	1.6	2.5	2.0
	4	1.6	1.5	2.3	2.0
	5	1.7	1.8	1.9	1.5
	6	2.3	2.0	1.8	1.6
	7	2.6	2.2	2.1	1.8
	8	—	—	2.4	1.9
	9	—	—	2.4	2.1
Tunnel angle (°)	1	49	45	29	25
	2	55	35	30	26
	3	37	25	42	26
	4	19	20	70	23
	5	21	28	—	28
	6	27	24	17	23
	7	—	—	19	16
	8	—	—	29	25
	9	—	—	—	30
Wall thickness (mm)	0	.024	.032	.008	.008
	1	.016	.024	.008	.008
	2	.032	.048	.008	.008
	3	.056	.056	.016	.016
	4	.096	.120	.040	.032
	5	.120	.128	.080	.048
	6	.136	.136	.088	.080
	7	.104	.096	.128	.088
	8	—	—	.152	.112
	9	—	—	.152	.104
	10	—	—	—	.072

from *S. diversiformis* Dunbar and Skinner in the possession of a generally smaller proloculus, and an evenly elliptical profile in the inner volutions; from *S. nelsoni* Dunbar and Skinner in having a smaller proloculus, a larger number of whorls and a limited amount of axial filling. *S. compacta* (White) is smaller, differently shaped and has its axial deposits in a broad belt in each end zone as well as along the axis.

OCCURRENCE. *Schwagerina knighti* is restricted to the Hueco Canyon formation in the Hueco Mountains, Texas. It was originally described from the Hueco limestone, Sierra Diablo, Texas (Dunbar and Skinner, 1937), and Ross (1959a, p. 376) reports it from the Lenox Hills formation in the western Glass Mountains (plus some questionably assigned specimens from the Leonard formation of the central Glass Mountains).

Schwagerina menziesi, n. sp.

(Plate 20, figures 1-6)

DESCRIPTION. An elongate-fusiform species of about 7 volutions, attaining a length of 14 mm and a diameter of 2.5-3.5 mm. The shell is thickest at the middle, and the lateral slopes are gently convex as they converge toward the somewhat rounded ends.

The proloculus is moderately large, ranging commonly between 250 and 300 microns; it is more or less spherical and thin-walled. The shell expands slowly and uniformly accompanied by a progressive increase in form ratio from 2.0 in the early chambers to 4.0 at maturity. The chambers are essentially uniform in height throughout their length with a slight increase in height toward the poles.

The septa are strongly and regularly folded from pole to pole. The folding appears to be restricted to the lower half of the septa as shown by the distribution of the septal loops. The folds of adjacent folds touch near the basal margin, forming a pattern of rounded cell-like chamberlets, and at times almost constitute cuniculi. Phrenothecae are common in all but the final whorl. A moderate axial filling occupies much of the end zone of the early whorls, coating the walls and partly or completely filling the chambers.

The wall is composed of a tectum and a thin but coarsely alveolar keriotheca. The wall thickens gradually from 16 microns in the proloculus to as much as 56 microns in the penultimate volution and thins again to 32 microns in the final volution.

Owing to a lack of chomata, the tunnel is distinguished only with difficulty. However, supplementary measurements made on polished axial surfaces indicate a general increase in tunnel angle from 25° in the early volutions to as much as 50° at maturity. The septa are resorbed for approximately one-third the chamber height to form the tunnel.

This species is named in honor of Mr. Russell Menzies, owner of the Menzies Ranch (formerly Helms Ranch) in appreciation of the many courtesies extended to the writer.

DISCUSSION. *Schwagerina menziesi* is characterized by its moderately large size, large proloculus, highly elongate profile with gently convex lateral slopes, and regular basal septal folding. It can be distinguished from *S. aculeata* Thompson and Hazzard and *S. andresensis* Thompson by its larger size, larger proloculus, more elongate profile, less uniform profile, less highly folded septa, and restriction of septal loops to basal margin; from *S. campensis* Thompson and *S. pinosensis* Thompson by its tighter coiling, regular septal folding confined to basal margin and the persistent presence of phrenothecae; from *S. eolata* Thompson by its more slender elongate shape, flatter lateral slopes, blunter ends and thinner walls; and from *S. franklinensis* Dunbar and Skinner by its larger size, larger proloculus and lack of "shuttle-shaped" profile in the inner whorls.

OCCURRENCE. *Schwagerina menziesi* is restricted to the upper portion of the Alacran Mountain formation. More specifically it occurs some 15 feet below a *Schwagerina crassitectoria-S. franklinensis* fauna, herein considered to mark the Wolfcamp-Leonard boundary. It is found in a downfaulted block south of Cerro Alto (measured section 6, bed 8) in the youngest beds of the Alacran Mountain formation yet remaining in the Hueco Mountains.

TABLE 20

MEASUREMENTS OF *SCHWAGERINA MENZIESI*

	Volution	YPM 22557	YPM 22558	YPM 22560	YPM 22561
Radius vector (mm)	0	.10	.12	.12	.15
	1	.22	.22	.20	.23
	2	.35	.38	.34	.38
	3	.49	.58	.52	.60
	4	.70	.75	.70	.80
	5	.90	1.05	.95	1.20
	6	1.15	1.35	1.20	1.50
	7	1.30	1.60	—	—
Half length (mm)	0	.13	.13	.16	.15
	1	.48	.44	.34	.34
	2	.85	.90	.88	.80
	3	1.60	1.60	1.60	1.35
	4	2.90	1.90	2.10	2.00
	5	3.90	3.10	3.10	3.10
	6	4.50	4.50	4.80	4.40
	7	5.70	5.60	—	—
Form ratio	1	2.2	2.0	1.7	1.5
	2	2.4	2.4	2.6	2.1
	3	3.3	2.8	3.1	2.3
	4	4.1	2.5	3.0	2.5
	5	4.3	3.0	3.2	2.6
	6	3.9	3.3	4.0	2.9
	7	4.4	3.5	—	—
Tunnel angle (°)	1	53	31	49	25
	2	35	33	39	47
	3	34	34	35	34
	4	58	29	36	33
	5	61	37	—	—
Wall thickness (mm)	0	.016	.024	.016	.024
	1	.016	.016	.024	.024
	2	.024	.024	.024	.024
	3	.032	.032	.032	.024
	4	.040	.040	.032	.032
	5	.040	.040	.048	.040
	6	.056	.048	.056	.056
	7	.032	.032	—	—

Schwagerina neolata Thompson
(Plate 21, figures 1-5)

Schwagerina neolata Thompson, Kans. Univ. Paleont. Contr., Protozoa, art. 5, pl. 36, figs. 9-15, 1954.

Description. A somewhat inflated fusiform species of 6 to 7 volutions, attaining a length of 8 to 11 mm and a diameter of 3.5 to 4.5 mm. The slopes are convex to slightly concave and the ends are almost pointed except in the final volutions where they are bluntly rounded.

The proloculus is thin-walled and generally small (200 to 240 microns), although proloculi with diameters of 250 microns are not infrequent. The walls of succeeding volutions increase to maxima of 95 to 105 microns in the penultimate volution followed by a slight decrease in the thickness of the last volution. The wall consists of a tectum and a well-defined keriotheca.

TABLE 21

MEASUREMENTS OF *SCHWAGERINA NEOLATA*

	Volution	YPM 22564	YPM 22563	YPM 22565	YPM 22567
Radius vector (mm)	0	.11	.11	.12	.11
	1	.25	.20	.30	.25
	2	.40	.40	.50	.50
	3	.70	.70	.80	.80
	4	1.00	1.10	1.25	1.05
	5	1.40	1.50	1.60	1.50
	6	1.80	1.90	1.90	1.80
	7	—	2.45	—	—
Half length (mm)	0	.12	.13	.13	.12
	1	.25	.60	.50	.50
	2	1.10	1.10	.90	.80
	3	1.50	1.90	1.50	1.40
	4	2.20	2.50	2.40	2.10
	5	3.40	3.10	3.50	2.80
	6	5.40	4.50	4.30	3.70
	7	—	5.80	—	—
Form ratio	1	1.0	3.0	1.7	2.0
	2	2.7	2.7	1.8	1.6
	3	2.1	2.7	1.9	1.7
	4	2.2	2.3	1.9	2.0
	5	3.1	2.1	2.2	1.9
	6	3.0	2.4	2.3	2.1
	7	—	2.4	—	—
Tunnel angle (°)	1	31	46	49	30
	2	40	48	42	31
	3	28	45	27	21
	4	21	19	24	18
	5	34	36	50	23
	6	—	43	—	—
Wall thickness (mm)	0	.032	.024	.032	.032
	1	.032	.024	.032	.032
	2	.040	.040	.040	.048
	3	.056	.056	.064	.042
	4	.063	.056	.096	.042
	5	.104	.096	.104	.088
	6	.096	.096	.088	—
	7	—	.064	—	—

The shell expands gradually and uniformly. The chambers are closely similar in height throughout their length in the inner four or five volutions, becoming somewhat higher at the polar ends of the outer volutions.

The septal folds are strong, somewhat regular and high, forming closed chamberlets of a height at least two-thirds of the chamber height; in axial sections the septal loops are high, narrow and rather closely crowded. The septa are thin and closely spaced. Phrenothecae are common in all but the final whorl. A moderate amount of axial filling is common, although the quantity is variable.

The tunnel is moderately wide when it can be distinguished. However there are no chomata and the limits of the tunnel are not always obvious. The measurements indicate considerable irregularity in the tunnel angle, and this is substantiated by supplementary measurements of polished axial surfaces. The tunnel angle appears to undergo a gradual increase from 30° in the early whorls to as much as 45° at maturity.

Discussion. This species is distinguished by its medium-to-large size, inflated fusiform profile, thick walls, and strong, high septal folds. It resembles rather closely *S. eolata* Thompson, with which it is commonly associated; however, it can be distinguished by its shorter, more highly inflated profile, and to a lesser degree by its generally larger proloculus and thicker wall. Although the writer was originally inclined to combine the two forms, the nature of their distribution indicates that both are valid species; they may occur in equal proportions in the same assemblage, but it is more common for an assemblage to be dominated by one or the other.

In the constancy of chamber height from pole to pole in the early whorls, *S. neolata* resembles *S. diversiformis* Dunbar and Skinner, but the rapid elongation of the ends of the shell in later volutions is not nearly so pronounced in this species. It differs from *S. knighti* Dunbar and Skinner in the possession of a larger proloculus and a much less sharply elliptical profile.

Occurrence. *Schwagerina neolata* was originally described from, is characteristic of, and restricted to the Cerro Alto limestone. It has been reported only from the Hueco Mountains, Texas, where, however, it is quite abundant.

Schwagerina nelsoni Dunbar and Skinner

(Plate 22, figures 1-5)

Schwagerina nelsoni Dunbar and Skinner, Texas Univ. Bull. 3701, p. 650-652, pl. 67, fig. 1 (upper six specimens), 2-3, 6-7, 11-12, 14, 1937.

Pseudofusulina nelsoni opima Thompson, Kans. Univ. Paleont. Contr., Protozoa, art. 5, pl. 44, figs. 5, 7-11, 1954.

Description. A medium to large, fusiform species of 5 or 6 volutions, attaining a length of about 10 mm and a diameter of 4 mm. The adult shell is short and inflated with a straight axis of coiling. The form ratio increases gradually during growth from 1.2 to 2.3; it reflects the change from the more inflated inner whorls with uniformly convex lateral slopes and bluntly rounded poles (whorls having a nearly uniform height from center to poles) to the samewhat less concave slopes (height of chambers increases toward the poles).

The proloculus is rather large, commonly between 300 and 420 microns, and generally (but not always) thin-walled. The early whorls increase in height rapidly, or, gradually and the shell is rather loosely coiled. The wall thickness increases uniformly with growth; it is quite thin in the early whorls, progressively thickens in later whorls to 110 or 120 microns; the thickness decreases slightly in the last volution. The wall consists of a well-defined tectum and keriotheca.

The septa possess strong, high folds which meet opposed folds of adjacent septa to subdivide the meridional chambers into cell-like chamberlets; they appear as high loops in axial sections. Septal pores are abundant but difficult to discern in axial sections because of the intense folding which causes the septa to cross the slice at high angles.

Phrenothecae appear to be a diagnostic feature of this species; they were present to at least some degree in all specimens that I examined.

The tunnel is especially difficult to delimit amid the intense septal folding and in the complete absence of chomata. Measurements of tunnel angles in polished axial surfaces indicate a range from 25° to 35°, which remains fairly constant from youth to maturity.

Discussion. *Schwagerina nelsoni* is characterized by its large proloculus, inflated form, ontogenetic change in shape, intensity of septal folding, loose coiling and the persistent presence of phrenothecae. It can be distinguished from *S. diversiformis* Dunbar and Skinner by its smaller size, more evenly convex volutions, lack of axial filling, and less regularly folded septa; from *S. hessensis* Dunbar and Skinner by its more inflated axial profile, thinner-walled inner whorls, and looser, more irregular septal loops; from *S. hawkinsi* Dunbar and Skinner by the thinner walls and uniformly convex lateral slopes of the inner whorls, less inflated outer whorls and looser coiling.

Occurrence. *Schwagerina nelsoni* was originally described from the Hueco limestone of the Franklin Mountains, Texas. It is characteristic of and restricted to the Alacran Mountain formation (excluding Deer Mountain member) in the Hueco Mountains, Texas. It has also been reported from the upper Neal Ranch strata at Gap Tank and the Lenox Hills formation in the western Glass Mountains (Ross, 1959a, p. 388).

TABLE 22

MEASUREMENTS OF *SCHWAGERINA NELSONI*

	Volution	YPM 22568	YPM 22569	YPM 22570	YPM 22571
Radius vector (mm)	0	.20	.16	.19	.12
	1	.35	.37	.51	.39
	2	.75	.75	.95	.75
	3	1.25	1.35	1.30	1.30
	4	1.70	1.70	1.70	1.80
	5	2.10	2.10	2.00	2.10
Half length (mm)	0	.21	.18	.20	.15
	1	.44	.45	.68	.46
	2	1.30	1.10	1.50	1.10
	3	2.00	2.10	2.60	2.15
	4	3.00	3.20	3.20	3.25
	5	4.80	4.20	4.70	4.20
Form ratio	1	1.3	1.2	1.3	1.2
	2	1.7	1.5	1.6	1.5
	3	1.6	1.6	2.0	1.7
	4	1.8	1.9	1.9	1.8
	5	2.3	2.0	2.3	2.0
Tunnel angle (°)	1	32	50	29	38
	2	23	25	29	38
	3	15	39	28	31
	4	23	41	23	41
Wall thickness (mm)	0	.016	.032	.024	.024
	1	.040	.088	.056	.048
	2	.056	.032	.072	.048
	3	.088	.096	.088	.104
	4	.120	.112	.104	.112
	5	.104	.080	.064	.096

Schwagerina thompsoni? Needham

(Plate 23, figures 1-6)

Schwagerina thompsoni Needham, N. Mex. School Mines Bull. 14, p. 50-51, pl. 8, figs. 7-10, 1937.

Schwagerina emaciata Needham, N. Mex. School Mines Bull. 14, p. 46-47, pl. 7, figs. 7-9, 1937.

[part] *Schwagerina emaciata jarillaensis* Needham, N. Mex. School Mines Bull. 14, p. 46-47, pl. 7, fig. 11, 1937.

TABLE 23

MEASUREMENTS OF *SCHWAGERINA THOMPSONI*?

	Volution	YPM 22573	YPM 22574	YPM 22575	YPM 22576
Radius vector (mm)	0	.08	.07	.07	.06
	1	.18	.15	.14	.08
	2	.30	.30	.24	.15
	3	.50	.50	.40	.25
	4	.85	.85	.60	.40
	5	1.20	1.25	.95	.60
	6	1.50	1.60	1.30	.90
	7	—	—	—	1.15
Half length (mm)	0	.09	.07	.07	.06
	1	.32	.40	.24	.10
	2	.60	.70	.48	.25
	3	1.00	1.20	.80	.45
	4	2.00	2.15	1.50	.85
	5	2.70	2.70	2.50	1.90
	6	3.60	4.00	4.30	2.85
	7	—	—	—	4.10
Form ratio	1	1.8	2.7	1.7	1.3
	2	2.0	2.3	2.0	1.7
	3	2.0	2.4	2.0	1.8
	4	2.4	2.5	2.5	1.9
	5	2.3	2.2	2.6	3.2
	6	2.4	2.5	3.3	3.2
	7	—	—	—	3.6
Tunnel angle (°)	1	20	21	15	32
	2	28	22	18	29
	3	29	45	23	35
	4	30	36	32	44
	5	36	—	52	60
Wall thickness (mm)	0	.008	.024	.016	.016
	1	.024	.024	.024	.008
	2	.024	.032	.024	.016
	3	.032	.040	.032	.032
	4	.048	.072	.072	.048
	5	.072	.064	.080	.072
	6	.072	.088	.088	.080
	7	—	—	—	.088

Description. A somewhat elongate fusiform species of 6 to 7 volutions, attaining a length of 8 to 9 mm and a diameter of 2.5 to 3.5 mm. The slopes are slightly convex and the ends somewhat pointed to rather blunt.

The proloculus is thin-walled and small, seldom exceeding 180 microns in diameter. The inner whorls are thin-walled and the succeeding volutions increase to a maximum of 88 microns in the final volution. The wall consists of a thin tectum and well-defined keriotheca.

The shell expands gradually and uniformly. The chambers are more or less constant in height across the middle third of the shell but increase in height toward the ends. The form ratio increases with growth from 1.5 to 3.5 at maturity.

The septal folds are strong, somewhat irregular and of medium height, displaying septal loops which are correspondingly medium-to-low, narrow and crowded in axial sections. The number of septa increases from 9 in the first whorl to 32 in the sixth whorl. Phrenothecae and axial fillings are rare to absent.

The tunnel is moderately wide, ranging from 15° to 20° in the early whorls to as high as 50° at maturity. Lack of chomata makes it difficult to recognize the tunnel limits, and supplementary study of polished axial surfaces is frequently necessary.

Discussion. *Schwagerina thompsoni*? is characterized by its small proloculus, a somewhat less than evenly elliptical profile, thin walls in the early volutions, strong but more or less irregular septal folds, and medium-to-low narrow septal loops. It can be distinguished from *S. aculeata* Thompson and Hazzard by its smaller size, thicker outer walls, more loosely coiled volutions and a less uniform rate of expansion; from *S. bellula* Dunbar and Skinner by its lack of an evenly elliptical profile, a larger proloculus, medium-to-low irregular folding of septa, and general absence of axial fillings; from *S. bowmani* Roberts by its thicker walls, higher and narrower septal loops and complete absence of axial filling; from *S. emaciata* (Beede) by its larger size, thicker walls, and more evenly convex profile; from *S. eolata* Thompson by its smaller proloculus, lack of an evenly elliptical profile, irregularly folded septa, low septal loops, and smaller size; from *S. fax* Thompson and Wheeler by its less highly inflated profile (with a consequent difference in form ratio), less highly inflated chambers, and thicker walls.

This species is questionably identified as *Schwagerina thompsoni* because it appears to be slightly larger than the types. Whether this difference in size should be considered as being within the range of variation of *S. thompsoni* or should dictate the erection of a new species is at present indeterminable. Needham's illustrations include only two axial sections, neither of optimum quality. The description of the type locality is very general; attempts to collect additional material were frustrated by uncertainty as to its exact location and stratigraphic level. However, the specimens herein described were collected from the same general area and probably from the same stratigraphic horizon; they may constitute a true sample of *S. thompsoni* but it would seem more prudent to await further study of the Hueco fauna in the northern part of the range before reaching a decision.

Occurrence. *Schwagerina thompsoni* was originally described from, and is restricted to the Hueco Canyon formation in the Hueco Mountains of Texas and New Mexico. It has not been reported outside of this area.

Genus STAFFELLA Ozawa, 1925

Staffella lacunosa Dunbar and Skinner

(Plate 24, figures 1-3)

Staffella lacunosa Dunbar and Skinner, Texas Univ. Bull. 3701, p. 598-599, pl. 52, figs. 9-13, 1937.

Description. A minute subspherical species with a maximum diameter of 2 mm. The whorls are bilaterally symmetrical and the mature forms display a broadly rounded periphery. The proloculus is small, generally less than 100 microns in diameter. The axial diameter of the first whorl is only about two-thirds the equatorial diameter. Although the length of the axial diameter approaches the equatorial diameter in the later whorls, it is always shorter, i.e. the maximum width of the outer whorls is greater than the axial length. Consequently the shape of the shell is somewhat nautiliform. At maturity the poles are rather deeply umbilicate and the periphery becomes slightly flattened so that the profile of axial sections is rounded subquadrate. Coiling is planispiral from the beginning.

The wall is thin, increasing from about 15 microns in the second or third whorl to 55 microns at maturity. As nearly as can be determined, the wall appears to consist of two layers: a thin dark tectum underlain by a thicker more transparent layer.

The genus *Staffella* is characterized by the possession of a narrow, median tunnel bordered by chomata. The preservation of my material was such that neither of those features was visible. Moreover it could not be determined if epithecal deposits of any kind were present.

TABLE 24

MEASUREMENTS OF *STAFFELLA LACUNOSA*

	Volution	YPM 22579	YPM 22580	YPM 22592
Radius vector (mm)	0	.040	.024	—
	1	.080	.120	—
	2	.120	.184	.136
	3	.224	.320	.224
	4	.320	.480	.340
	5	.440	.720	.490
	6	.620	.880	.670
	7	.830	—	.860
Half length (mm)	0	.040	.024	—
	1	.040	.144	—
	2	.096	.184	.096
	3	.200	.360	.160
	4	.320	.440	.320
	5	.400	.600	.440
	6	.560	.640	.520
	7	.720	—	.640
Form ratio	1	.50	.12	—
	2	.80	1.00	.60
	3	.82	1.10	.71
	4	1.00	.92	.94
	5	.91	.83	.90
	6	.90	.73	.78
	7	.87	—	.75
Wall thickness (mm)	0	.008	—	—
	1	—	—	—
	2	.016	—	—
	3	.024	—	.016
	4	.024	—	.040
	5	.032	—	.024
	6	.048	—	.040
	7	.056	—	.056

The septa are plane, and septal counts of 18, 24, and 34 are typical for the outer whorls. The interior whorls are particularly susceptible to recrystallization, and septal counts for those parts of the shell are not available.

DISCUSSION. Although *Staffella lacunosa* is abundant in the Hueco group, silicification and/or recrystallization completely obscures the interiors of most specimens. Attempts were made to prepare thin sections of some 50 specimens from various parts of the column in the Hueco Mountains. The specimens which I have illustrated, and on which my description is based, are the best of the lot. The same was apparently true of the material from the Glass Mountains which formed the basis for the original description.

OCCURRENCE. *Staffella lacunosa* is abundant throughout the Hueco Canyon formation. Forms which may be *S. lacunosa* are also present in the Alacran Mountain formation; preservation is too poor to permit of more positive identification. Ross (1959a, p. 254) reports forms questionably identified as *S. lacunosa* from the Lenox Hills formation in the eastern Glass Mountains, Texas.

GENUS TRITICITES Girty, 1904

Triticites cf. *T. cellamagnus* Thompson and Bissell

(Plate 17, figures 5-8)

DESCRIPTION. A short, highly inflated, fusiform species of medium size and consisting of 6 or 7 volutions, with a length of 7.0 mm and a diameter of 3.5 mm. The lateral slopes are distinctly convex and terminate in somewhat pointed poles.

The proloculus is quite large, commonly exceeding 300 microns. The shell expands rapidly and uniformly. Chamber height is essentially uniform from the central region to the poles, where, however, it increases slightly. The form ratio ranges from 1.1 in the first volution to 1.8 at maturity, the increase occurring gradually in rather small increments. The wall is thick, consisting of a thin tectum and a well-defined, coarsely alveolar keriotheca. It thickens from 24 microns in youth to as much as 120 microns at maturity.

The septa are only moderately folded, as evidenced by the consistent scarcity of septal loops in axial sections. Such folding as is present appears to be best developed at the poles where it extends to the top of the chambers; it gradually decreases in height toward the tunnel margins.

The tunnel is moderately wide, with a relatively straight path. The tunnel angle increases from 20° in the early whorls to 40° in the final volution. Tunnel limits are well marked by distinct chomata, which show steep sides immediately adjacent to the tunnel and slope toward the poles.

DISCUSSION. Lack of an adequate sample precludes positive identification of this form as *Triticites cellamagnus* Thompson and Bissell. However, such material as is available suggests identity, especially in general size, diameter of proloculus, overall profile, and degree of septal folding but differs in that it is slightly smaller for a given number of volutions and displays more pronouncedly convex lateral slopes.

OCCURRENCE. *Triticites* cf. *T. cellamagnus* is found in the Hueco Mountains at Locality 1 in association with *Schwagerina* aff. *S. grandensis* Thompson in the upper member of the Magdalena limestone, in what are referred to herein as the Bursum beds.

TABLE 25

MEASUREMENTS OF *TRITICITES* cf. *T. CELLAMAGNUS*

	Volution	YPM 22545	YPM 22546	YPM 22547	YPM 22548
Radius vector (mm)	0	.16	.17	.12	.10
	1	.23	.28	.20	.18
	2	.35	.42	.36	.34
	3	.70	.65	.55	.50
	4	.95	.90	.75	.75
	5	1.25	1.20	1.10	1.00
	6	1.60	1.60	1.40	1.35
	7	1.95	—	1.70	—
Half length (mm)	0	.15	.17	.13	.11
	1	.25	.36	.25	.32
	2	.45	.60	.44	.55
	3	.90	.90	.76	.85
	4	1.20	1.35	1.10	1.30
	5	1.80	1.80	1.60	1.75
	6	2.20	2.70	2.10	2.40
	7	3.00	—	3.40	—
Form ratio	1	1.1	1.3	1.1	1.8
	2	1.3	1.4	1.2	1.6
	3	1.3	1.4	1.4	1.7
	4	1.3	1.5	1.5	1.7
	5	1.4	1.5	1.5	1.8
	6	1.4	1.7	1.5	1.8
	7	1.5	—	2.0	—
Tunnel angle (°)	1	12	27	20	20
	2	17	26	26	21
	3	17	30	24	22
	4	23	23	40	22
	5	30	32	40	27
	6	40	—	—	—
Wall thickness (mm)	0	.016	.016	.016	.016
	1	.024	.040	.032	.032
	2	.032	.056	.040	.040
	3	.040	.072	.035	.064
	4	.080	.080	.080	.072
	5	.120	.096	.096	.080
	6	.144	.120	.096	.088
	7	.112	—	—	—

Triticites powwowensis Dunbar and Skinner
(Plate 25, figures 1-6)

Triticites powwowensis Dunbar and Skinner, Texas Univ. Bull. 3701, p. 617-619, pl. 48, figs. 1-12, 1937.

Description. A rather small, evenly fusiform species, attaining 5 or 6 volutions, with a length of 7 or 8 mm and a diameter of 2.5 to 3.0 mm. The poles are subacutely rounded.

The proloculus is of medium size with an average outside diameter of 200 microns. The first volution is short and pronouncedly convex but succeeding volutions are considerably more elongate and the form ratio increases steadily to as much as 3.0 at

TABLE 26

MEASUREMENTS OF *TRITICITES POWWOWENSIS*

	Volution	YPM 22582	YPM 22583	YPM 22584	YPM 22585
Radius vector (mm)	0	.11	.06	.10	.10
	1	.20	.12	.18	.22
	2	.40	.17	.30	.35
	3	.60	.30	.50	.50
	4	.90	.50	.90	.80
	5	1.20	.90	1.25	1.15
	6	1.60	1.20	—	—
Half length (mm)	0	.12	.07	.10	.10
	1	.32	.13	.28	.32
	2	.80	.38	.44	.60
	3	1.25	.70	1.10	1.10
	4	2.30	1.25	2.00	1.90
	5	3.00	2.15	3.30	3.05
	6	4.00	3.70	—	—
Form ratio	1	1.6	1.1	1.6	1.5
	2	2.0	2.2	1.5	1.7
	3	2.1	2.3	2.2	2.1
	4	2.6	2.5	2.2	2.4
	5	2.5	2.4	2.6	2.7
	6	2.5	3.0	—	—
Tunnel angle (°)	1	29	31	34	35
	2	30	32	29	31
	3	37	31	49	63
	4	59	72	38	54
	5	41	52	—	—
Wall thickness (mm)	0	.024	.008	.024	.016
	1	.040	.008	.024	.024
	2	.048	.016	.024	.040
	3	.064	.032	.056	.056
	4	.096	.056	.096	.096
	5	.128	.064	.072	.112
	6	.104	.064	—	—

maturity. A vaguely defined but nonetheless discernible juvenarium of 3 or so volutions is followed by more rapid inflation in the next one-fourth volution. The whorls then increase rapidly in height, and in axial section the shells appear rather loosely coiled with each volution becoming higher from the middle of the shell toward the poles.

The wall is of medium thickness, even in the early whorls; it increases gradually from about 25 microns in the early volutions to as much as 128 microns in the penultimate volution, and then decreases slightly in the final whorl. Narrow chomata are well developed in (and restricted to) the juvenarium; they are associated with a secondary deposit that commonly floors the tunnel. The wall consists of a tectum and a well-defined keriotheca.

The lower portions of the septa are regularly and rather strongly folded, producing rounded and somewhat irregular septal loops in axial section. Septal pores are abundant but rather small; they appear to be present only in the outer whorls. The tunnel angle is narrow in the early whorls and then, coincident with the slight increase in rate of expansion and loss of chomata, widens rapidly; tunnel angle values tend to be irregular in the outer volutions, ranging from 40° to 70°.

DISCUSSION. The authors (Dunbar and Skinner, 1937, p. 618) assigned the species to the genus *Triticites,* noting that although the septa were more intensely folded than is usual in *Triticites,* chomata were conspicuously developed; they believed it represented a transtitional stage between *Triticites* and *Schwagerina.* Examination of a sample of topotype material of some 20 axial sections revealed considerable individual variation; certain forms possess characters that ally them most closely with *Triticites* whereas others are more typically *Schwagerina* and a complete gradational series can be demonstrated between these two extremes.

Triticites powwowensis may be readily distinguished from *P. texana* Dunbar and Skinner by its smaller size, smaller proloculus and less pronounced change in rate of expansion; from *Triticites uddeni* Dunbar and Skinner by its larger proloculus, larger size, stronger chomata and less strongly folded septa; from *P. grinnelli* Thorsteinsson by its smaller proloculus, strong and regular folding of the basal margin of the septa and lack of pronounced change in rate of expansion.

OCCURRENCE. *Triticites powwowensis* was originally described from, and is restricted to, the basal portion of the Hueco Canyon formation in the Hueco Mountains, Texas.

LOCALITY REGISTER

Collecting localities in measured sections are included in the descriptions of the measured sections; the locality designation corresponds to the section and bed number (i.e. the first number indicates the measured section and the second the bed number). Collecting localities which are not in measured sections are included herein and are indexed by both the number corresponding to the locality numbers on the geologic map (fig. 1, frontispiece; Williams, 1962) and the code number used in my field notes. The latter consists of four parts: (1) an abbreviation of the name of the map (e.g. HT-Hueco Tanks); (2) the size of the quadrangle in minutes; (3) the pertinent ninth of the map as divided by parallels and meridians (e.g. northwest, north, northeast, west, center, east, southwest, south, and southeast); (4) the locality number within that ninth. A list of the topographic maps and their abbreviations follows:

HM—Hueco Mountains, 15 minute, Texas
HT—Hueco Tanks, 7.5 minute, Texas
HWW—Helms West Well, 7.5 minute, Texas
BL(SW)—Bassett Lake (Southwest), 7.5 minute, New Mexico-Texas [photographic enlargement of southwest part of Bassett Lake (1943), 15 minute quadrangle]

Magdalena limestone

1. HT-7.5-SE-1	Upper division (Bursum beds), 0.5 milles WNW of hill 5226; fusulinids in matrix; *Schwagerina* aff. *S. grandensis, Triticites* cf. *T. cellamagnus.*
2. HT-7.5-E-3	Upper division (*Pseudoschwagerina* beds), south side of Hueco Canyon, 0.5 miles NW of hill 5360; fusulinids in matrix; *Pseudoschwagerina* sp., *Triticites* sp.
3. HT-7.5-E-4	Upper division (*Pseudoschwagerina* beds), north side of Hueco Canyon, 0.2 miles SSW of hill 5280; fusulinids in matrix; *Pseudoschwagerina* sp., *Schwagerina* sp., *Triticites* sp.
4. HT-7.5-E-5	Upper division (*Pseudoschwagerina* beds), 0.2 miles south of Juan Peak (hill 5522); free specimens; *Pseudoschwagerina* sp.

Hueco Canyon formation

5. HM-15-W-18	Powwow member, south side of ridge north of U. S. Highway 62-180 in Powwow Canyon near roadside rest; free specimens; *Pseudoschwagerina beedei, Schwagerina bellula, Triticites powwowensis.*
6. HWW-7.5-NE-1	Powwow member, saddle on ridge north of entrance to Powwow Canyon, 0.4 miles WNW of hill 5460; free specimens; *Pseudoschwagerina beedei, P. texana, Schwagerina bellula, Triticites powwowensis* [Dunbar and Skinner (1937) locality 73].
7. HT-7.5-SE-2	Powwow member, escarpment southeast of Hueco Tanks; 0.3 miles NNW of hill 5368; free specimens; *Pseudoschwagerina texana, P. uddeni, S. knighti.*
8. HT-7.5-NE-3	Powwow member, along Rimrock, 0.5 miles WNW of hill 5548; free specimens; *Pseudoschwagerina geiseri, P. texana, P. uddeni, Schwagerina huecoensis.*
9. HM-15-W-17	Roadcut on north side of U. S. Highway 62-180, 1.4 miles WSW of Hueco Inn; free specimens; *Monodiexodina bispatulata, Pseudoschwagerina beedei, P. texana, Schwagerina bellula.*

10. HM-15-W-1	Roadcut on south side of U. S. Highway 62-180, 0.4 miles west of Hueco Inn; fusulinids in matrix; *Monodiexodina bispatulata, Pseudoschwagerina texana.*
11. HWW-7.5-NE-2	Northwest side of peak (hill 5460) on ridge north of entrance to Powwow Canyon, 100 feet below peak; fusulinids in matrix; *Monodiexodina bispatulata, Pseudoschwagerina beedei, P. texana, Schwagerina bellula, Staffella lacunosa.*
12. HWW-7.5-NW-1	Projection south from hill 4884; fusulinids in matrix; *Pseudoschwagerina texana, P. uddeni, Schwagerina bellula.*
13. HT-7.5-SW-2	End of ridge just north of Old Butterfield Trail, 0.4 miles NE of elevation 4287; fusulinids in matrix; *Pseudoschwagerina texana, Schwagerina bellula.*
14. HM-15-NW-20	Bed of southwest-draining intermittent stream 0.6 miles due west of hill 5590; fusulinids in matrix; *Pseudoschwagerina texana.*
15. HM-15-NW-10	Bed of west-draining intermittent stream 0.8 miles WSW of Naville Mountain (hill 6064), immediately downstream from ranch road; fusulinids in matrix; *Monodiexodina bispatulata, Pseudoschwagerina texana, Schwagerina bellula, S. emaciata.*
16. HM-15-NW-18	East side of ridge 0.4 miles northwest of Cement Tank, northwest of Cerro Alto; free specimens; *Pseudoschwagerina uddeni, Schwagerina thompsoni?, S. emaciata.*
17. [BL(SW)-7.5-SW-2]	Southeast end of northwest-trending ridge, Wallbridge Tank, southwest portion of the Bassett Lake 15-minute quadrangle, New Mexico-Texas; fusulinids in matrix; *Pseudoschwagerina texana, P. uddeni, Schwagerina bellula, S. knighti.*
18. [BL(SW)-7.5-SW-1]	Hill 0.5 miles southeast of Little Cement Tank in the southwest portion of the Bassett Lake 15-minute quadrangle, New Mexico-Texas; fusulinids in matrix; *Pseudoschwagerina texana, P. uddeni, Schwagerina knighti.*

Cerro Alto limestone

19. HM-15-W-3	Hillside on west side of ranch road which parallels Hueco Mountains on east side of the escarpment, 0.4 miles north of U. S. Highway 62-180; fusulinids in matrix; *Schwagerina eolata, S. neolata* [Thompson's (1954) localities T-236 through T-238].
20. HM-15-W-15	Bed of west-draining intermittent stream at foot of escarpment 0.8 miles SSW of Alacran Mountain (hill 5706); *Schwagerina neolata.*
21. HM-15-W-14	Base of hill at north end of Alacran Mountain, 0.4 miles NNW of hill 5706; free specimens; *Schwagerina neolata.*
22. HM-15-W-9	North end of northeast trending ridge, 0.8 miles north of Alacran Mountain (hill 5706); free specimens; *Schwagerina neolata.*
23. HM-15-W-12	Southward projection of escarpment 0.4 miles due south of hill 5643; fusulinids in matrix; *Schwagerina eolata.*
24. HM-15-NW-3	Upper part of Hueco Canyon, ridge northwest of Goat Tub Tank; fusulinids in matrix; *Schwagerina eolata.*
25. HM-15-NW-19	Bed of small tributary stream, 0.9 miles due south of Cerro Alto (hill 6717); fusulinids in matrix; *Schwagerina eolata.*
26. HT-7.5-SW-1	Hillside 0.75 miles WNW of hill 4996; free speciments; *Schwagerina neolata.*
27. HM-15-NW-8	Bed of west-draining intermittent stream west of Naville Mountain, 0.6 miles east of the ranch road which parallels the Hueco Mountains escarpment on the east side; fusulinids in matrix; *Schwagerina eolata, Schwagerina neolata.*

28. HT-7.5-NE-1	South bank of southeast-draining intermittent stream, 1.2 miles NNE of Juan Peak (hill 5522); free specimens; *Schwagerina eolata.*
29. HM-15-NW-9	Southeast of Daily Hill; fusulinids in matrix; *Schwagerina eolata, S. neolata.*
30. [BL(SW)-7.5-E-1]	Saddle in ridge, 0.6 miles ENE of Mountain Tank in the south-central portion of the Bassett Lake 15-minute quadrangle, New Mexico-Texas; fusulinids in matrix; *Schwagerina neolata.*

Alacran Mountain formation

31. HM-15-NW-11	Bed of southwest-draining intermittent stream which flows into earth tank 0.2 miles NNE of Goat Tub Tank; fusulinids in matrix; *Pseudoschwagerina texana.*
32. HM-15-NW-22	Immediately southeast of Cerro Alto along ranch road leading out of Hueco Canyon to Menzies Ranch; near top of northwest-facing escarpment; fusulinids in matrix; *Pseudoschwagerina texana.*
33. HM-15-NW-7	Immediately south of Cerro Alto along ranch road leading out of Hueco Canyon to Menzies Ranch; first limestone above Deer Mountain red shale member in north-facing escarpment; free specimens; *Pseudoschwagerina gerontica, P. uddeni, Schwagerina diversiformis.*

MEASURED SECTIONS

MEASURED SECTION 1 IN CANYON NORTH OF POWWOW CANYON, CENTRAL PART OF HUECO MOUNTAINS, TEXAS

Base of measured section of Powwow member (fig. 7, sec. 1) is on the north side of ridge (hill 5460) north of Powwow Tank, 0.8 miles east southeast of earth tank at mouth of canyon north of Powwow Canyon and is continuous with base of measured section of Hueco Canyon formation and Cerro Alto limestone in canyon bottom at fork 0.4 miles due north of hill 5454.

Permian

Alacran Mountain formation:	Ft.
32. Limestone, light olive gray, thick- and very thick-bedded; stylolites; silicified brachiopod fauna of limited variety	20
Cerro Alto limestone:	
31. Covered; probably limestone, medium gray, medium bedded	40
30. Limestone, light olive gray, thick-bedded	11
29. Covered; probably limestone, medium gray, medium-bedded; fusulinids in matrix at base; *Schwagerina eolata, S. neolata*	93
28. Limestone, medium gray, medium-bedded; fusulinids in matrix; *Schwagerina eolata, S. neolata*	23
27. Limestone, medium gray, medium-bedded	23
26. Marl, medium gray, medium-bedded, interbedded with limestone, medium gray, medium-bedded; undulatory bedding	52
25. Limestone, light gray, medium- and thick-bedded	40
24. Marl, medium gray, medium-bedded, interbedded with limestone, medium gray, medium-bedded; undulatory bedding	73
23. Limestone, medium gray, medium-bedded	92
Total thickness Cerro Alto limestone	447
Hueco Canyon formation:	
22. Limestone, light gray, medium- and thick-bedded	20
21. Limestone, light gray, medium- and thick-bedded; chert nodules	26
20. Limestone, light olive gray to olive gray, medium- and thick-bedded; fusulinids in matrix 24 and 36 feet above base; *Monodiexodina bispatulata, Schwagerina bellula, S. emaciata.*	67
19. Limestone, light olive gray, medium-bedded, fusulinids in matrix 8 feet above base; *Monodiexodina bispatulata, Pseudoschwagerina texana.*	40
18. Limestone, light olive gray, thick-bedded; fusulinids in matrix, *Staffella* at base, 28 and 90 feet above base; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. emaciata.*	140
17. Covered; probably limestone, light olive gray, medium-bedded; 4 foot bed of resistant limestone, medium light gray, medium-bedded, bearing fusulinids in matrix; *Pseudoschwagerina texana, P. uddeni, Staffella*	24
16. Limestone, light olive gray, thick-bedded; stylolites	35

15. Limestone, light olive gray, medium-bedded; undulatory bedding; chert nodules; fusulinids in matrix in upper half; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. emaciata, Staffella*	11
14. Limestone, light olive gray, thick-bedded	18
13. Covered; probably limestone, medium-bedded	10
12. Limestone, medium light gray, thick-bedded; *Staffella*	8
11. Limestone, medium light gray, medium-bedded; fusulinids in matrix; *Pseudoschwagerina beedei, P. texana, Schwagerina bellula, Triticites powwowensis*	26
10. Limestone, medium-gray, thin-bedded, undulatory bedding; fusulinids in matrix; *Pseudoschwagerina texana, Schwagerina bellula, S. emaciata, Triticites powwowensis*	15
9. Limestone, pale yellowish brown, massive interbedded with covered intervals, probably thin-bedded limestone; *Monodiexodina linearis?, Pseudoschwagerina beedei, P. texana, Schwagerina bellula, S. knighti, Triticites powwowensis*	29
Thickness Hueco Canyon formation above Powwow member	469

Powwow member of Hueco Canyon formation:

8. Marl, light gray, medium-bedded; undulatory bedding; nodules of dark-gray chert	11
7. Limestone, olive-gray, medium-bedded	4
6. Covered; probably calcareous mudrock, dark reddish-brown changing to light gray, medium-bedded marl with undulatory bedding at top	21
5. Conglomerate, pebble- and cobble-size fragments of limestone and chert, interbedded with calcareous mudrock, dark reddish-brown	29
4. Covered; probably calcareous mudrock, dark reddish-brown	6
3. Conglomerate, pebble- and cobble-size fragments of limestone and chert; overlain by thin layer of sandy limestone	6
2. Covered; probably calcareous mudrock, dark reddish-brown	11
1. Conglomerate, pebble-size fragments of limestone and chert	6
Total thickness Powwow member	94
Total thickness Hueco Canyon formation	563
Upper division of Magdalena limestone (in part):	
Limestone, light gray, medium-bedded	4

MEASURED SECTION 2 AT ALACRAN MOUNTAIN, CENTRAL PART OF HUECO MOUNTAINS, TEXAS

Base of measured section (fig. 7, sec. 2) in bottom of canyon on south southwest side of Alacran Mountain.

Permian:

Alacran Mountain formation:	Ft.
13. Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding; fusulinids in matrix 60 feet above base; *Schwagerina nelsoni*	75
12. Limestone, light gray to medium light gray, very thick-bedded	25
11. Limestone, light olive gray to olive gray, medium-bedded, undulatory bedding; chert nodules; fusulinids in matrix at top; *Pseudoschwagerina convexa*	29
10. Limestone, light gray to medium light gray, very thick-bedded	10
9. Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding	75
Thickness of Alacran Mountain formation above Deer Mountain member	214

Deer Mountain red shale member:	
8. Covered; indications of reddish-brown calcareous mudrock from 30 to 65 feet above base overlain by scattered outcrops of brown marl	109
Thickness of Deer Mountain red shale member	109
Alacran Mountain formation below Deer Mountain member:	
7. Limestone, light olive gray, thick-bedded at base becoming thin-bedded toward top	22
6. Covered; probably marl, light olive gray to olive gray, thick-bedded; undulatory bedding	23
5. Algal limestone, light olive gray, bedding not discernible; 10 feet of light olive gray to olive gray, thin-bedded limestone in middle of unit; fusulinids in matrix; *Pseudoschwagerina convexa*	33
Thickness Alacran Mountain formation below Deer Mountain member	78
Total thickness Alacran Mountain formation	401
Cerro Alto limestone:	
4. Covered; probably marl, light olive gray to olive gray, medium-bedded; bedding somewhat undulatory	31
3. Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding	40
2. Covered; probably marl, light olive gray to olive gray, medium-bedded; undulatory bedding	14
1. Limestone, light olive gray to olive gray, medium-bedded, silicified *Composita, Wellerella,* omphalotrochid gastropods; fusulinids in matrix; *Schwagerina eolata*	37

MEASURED SECTION 3 IN ESCARPMENT SOUTH SOUTHEAST OF HUECO TANKS, CENTRAL PART OF HUECO MOUNTAINS, TEXAS

Base of section (fig. 7, sec. 3) southwest of hill 5226; section extends from base of escarpment to saddle southeast of peak.

Permian:

Hueco Canyon formation:	Ft.
11. Limestone, light gray, medium-bedded; scattered chert; fusulinids in matrix; *Pseudoschwagerina beedei, P. texana, Schwagerina emaciata*	12
10. Covered; probably limestone, light olive gray, thin-bedded; undulatory bedding	45
9. Limestone, light olive gray, thin- to medium-bedded; undulatory bedding; cherty	35
8. Limestone, light olive gray, thick-bedded; stylolites	75
7. Limestone, light olive gray, medium- and thin-bedded; alternating resistant ledges and covered intervals; fusulinids in matrix 25 and 30 feet above base; *Pseudoschwagerina beedei, P. texana, Schwagerina bellula, S. emaciata*	35
6. Limestone, light olive gray, thin-bedded; undulatory bedding; fusulinids in matrix; *Pseudoschwagerina texana, P. uddeni, Schwagerina emaciata*	15
5. Limestone, medium gray, thin- to medium-bedded; upper and lower portion with undulatory bedding; middle portion thick-bedded	23
4. Limestone, medium light gray, medium- to thick-bedded	20
3. Limestone, light olive gray, thin- to medium-bedded; undulatory bedding	21

Powwow member of Hueco Canyon formation:	
2. Covered; 5-10 feet of thin-bedded, marly limestone with undulatory bedding at top; 5 foot thick ledge of light olive gray limestone 22 feet below top of covered interval bearing fusulinids in matrix; *Pseudoschwagerina beedei, P. uddeni, P. texana, Schwagerina bellula, S. emaciata*	180
Upper division of Magdalena limestone:	
1. Limestone, light olive gray, thick-bedded	15

Covered

MEASURED SECTION 4 AT DEER MOUNTAIN, CENTRAL PART OF HUECO MOUNTAINS, TEXAS

Base of measured section (fig. 7, sec. 4) in bed of south southeast draining intermittent stream and measured on south side of hill 5882, Deer Mountain.

Permian:

Alacran Mountain formation:	Ft.
10. Limestone, light olive gray, very thick-bedded	18
9. Limestone, light olive gray, medium-bedded; chert nodules	24
8. Limestone, light olive gray, very thick-bedded	15
Thickness Alacran Mountain formation above Deer Mountain member	57
Deer Mountain red shale member:	
7. Limestone, medium light gray, medium-bedded; undulatory bedding, chert nodules	29
6. Covered	55
5. Limestone, light olive gray to olive gray, medium-bedded; discontinuously exposed	8
4. Covered; probably a reddish-brown calcareous mudrock	30
Thickness Deer Mountain red shale member	122
Alacran Mountain formation below Deer Mountain member:	
3. Limestone, medium light gray to medium gray, medium-bedded	85
Thickness Alacran Mountain formation below Deer Mountain member	85
Total thickness Alacran Mountain formation	264
Cerro Alto limestone:	
2. Covered; probably limestone, light olive gray, thin-bedded	70
1. Limestone, light olive gray, medium-bedded; undulatory bedding	40+

MEASURED SECTION 5 IN ESCARPMENT SOUTHEAST OF HUECO TANKS, CENTRAL PART OF HUECO MOUNTAINS, TEXAS

After King, *et al.*, 1945

Base of section (fig. 7, sec. 5) southwest of hill 5368; section extends from base of escarpment to saddle 0.3 miles southeast of peak [measured section L-1 of King, *et al.* 1945].

Permian:

Hueco Canyon formation:	Ft.
5. Limestone, light-gray, medium- and thick-bedded	49
4. Limestone, light-gray, medium- and thick-bedded	56

3.	Limestone, light-gray, medium-bedded; cherty	39
2.	Limestone, light-gray, medium- and thick-bedded; fusulinids in matrix 30, 60, 65, and 75 feet above base: *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. emaciata, S. knighti, Triticites powwowensis*	134
1.	Limestone, light-gray, thin- and medium-bedded; cherty; fusulinids in matrix at base and 7 feet above base; *Pseudoschwagerina beedei, P. texana?, Schwagerina bellula, S. emaciata, Triticites powwowensis*	40

MEASURED SECTION 6 SOUTH OF MENZIES RANCH HEADQUARTERS, CENTRAL PART OF HUECO MOUNTAINS, TEXAS

Base of measured section (fig. 7, sec. 6) at mouth of west draining intermittent stream on west side of ridge immediately east of Tank No. 1; measured upstream to the east and southeast.

Permian:

Alacran Mountain formation:		Ft.
11.	Covered, occasional ledges of olive gray, medium-bedded limestone, probably largely marl	40
10.	Limestone, olive gray, thick-bedded	6
9.	Interbedded light olive gray to olive gray, thin-bedded limestone, and covered intervals, probably marl, grayish orange; fusulinids in matrix 20 feet above base; *Schwagerina crassitectoria, S. franklinensis*	54
8.	Limestone, light olive gray, medium-bedded; fusulinids in matrix; *Schwagerina menziesi*	6
7.	Covered except for a medial 10 feet thick ledge of light olive gray to olive gray, medium-bedded limestone; probably marl, grayish orange	36
6.	Limestone, light olive gray, medium-bedded	16
5.	Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding	27
4.	Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding	35
3.	Covered; probably limestone, light brownish gray to brownish gray, medium-bedded; undulatory bedding	60
2.	Limestone, light olive gray to yellowish gray; medium-bedded; undulatory bedding	56
1.	Limestone, light olive gray and olive gray, thick-bedded; undulatory bedding	24
Thickness Alacran Mountain formation above Deer Mountain member		360

Deer Mountain red shale member

MEASURED SECTION 7 IN HUECO CANYON CENTRAL PART OF HUECO MOUNTAINS, TEXAS

Base of measured section (fig. 7, sec. 7) is in canyon bottom, 1.7 miles east northeast of ranch headquarters at Hueco Tanks, south side of canyon.

Permian:

Alacran Mountain formation:		Ft.
31.	Limestone, light olive gray to olive gray, thin-bedded; undulatory bedding; chert nodules; small fauna of silicified brachiopods	20+

Cerro Alto limestone:

30.	Covered except for 6 feet of medium light gray to medium gray, medium-bedded limestone at base; probably a medium gray, medium-bedded marl	28
29.	Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding; chert nodules; fusulinids in matrix at base; poorly preserved productid brachiopods about 30 feet above base; *Schwagerina eolata*	68
28.	Limestone, light olive gray to olive gray, medium-bedded; undulatory bedding; scattered chert nodules	74
27.	Covered	28
26.	Limestone, light olive gray to olive gray, medium-bedded	17
25.	Covered, scattered outcrops indicate medium-bedded marl with undulatory bedding; fusulinids in matrix; *Schwagerina neolata*	54
24.	Limestone, medium gray, medium-bedded with thin interbedded layers of marl; undulatory bedding; poorly preserved omphalotrochid gastropods	74
23.	Limestone, medium light gray and medium gray, medium-bedded; occasional interbeds of laminated marl	25
22.	Covered; occasional edges of thin-bedded limestone; probably interbedded medium light gray limestone and light olive gray marl, both medium-bedded; poorly preserved omphalotrochid and bellerophontid gastropods; somewhat prominent ledge of thin-bedded, fusulinid-bearing limestone about 8 feet above base; *Schwagerina eolata*	16
21.	Limestone, light olive gray to olive gray, thick-bedded; undulatory bedding	40
20.	Limestone, medium light gray to medium gray, medium- and thick-bedded; undulatory bedding; poorly preserved gastropods and pelecypods	40
	Total thickness Cerro Alto limestone	464

Hueco Canyon formation:

19.	Limestone, light olive gray, thin- and medium-bedded	22
18.	Covered; probably limestone, thin-bedded	29
17.	Limestone, light olive gray, medium- and thick-bedded; stylolites	43
16.	Limestone, medium light gray to medium gray, medium and thick-bedded	36
15.	Covered; probably limestone, thin-bedded	15
14.	Limestone, light olive gray to olive gray, very thick-bedded; stylolites	50
13.	Limestone, light olive gray; medium- and thick-bedded	68
12.	Limestone, medium dark gray, medium- and thick-bedded; undulatory bedding	10
11.	Limestone, medium-gray, thick-bedded; stylolites	22
10.	Covered; occasional ledges of limestone, medium light gray to medium gray, medium-bedded	32
9.	Limestone, light olive gray to olive gray; thick-bedded; stylolites	20
8.	Limestone, medium gray, thin-bedded; undulatory bedding; conspicuously indented weathered profile; abundant free fusulinids; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. knighti, S. nelsoni*?	18
7.	Limestone, light olive gray, thick-bedded; stylolites; fusulinids in matrix in lower 5 feet; *Pseudoschwagerina beedei, Schwagerina emaciata*	47
6.	Limestone, light olive gray, very thick-bedded; cliff-former; stylolites; fusulinids in matrix at base; *Pseudoschwagerina beedei, Schwagerina emaciata, S. knighti*	30

5.	Covered; upper 5 feet has limestone, olive gray to light olive gray, medium-bedded, undulatory bedding; considerable medium gray chert which weathers medium gray and moderate brown; fusulinids in matrix at base; *Pseudoschwagerina beedei, P. texana, Schwagerina bellula*	16.5
4.	Limestone, light olive gray, thick-bedded; some chert nodules; fusulinids in matrix at base; *Pseudoschwagerina beedei, P. texana, Schwagerina bellula*	10
3.	Covered	25
2.	Limestone, light olive gray, thick-bedded	18
1.	Covered; occasional resistant beds of limestone, light olive gray and olive gray, medium-bedded; 5 foot thick fusulinid coquina near base (free specimens); *Monodiexodina bispatulata, Pseudoschwagerina texana, Schwagerina emaciata*	95
	Thickness Hueco Canyon formation above Powwow member	606.5

Powwow member of Hueco Canyon formation:

Covered; outcrop of reddish-brown soil about midway up covered slope	60
Total thickness Hueco Canyon formation	666.5

Pseudoschwagerina beds of Magdalena limestone.

COMPOSITE MEASURED SECTION 8 IN ESCARPMENT NEAR JUAN PEAK, CENTRAL PART OF HUECO MOUNTAINS, TEXAS

Units 1 through 13 measured on southwest slope of Juan Peak (hill 5522); remainder of section measured on ridge due north of Juan Peak in beds stratigraphically above those capping Juan Peak (fig. 7, sec. 8).

Permian:

	Hueco Canyon formation:	Ft.
17.	Covered; discontinuous ledges of limestone, medium gray, medium-bedded; fusulinids in matrix 5, 10, 25 and 45 feet above base; *Paraschwagerina shuleri, Pseudoschwagerina texana, Schwagerina bellula, S. davisi*	55
16.	Limestone, olive gray, thin- to medium-bedded; undulatory bedding; fusulinids in matrix; *Pseudoschwagerina texana*	110
15.	Limestone, light olive gray, thick-bedded; stylolites; fusulinids in matrix; *Pseudoschwagerina texana, Schwagerina bellula*	30
14.	Covered; 15 feet of light gray, thin- to medium-bedded limestone at base; fusulinids in matrix at top of basal limestone; *Pseudoschwagerina uddeni, Schwagerina bellula*	60
13.	Limestone, light olive gray, thick-bedded; fusulinids in matrix at top; *Pseudoschwagerina texana, P. uddeni*	60
12.	Limestone, medium light gray, thin-bedded; undulatory bedding; fusulinids in matrix at base; *Pseudoschwagerina texana, Schwagerina huecoensis*	20
11.	Limestone, light olive gray, medium- to thick-bedded; fusulinids in matrix; *Pseudoschwagerina texana, Schwagerina bellula*	10
10.	Covered; probably limestone, light olive gray, thin- to medium-bedded; undulatory bedding	43
9.	Limestone, light olive gray, medium- to thick-bedded; fusulinids in matrix and abundant free specimens; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. emaciata, S. huecoensis*	17

8. Covered; probably limestone, very light gray, thin- to medium-bedded	10
7. Limestone, light olive gray, medium- to thick-bedded	30
6. Limestone, olive gray, medium-bedded; undulatory bedding; fusulinids in matrix	10
Powwow member of Hueco Canyon formation:	
5. Covered; free fusulines on weathered slopes; *Schubertella kingi, Schwagerina bellula, S. emaciata, S. thompsoni*?	70
Upper division of Magdalena limestone:	
4. Limestone, light gray, medium-bedded	16
3. Limestone, very light gray, thick-bedded	27
2. Covered	18
1. Limestone, light gray, medium-bedded	12
Covered	

MEASURED SECTION 9 IN CANYON SOUTH OF NEW MEXICO-TEXAS STATE LINE, NORTHERN PART OF HUECO MOUNTAINS, TEXAS

Base of measured section (fig. 7, sec. 9) in canyon bottom; section measured from west to east on north wall of canyon; base not exposed.

Permian:

Alacran Mountain formation:	Ft.
31. Limestone, medium olive gray, thick-bedded	94
30. Limestone, medium olive gray, medium bedded; undulatory bedding	19
Cerro Alto limestone:	
29. Limestone, light gray, thick-bedded; chert nodules in upper third	112
28. Limestone, medium olive gray, medium- to thick-bedded; undulatory bedding	28
27. Limestone, dark gray, thick-bedded	15
26. Limestone, olive gray, medium-bedded	20
25. Limestone, medium dark gray, very thick- and thick-bedded	55
24. Limestone, medium gray to dark gray, medium-bedded; undulatory bedding	27
23. Covered	39
22. Limestone, dark gray, thick-bedded	7
21. Covered; ledges of thin- and medium-bedded limestone discontinuously exposed	46
20. Limestone, medium dark gray, thick-bedded	14
19. Limestone, medium dark gray, medium-bedded	28
18. Covered	21
17. Limestone, medium dark gray, thick-bedded	25
16. Covered	11
15. Limestone, olive gray, medium-bedded; undulatory bedding	17
Total thickness Cerro Alto limestone	465
Hueco Canyon formation:	
14. Limestone, light brownish gray to brownish gray, medium- and thick-bedded	32
13. Limestone, medium olive gray, thick-bedded	89

12. Limestone, light olive gray to medium olive gray, thick-bedded; chert nodules	62
11. Covered; probably medium-bedded limestone; fusulinids in matrix at base, 30 feet above base; *Pseudoschwagerina beedei, P. uddeni, P. texana, Schwagerina bellula, S. emaciata, S. knighti*	12
10. Limestone, light olive gray to medium olive gray, thick-bedded; scattered chert nodules; fusulinids in matrix 39, 43, and 66 feet above base; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. emaciata, S. knighti*	117
9. Limestone, medium-bedded, interbedded with thin-bedded limestone; fusulinids in matrix and free specimens; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. emaciata, S. knighti*	17
8. Limestone, very thick-bedded; fusulinids in matrix; *Pseudoschwagerina texana, P. uddeni, Schwagerina emaciata*	9
7. Interbedded, medium-bedded limestone and covered intervals; the latter probably thin-bedded limestones; fusulinids in matrix 15, 20, 82, and 75 feet above base; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. davisi, S. emaciata*	84
6. Limestone, medium-bedded; fusulinids in matrix; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. emaciata*	21
5. Interbedded, medium-bedded limestones and covered intervals; probably thin-bedded limestones	35
4. Limestone, medium-bedded	12
3. Interbedded, medium-bedded limestones and covered intervals; probably thin-bedded limestones; fusulinids in matrix 20, 30, 35, 40, and 45 feet above base; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina emaciata, S. huecoensis, Staffella*	70
2. Limestone, thick-bedded	10
1. Limestone, interbedded medium-bedded and thick-bedded; largely covered with the thick-bedded units being topographically prominent; fusulinids in matrix 5, 10, 15 and 45 feet from base; *Pseudoschwagerina beedei, P. texana, P. uddeni, Schwagerina bellula, S. emaciata, S. huecoensis*	66
Total thickness of exposed Hueco Canyon formation	636

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INDEX

Numbers in bold face type refer to species descriptions.

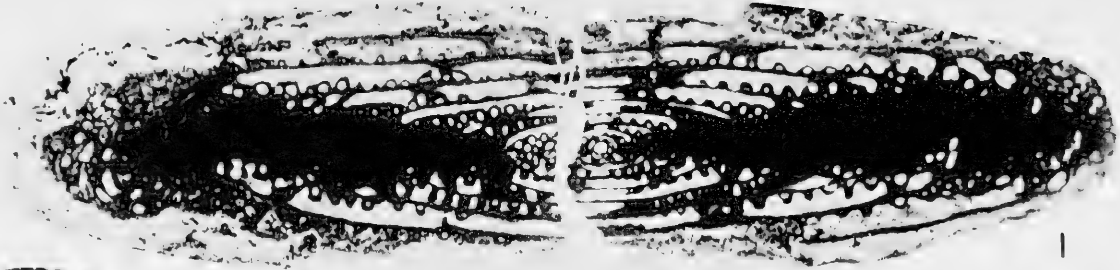
PLATES

PLATE 1

Figures 1-5. *Monodiexodina bispatulata,* n. sp. (p. 33)

Hueco Canyon formation, Hueco Mtns., Texas.

1. Axial section of holotype, ×10, measured section 1, bed 19; YPM 22460.
2. Sagittal section of paratype, ×10, measured section 1, bed 19; YPM 22461.
3. Axial section of paratype, ×10, measured section 1, bed 19, YPM 22462.
4. Axial section of paratype, ×10, locality 9; YPM 22463.
5. Axial section of paratype, ×10, locality 9; YPM 22464.



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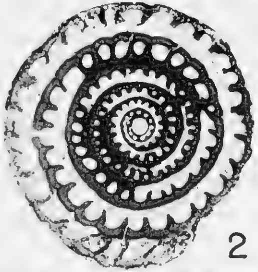

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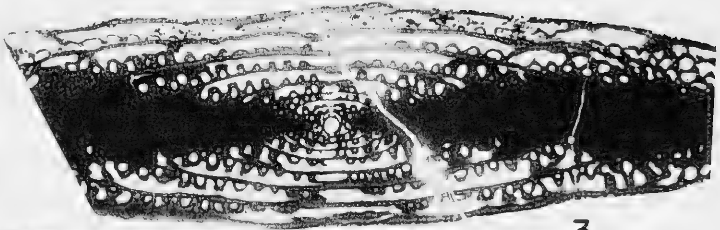

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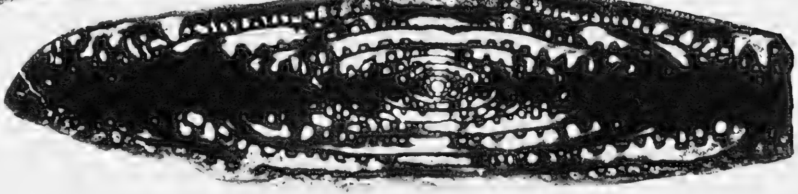

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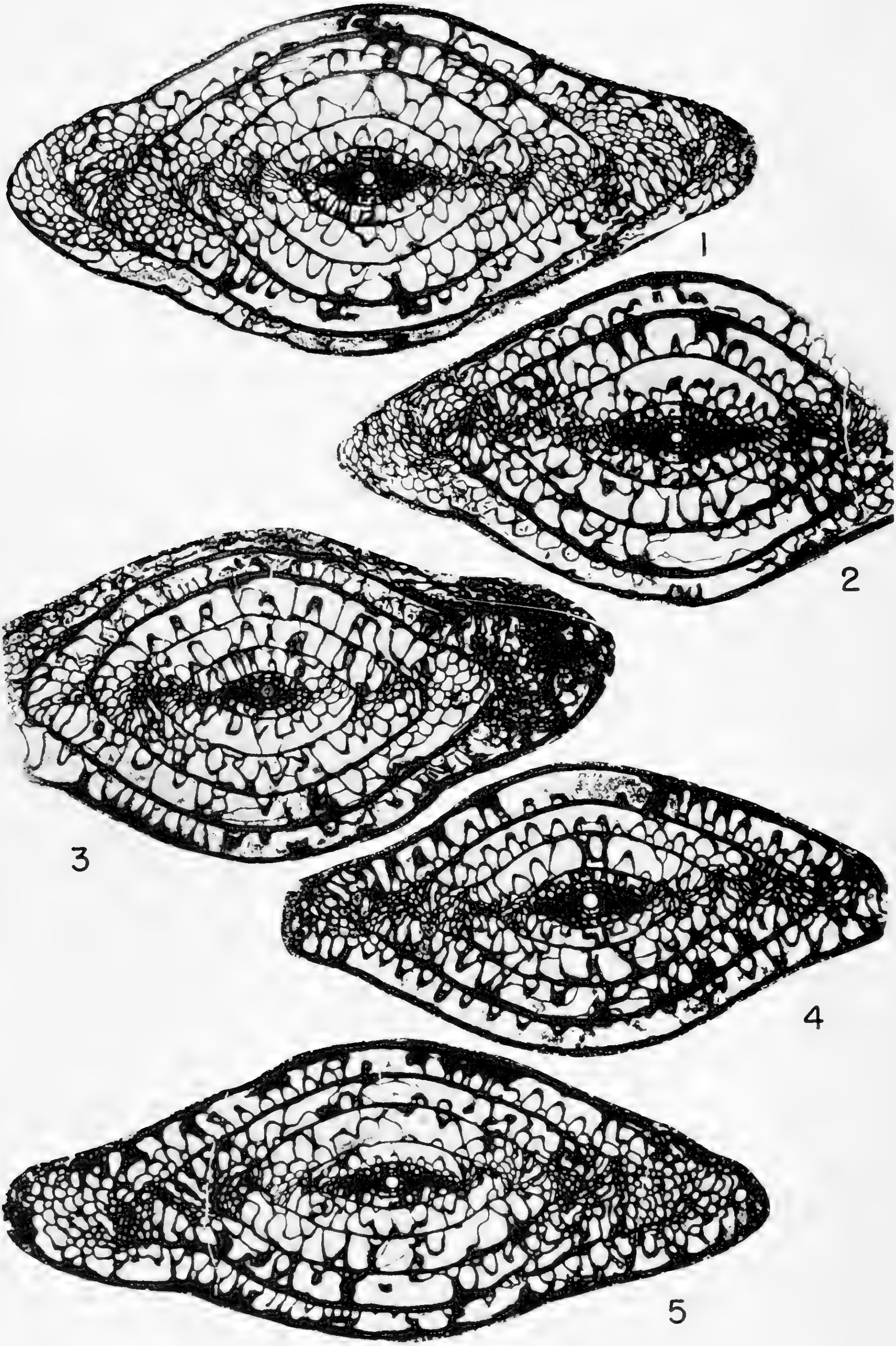
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PLATE 2

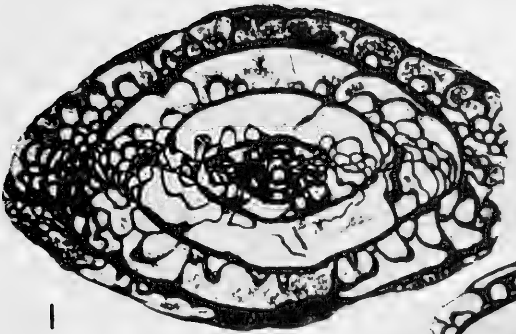
Figures 1-5. *Paraschwagerina shuleri,* n. sp. (p. 35)

Hueco Canyon formation, Hueco Mtns., Texas.

1. Axial section of holotype, ×10, measured section 8, bed 17, YPM 22465.
2. Axial section of paratype, ×10, measured section 8, bed 17, YPM 22466.
3. Axial section of paratype, ×10, measured section 8, bed 17, YPM 22467.
4. Axial section of paratype, ×10, measured section 8, bed 17; YPM 22468.
5. Axial section of paratype, ×10, measured section 8, bed 17; YPM 22469.

PLATE 3

Figures 1-8. *Pseudoschwagerina beedei* Dunbar and Skinner (p. 37)
Hueco Canyon formation, Hueco Mtns., Texas.
1-8. Axial sections of topotypes, ×10, locality 6; YPM 22470-22477.



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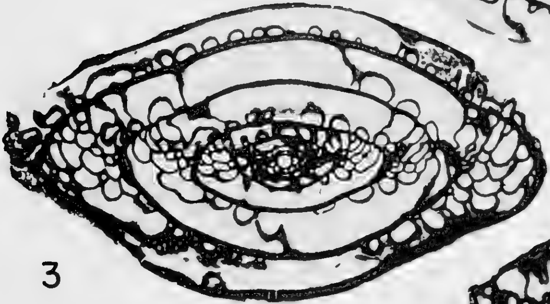

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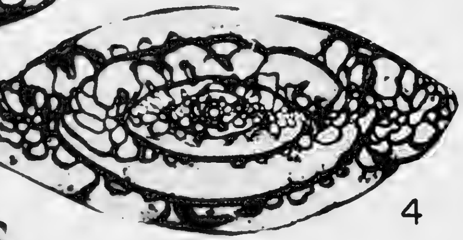

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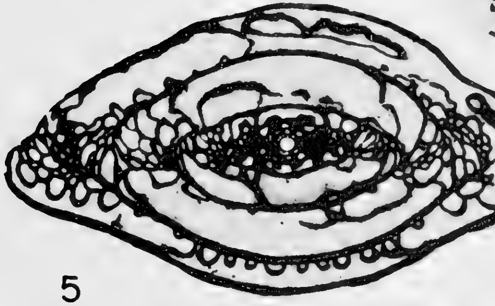

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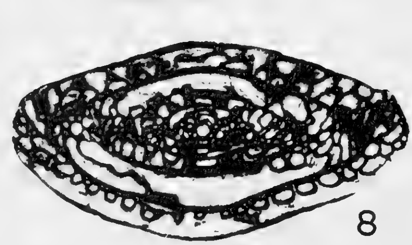

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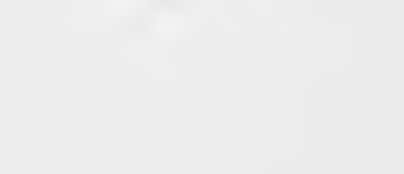

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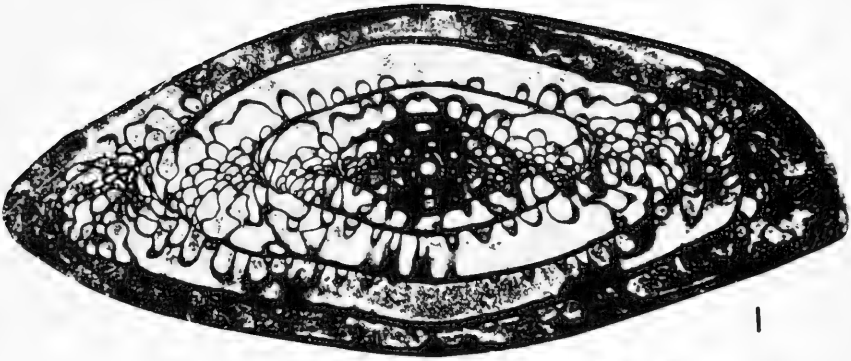

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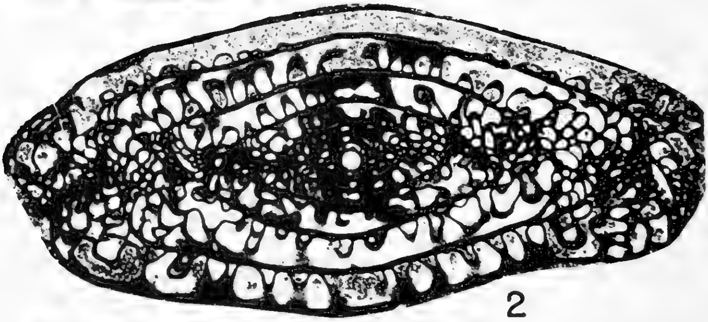

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PLATE 4

Figures 1-4. *Pseudoschwagerina convexa* Thompson (p. 38)

Alacran Mountain formation, Hueco Mtns., Texas.

1-2. Axial sections of topotypes, ×10, measured section 2, bed 5; YPM 22478-22479.

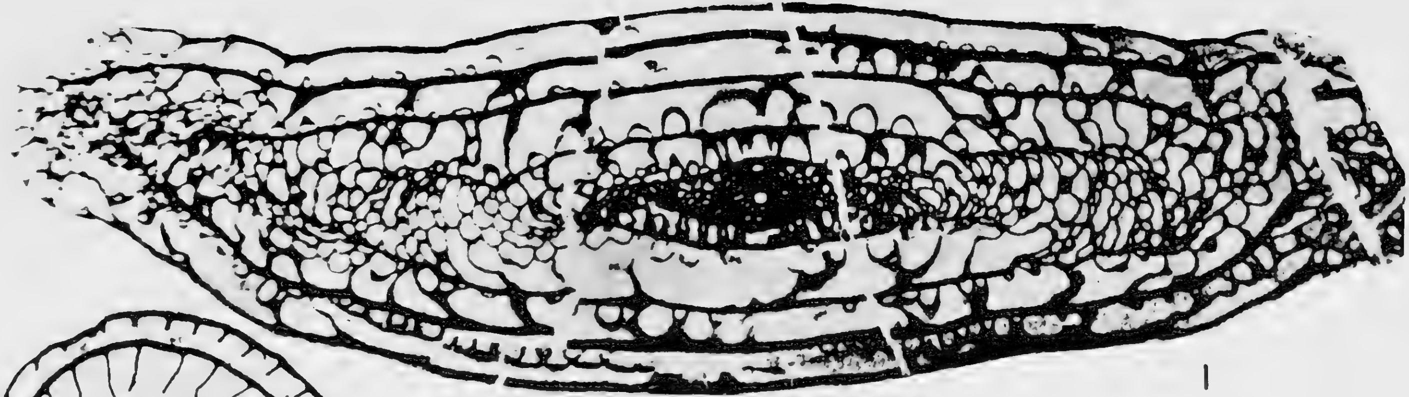
3-4. Axial sections of topotypes, ×10, measured section 2, bed 11; YPM 22480-22481.

PLATE 5

Figures 1-3. *Pseudoschwagerina geiseri,* n. sp. (p. 40)

Hueco Canyon formation, Hueco Mtns., Texas.

1. Axial section of holotype, ×10, locality 8, YPM 22482.
2. Sagittal section of paratype, ×10, locality 8, YPM 22483.
3. Axial section of paratype, ×10, locality 8, YPM 22484.



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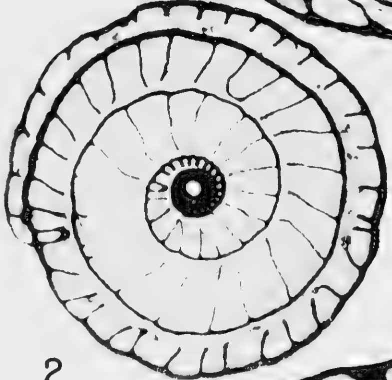

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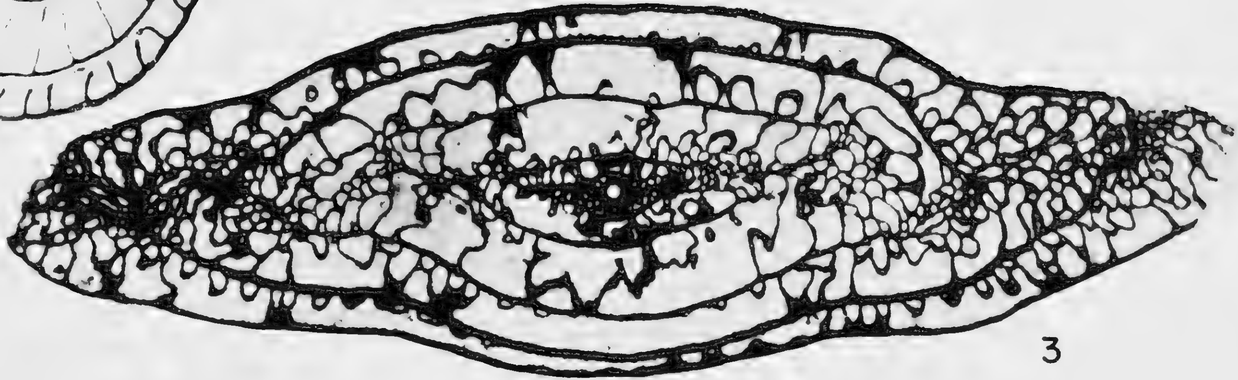

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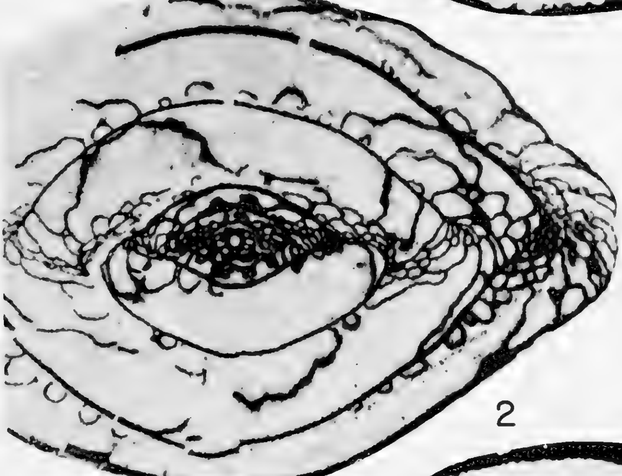

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PLATE 6

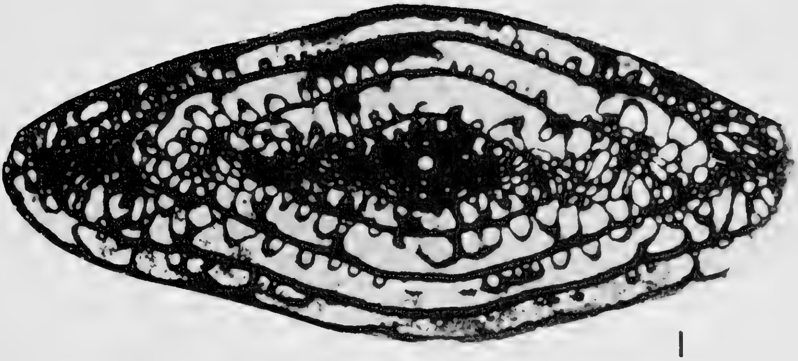
Figures 1-3. *Pseudoschwagerina gerontica* Dunbar and Skinner (p. 41)
Alacran Mountain formation, Hueco Mtns., Texas.
1-3. Axial sections, × 10, locality 33; YPM 22485-22487.

PLATE 7

Figures 1-4. *Pseudoschwagerina texana* Dunbar and Skinner (p. 43)

Hueco Canyon formation, Hueco Mtns., Texas.

1-4. Axial sections of topotypes, ×10, measured section 7, bed 8, YPM 22488-22491.



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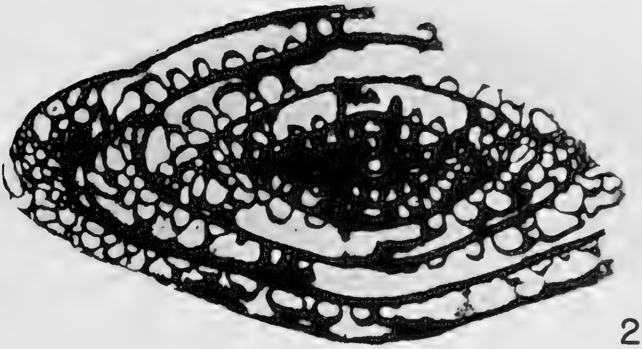

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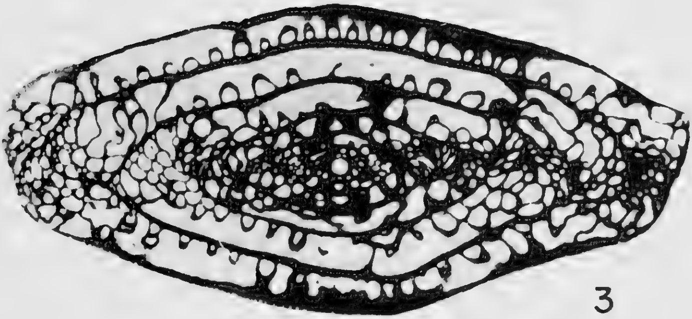

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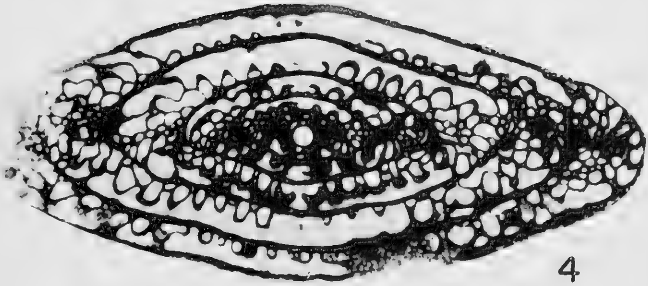

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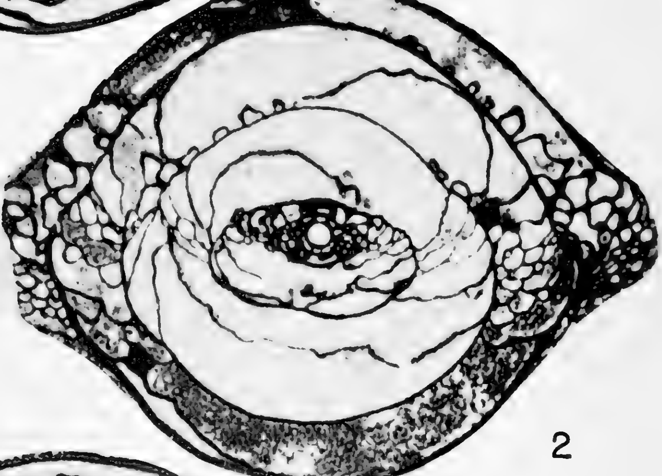

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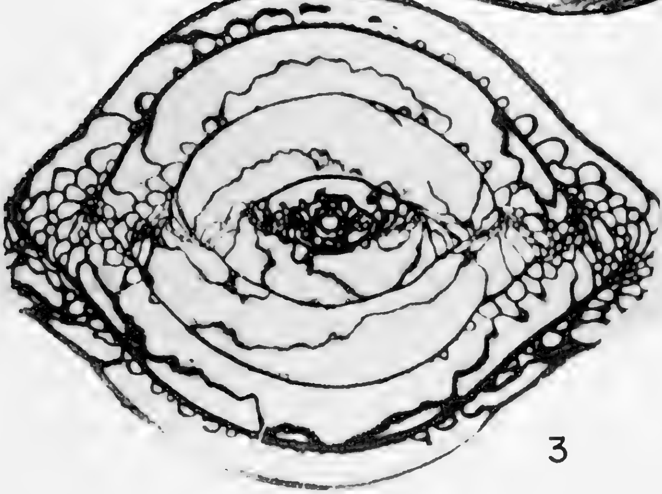

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PLATE 8

Figures 1-3. *Pseudoschwagerina uddeni* (Beede and Kniker) (p. 45)

Hueco Canyon formation, Hueco Mtns., Texas.

1-3. Axial sections of topotypes, ×10, measured section 7, bed 8; YPM 22492-22494.

PLATE 9

Figures 1-5. *Schubertella kingi* Dunbar and Skinner (p. 47)

Hueco Canyon formation, Hueco Mtns., Texas.

1-5. Axial sections of topotypes, ×50, measured section 8, bed 5; YPM 22495-22499.

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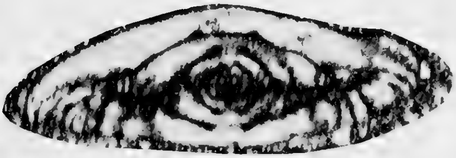

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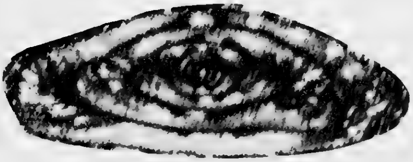

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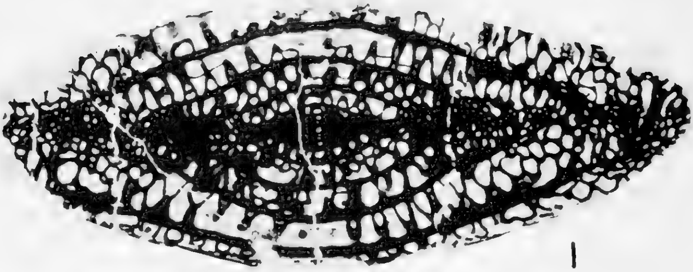

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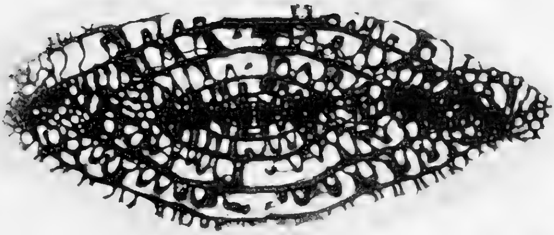

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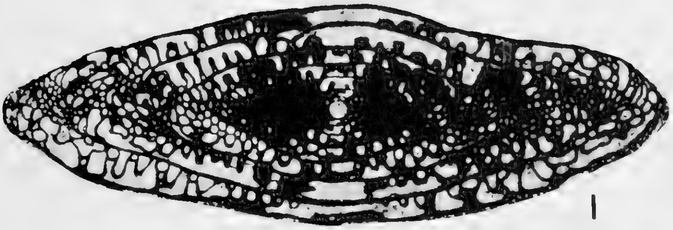
PLATE 10

Figures 1-6. *Schwagerina bellula* Dunbar and Skinner (p. 48)
Hueco Canyon formation, Hueco Mtns., Texas.
1-6. Axial sections of topotypes, ×10, locality 6; YPM 22501-22506.

PLATE 11

Figures 1-7. *Schwagerina crassitectoria* Dunbar and Skinner (p. 50)
Hueco Canyon formation, Hueco Mtns., Texas.
1-7. Axial sections, ×10, measured section 6, bed 9; YPM 22507-22513.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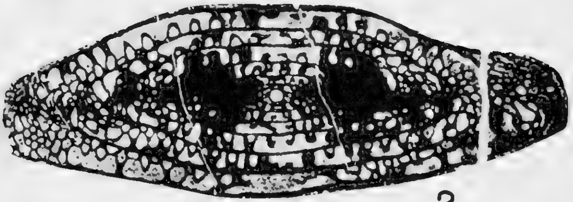
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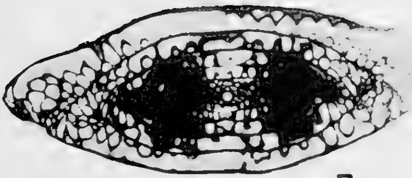
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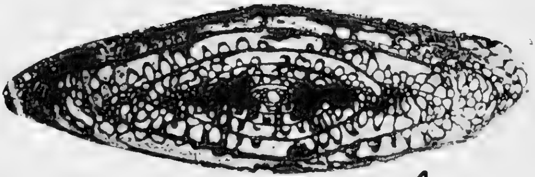
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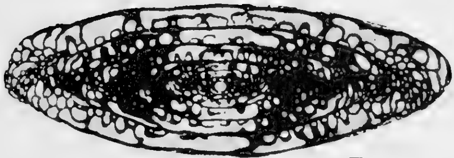
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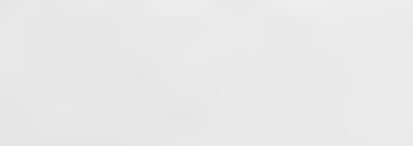
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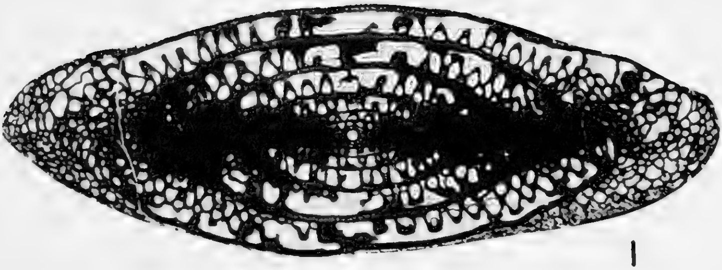

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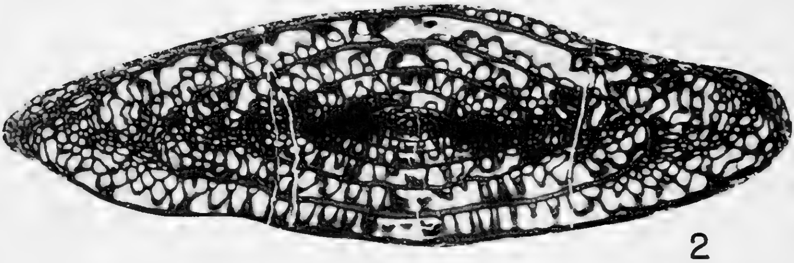

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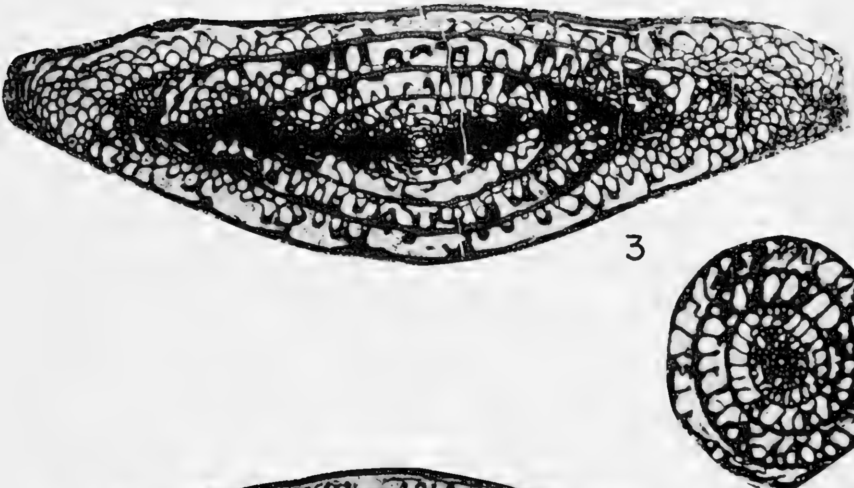

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PLATE 12

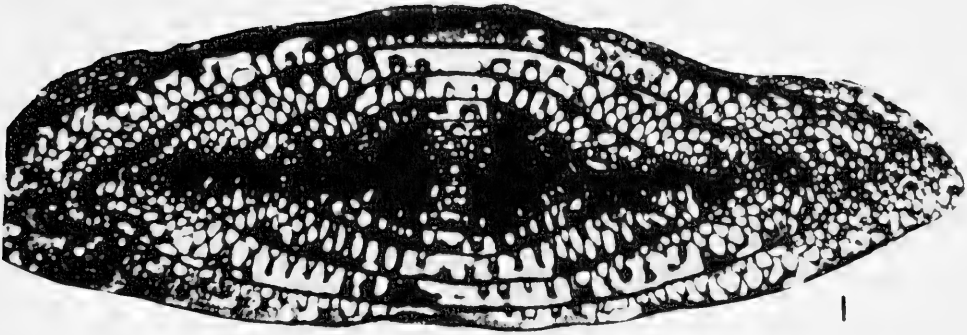
Figures 1-5. *Schwagerina davisi,* n. sp. (p. 52)

Hueco Canyon formation, Hueco Mtns., Texas.

1. Axial section of paratype, ×10, measured section 8, bed 17; YPM 22514.
2. Axial section of holotype, ×10, measured section 8, bed 17; YPM 22515.
3. Axial section of paratype, ×10, measured section 8, bed 17; YPM 22516.
4. Sagittal section of paratype, ×10, measured section 8, bed 17; YPM 22517.
5. Axial section of paratype, ×10, measured section 8, bed 17; YPM 22518.

PLATE 13

Figures 1-4. *Schwagerina diversiformis* Dunbar and Skinner (p. 54)
Alacran Mountain formation, Hueco Mtns., Texas.
1-4. Axial sections, × 10, locality 33; YPM 22519-22522.



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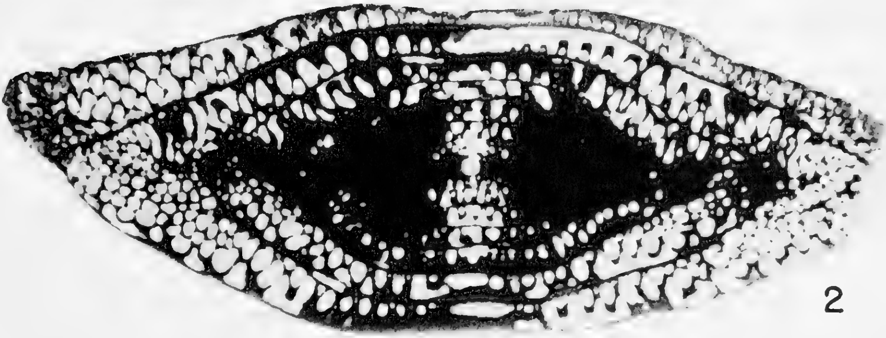

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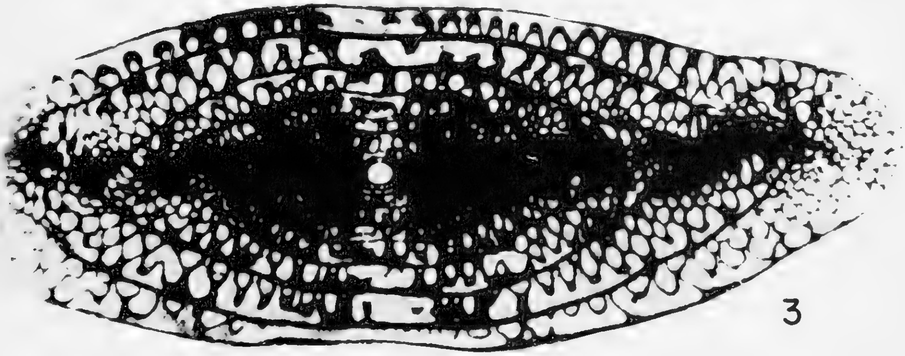

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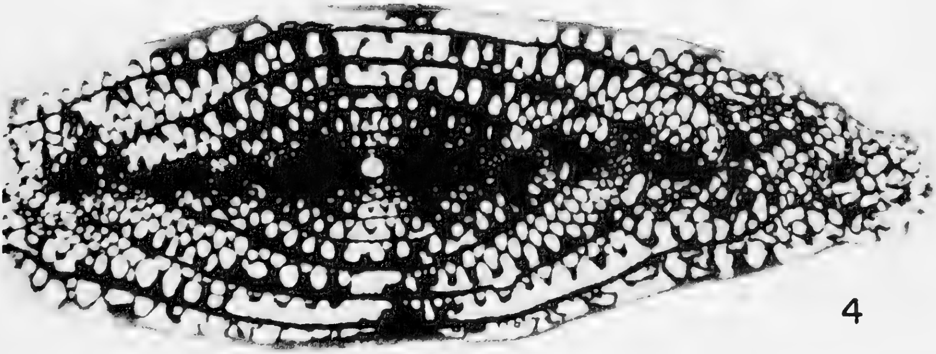

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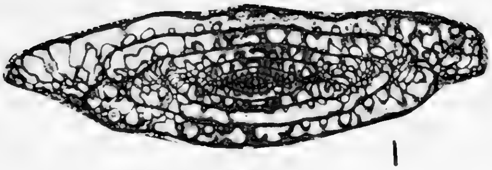

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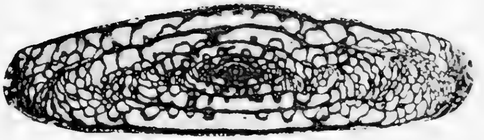

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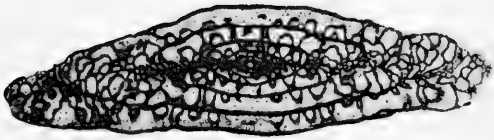

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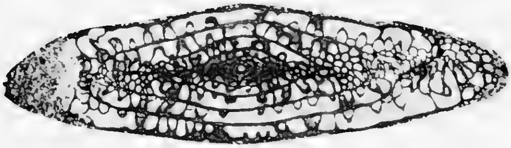

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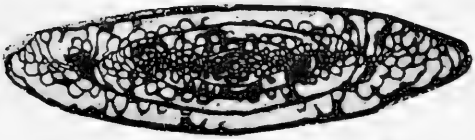

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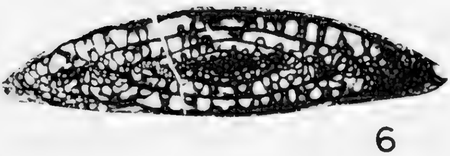

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PLATE 14

Figures 1-6. *Schwagerina emaciata* (Beede) (p. 56)

Hueco Canyon formation, Hueco Mtns., Texas.

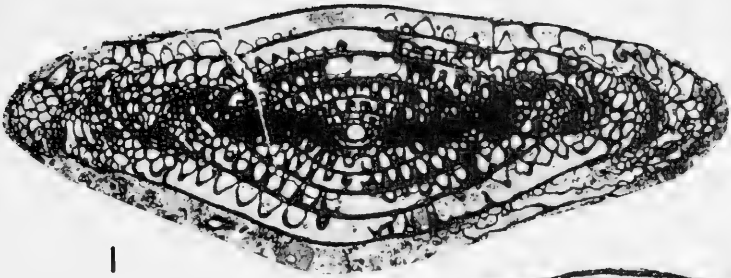
1-6. Axial sections, ×10, measured section 8, bed 5; YPM 22523-22528.

PLATE 15

Figures 1-6. *Schwagerina eolata* Thompson (p. 58)

Cerro Alto limestone, Hueco Mtns., Texas.

1-6. Axial sections of topotypes, ×10, locality 19; YPM 22529-22534.



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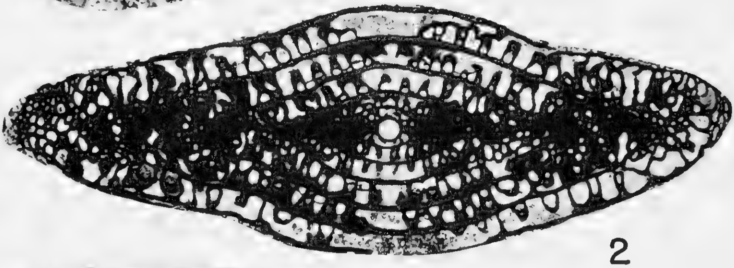

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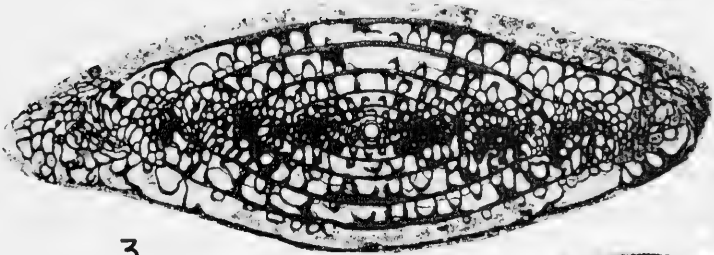

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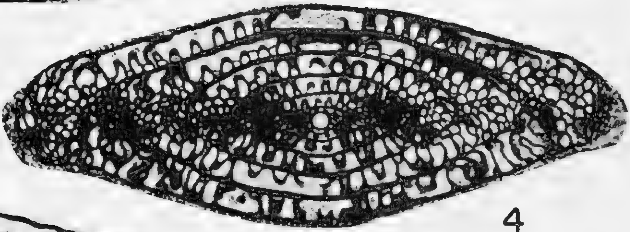

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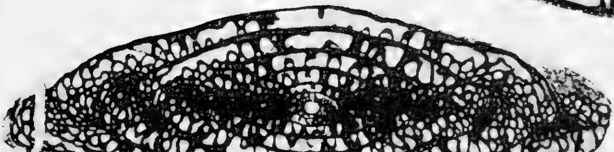

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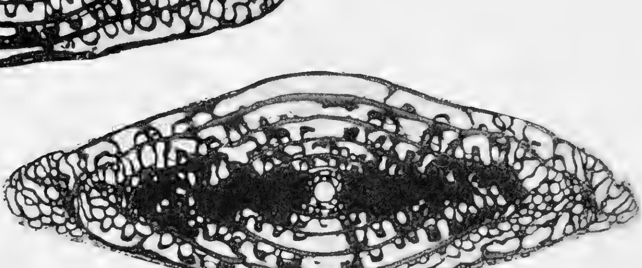

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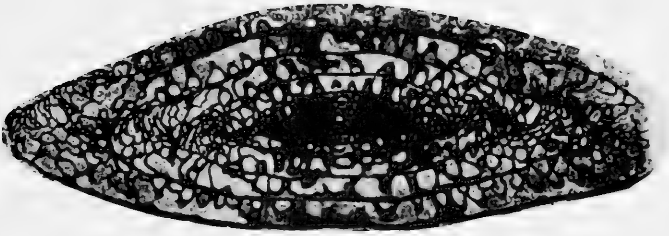

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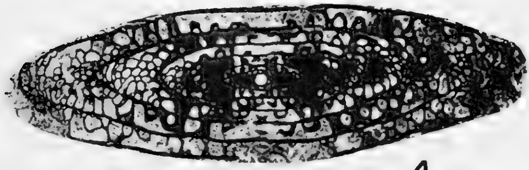

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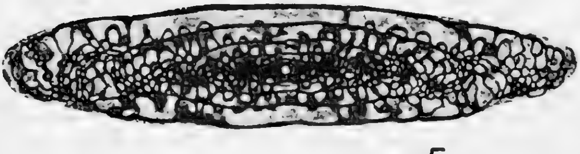

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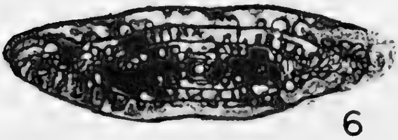

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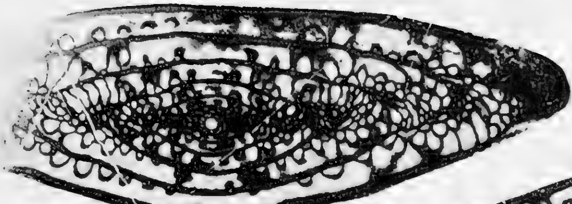
PLATE 16

Figures 1-6. *Schwagerina franklinensis* Dunbar and Skinner (p. 59)
Alacran Mountain formation, Hueco Mtns., Texas.
1-6. Axial sections, ×10, measured section 6, bed 9; YPM 22535-22540.

PLATE 17

Figures 1-4. *Schwagerina* aff. *S. grandensis* Thompson (p. 61)
Magdalena limestone, upper member, Bursum beds; Hueco Mtns., Texas.
1-4. Axial sections, × 10, locality 1; YPM 22541-22544.

Figures 5-8. *Triticites* cf. *T. cellamagnus* Thompson and Bissell (p. 74)
Magdalena limestone, upper member, Bursum beds; Hueco Mtns., Texas.
5-8. Axial sections, × 10, locality 1; YPM 22545-22548.



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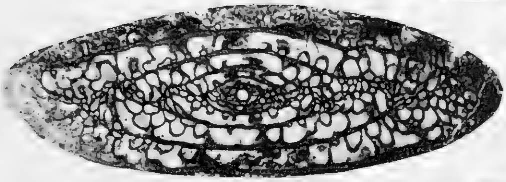

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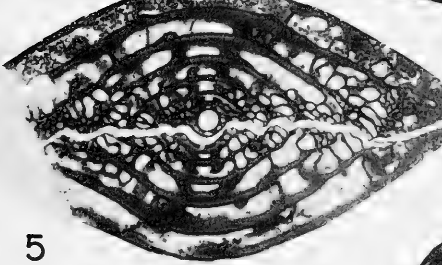

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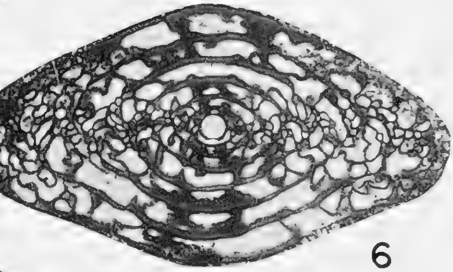

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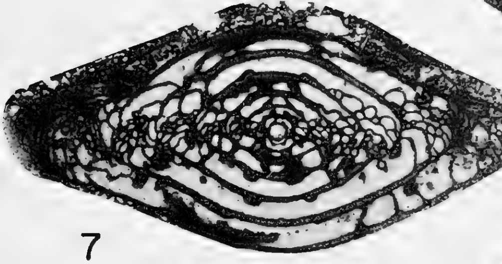

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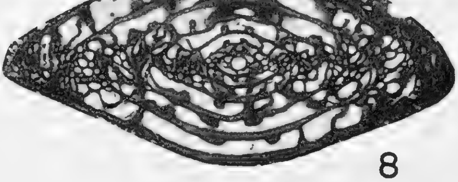

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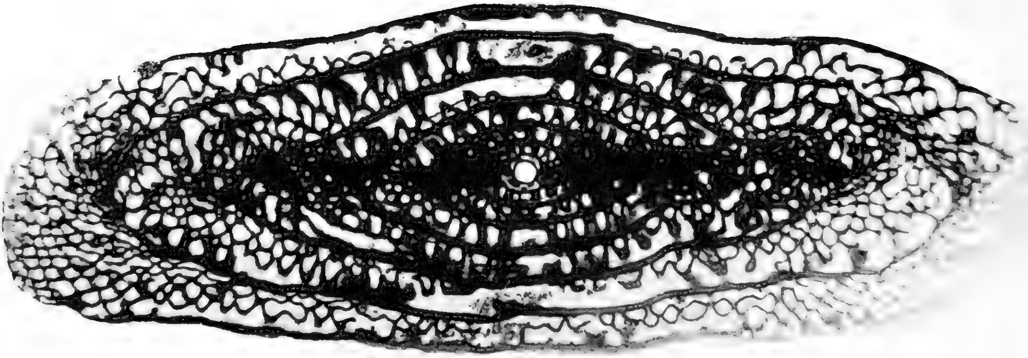

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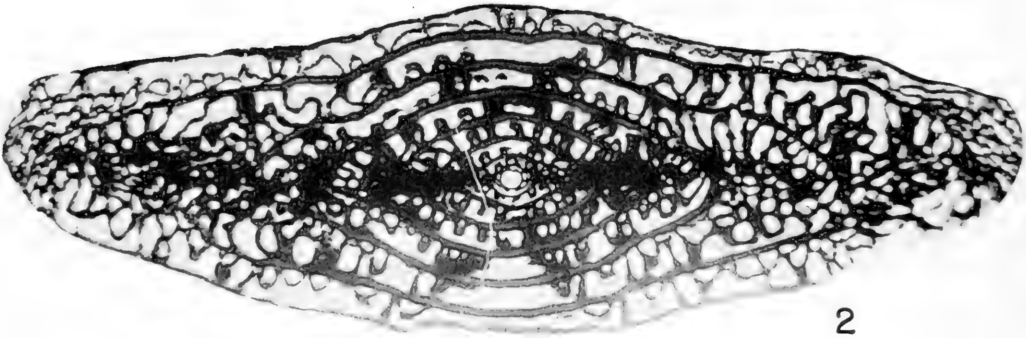

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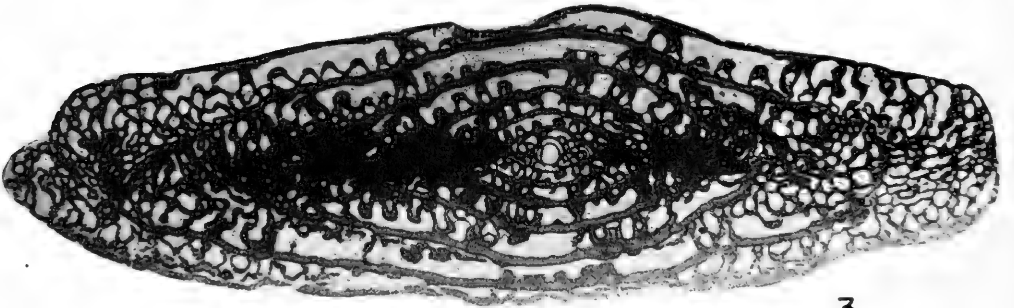

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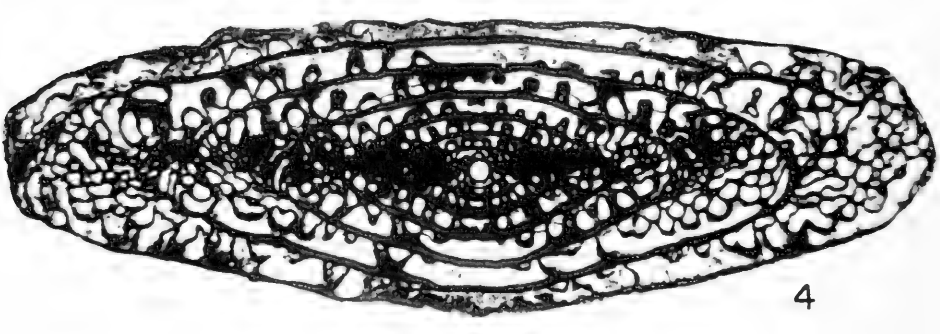

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PLATE 18

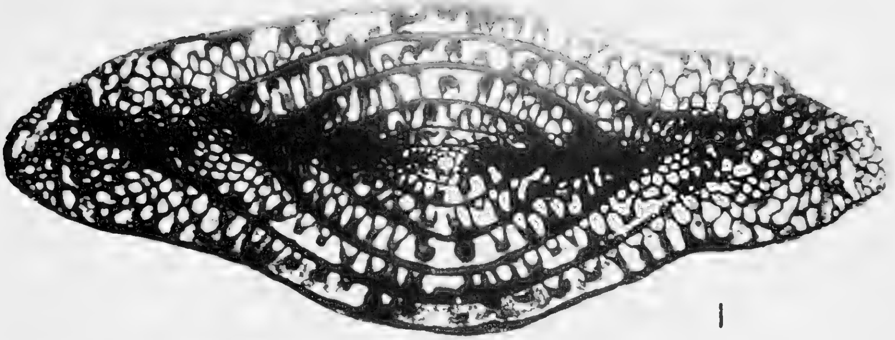
Figures 1-4. *Schwagerina huecoensis* (Dunbar and Skinner) (p. 62)
Hueco Canyon formation, Hueco Mtns., Texas.
1-4. Axial sections of topotypes, ×10, locality 8; YPM 22549-22552.

PLATE 19

Figures 1-4. *Schwagerina knighti* Dunbar and Skinner (p. 64)

Hueco Canyon formation, Hueco Mtns., Texas.

1-4. Axial sections, ×10, measured section 7, bed 8; YPM 22553-22556.



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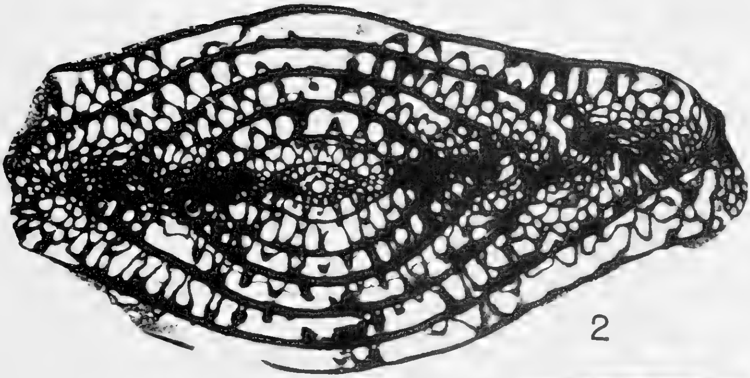

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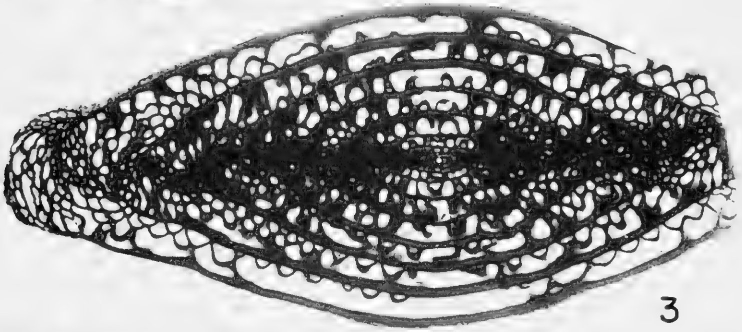

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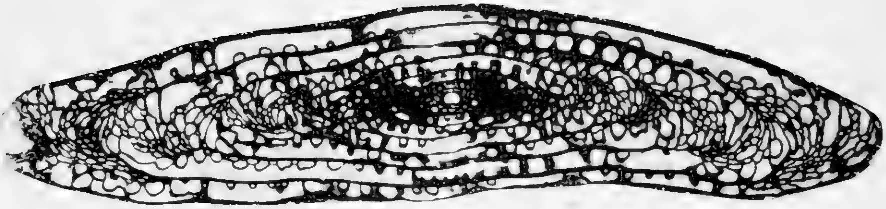

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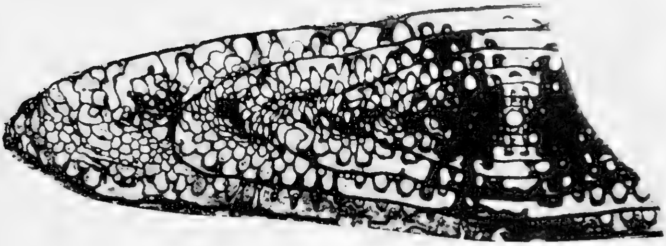

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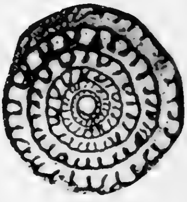

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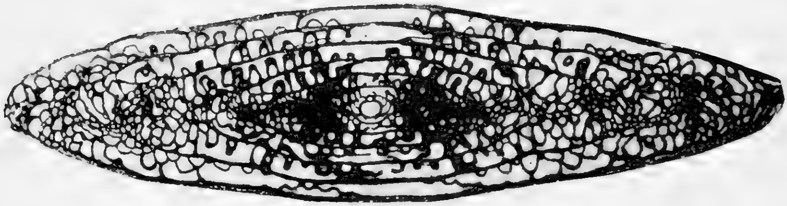

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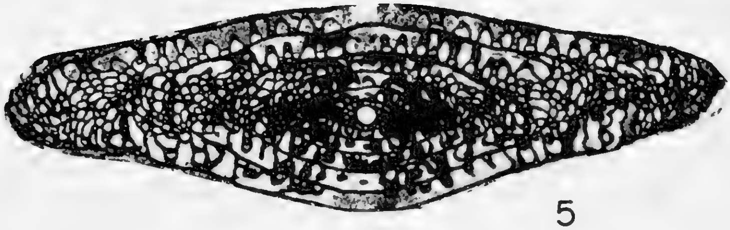

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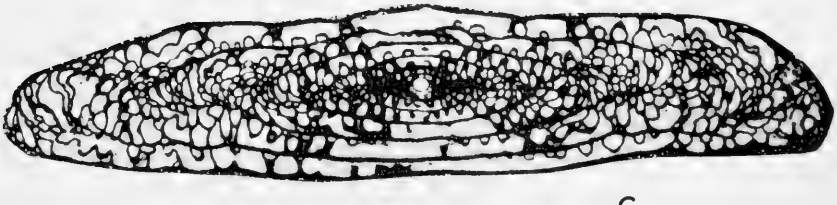

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PLATE 20

Figures 1-6. *Schwagerina menziesi,* n. sp. (p. 66)

Alacran Mountain formation, Hueco Mtns., Texas.

1. Axial section of holotype, ×10, measured section 6, bed 8; YPM 22557.
2. Axial section of paratype, ×10, measured section 6, bed 8; YPM 22558.
3. Sagittal section of paratype, ×10, measured section 6, bed 8; YPM 22559.

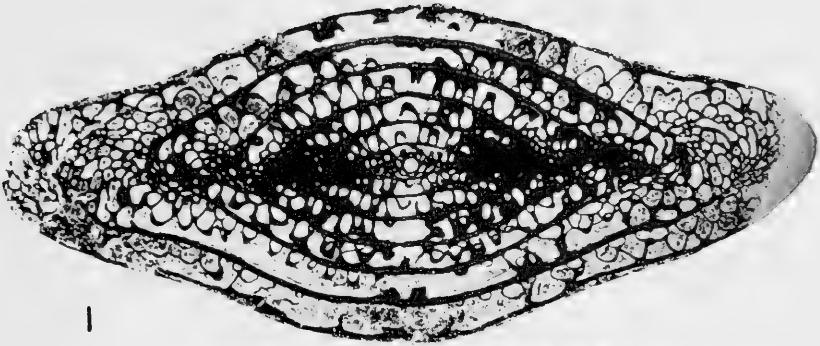
4-6. Axial sections of paratypes, ×10, measured section 6, bed 8; YPM 22560-22562.

PLATE 21

Figures 1-5. *Schwagerina neolata* Thompson (p. 67)

Cerro Alto limestone, Hueco Mtns., Texas.

1-5. Axial sections of topotypes, × 10, measured section 1, bed 28; YPM 22563-22567.



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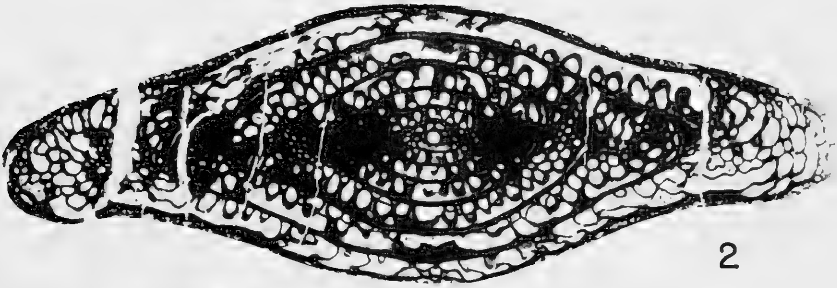

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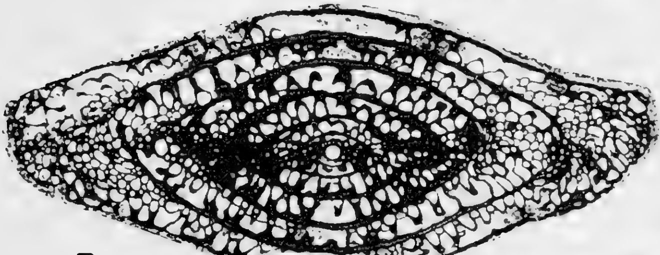

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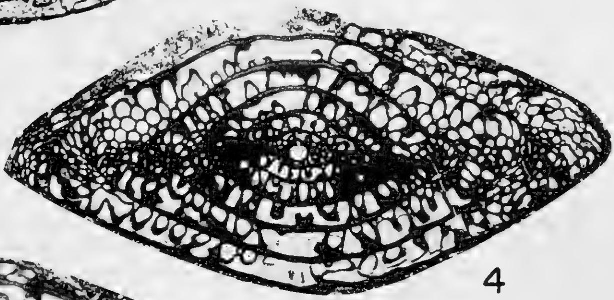

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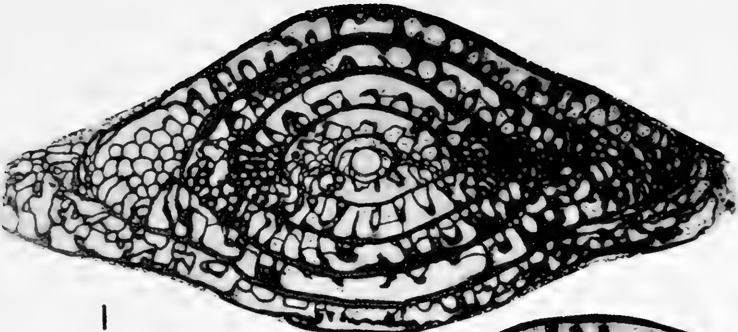

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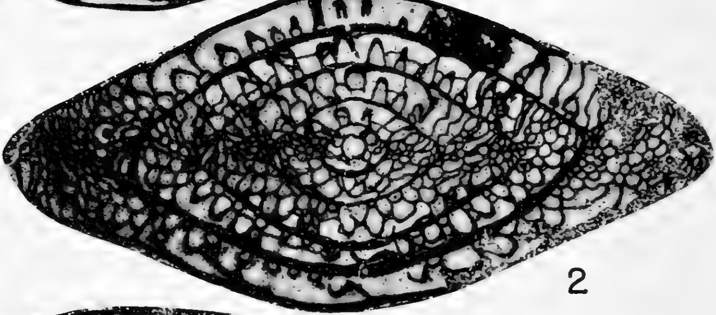

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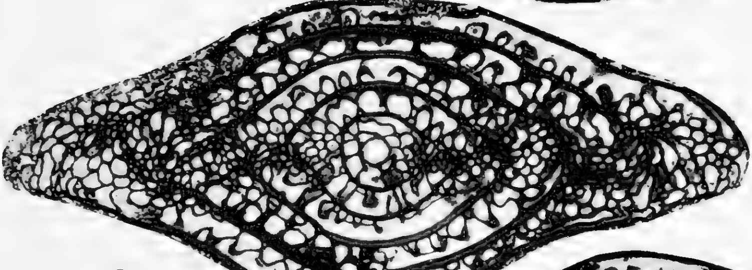

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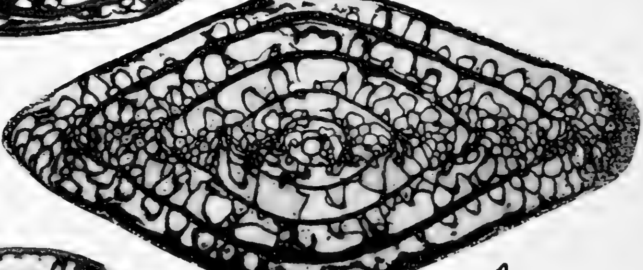

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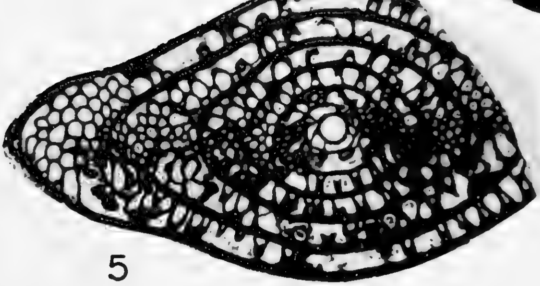

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PLATE 22

Figures 1-5. *Schwagerina nelsoni* Dunbar and Skinner (p. 69)

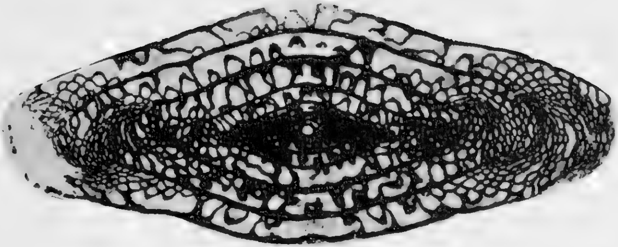
Alacran Mountain formation, Hueco Mtns., Texas.

1-5. Axial sections, ×10, measured section 2, bed 13; YPM 22568-22572.

PLATE 23

Figures 1-6. *Schwagerina thompsoni*? Needham (p. 71)

Hueco Canyon formation, Hueco Mtns., Texas.
1-5 Axial sections, ×10, measured section 8, bed 5; YPM 22573-22577.
6. Sagittal section, ×10, measured section 8, bed 5; YPM 22578.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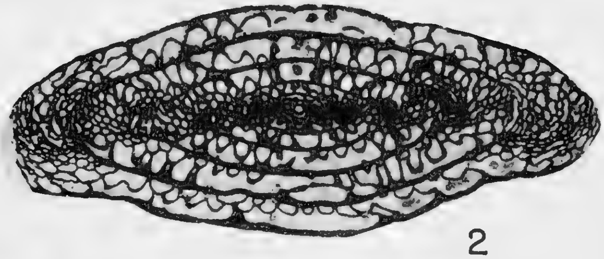
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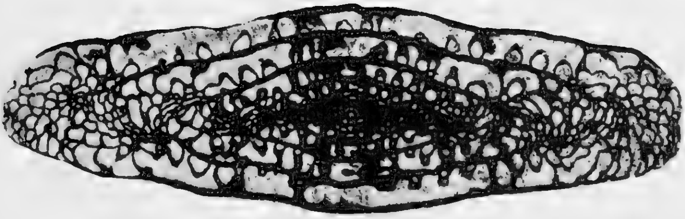
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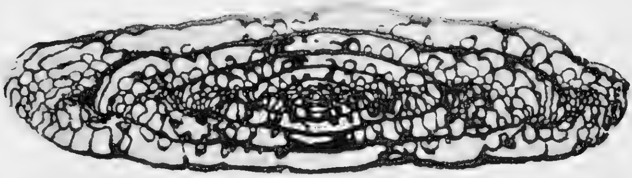
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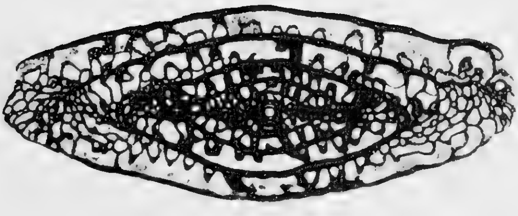
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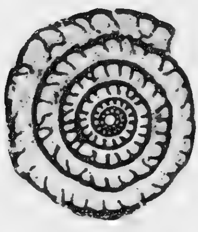
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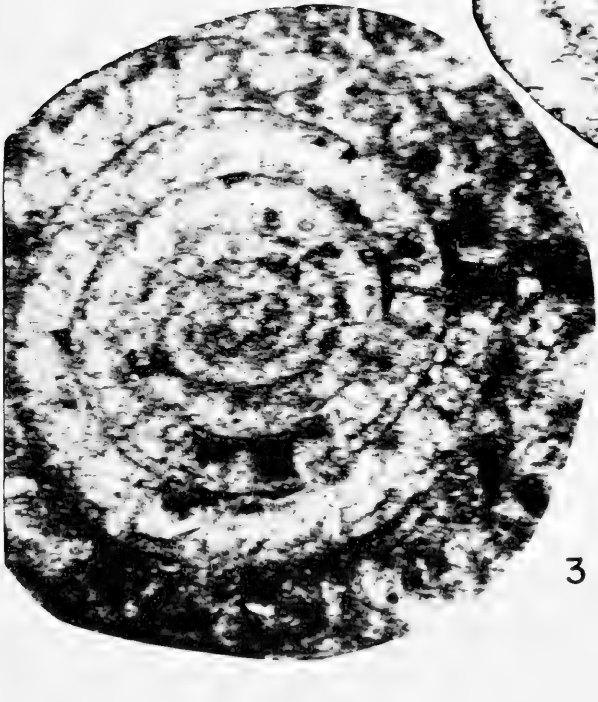

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PLATE 24

Figures 1-3. *Staffella lacunosa* Dunbar and Skinner (p. 72)

Hueco Canyon formation, Hueco Mtns., Texas.

1-2. Axial sections, ×50, locality 11; YPM 22579-22580.

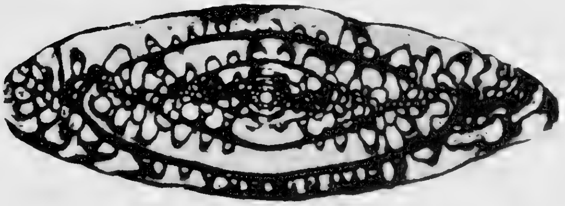
3. Sagittal section, ×50, locality 11; YPM 22581.

PLATE 25

Figures 1-6. *Triticites powwowensis* Dunbar and Skinner (p. 76)
Hueco Canyon formation, Hueco Mtns., Texas.
1-6. Axial sections of topotypes, ×10, locality 6; YPM 22582-22587.

1

2



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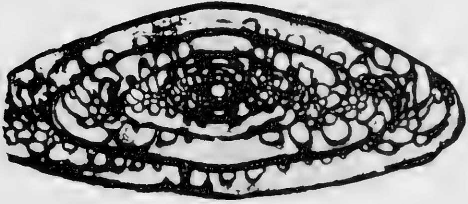

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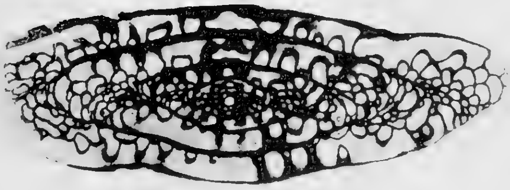

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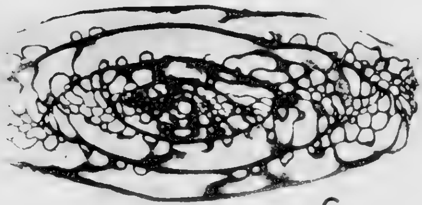

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