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PART I
The Wolfcampian Joyita Uplift in Central New Mexico

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PART II
Fusulinids of the Joyita Hills Socorro County, Central New Mexico

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Contents

PART I

Page

PART II

Illustrations

FIGURES1

PLATES1

TABLES

PART I

THE WOLFCAMPIAN JOYITA UPLIFT IN CENTRAL NEW MEXICO

FRANK E. KOTTLOWSKI
and
WENDELL J. STEWART

Abstract

The present-day Joyita Hills (Los Cañoncitos) is a complex Cenozoic horst on the east side of the Rio Grande graben in north-central Socorro County, New Mexico. Previous reports postulated a nearby uplift during late Desmoinesian, Missourian, and Virgilian time coextensive with the Peñasco or southern Uncompahgre landmass.

Recently (1963) Missourian fusulinids were identified from upper Pennsylvanian limestones in the Joyita Hills. Early Wolfcampian Bursum-facies arkosic limestone-conglomerates, derived from Pennsylvanian limestones and Precambrian granite gneiss of southern Joyita Hills area, unconformably truncate southwestward, in order, Missourian, Desmoinesian, Atokan, and Precambrian rocks. In southern Joyita Hills, Bursum strata abut against remnant hills of Precambrian granite gneiss. These hills were buried by basal Abo red beds which, adjacent to the hills, gradationally overlie Bursum purplish-green shales and limestones.

Joyita Hills area, lying east of the Lucero basin and southwest of the Estancia basin, was a submarine platform with small, low islands during Atokan and Desmoinesian time, as attested by black Atokan shales and Desmoinesian arkosic limestone-pebble conglomerate. The thinness of remnant upper Pennsylvanian strata is believed due mainly to erosion during early Wolfcampian time, not owing to erosion during late Desmoinesian, Missourian, or early Virgilian times.

As the early Wolfcampian Bursum facies, bearing a *Schwagerina* and *Triticites* fauna, is unconformably on Virgilian beds in many parts of central New Mexico, the Joyita uplift is a documented key to this late Virgilian and early Wolfcampian episode of erosion and of accompanying deposition of elastic strata.

Introduction

Structural features of Pennsylvanian age in north-central and south-central New Mexico appear to have been aligned roughly north-south (fig. 1). Major sediment traps in north-central New Mexico during Pennsylvanian time were the Rowe-Mora basin (or Taos trough of Sutherland), in central New Mexico the Estancia basin and Lucero basin, and in south-central New Mexico the Orogrande basin and San Mateo basin. Source areas for these sediments were the Uncompahgre, Peñasco, Pedernal, and Zuni uplifts. The Joyita uplift is on the east flank of the Lucero basin and on the southwest margin of the Estancia basin; its present-day elevated expression dates from late Tertiary time, but pre-Mesozoic strata are relatively thin in the Joyita Hills.

Wilpolt et al. (1946) and Read and Wood (1947) believed that the Joyita Hills area was uplifted in middle Pennsylvanian time, and that it was a positive feature during middle and late Pennsylvanian time and was connected northward with the Peñasco uplift. Wengerd (1959) thought the field evidence indicated a north-south-trending shelf separating the Estancia basin on the east from the Lucero basin on the west, in the form of a submarine shallows-and-shoals area that he called the Manzanita platform. Recently discovered faunal evidence (Kottlowski and Stewart, 1966) suggests that if the Joyita Hills area was a relatively positive block during Pennsylvanian time, it was more likely a submarine platform with small, low islands rather than a large island exposed to erosion. Furthermore, the lithology and thinness of the basal Wolfcampian beds in and near the Joyita Hills, as well as their truncation southward of the underlying Pennsylvanian strata, suggest that major uplift took place during early Wolfcampian time, not prior.

REGIONAL SETTING

The Joyita Hills, or Los Cañoncitos, as labeled on the La Joya topographic quadrangle map, are a complex series of fault blocks lying on the east edge of the Rio Grande valley about 15 miles (24 km) north of Socorro in central New Mexico. To the west, the Rio Grande structural depression, a complex graben, is filled by elastic rocks of the Cenozoic Santa Fe Group and Holocene alluvial deposits (Kelley, 1952). To the east, Quaternary alluvium of Valle del Ojo de la Parida and of El Valle de la Jaya thinly covers Cretaceous and Tertiary rocks in a structurally low region west of the Los Piños Mountains. To the north and south, conglomerates and sandstones of the Santa Fe Group overlap the pre-Miocene rocks.

The Joyita Hills pre-Tertiary outcrops are about 6 miles Oro km) long in a north-northeast direction (fig. 2) and 1 to 2 miles (1.5-3 km) wide (Wilpolt et al., 1946; Wilpolt and Wanek, 1952). Along the West Joyita fault, Santa Fe Group beds are downdropped on the west against the pre-Tertiary rocks, whereas on the east side of the Joyita Hills horst, along the East Joyita fault, volcanic rocks of the Oligocene Datil Formation are downdropped to the east. The main core of the hills is a 1-mile-wide (1.5 km) block of Precambrian granite gneiss. For the most part, younger beds dip to the west off of this mass of Precambrian rocks. Numerous transverse faults of northeast trend and nearly longitudinal faults trending north to northeast have broken the pre-Tertiary and early Tertiary rocks into a complex series of fault slices. Some compressive deformation is shown in the canyon walls by small thrust wedges of resistant beds, and by squeezed incompetent units of gypsum, black shale, red shale, and siltstone. The rocks are well exposed in this barren jumble of canyons and

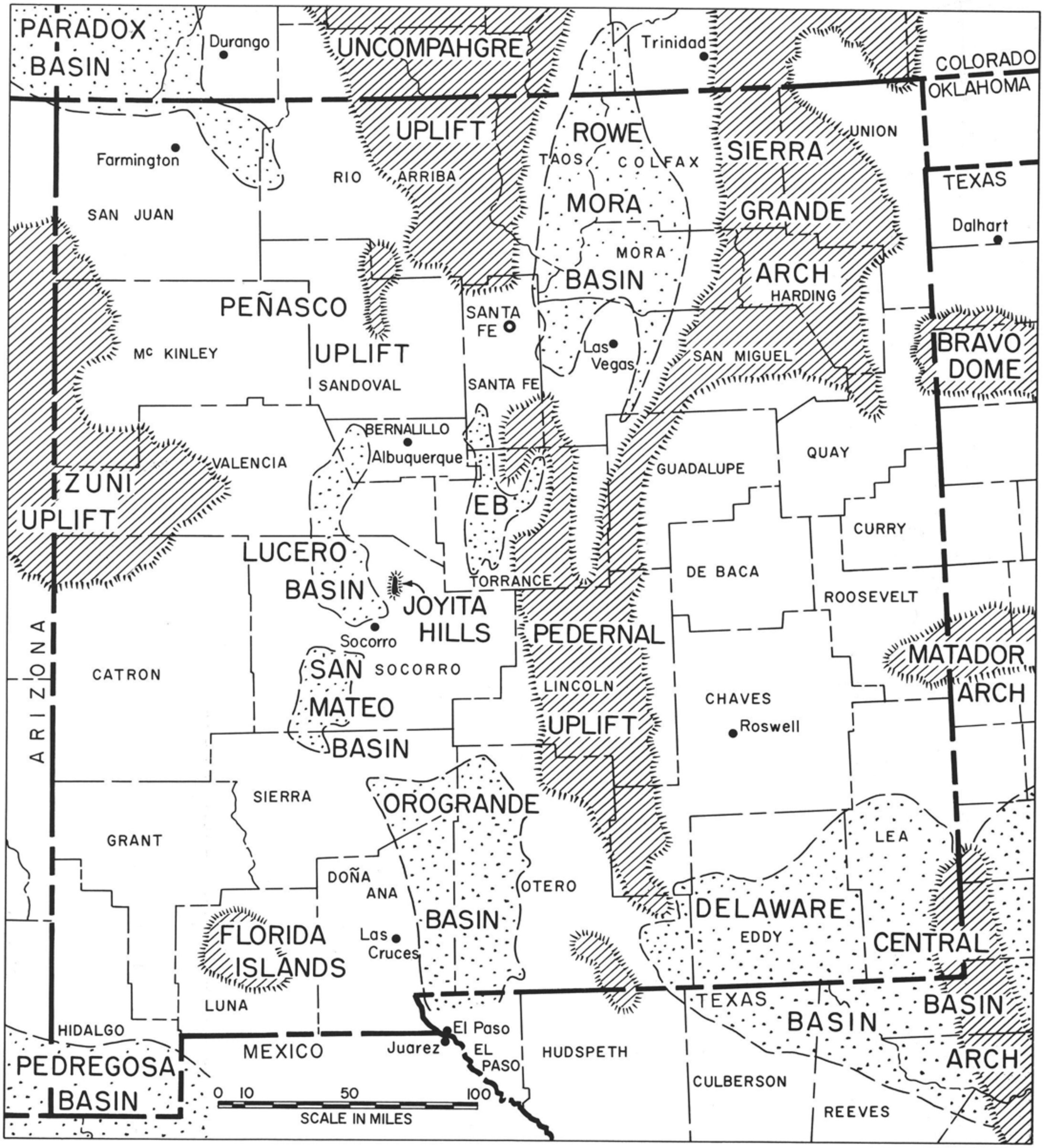

Figure 1

PENNSYLVANIAN PALEOGEOGRAPHIC MAP OF NEW MEXICO. EB IS ESTANCIA BASIN

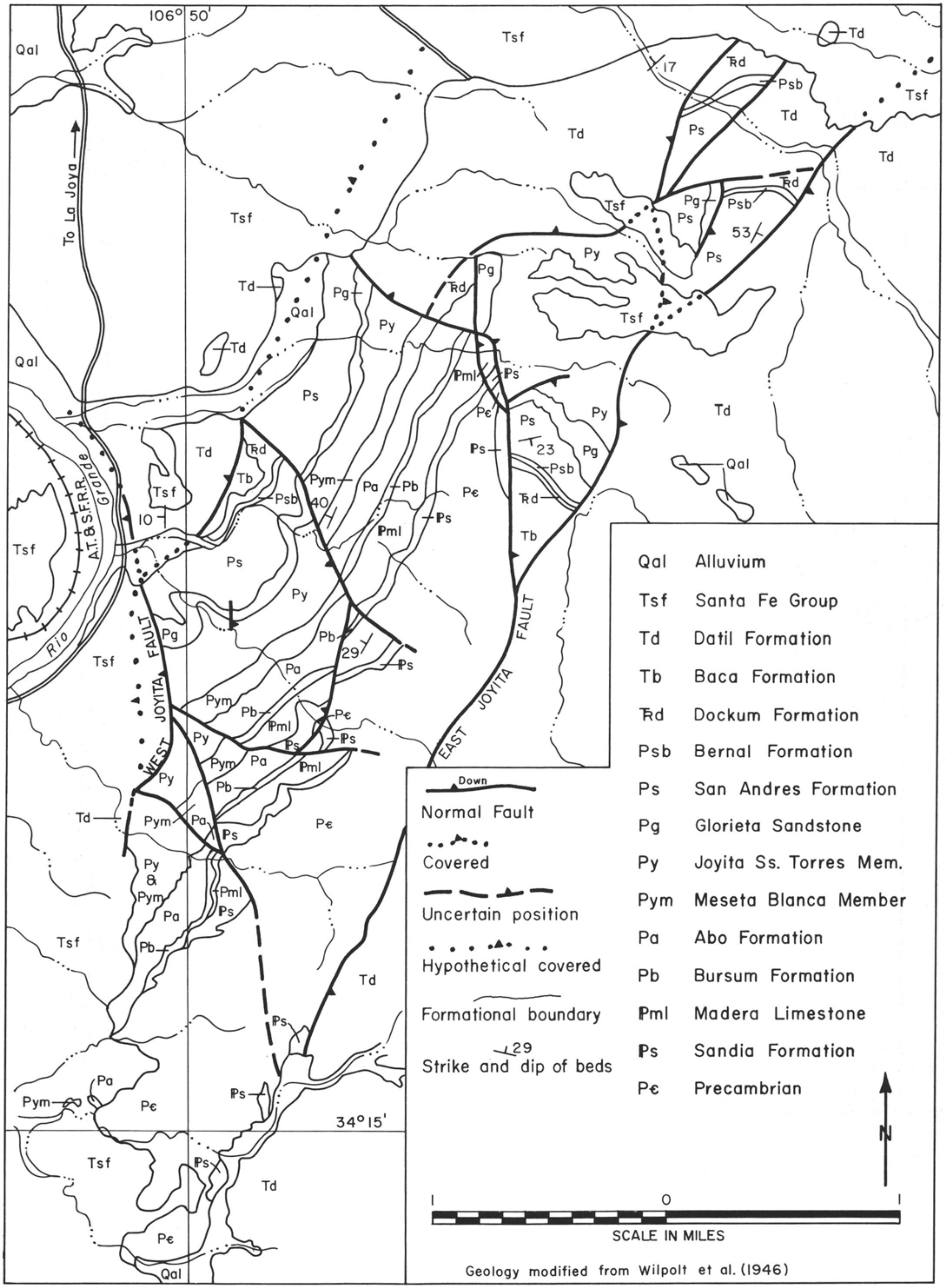

Figure 2
Geologic sketch map of Joyita Hills

ridges, but the structural complexities make suspect any thicknesses obtained by measuring stratigraphic sections.

Six miles (1 o km) northeast of the northernmost Pennsylvanian outcrops of Los Cañoncitos, Precambrian rocks occur overlain by upper Santa Fe Group sands and sandstones. The Precambrian outcrops are about I mile (1.6 km) long and 0.5 mile (o.8 km) wide; they appear to be an erosional remnant of a subsurface extension of the Joyita horst.

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Stratigraphic Sequence

Precambrian rocks in the Joyita Hills are mostly granite gneiss with some amphibolite and various types of schists (Herber, 1963). The unconformably overlying Pennsylvanian strata are as much as 416 feet (127 m) thick, consisting of the Sandia Formation below and the Madera Limestone above. The Sandia Formation is 112 to 161 feet (34-49 m) thick. It consists predominantly of silicate elastic rocks with a basal lenticular, brownish to light-gray quartzite that grades upward into dark-gray shales and thin argillaceous bioclastic limestones; local laminae of bone coal occur in the dark shales. The Madera consists mainly of carbonate rocks which are cherty, massive to medium-bedded, fossiliferous beds and cap westward-dipping cuestas. Thickness of the Madera (where present) varies greatly owing to post-Madera erosion. As much as 255 feet (78 m) have been measured near the northern outcrops, with none present to the south.

The overlying marginal-marine Bursum facies of Wolfcampian age is about 30 feet (9 m) thick and consists of basal green limestone-granule conglomerate and reddish-brown quartz-pebble conglomerate beneath red beds and thin lenses of impure limestone, crinoidal calcarenite, and calcareous gray shale. The unit grades up into the Abo red-bed facies, which is about 300 feet (91 m) thick and contains dark reddish-brown shale and sandstone with some arkose and conglomerate lenses.

The validity of Bursum as both a formation name and a time sequence deserves comment. The two major stratigraphic units within the Wolfcampian Series of west Texas and southern New Mexico are the Hueco and the Abo Formations. The Hueco Formation, composed mainly of high-energy carbonate rocks, represents the marine shelf facies, whereas the red shales, sandstones, and conglomerates of the Abo Formation represent mostly continental deposits. The type Bur-sum of Wilpolt et al. (1946) consists of interbedded marine limestones and possible continental red beds and coarse-grained silicate elastic rocks of a marginal facies in the lower Wolfcampian between the Hueco and Abo facies. As this marginal facies is represented by erratic depositional and lithological sequences, it is doubtful that mapping of the unit can be consistent enough for formational consideration, except locally.

Fusulinids of the type section for the Bursum Formation near the Oscura Mountains, 25 miles (40 km) southeast of the Joyita Hills, have been studied in detail. This stratigraphic unit falls within the biozone of *Triticites* and the lower biozone of *Schwagerina, Stewartina* (Garner L. Wilde, unpub. ms.), and *Pseudoschwagerina* consistent with the lower Wolf-camp in many areas. Many workers in biostratigraphy have inferred that the Bursum fusulinid fauna is older than that of most other Wolfcamp areas and use the name to imply an older time zonation. It is believed that the Bursum is not older than the lower Wolfcamp in the Hueco Mountains, the Glass Mountains, central Texas, and many other areas, and it should not be used to imply a discrete older rock zone. If the formational name is used, it would apply only locally to the marginal facies between the Hueco and Abo Formations.

Younger Permian beds include, in ascending order, the siltstone, sandstone, silty dolomitic limestone, and gypsum of the Yeso Formation, the Glorieta Sandstone, the San Andres Limestone, and a thin remnant of the Bernal (Artesia) Formation. The Triassic Dockum Formation unconformably overlies the Permian strata and to the southeast is overlain by Cretaceous beds, the Dakota Sandstone, Mancos Shale, and Mesaverde Formation. Unconformably on the pre-Tertiary rocks is the early Tertiary Baca Formation of conglomerate, conglomeratic sandstone, and red siltstone; this unit is overlain by the volcanic rocks of the Oligocene Datil Formation. All of the older rocks in the area are unconformably overlain by the Miocene-Pliocene Santa Fe Group.

BASAL PENNSYLVANIAN STRATA

West of the Rio Grande in the Ladron, Lemitar, and Magdalena Mountains (fig. 3), thin remnants of Mississippian

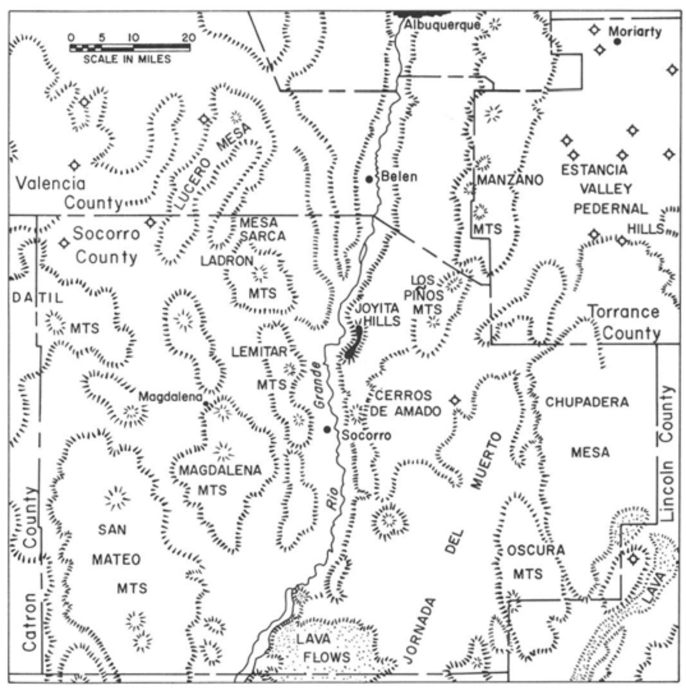


Figure 3

INDEX MAP OF CENTRAL NEW MEXICO

limestones occur between the Precambrian rocks and the basal Pennsylvanian beds. A few remnant lenses of the Mississippian are also reported northeast of the Joyita Hills in the Manzano Mountains (Armstrong, 1958). East of the Rio Grande in most of the Manzano Mountains, in the Los Piños Mountains, Joyita Hills, and Cerros de Amado areas, the Pennsylvanian strata rest with erosional unconformity on Precambrian granitoid and metamorphic rocks. Thus the Joyita Hills area at the beginning of Pennsylvanian time was slightly higher than adjoining regions to the north, west, and southwest, as erosion during late Mississippian and earliest Pennsylvanian time stripped from the area the Mississippian limestones that are partly preserved to the north, west, and southwest.

The age of the basal Pennsylvanian sediments is not precisely known for the Joyita Hills. Atokan (Derryan) fusulinids, chiefly *Fusulinella,* have been collected from the lower Pennsylvanian strata to the west in the Ladron Mountains and on Mesa Sarca by Thompson (11942), by him to the south in Cerros de Amado, and by Wilpolt et al. (1946), as well as by Stark and Dapples (1946), in the Los Piños Mountains east of the Joyita Hills. Wilpolt and Wanek (1951) reported only Desmoinesian *Fusulina* from the Joyita Hills, but Wilpolt et al. (1946) had previously found *Fusulinella* in the Sandia Formation. Both early and late Atokan fusulinids occur in the lower Pennsylvanian of the Joyita Hills; thus these beds are at least as old as Atokan. Beds of Morrowan age are known to the north in the Nacimiento Mountains (Northrop and Wood, 1946) and to the south in the Sacramento (Pray, 1961) and Hueco (Thompson, 1948) Mountains. Morrowan beds probably are absent in the Joyita Hills area, suggesting again that this region was somewhat higher than some parts of regions to the north and south during earliest Pennsylvanian time.

For the most part, the Sandia Formation includes the beds of Atokan age in central New Mexico. Locally, the division of the Pennsylvanian into the basal clastic beds called the Sandia Formation and the upper limestone-dominated sequence of the Madera Limestone does not follow time planes nor fossil zonation. For example, locally in the Los Piños Mountains, elastic beds dominate the sequence up into the Zone of *Fusulina* of Desmoinesian age, and these strata should be included in the Sandia Formation as based on their litho-logic features. In the Joyita Hills, the basal clastic rocks do appear to be mainly of Atokan age, whereas the overlying remnant Madera Limestone sequence is of Atokan, Early Desmoinesian, and Early Missourian age. Comparisons with adjoining areas of Pennsylvanian outcrop, however, are best made on the basis of faunal zones, when possible.

Basal Pennsylvanian beds in most parts of the Joyita Hills are of lenticular, light-gray to reddish-brown quartzite; faulting along the contact with Precambrian rocks obscures true thicknesses in many localities, but the maximum thickness of quartzite appears to be about 3o feet (9 m), with 11 o feet (3 m) being the average. Although this quartzite was deposited on an uneven surface, with some beds of the sandstone lapping up onto small hillocks of gneiss, in most places the rock is a relatively pure quartz sandstone with scattered grains of feldspar and mica. A few subrounded pebbles of granite gneiss occur in basal laminae, but rounded to angular pebbles of hematitic siltstone are scattered throughout the quartzite. Locally there are lenses of conglomerate, as at Central Canyon, where crossbedded basal lenses contain large angular pebbles of quartz, gneiss, and feldspars. Fragments of crinoids, brachiopods, and algae filaments occur in the quartzite in the southern outcrops.

The quartzite may be of Early Atokan age where it grades upward into dark-gray shales and interbedded quartzitic sandstones that contain an Atokan fauna in immediately overlying beds.

EARLY ATOKAN STRATA

The main bulk of Early Atokan strata is of intertongued dark-gray carbonaceous shale and thin, laminated, silty, dark-gray limestone, with lenses of rust-brown sandstone and limy, nodular, fossiliferous, green to gray shale, as well as laminae of gypsum and bone coal.

These lower Atokan rocks in the Joyita Hills contrast with Atokan sequences in the surrounding areas, being thinner and containing a higher percentage of fine-grained elastic rocks. To the east and northeast, in the Los Piños and Manzano Mountains, Atokan beds range from 23o to 53o feet (70- 160 m) in thickness. In the Manzano Mountains, they are chiefly greenish-gray to dark-gray shaly siltstones and sandstones with thin beds of clayey shale, silty limestone, and limestone-chert-quartz pebble conglomerate. Atokan beds in the Los Piños Mountains are of brownish- to greenish-gray sandstone, mostly quartz-rich but some arkosic, and of green to black shale and siltstone, and thin dark-gray silty limestone. To the west in the Ladron Mountains and on Mesa Sarca, the Atokan unit is about 450 feet (137 m) thick and is dominantly sandstone and shale with lesser amounts of elastic limestone. A thicker section crops out to the south in Cerros de Amado, where Atokan beds are about 805 feet (245 m) thick and consist of brownish, reddish, and greenish, pebbly sandstone, green to black, limy to carbonaceous shale, and dark-gray, silty limestone.

The thin Early Atokan sequence of the Joyita Hills area, which is dominantly dark-gray shale, appears to have been deposited in shallow, stagnant, marine waters far from eroding source uplands, whereas Atokan sections to the east and west are of clastic marine beds whose constituents probably were washed in from the west from the Zuni upland and from the east from the Pedernal upland.

Late Atokan rocks are mainly dark-gray, cherty, micritic limestones. The Early Atokan sequence below these limestones (see figs. 5-9) consists of five persistent units, in ascending order: (11) the basal quartzite, (2) black to gray shale with interbedded sandstone and arenaceous calcarenite, (3) black shale with lenses of black silty limestone and of crinoidal calcarenite, (4) brownish-black silty limestone with laminae of yellow and pale-red siltstone, and (5) brown-weathering, slightly oolitic, algal, fossiliferous, ledge-forming limestone. These limestones contain high percentages of lime mud and green algae indicative of a low-energy, shallow-water shelf environment of deposition. The sequence appears to thin irregularly southward from 161 feet (49 m) in Coal' Mine Canyon to 11 12 feet (34 m) in East Fork of South Canyon (farther southward it was removed by erosion during early Wolfcampian time).

In the southern sections (fig. 4), section B, Central Canyon (JH3), and East Fork of South Canyon (JH4), the apparent top of the Early Atokan is the brown-weathering, slightly oolitic, algal, fossiliferous limestone of B9, JH3-11, and JH4-6a. This apparently is unconformably beneath the Late Atokan cherty limestones, and appears to pinch out northward. It is a maximum of 5 feet (1.5 m) thick. This probably implies a local nondepositional high between Early and Late Atokan time, rather than uplift and erosion. Basal Late Atokan beds do not appear to contain eroded detritus of the underlying Early Atokan rocks.

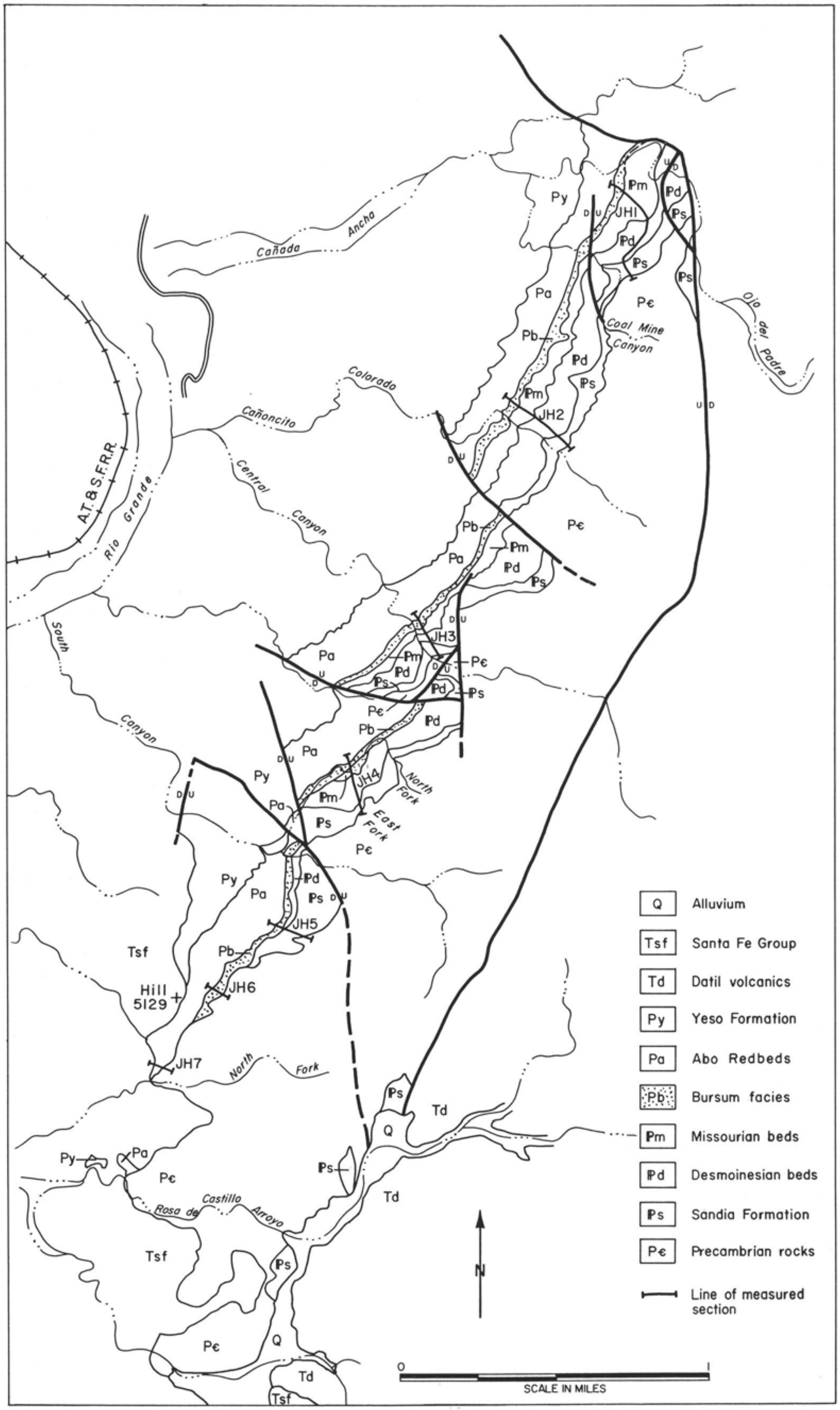


Figure 4

PENNSYLVANIAN AND BURSUM OUTCROP MAP OF JOYITA HILLS

In northern sections, Coal Mine Canyon (JH I) and Cañoncito Colorado (JH2), beneath the Late Atokan cherty limestone is a black to gray shale with lenses of crinoidal calcarenite and black limestone, units JH1-10 and JH2-6 to JH2-8. This unit appears to thin somewhat southward; its upper beds may be partly equivalent to the brown algal calcarenite of the southern sections.

Key marker beds below are the black to brown silty limestones which contain laminae and beds of yellow to pale-red siltstone. These are units JH1-9, JH2-5, B8, the top few inches of JH3-10, and JH4-5. They range from about 22 feet (7 m) thick in section JH2 along Cañoncito Colorado to the few inches that appear to be exposed along Central Canyon.

Below these yellow and pale-red siltstones interbedded with black silty limestones are black shales which contain lenses of black silty limestone. In the southern sections, this unit contains lenticular beds of very coarse-grained crinoidal calcarenite, particularly in the upper third of the black shale unit. In the Coal Mine Canyon section this is JH1-8; along Cañoncito Colorado it is unit JH2-4 and part of JH2-3; southwest it is unit B7 to the upper part of B5; then unit JH3-10, and in the East Fork section it is unit JH4-3 and JH4-4. The unit appears to thicken northward from 16 to 20 feet (5-6 m) at East Fork to 43 feet (13 m) in Coal Mine Canyon.

Below these black shales with crinoidal calcarenites and above the basal quartzite is a black to gray shale with interbedded lenses of sandstone and arenaceous calcarenite. This unit ranges from about 47 feet (14 m) thick along Coal Mine Canyon to as much as 113 feet (34 m) thick along Central Canyon. The beds are JH1-2 to 7, JH2-3 and lower JH2-2, B5 to lower B2, JH3-9 to 2, and JH4-2.

Coal Mine Canyon (Section JH i)

The Early Atokan section in Coal Mine Canyon, section JH1, is as follows in descending order:

JH1-10; black *shale* with scattered lenses of black fossiliferous limestone and coarse crinoidal calcarenite; 47 feet (14 m) thick (equals JH2-6 to 8). Amid the black fossiliferous carbonaceous shale are 3 types of limestone: (1) black silty fossiliferous micrite containing fragments of brachiopods, bryozoans, crinoids, algae, and very small black gastropods; (2) grayish-brown to greenish-gray, medium-grained calcarenite containing fossil fragments and limestone fragments in a silt-size ferruginous groundmass very rich in crinoidal fragments; and (3) dense black to dark-brown silty micrite.

JH1-9; ledgy thin-bedded black-brown to green-gray silty *limestone* and limy *siltstones* with some upper reddish to yellowish laminae; 12 feet (3.7 m) thick (equals JH2-5).

JH 1-8; black carbonaceous *shale* with gypsum and bone coal laminae and some lenses of silty laminated sandstone; scattered fragments of gastropods and pelecypods; 43 feet (13 m) thick.

JH1-7; lenticular grayish-brown *sandstone, r* to 3 feet (0.3-1 m) thick.

JH1-6; black fossiliferous arenaceous *limestone* with lenses of black shale; 6 feet (1.8 m) thick; shale is micaceous and finely laminated; limestone ranges from black to dark brown; contains fragments of brachiopods, bryozoans, crinoids, algae, and very small black gastropods.

JH1-5; lenticular, gray to brown *sandstone;* 3 to 5 feet (I-1.5 m) thick; sandstone is quartzitic, medium- to coarse-grained; grains are angular to subrounded, consisting mainly of quartz with some feldspar and some bluish quartz in a matrix of ferruginous silt and silica; fairly well sorted grains.

JH1-4; *shale,* gray to black, micaceous, finely laminated, carbonaceous with laminae of gypsum; 8 feet (2.5 m) thick.

JH1-3; medium-grained *sandstone;* ranges from grayish-brown calcareous laminae to hematitic reddish-brown lenses; grains are subangular to subrounded, composed of quartz and minor feldspar with much hematitic silt-size cement; lenticular bed 4 inches to 18 inches (10-46 cm) thick.

JH1-2; mostly covered interval of gray to dark-gray silty *shale* with some black micaceous laminae and some gypsum laminae and veinlets; scattered lenses of shaly dark-gray sandstone; 24 feet (7 m) thick.

JH1-1; *quartzite,* light-gray to brown, in places stained reddish brown; crosslaminated; quartz-rich with lenses of quartz and feldspar pebbles and fragments of hematitic siltstone; fine-grained to coarse-grained, containing angular fragments of chert and silicified limestone, micaceous laminae, and scattered feldspar grains; cement is mainly silica; unit is very lenticular; ranges from 5 to 12 feet (1.5-3.7 m) in thickness.

JH1-8 thins southward near the North Fork of Cañoncito Colorado. Thickness of the Early Atokan strata is 161 feet (49 m).

Cañoncito Colorado (Section JH2)

The Early Atokan section (JH2) along Cañoncito Colorado is as follows in descending order:

JH2-8; mostly covered; along strike are outcrops of yellowish-brown *shale* and lenses of fossiliferous crinoidal calcarenite; near top of unit are discontinuous lenses of brownish-gray quartzose sandstone; 12 feet (3.7 m) thick.

JH2-7; *limestone,* grayish-black, fine-crystalline, shaly; scattered fossil fragments and crinoids, 2-foot-thick (o.6 m) ledge.

JH2-6; mostly covered; along strike upper beds are of black fossiliferous *shale;* 8 feet (2.5 m) thick.

JH2-5; *limestone,* gray, argillaceous, medium- to thin-bedded; fine- to medium-grained calcarenite containing brachiopods and crinoids; weathers yellowish-tan; limy micaceous laminated marly shale partings; equivalent to JH1-9; 22 feet (7 m) thick.

JH2-4; mostly covered; medium-gray calcareous *shale* near top; along strike in lower part are lenses (about 5o feet, 15 m, long and maximum of z feet, o.6 m, thick) of greenish-gray micaceous graywacke which weathers rust brown; unit 14 feet (4.3 m) thick.

JH2-3; partly covered black fissile *shale,* thinly laminated, micaceous; contains plant films; 35 feet (10.6 m) thick.

JH2-2; mostly covered slope; along strike are black to greenish-gray *shales* with scattered nodules of black silty limestone; 39 feet (12 m) thick.

JH2-I; *quartzite,* light-gray, coarse- to medium-grained, medium- to thick-bedded; minor feldspar grains, mica flakes; quartz subrounded; unconformable on Precambrian granite gneiss, undulating surface; basal lenses contain subrounded pebbles and cobbles of quartz, feldspars, and granite gneiss; 26 feet (8 m) thick. Total thickness of the Early Atokan beds along Canoncito Colorado is 158 feet (48 m).

Central Canyon (Section JH 3)

The Early Atokan section (JH3) along Central Canyon, measured about 900 feet (275 m) south of section B, is as follows in descending order:

JH3-11; *limestone,* black to dark-gray, medium-grained oolitic and pelletoid calcarenite, arenaceous, very fossiliferous; contains crinoids, algae, brachiopods, formanifera, and early Atokan fusulinids; crops out as a 4-foot-thick (5.2 m) ledge, thickening and thinning, from 5 to 3 feet (1.5-0.9 m) along strike; undulating contact with underlying beds.

JH3-10; partly covered black *shale* with lenses of black silty limestone and fossiliferous micrite; persistent 1-foot-thick (0.3 m) limestone ledge 20 feet (6 m) above base, of micrite with scattered fragments of crinoids, brachiopods, pelecypods, and early Atokan fusulinids (possibly reworked); uppermost beds are brown to light-gray fossiliferous arenaceous limestones, 6 to 9 inches (15-23 cm) thick with yellowish-gray limy siltstone laminae, micrite to fine-crystalline, with scattered crinoids and brachiopods; below are lenses of black to grayish-brown, fine- to medium-grained crinoidal fossiliferous calcarenite containing tiny black trilobites and Atokan *Fusulinella;* unit is 32 feet (10 m) thick; slope.

JH3-9; *sandstone,* siliceous, light-gray to brown, crosslaminated (dip toward north); upper beds greenish; medium- to coarse-grained, quartz grains subangular; about 5 percent feldspar; cement is silica and ferruginous silt; forms ledges; 8 feet (2.5 m) thick.

JH3-8; *shale,* dark-gray to black, slightly micaceous, fissile; laminated with fine-grained siltstones; lenses and nodules of black fine-crystalline silty micrite containing scattered brachiopods; forms slope; unit 58 feet (17.5 m) thick.

JH3-7; *sandstone,* dark-gray to greenish-gray, thin-bedded, micaceous, fine-grained, with 10 percent feldspars; laminae of gray to dark-gray micaceous shale; thin ledges; unit 2 feet (o.6 m) thick.

JH3-6; *sandstone,* siliceous, light-gray to brown, medium- to coarse-grained, crosslaminated (dips from north); medium-bedded ledges; grains subangular, of quartz and minor feldspar in matrix of ferruginous silt and silica; some scattered subrounded quartz pebbles; lenticular unit, 5 to 8 feet (1.5-2.5 m) thick.

JH3-5; mostly covered; along strike dark-gray to light-gray, fine-grained calcareous sandstone laminae and lenses amidyellow-gray to gray, slightly micaceous *shale;* contain pelecypod and crinoid fragments; slope, r z feet (3.7 m) thick.

JH3-4; intercalated brown fossiliferous limy medium-grained *sandstone* and arenaceous *calcarenite* containing brachiopods, crinoids, gastropods, and bryozoan; micaceous, glauconitic, and ferruginous; laminae of arenaceous limy shale; upper foot is a limy fossiliferous sandstone-calcarenite ledge containing very small black gastropods; unit 9 feet (2.7 m) thick.

JH3-3; intercalated *shale* and limy *sandstone;* shale is yellowish brown, calcareous, micaceous; sandstone is brown, limy, fossiliferous, fine to medium grained, thin bedded; grains are subangular to subrounded; contains fragments of brachiopods and crinoids, and very small black gastropods; top **2** feet (o.6 m) is sandstone ledge; rest slope and thin ledges; unit 6 feet (i.8 m) thick.

JH3-2; partly covered greenish-gray to gray to brown sandy *shale;* lenses up to1 foot (0.3 m) thick of brown quartzite, arenaceous calcarenite, and limy sandstone, fine- to medium-grained; grains angular to subrounded in limy ferruginous silt matrix containing fragments of brachiopods and crinoids; 85% shale; unit r r feet (3.3 m) thick.

JH3-1; *quartzite* unconformable on underlying Precambrian granite gneiss; gray to brown, fine- to coarse-grained; grains angular to subrounded, mostly quartz with 5% feldspars; cement is silica with some calcite and yellow ferruginous silt; lenses of angular pebbles of quartz, gneiss, and feldspars; scattered fossil fragments and algal laminae; unit 2 to 5 feet (0.6-1.5 m) thick, lenticular. Thickness of the Early Atokan sequence along Central Canyon is 154 feet (47 m).

Section **B**

The Early Atokan part of section B, measured north of Central Canyon, about goo feet (275 m) north of section JH3 is as follows in descending order:

B9; *limestone,* light-gray, weathers buff, algal, fossiliferous, medium-to coarse-grained, slightly oolitic; specks of orange ferruginous silt; *Profusulinella;* equivalent to JH3-11; one lenticular bed, 3.5 feet (1 m) thick.

B8; argillaceous *limestone,* ranges from bioclastic fine-grained calcarenite to silty, shaly, microfossiliferous micrite; thin- to medium-bedded with limy micaceous shale partings; light-brown to gray with pale-orange, red, maroon, and violet silty laminae; forms thin ledges and slope; equivalent to JH1 -9(?) and basal JH3-11 with top of JH3- 10; *Eostaffella, Pseudostaffella,* and *Plectogyra:* unit 21.5 feet (3.8 m) thick.

B7; mostly covered; along strike is black *shale;* unit 5 feet (1.5 m) thick.

B6; *shale,* black, micaceous, with laminae and veinlets of gypsum; scattered lenses dark-gray to black shaly silty limestone, fine-crystalline, nodular to thin-bedded, containing small brachiopods and crinoids; equivalent to lenses in JH3-10; unit forms slope with thin ledges and is 15 feet (4.6 m) thick.

B5; mostly covered; along strike are *shale* and limestones like B6; unit is 34.5 feet (10 m) thick.

B4; *sandstone* ledge, light greenish-gray, micaceous, medium- to coarse-grained, thin- to medium-bedded; angular quartz grains; quartzitic, with impressions of brachiopods; unit 5 feet (1.5 m) thick.

B3; partly covered *shale,* gray to light greenish-gray to dark-gray; contains plant remains, gypsum laminae, and ferruginous nodules; slope; unit is 22 feet (6.7 m) thick.

Bz; *limestone,* bioclastic coquina, silty, arenaceous, buff, fine- to coarse-grained; fragments of brachiopods and crinoids, and very small black gastropods; ledge 5 feet (1.5 m) thick.

B 1; *quartzite,* conglomeratic, olive to light-gray; coarse-grained and conglomeratic near base, grading upward into fine-grained beds; calcareous in part with upper beds dolomitic; relief on underlying Precambrian granite gneiss is as much as 10 feet (3 m); unit lenticular, averages r r feet (3.4 m) in thickness. Total thickness of Early Atokan beds at section B is 114 feet (35 m).

East Fork of South Canyon (Section JH4)

The Early Atokan part of section JH4 measured along the East Fork of South Canyon is as follows in descending order:

JH4-6a; *calcarenite,* brownish-gray, silty, oolitic; upper part is locally a limestone-pebble conglomerate; lenticular ledge, r to 4 feet (0.3-1.2 m) thick with upper surface very irregular; equivalent to JH3-11; contains Pro *fusulinella* fragments.

JH4-5; *limestone,* micrite, nodular, shaly, silty, gray to black, dense; upper beds with laminae of yellow and reddish siltstones; contains *Profusulinella,* nonfragmental in a calcilutite matrix, as well as pelecypods, brachiopods, and very small black gastropods; rubbly ledges 8 to r z feet (2.5-3.7 m) thick.

JH4-4; *shale,* gray to dark-gray, fossiliferous; slope; unit 5 feet (1.5 m) thick.

JH4-3; two z-foot (o.6 m) *limestones* separated by 7 feet (2 m) of *shale;* two ledges and intervening slope; shale is dark gray, limy, silty, and fossiliferous; upper limestone is dark-gray, silty, bioclastic calcarenite and calcilutite; lower limestone similar but locally swells to 3 feet (0.9 m) thick and consists of very coarse-grained calcarenite containing large fragments of crinoids, brachiopods, pelecypods, and sponges; along strike contains reworked fragments of Pro *fusulinella.*

JH4-2; shale, mostly covered, greenish-gray to very dark-gray, silty, micaceous; laminae of gypsum and small ferruginous concretions; brachiopods and plant impressions; scattered thin lenses of greenish-gray, micaceous, silty sandstone and in upper part of dark-gray, silty fossiliferous (brachiopods and crinoids) calcarenite and micrite; slope; unit approximately 6z feet (19 m) thick.

JH4-1; *quartzite,* light-gray to buff, medium- to fine-grained; beds o.5 to 3 feet (0.2-0.9 m) thick; scattered fragments of silicified crinoids and brachiopods; unconformable on underlying Precambrian pale reddish-brown granite gneiss; unit very lenticular, 5 to **20** feet (1.5-6 m) thick, averaging 15 feet (4.6 m). Total thickness of Early Atokan beds along East Fork of South Canyon is 112 feet (34 m).

South Fork of South Canyon (Section JH5)

The section of Early Atokan strata exposed along the main "fork" of South Canyon is similar to that which crops out along South Fork. The Early Atokan section JH5 along South Fork of South Canyon is as follows in descending order:

JH5-5; *limestone,* nodular, silty, gray to dark-gray with upper yellow to red siltstone laminae; 4 feet (1.2 m) thick unconformably beneath greenish-gray arkosic limestone-pebble conglomerate of Bursum facies; along strike to north thickens to 7 feet (2.1 m) where overlain by as much as I I feet (3.4 m) of cliff-forming Atokan limestone preserved beneath the Permian beds.

JH5-4; *shale,* fossiliferous, silty, lenticular; 3 to 12. feet (o.9-3.6 m) thick; slope.

JH5-3; *limestone,* black, silty micrite, thin-bedded; laminae and lenses of fossiliferous crinoidal calcarenite; **4** feet (1.2 m) thick ledges.

JH5-2; mostly covered *shale,* greenish-gray to black; slope; 42 feet (13 m) thick.

JH5-1; quartzite, light-gray to brown, fossiliferous; basal beds conglomeratic; contains fragments of brachiopods and crinoids; lenticular, dipslope-capping ledges, averaging 19 feet (6 m) thick; unconformable on Precambrian granite gneiss.

Farther south, Early Atokan beds consist of only a few isolated patches of the basal quartzite which have been preserved beneath the erosional surface at the base of the Permian clastic strata (fig. 5).

LATE ATOKAN STRATA

The Late Atokan beds are uniformly 24 feet (7 m) thick except in the South Canyon sections where the lower part of the sequence appears to be absent. For the most part, they are dark-gray cherty ledge- or cliff-forming limestones.

At the northeasternmost exposure of the Pennsylvanian strata in the Joyita Hills, along an S-curve of Cañada Ancha, the upper 5 feet (1.5 m) of Late Atokan limestone crops out, its base concealed by the stream alluvium. Above this limestone and above an undulating surface, is a lenticular brown, arenaceous, fossiliferous, crosslaminated calcarenite, **2 to** 5 feet (o.6-1.5 m) thick, containing scattered subrounded pebbles of quartz, granite gneiss, chert, and black fish teeth. This clastic lens is overlain by typical thick-bedded, gray Desmoinesian limestones, more than **21** feet (6.4 m) thick. No fusulinids were collected from these outcrops, the correlations being based on lithic features. The pebbly calcarenite does suggest uplift of some nearby area during late Atokan and early Desmoinesian time, uplift of a source area from which quartz, gneiss, and sedimentary chert (derived from cherty limestones) were eroded and transported a considerable distance. The pebbles are subrounded and are of hard, resistant types of rocks.

This is the only outcrop of basal, possible early Desmoinesian coarse-grained elastic materials in the Joyita Hills.

Coal Mine Canyon (Section **JH i)**

The Late Atokan sequence in Coal Mine Canyon (section JH r) is as follows in descending order:

JH1-11c; *limestone,* light-gray to gray, weathers dark-brown, slightly dolomitic, fine-crystalline *with* scattered specks of orange ferruginous silt, cherty, thick-bedded; forms prominent ledges; *Fusulinella Iowaensis, Plectofusulina; 10* feet (3 m) thick.

JH1-11b; intercalated *limestone* and *shale;* forms notch in cliffs; shale is gray, calcareous, and fossiliferous; limestone is nodular to lenticular, thin-bedded; either of dense, light-gray, silty micrite or gray to brownish-gray microfossiliferous micrite, pelletoid and algal, with scattered specks of yellowish-orange silt and some oolites; *Fusulinella iowaensis;* unit 2 to 3 feet (0.6-0.9 m) thick (=JH2-10).

JH1-11a (=JH2-9); *limestone,* medium-gray, weathers dark-gray to black, microfossiliferous; prominent chert nodules and lenses; scattered brachiopods and crinoids; thick-bedded cliff; micrite with scattered fossils, micro-oolites, Foraminifera, and pellets; contains *Plectofusulina, Pseudostaffella, Fusulinella, Millerellu, Profusulinella;* unit is lenticular, maximum of 11 feet (3.4 m) thick.

Total thickness of Late Atokan along Coal Mine Canyon is 24 feet (7.3 m). Southward to Cañoncito Colorado the limestone lenses thicken; unit JH1-11c appears to be unconformably overlain by the arenaceous Early Desmoinesian limestone of JH2-12.

Cañoncito Colorado (Section JH2)

The Cañoncito Colorado section (JH2) of the Late Atokan strata is as follows in descending order:

JH2-11; *limestone,* dolomitic, siliceous, fine-granular, light brownish-gray, weathers dark-brown; scattered specks of orange silt; upper gray chert in lenses and nodules; prominent ledge 10 feet (3 m) thick; *Chaetetes* at top; *Fusulinella iowaensis* and *Plectofusulina.*

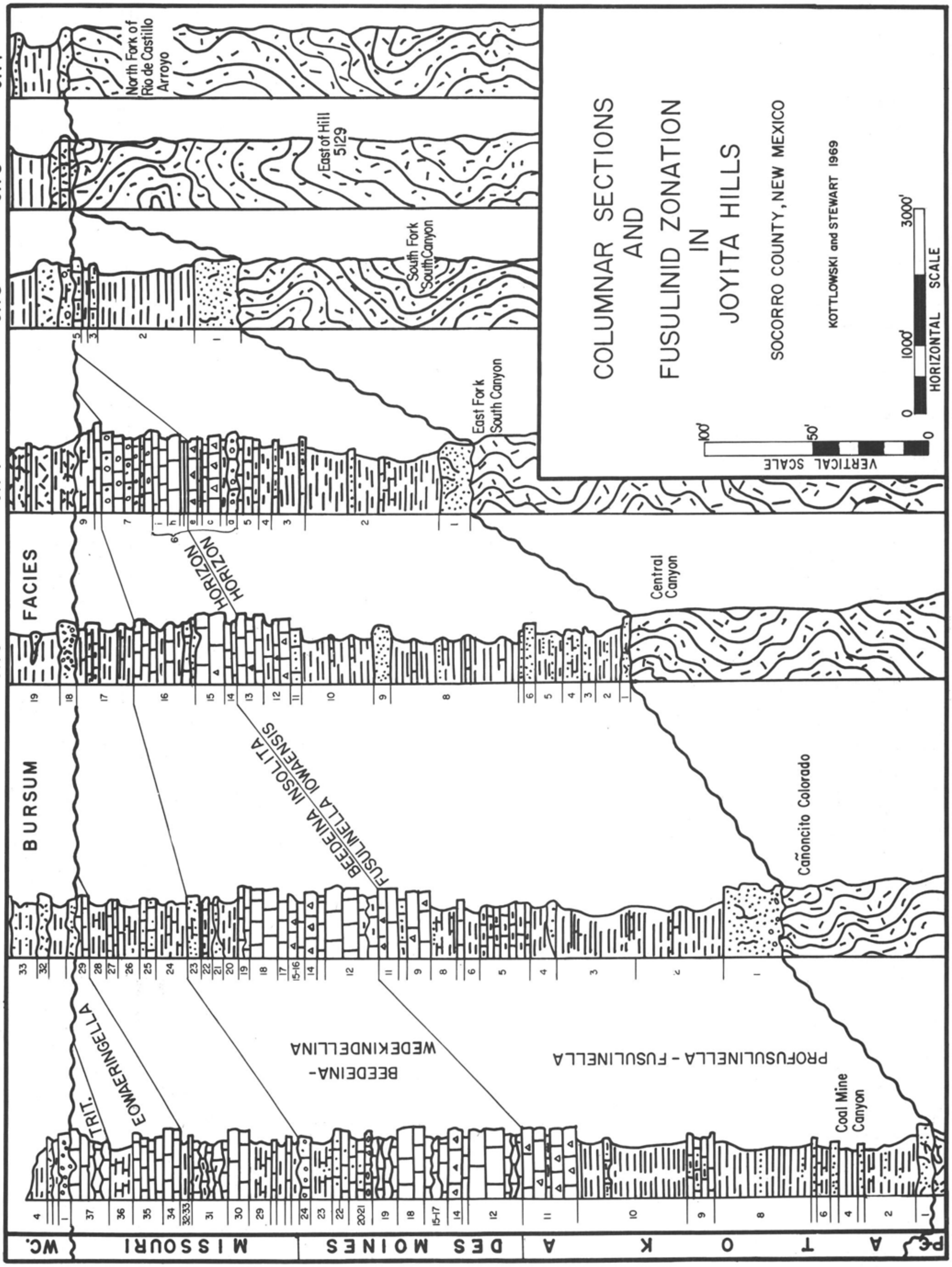
JH2,-10; limestone, arenaceous, bioclastic, shaly, light-gray, medium-to coarse-grained with fine-grained matrix; forms 3-foot-thick (0.9 m) notch; *Fusulinella iowaensis* microfossiliferous, some oolites, pellets, algal fragments, and yellowish-orange silt specks.

JH2-9; *limestone,* gray to dark-gray, weathers light gray to brownish gray, fine-crystalline to micritic and microcalcarenite; thick, prominent, cliffy ledge; scattered to abundant medium dark-gray chert, fossiliferous; upper part speckled with orange silt; numerous fossil fragments and algae; brachiods, corals, *Chaetetes, Millerella, Plectofusulina, Pseudostaffella an Fusulinella;* unit I 11 feet (3.5 m) thick.

This Cañoncito Colorado section of Late Atokan strata is 24 feet (7 m) thick. Section B, about 900 feet (275 m) north of Central Canyon (section JH3), and 2800 feet (855 m) south of Cañoncito Colorado (section JH2), exposes only the lower bed of the Late Atokan sequence, which is faulted against Missourian limestones. This unit, B10, is of microfossiliferous micrite, gray to light gray, with middle beds of finely crystalline limestone; the thick prominent ledges are marked by much gray to dark-gray chert as nodules and irregular lenses; contains *Chaetetes, Pseudostaffella, Profusulinella, Millerella,* and *Fusulinella;* upper 5 feet (1.5 m) is highly silicified along the fault zone; unit is 15 feet (4.5 m) thick.

Central Canyon (Section JH3)

In the Central Canyon section, JH3, the upper unit of the Late Atokan sequence is JH3-13 (equivalent to JH2-11 and lc), consisting of two prominent 6-foot-thick (1.8 m) limestone ledges separated by a recession formed by nodular shaly limestone; unit is 13 feet (4 m) thick; lower limestone is gray micrite with scattered fossil fragments and Foraminifera. Bryozoa, algae, brachiopods, corals, and sparse *Fusulinella.* Upper limestone is gray to light-gray micrite with scattered fossils and very advanced forms of *Fusulinella;* both contain sparse nodules of light-gray aphanitic, dense chert. JH3-13 appears to be unconformable on JH2-12, as the lower unit ranges from 6 to 11 feet (1.8-3.4 m) in thickness along an outcrop length of about 30o feet (91 m). There is the possibility



COLUMNAR SECTIONS AND FUSULINID ZONATION IN JOYITA HILLS
SOCORRO COUNTY, NEW MEXICO
KOTTLOWSKI and STEWART 1969
VERTICAL SCALE
HORIZONTAL SCALE
JH1
JH2
JH3
JH4
JH5
JH6
JH7
BURSUM
FACIES
WC.
MISSOURI
DES MOINES
A T O K A
PC.
TRIT.
EOWAERINGELLA
BEEDEINA-WEDEKINDELLINA
PROFUSULINELLA - FUSULINELLA
FUSULINELLA IOWAENSIS HORIZON
BEEDEINA INSOLITA HORIZON
Coal Mine Canyon
Cañoncito Colorado
Central Canyon
East Fork South Canyon
South Fork South Canyon
East of Hill 5129
North Fork of Rio de Castillo Arroyo

Figure 5

that the upper limestone of JH3-13 is of very earliest Desmoinesian age, as it contains advanced forms of *Fusulinella.*

Unit JH3-12 is a lower 9-foot-thick (2.7 m) gray to light-gray medium-crystalline micrite. It weathers dark gray with massive beds marked by wavy laminations; has numerous chert nodules, gray to dark-gray and fossiliferous; contains fossil fragments and gastropods, corals, Bryozoa, brachiopods, and *Fusulinella;* capped by 2 feet (o.6 m) of gray nodular shaly limestone; unit is a maximum of I I feet (3.4 m) thick. Total thickness of the Late Atokan strata is 24 feet (7 m).

East Fork of South Canyon (Section JH4)

Along the East Fork of South Canyon, section JH4, the Late Atokan appears to consist of four units, a lower lenticular greenish-gray shale, I to 2 feet (0.3-0.6 m) thick, JH4-6b; then above is a gray cherty lenticular limestone, JH4-6c, 5 to 8 feet (1.5-2.5 m) thick, which contains *Fusulinella* and is capped by an irregular chert bed. The top of JH4-6c may have been an erosional surface during Late Atokan time. Above is JH4-6d, 4 feet (1.2 m) thick, of light-gray, argillaceous, nodular limestone; and the upper bed of the Atokan appears to be unit JH4-6e, a massive, cherty, gray limestone, 6 feet (1.8 m) thick, resembling JH3-13 and equivalent beds.

The Late Atokan does appear to include two episodes of limestone deposition, perhaps separated by an interval of some erosion or nondeposition. Its thinness contrasts greatly with the thicker sections of similar age that occur in other areas of Pennsylvanian outcrops to the east, south, and west.

DESMOINESIAN STRATA

Desmoinesian beds to the west in the Ladron Mountains and on Mesa Sarca are Boo to 85o feet (245-260 m) thick and are chiefly of gray limestone but with considerable amounts of interbedded shale and some sandstone, the sandstones being mainly near the base and the middle of the Desmoinesian. These sandstones are light gray, quartz rich, cemented by calcite, and contain some lenses of limestone cobble conglomerate with well-rounded clasts. Such lithology is suggestive of marine deposition at a considerable distance from a landmass, with the silica clastic fraction probably derived from the Zuni upland. Desmoinesian rocks to the east in the Los Piños Mountains are 500 to 770 feet (150-235 m) thick; reportedly they thin in a southwestward direction toward the Joyita Hills and change in that direction from a limestone facies to one consisting of intertongued cherty limestone, gray shale, and light-gray sandstone with some pebbly and arkosic beds. South of the Joyita Hills, in Cerros de Amado, Desmoinesian beds are about 785 feet (240 m) thick and are typical gray cherty and noncherty limestones, but with considerable interbedded gray limy shale and some lenses of pebbly arkosic sandstone.

Wilpolt et al. (1946) believed a resistant monadnock of Precambrian rocks existed north of the present-day Los Cañoncitos during Atokan and early Desmoinesian time, and that this positive area supplied the clastic materials found in the Atokan and lower Desmoinesian beds of the Los Piños Mountains. Six miles (I o km) northeast of the northern tip of the Joyita Hills Precambrian core, Precambrian rocks crop out but are overlain by alluvial-fan gravels and clastic beds of the Cenozoic Santa Fe Group. Is this granite gneiss outcrop, about i mile (1.6 km) long and a maximum of 0.5 mile (o.8 km) wide, a remnant of a Precambrian core of the Joyita axis? However, the Atokan and basal Desmoinesian strata in the Joyita Hills are closer to this "remnant core" than the lower Pennsylvanian outcrops in the Los Piños Mountains, yet these early Pennsylvanian rocks of Los Cañoncitos are not types found immediately adjacent to emergent uplands.

The feldspars, quartz, and other detrital materials of these early Pennsylvanian beds in the Los Pinos Mountains probably were washed from the Pedernal upland to the east. The thick lenses of feldspathic sandstone of the lower Pennsylvanian in the southwestern Los Piños Mountains form a huge mass of detrital material, necessitating derivation from a large eroding source area. Thus they are suggested as being current deposits swept from the east, not from the west. The outcrop belt of the lower Pennsylvanian rocks in the Los Piños Mountains trends southwestward. The southwestward facies change from limestone on the northeast to sandstone and shale on the southwest gives a biased southwestward directional trend. This trend actually may be from limestone on the north to clastic rocks on the south, with no true westerly component. Considering the large amounts of sandstone and shale in the lower Pennsylvanian of Cerros de Amado to the south, the source of the elastic materials is more likely from the east and southeast, than from any major Joyita axis exposures.

The sparse feldspar occurring in the upper part of the Early Desmoinesian clastic beds in the Joyita Hills, as well as sedimentary features, suggest that these elastic strata are shallow-water deposits. They do indicate that some small nearby areas of granite, granite gneiss, or similar quartz-and-feldspar-bearing rocks were exposed to erosion during the latter part of Early Desmoinesian time. If these "islands" were very close to the area of the present Desmoinesian outcrops in Los Cañoncitos, they must have been small, not eroded for any long period of time, or eroded slowly, as the amount of siliciclastic detritus is relatively small.

Where was the geographic location of these islands? Arkosic material is sparse in the Lower Desmoinesian beds to the west in the Ladron Mountains and to the northeast in the northern Los Piños Mountains, but is abundant to the east in the southern Los Piños Mountains and to the south in Cerros de Amado. A location to the east or southeast of the Joyita Hills and near, but southwest of the southern Los Piños Mountains seems most likely.

Late Desmoinesian strata do contain a few elastic beds in the southern Los Piños and Cerros de Amado areas, but for the most part, beds of the age near the Joyita Hills are marine cherty limestones and calcareous fossiliferous shales. Late Desmoinesian rocks are not present in the Joyita Hills, with the Early Desmoinesian clastic sequence unconformably overlain by Missourian strata. The Joyita Hills area was one of nondeposition during Late Desmoinesian time, either being slightly above sea level or a very shallow area of stagnant water, where any thin deposits were removed quickly in early Missourian or latest Desmoinesian time. The Missourian beds contain very little reworked Desmoinesian-appearing clasts, so there does not seem to have been deposition of thick Late

Desmoinesian strata and their subsequent removal. Additional evidence is given by the upper beds of the Early Desmoinesian, which are immediately below the Missourian strata in the Coal Mine Canyon area OHO, and contain high percentages of quartz sand that grade upward into conglomeratic beds bearing clasts of limestone and feldspar.

Desmoinesian beds in the Joyita Hills consist of lower massive to medium-bedded, ledge-forming limestones, of irregular thickness, overlain by a elastic sequence of calcirudite, calcarenite, calcareous sandstone, and calcareous, pale reddish-brown shale. The above elastic sequence appears to be erosionally unconformable on the lower limestones in places and is mostly a shallow-marine deposit, suggesting a nearby source for its siliciclastic detritus. Several normal marine limestones, bearing the fusulinid genera *Beedeina* and *Wedekindellina,* do occur within the elastic sequence, dating it Early Desmoinesian in age.

EARLY DESMOINESIAN LIMESTONE SEQUENCE

As noted previously, the basal unit of limestones exposed in the northeast tip of the area of Pennsylvanian rocks in the Joyita Hills along Canada Ancha is believed to be of Desmoinesian age. This is based on the lithology of the lenticular 2- to 5-foot-thick (0.6-7.5 m) brown arenaceous crosslaminated calcarenite that contains scattered, subrounded pebbles of quartz, granite gneiss, and detrital chert. This bed rests on an erosional surface of probable Late Atokan cherty limestones.

Along Coal Mine Canyon OHO, the lower part of the Desmoinesian sequence caps dip slopes so that the thickness of some of the beds is uncertain. The lithology and thickness is almost identical to that of the lower Desmoinesian rocks measured along Canoncito Colorado (JH2), except the sequence near Coal Mine Canyon, being about 63 feet (19 m) thick, appears to be slightly thinner (fig. 6).

Canoncito Colorado (Section JH2)

The measured section, JH2, of lower Desmoinesian strata below the clastic sequence along Canoncito Colorado is as follows in descending order:

M2-19; *limestone,* gray, dense, nodular; irregular thin lenses and nodules in calcareous shale matrix; micrite with irregular intraclasts and scattered fossils; some of the intraclasts are gray to yellow-gray micrite fragments cemented by sparite; *Beedeina, Wedekindellina,* and *Pseudostaffella;* unit thickens and thins beneath overlying clastic strata of unit JH2-20, being 6 to 12 feet (1.8-3.7 m) thick; slope.

JH2-18; *limestone,* gray, fine-crystalline; massive ledge that caps dip slope; locally weathers thin bedded; many fossil fragments, crinoids; *Wedekindellina;* unit is 12 feet (3.7 m) thick.

JH2-17; *limestone,* gray, very fine-grained, somewhat recrystallized, medium-bedded to nodular; crops out as thin nodular ledges; numerous microfossils, *Wedekindellina, Plectofusulina;* unit is 4 feet (La m) thick.

JH2-16; *limestone,* micrite, gray, partly recrystallized; upper medium-bedded ledge, lower nodular slope; scattered gray to reddish-brown chert flakes and nodules; brachiopods; *Plectofusulina;* unit is 4.5 feet m) thick.

JH2-15; *limestone,* gray-brown, fine- to medium-grained; medium-bedded ledges, wavy laminae; fragments of crinoids, brachiopods, algae; unit is 2.5 feet (o.8 m) thick.

M2-14; *limestone,* light-gray to gray, fine-grained, recrystallized; very cherty with light-gray chert; thick-bedded, forms massive ledge; brachiopods and *Beedeina, Wedekindellina,* and *Plectofusulina;* unit is 6 feet (1.8 m) thick.

JH2-13; *limestone,* gray to grayish-brown, fine-grained, medium-bedded; microfossiliferous, bioclastic; *Plectofusulina, Wedekindellina, Beedeina,* and *Frumentella;* unit is a 3-foot-thick (0.9 m) recession.

JH2-12; upper two-thirds is prominent ledge of light-gray *limestone,* fine- to medium-grained, thick-bedded, of algal micrite; lower third is medium- to thick-bedded but irregular bedding forming recession, of brownish-gray limestone, fine- to medium-grained; basal part with shale partings; microfossiliferous calcarenitic micrite containing brachiopods, horn corals, *Chaetetes;* appears to be unconformable on the underlying Atokan limestones; unit is 23 feet (7 m) thick.

Total thickness of the lower Desmoinesian limestones along Cañoncito Colorado (JH2) is 6, to 67 feet (18-20 m) thick.

Central Canyon (Section JH3)

The lower Desmoinesian limestones in the Central Canyon section, JH3, are only 18 feet (5.5 m) thick. The overlying elastic Desmoinesian strata fill local channels cut into the upper part of JH3-75. At the base is JH3-14, a gray nodular limestone that crops out as a rubbly slope or thin ledges, 3 feet (0.9 m) thick; it is micrite with scattered fossils and with lenses of fine-grained bioclastic calcarenite similar to JH2-12. JH3-15 is a massive, light-gray limestone, cropping out in three 5-foot-thick (1.5 m) ledges; top mottled and conglomeratic; *Plectofusulina, Beedeina,* and *Wedekindellina* occur throughout, as well as brachiopods, crinoids, horn corals, and algae; micrite with scattered fossils and many fossil fragments; local lenses of limestone-pebble conglomerate at base.

East Fork of South Canyon (Section JH4)

In the East Fork of South Canyon section, JH4, only the lower part of the lower Desmoinesian beds is exposed, the upper part being cut out along a strike, dip-slip fault. This fault is not shown on Figure 5 in the columnar section for JH4 because the missing beds of JH4-7 were measured a short distance to the north. The section is as follows in descending order:

R_4-6i; *limestone,* micrite, gray, medium-bedded, wavy laminae; sparingly fossiliferous, *Wedekindellina, Beedeina;* 6-foot-thick (1.8 m) ledge.

JH4-6h; *limestone,* argillaceous micrite, light-gray, nodular; 3-footthick (0.9 m) notch.

JH4-6g; *limestone,* gray, massive, fine-crystalline; *Wedekindellina;* 4foot-thick (r.2 m) ledge.

JH4-6f; *limestone,* nodular and argillaceous, light-gray, fossiliferous; irregular contact with underlying cherty Atokan limestone; notch, 3.5 feet (s m) thick.

Thus the lower Desmoinesian sequence, with unit JH4-6i against a fault, is only 16.5 feet (5 m) thick. About 1000 feet (305 m) to the south, the Desmoinesian beds were removed by erosion prior to deposition of the basal Wolfcampian rocks. To the north toward Central Canyon, the maximum thickness of lower Desmoinesian limestones is about 21 feet (6 m) thick. It appears that in the southern sections the lower Desmoinesian marine limestones have been cut deeper beneath the erosion surface that appears to mark the base of the over-

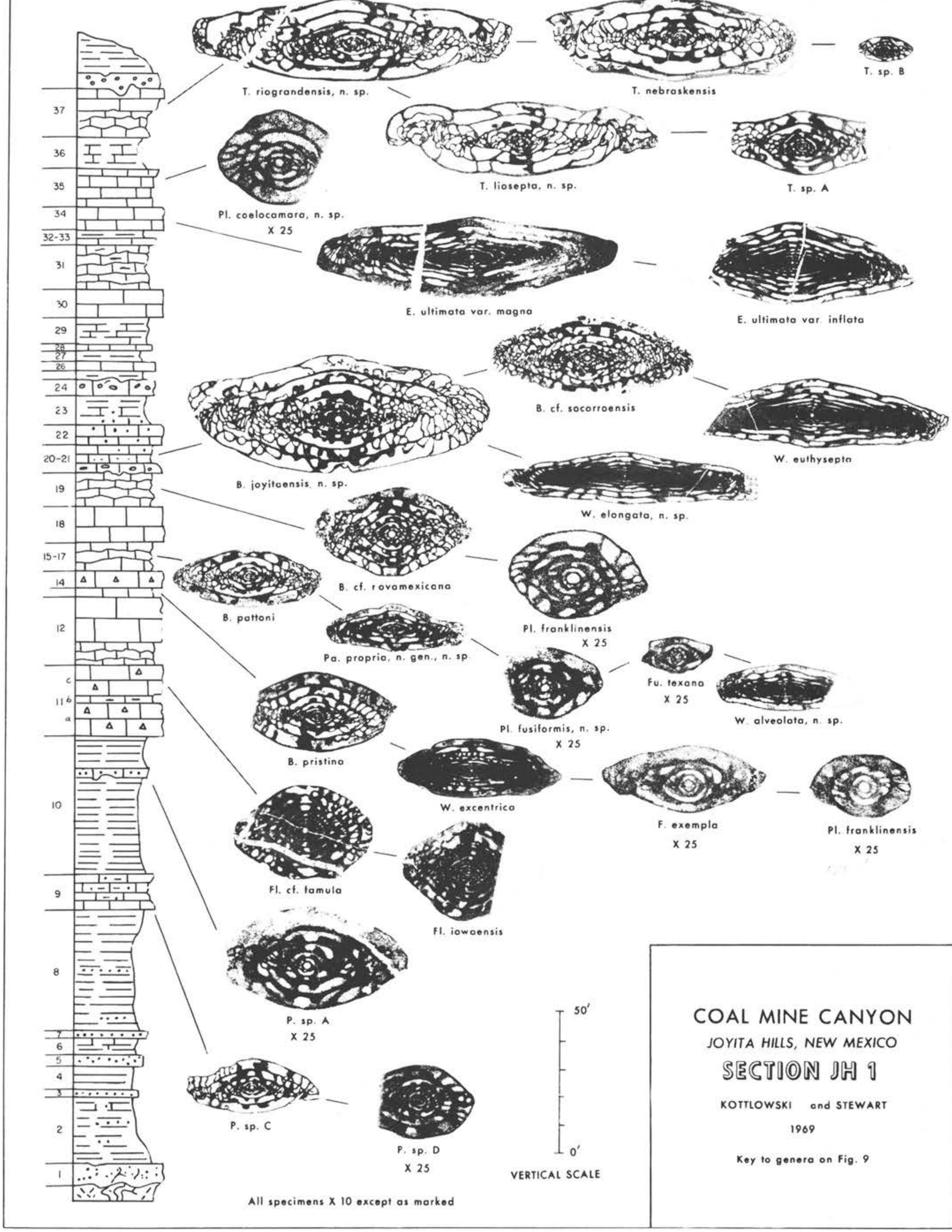

T. riograndensis, n. sp.
T. nebraskensis
T. sp. B
T. liosepta, n. sp.
T. sp. A
Pl. coelocamara, n. sp.
X 25
E. ultimata var. magna
E. ultimata var. inflata
B. cf. socorroensis
B. joyitaensis, n. sp.
W. euthysepta
W. elongata, n. sp.
B. cf. rovamexicana
B. pattoni
Pl. franklinensis
X 25
Pa. propria, n. gen., n. sp.
Pl. fusiformis, n. sp.
X 25
Fu. texana
X 25
W. alveolata, n. sp.
B. pristina
W. excentrica
F. exempla
X 25
Pl. franklinensis
X 25
Fl. cf. famula
Fl. iowaensis
P. sp. A
X 25
P. sp. C
P. sp. D
X 25
50′
0′
VERTICAL SCALE
All specimens X 10 except as marked
COAL MINE CANYON
JOYITA HILLS, NEW MEXICO
SECTION JH 1
KOTTLOWSKI and STEWART
1969
Key to genera on Fig. 9

Figure 6

lying Early Desmoinesian elastic sequence. This suggests any eroded uplift was toward the south.

EARLY DESMOINESIAN CLASTIC SEQUENCE

Apparently conformably to erosionally unconformably on the lower Desmoinesian limestones is a variable sequence of elastic beds. Most of these sediments are marine, but all are very shallow-water types, and some may have been deposited subaerially. Locally, normal marine limestone lenses occur within this elastic sequence, and bear Early Desmoinesian fusulinids, such as *Beedeina* and *Wedekindellina* from unit JH1-24 near Coal Mine Canyon.

Canada Ancha Section

In the northeasternmost Pennsylvanian outcrops of Los Canoncitos, along an S-curve of Canada Ancha, these elastic carbonate strata are well exposed in the canyon walls where they form a lenticular unit about 24 feet (7 m) thick consisting of intertongued: (I) basal nodular fossiliferous gray argillaceous bioclastic micrite with lenses of calcarenite, (2) gray to pink, calcareous shale, (3) brown fossiliferous calcarenite, and (4) reddish-brown to gray arenaceous calcarenite and conglomerate; pebbles are mostly subrounded limestone clasts, the grains being mostly limestone but with considerable sub-rounded to subangular quartz and subrounded feldspar. Conglomerate lenses occur in most places along Canada Ancha at the top of the elastic sequence, but locally are in the basal beds, filling shallow channels cut in the top of the lower Desmoinesian limestone sequence.

Along the strike, northward, the limestone conglomerates grade laterally into a series of nodular marine limestones that have red-shale partings. Similar nodular limestones were partly the source of the clasts in the limestone conglomerates, and suggest the varying environment of deposition of this intertonguing lime mud and calcarenite sequence.

Between Canada Ancha and Coal Mine Canyon, on the dip slope cuesta formed on top of the massive lower Desmoinesian limestones, the elastic sequence consists of : (I) thin basal limestone-pebble conglomerate, (2) gray coarse-grained lenticular calcarenite, 5 to 20 feet (1.5-6 m) thick, and (3) upper intercalated pinkish limestone-pebble conglomerate, arkosic calcarenite, and thin lenses of reddish- to yellowish-gray shales. Locally this conglomerate-calcarenite sequence is 4o feet (12 m) thick, and is unconformable on the underlying lower Desmoinesian limestones whose top surface is weathered, channeled, red-stained, and knobby beneath the basal limestone conglomerate and intercalated bluish limy shale lenses containing limestone cobbles and nodules. As along Canada Ancha, the elastic sequence appears to be, at least partly, an intraformational conglomerate, grading laterally from a nodular argillaceous limestone in a matrix of reddish calcareous shale into a limestone conglomerate with a calcarenite matrix.

About loo feet (3o m) south of Coal Mine Canyon, lenses of gray fossiliferous micrite that are several feet thick contain Early Desmoinesian species of *Wedekindellina* and *Beedeina;* they are above a limestone-conglomerate that is plastered on the underlying lower Desmoinesian limestone, and are overlain by a lenticular series of limestone-pebble conglomerates and brown limy sandstones and arenaceous calcarenites.

Coal Mine Canyon (Section JH I)

On the cuesta dip slope on the north side of Coal Mine Canyon, in section JH1, the elastic sequence is 32 feet (10 m) thick, consisting of the following units listed in descending order:

JH 1-24; *calcirudite,* gray, with coarse- to medium-grained calcarenite matrix and partings of red clay, as well as red shale balls and rolled red shale "pebbles"; fossiliferous coquina in part; thickness ranges from 2 to 6 feet (o.6-1.8 m) laterally, in part owing to lenticular bedding and in part apparently due to erosion before deposition of the overlying reddish to light-gray, silty, and arenaceous shale.

JH1-23; partly covered light- to medium-gray *shale,* with red laminae, arenaceous; in lower part are scattered lenses of gray-speckled, red, argillaceous, fossiliferous micrite; gastropods prominent; 10-foot-thick (3 m) slope.

JH1-22; *calcirudite,* gray, crosslaminated with lenses of gray calcarenite, arenaceous, fossiliferous, with red shale laminae and balls; thick-bedded ledge, lenticular, 7 feet (2 m) thick; numerous horn corals, crinoids.

JH1-21 ; *limestone,* gray to pinkish-gray, arenaceous, bioclastic, thick-bedded; forms lenticular ledges; ranges upward from calcirudite to calcarenite; *Beedeina, Plectofusulina;* unit is 6 feet (i.8 m) thick.JH1

-20; *calcirudite,* gray, thick-bedded ledge; numerous fossil fragments; rounded to subrounded limestone pebbles up to 1 inch (2.5 cm) in diameter; some quartz clasts up to 0.25 inch (6 mm) in diameter, subrounded; sparse feldspar in subrounded grains, mostly 2 mm or less, but one seen is 0.75 inch (2 cm) in diameter; clam-tubes or burrows of huge worms, 2 inches (5 cm) in diameter and about 6 inches (15 cm) long, suggest deposition in very shallow water, perhaps only several inches (5 cm) deep; *Wedekindellina*, *Beedeina* in calcarenites; unit is lenticular, maximum of 3 feet (0.9 m) thick.

Cañoncito Colorado (Section JH2)

On the dip slopes on the north side of Cañoncito Colorado, section JH2 (fig. 7), the elastic sequence is poorly exposed, about 22 feet (6.7 m) thick, and consists of the following units in descending order:

JH2-23; *sandstone,* arkosic, grayish-brown speckled yellow, medium-grained to fine-grained with scattered coarse grains of calcite, quartz, and feldspar (bimodal); lower beds weather reddish brown, upper beds tan; hematitic laminae; calcareous in part; fossiliferous, with *Beedeina;* ranges from 4o% to 6o% calcite; dissolved in HCI the residue is separated grains of quartz, feldspar, iron oxide, and silty clay; lenticular unit averaging 5 feet (1.5 m) thick ledge.

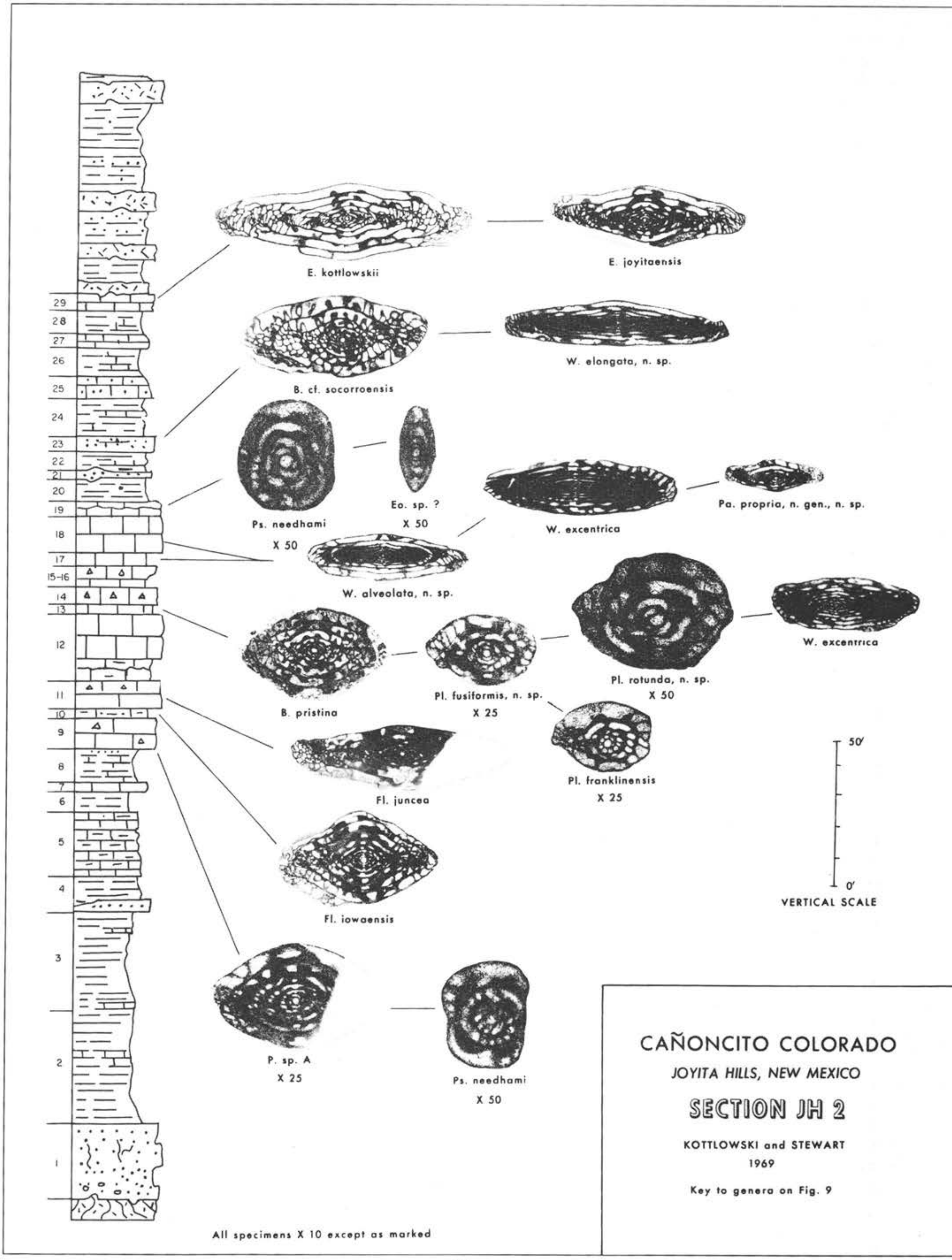
JH2-22; interlaminated light-gray to gray *shale* and argillaceous *limestone* slope; argillaceous, silty micrite with small lenses of medium-grained bioclastic calcarenite containing many crinoid columnals and small black gastropods; unit is 7 feet (2.I m) thick.

JH2-21; *sandstone,* calcareous, arkosic, poorly sorted, brown to green and gray; range from fine- to coarse-grained with angular to sub-rounded quartz, feldspars, fossil fragments, and calcite; laminae of z mm subangular grains of quartz, feldspars, and intraclasts floating in fine-grained matrix; lenticular unit, 2-foot-thick (o.6 m) ledge.

JH2-20; partly covered *shale,* light-gray to pale reddish-brown, micaceous, silty, calcareous; slope; unit is 8 feet (2.4 m) thick.

Central Canyon (Section JH3)

Along Central Canyon, section JH3, the basal beds of the elastic sequence fill local channels (as much as 5 inches, 13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E. kottlowskii
E. joyitaensis
W. elongata, n. sp.
B. cf. socorroensis
Ps. needhami
X 50
Eo. sp. ?
X 50
W. excentrica
Pa. propria, n. gen., n. sp.
W. alveolata, n. sp.
W. excentrica
Pl. rotunda, n. sp.
X 50
B. pristina
Pl. fusiformis, n. sp.
X 25
Pl. franklinensis
X 25
Fl. juncea
Fl. iowaensis
50′
0′
VERTICAL SCALE
P. sp. A
X 25
Ps. needhami
X 50
CAÑONCITO COLORADO
JOYITA HILLS, NEW MEXICO
SECTION JH 2
KOTTLOWSKI and STEWART
1969
Key to genera on Fig. 9
All specimens X 10 except as marked

Figure 7

cm, deep, and 2 feet, 61 cm, across) cut into the underlying lower Desmoinesian limestones of unit JH3-15. These lower limestones are thin, only 18 feet (5.5 m) thick, and the overlying elastic beds are highly variable in thickness, ranging from 17 to 27 feet (5-8 m) in thickness. Basal lenses are of limestone conglomerate and poorly exposed light-gray arenaceous conglomeratic calcarenite, as much as 2 feet (o.6 m) thick. The main mass of the unit is light gray-weathering, gray to dark-gray micrite, fossiliferous, nodular; lenses and laminae of light-gray to blue-gray calcareous shale; intraclasts are scattered throughout the micrite; 15 feet (4.6 m) above the base are numerous *Beedeina;* outcrops are of alternating ledges and slopes.

East Fork of South Canyon (Section JH4)

In and near the East Fork of South Canyon, the Early Desmoinesian elastic beds are faulted against the underlying Early Desmoinesian limestones. They form a very lenticular unit, ranging from 2 to more than 20 feet (o.6-6 m) in thickness (8 feet, 2.4 m, in measured section JH4, but thinned by faulting), and consist of intertonguing limestone conglomerate and coarse-grained crinoidal calcarenite, light-gray, in lenticular beds I to 2 feet (0.3-0.6 m) thick; limestone clasts are mostly subrounded, up to cobble size; minor quartz and feldspar grains. Locally they are irregularly overlain by fossiliferous Missourian limestone, and locally by channel-filling Bursum-facies arkoses in places where the Missourian strata had been removed by erosion prior to deposition of the Wolfcampian beds.

MISSOURIAN STRATA

The thinness of the section of Desmoinesian beds in the Joyita Hills, measured by Wilpolt et al. (1946) as a maximum of 8o feet (24 m), they believed is due to uplift of a Joyita axis in late Desmoinesian time; this positive area, they suggested, remained exposed to erosion during middle and late Pennsylvanian time and supplied sand and clay to Missourian and Virgilian beds in adjoining regions. In this report we establish that such a local high existed only in late Desmoinesian time, and it appears to have been a nondepositional shallow or very low-relief island feature which was a poor source of sediments.

Missourian and Virgilian sequences in the surrounding areas, Mesa Sarca, Ladron Mountains, Cerros de Amado, and Los Piños Mountains, range from about 140o feet (425 m) thick to the west, and 63o feet (190 m) thick to the south, to 350-55o feet (105-165 m) in thickness to the east of the Joyita Hills. These upper Pennsylvanian beds do include more shale and sandstone than do the Desmoinesian strata, but that is typical of the upper Pennsylvanian throughout much of New Mexico. Missourian sandstones west of the Rio Grande (Kottlowski, 1963b) are mostly brown, limy, arkosic beds that contrast with the olive micaceous sandstones of the Missourian to the east. This difference suggests derivation from different sources, the Zuni upland to the west and the Pedernal upland to the east. No local source, such as the postulated Joyita axis, was needed, nor is it indicated except locally.

In the Joyita Hills, the Missourian strata thin southward from about 126 feet (38 m) along Canada Ancha to a wedge out near East Fork of South Canyon owing to the erosion prior to deposition of the basal Wolfcampian elastic beds. Although there is a hiatus encompassing Late Desmoinesian time between the basal Missourian strata and the underlying Early Desmoinesian elastic beds, only locally does the contact appear to be an erosional surface.

Canada Ancha Section

At the northeast tip of the Pennsylvanian outcrops, along Canada Ancha, the Missourian beds crop out on a long dip slope and are in part poorly exposed. Three major units occur: (3) upper 55 feet (17 m) of light-gray, partly argillaceous micrite, nodular to medium-bedded, with about 3o% interbeds of yellowish to light-gray, calcareous shale; forms alternating ledges and slopes; *Triticites* in upper beds; (2) intercalated light-gray, argillaceous, thin-bedded, yellowish brown-weathering, fossiliferous micrite containing *Eowaeringella* and light-gray, calcareous shale; forms 9-foot-thick (2.7 m) slope in middle of section; and (1) lower dense micrite, light-gray to gray, weathers yellowish, nodular to massive; pink to yellow shale partings and a few lenses (1 to 2 feet, 0.3 to o.6 m, thick) of yellow and pink shale containing limestone nodules; unit is 62 feet (19 m) thick and forms irregular cliff along Canada Ancha. The top is an erosional surface beneath Bursum-facies arkoses.

Coal Mine Canyon (Section JH1)

On the dip slope northwest of Coal Mine Canyon, the Missourian strata are 100 feet (30 m) thick, and are unconformably overlain by a lenticular Bursum grayish-brown quartz-breccia conglomerate with lenses of limestone-pebble conglomerate. This section, JH 1, is as follows in descending order:

JH1-37; *limestone,* gray to light-gray with pinkish tint, fine-grained, recrystallized; lower half nodular to thin-bedded ledges, upper half medium- to thick-bedded ledges; microfossiliferous micrite containing brachiopods, crinoids, and *Triticites* in the uppermost beds; unit is at least 18 feet (5.5 m) thick.

JH1-36; mostly covered slope; along strike is intercalated nodular, argillaceous, light-gray *limestone* and light-gray, calcareous *shale;* unit o feet (3 m) thick.

JH1-35; *limestone,* light-gray, fine-crystalline to fine- to medium-grained, thick- to medium-bedded; algal calcarenite to micrite; near middle of unit are scattered dark brown-weathering siliceous nodules; *Plectogyra, Plectofusulina?,* and *Eowaeringella joyitaensis* (Stewart, 1968); outcropping ledges; unit is 13 feet (4 m) thick.

JH1-34; *limestone,* gray to light-gray,partly recrystallized micrite, medium- to thick-bedded; brachiopods, *Plectofusulina, Fusiella texana, Eowaeringella ultimata magna, E. ultimata inflata, E. kottlowskii;* 7foot-thick (2.1 m) ledge.

JH x -33; covered slope; along strike are patches of light-gray, calcareous *shale;* 3 feet (0.9 m) thick.

JH1-32; *limestone,* gray with red ferruginous specks; outcrops as ledges; many crinoids; very fine-grained microcalcarenite; 2 feet (o.6 m) thick.

JH -3 1; *limestone,* marly, argillaceous, thin- and nodular-bedded to irregular medium-bedded, light-gray to reddish-gray, very fine-grained; scattered brachiopods, crinoids; very fine-grained, calcarenitic crinoidal micrite; 16-foot-thick (4.9 m) slope.

JH1-30; *limestone,* gray-tinted reddish-gray, weathers yellowish-brown, very fine-grained calcarenite; crinoids; medium-bedded cliff; unit is 10.5 feet (3.2 m) thick.

JH1-29; partly covered, intercalated purplish *shale* and reddish to gray, nodular, argillaceous *limestone;* 10-foot-thick (3 m) slope.

JH1-28; *limestone,* reddish-gray to gray, medium- to coarse-grained, silty bioclastic calcarenite; a single 1-foot-thick (0.3 m) ledge; scattered brachiopods.

JH1-27; covered; along strike is light-gray to pale reddish-brown calcareous *shale;* 4-foot-thick m) slope.

JH1-26; *limestone,* gray with pinkish tint, slightly argillaceous; flakes of red clay; fine-grained bioclastic calcarenite; 3-foot-thick (0.9 m) ledge.

JH1-25; *shale,* calcareous, light-gray to reddish-gray, silty and sandy; 2. 5-foot-thick (o.8 m) slope; base appears to be an undulating erosional surface cut on underlying Early Desmoinesian fossiliferous coquina calcarenite.

Cañoncito Colorado (Section JH2)

Along Cañoncito Colorado, section JH2, the Missourian beds are 49 feet (15 m) thick and are overlain unconformably by the basal Bursum-facies greenish-gray conglomeratic arkose. In descending order, these Missourian units are as follows:

JH2-29; *limestone,* light-gray to pinkish-gray micrite with fine-grained lenses of bioclastic calcarenite containing abundant *Eowaeringella kottlowskii* and algal filaments; outcropping medium-bedded ledges; unit is a maximum of 6 *feet* (1.8 m) thick, but locally cut out beneath overlying erosional surface.

JH2-28; partly covered *shale,* reddish-brown to gray, calcareous; 2-inch-thick (5 cm) lenses of limy, reddish-brown to blue-gray siltstone; 8-foot-thick (2.4 m) slope.

JH2-27; *limestone,* gray to brown, thin slabby-bedded to medium-bedded, thin ledges; top weathers yellowish-brown; micrite with scattered fragments of crinoid columnals and brachiopods; some lenses of chocolate, silty, fine-grained calcarenite; unit is 5 feet (1.5 m) thick.

JH2-26; intercalated calcareous, fossiliferous *shale* and lenticular, fossiliferous *limestone* on ledgy slope; limestone is gray to light gray, fine-to coarse-grained argillaceous calcarenite containing crinoid columnals, small brachiopods, and small gastropods; some of the clayey micrite matrix is pinkish gray; scattered large intraclasts 5-10 mm in diameter; upper limestone laminae partly silicified; unit is 9 feet (2.7 m) thick.

JH2-25; *limestone,* gray to light-gray, fine- to medium-grained calcarenite, with micrite and some sparite matrix; fragments of limestone, calcite, fossils, brachiopods, and crinoid columnals; 8-foot-thick (2.4 m) ledges.

JH2-24; intercalated, nodular, light gray-weathering *limestone* and calcareous fossiliferous *shale;* limestone on fresh fracture is gray to dark gray, fine-grained calcarenite and micrite speckled with orange silt; numerous brachiopods and crinoid columnals; fossils selectively silicified to pink chert; nodular to thin-bedded, slope; unit is 13 feet (4 m) thick; contact with underlying limy sandstone is undulating surface.

Section B

At section B, goo feet (275 m) north of Central Canyon, the Missourian strata are faulted against Late Atokan limestones; thus the lower part of the Missourian beds is missing. The thickness of this partial Missourian section (not illustrated in this report) is 37 feet (xi m); it is unconformably overlain by reddish-brown, arkosic breccia-conglomerate of the basal Bursum facies. The Missourian units are as follows, in descending order:

B 7; interbedded light-brown to purple, nodular *micrite* and gray to blue-gray *shale;* 8-foot-thick (2.4 m) slope.

B16; *limestone,* light-gray, fine-crystalline, medium-bedded; *Eowaeringella ultimata magna, E. ultimata inflata,* and *Fusiella* texana; crops out as a single 2.5-foot-thick (o.8 m) ledge.

B r 5; interbedded *limestone* and *shale;* forms slope; reddish-brown to gray calcareous shale; limestone is fine-crystalline to bioclastic micrite; thin, irregular bedding; nodular limestone lenses in purple shale matrix; brachiopods and crinoid columnals silicified to red chert; *Eowaeringella joyitaensis;* unit is 5.5 feet (1.7 m) thick.

B14; *limestone,* light-gray, thin-bedded ledges; red silicified fossils; 3 feet (0.9 m) thick.

B I 3; *limestone,* light-gray to tan, fine- to medium-grained; medium-to thick-bedded ledges; crinoidal microfossiliferous micrite; unit is 8 feet (2.4 m) thick.

Bit; interbedded *limestone* and *shale;* shale reddish-brown to gray, calcareous, fossiliferous; limestone light-gray, coarse-grained crinoid calcarenite in fine-grained matrix; thin, irregular beds and nodules; 5foot-thick (1.5 m) slope.

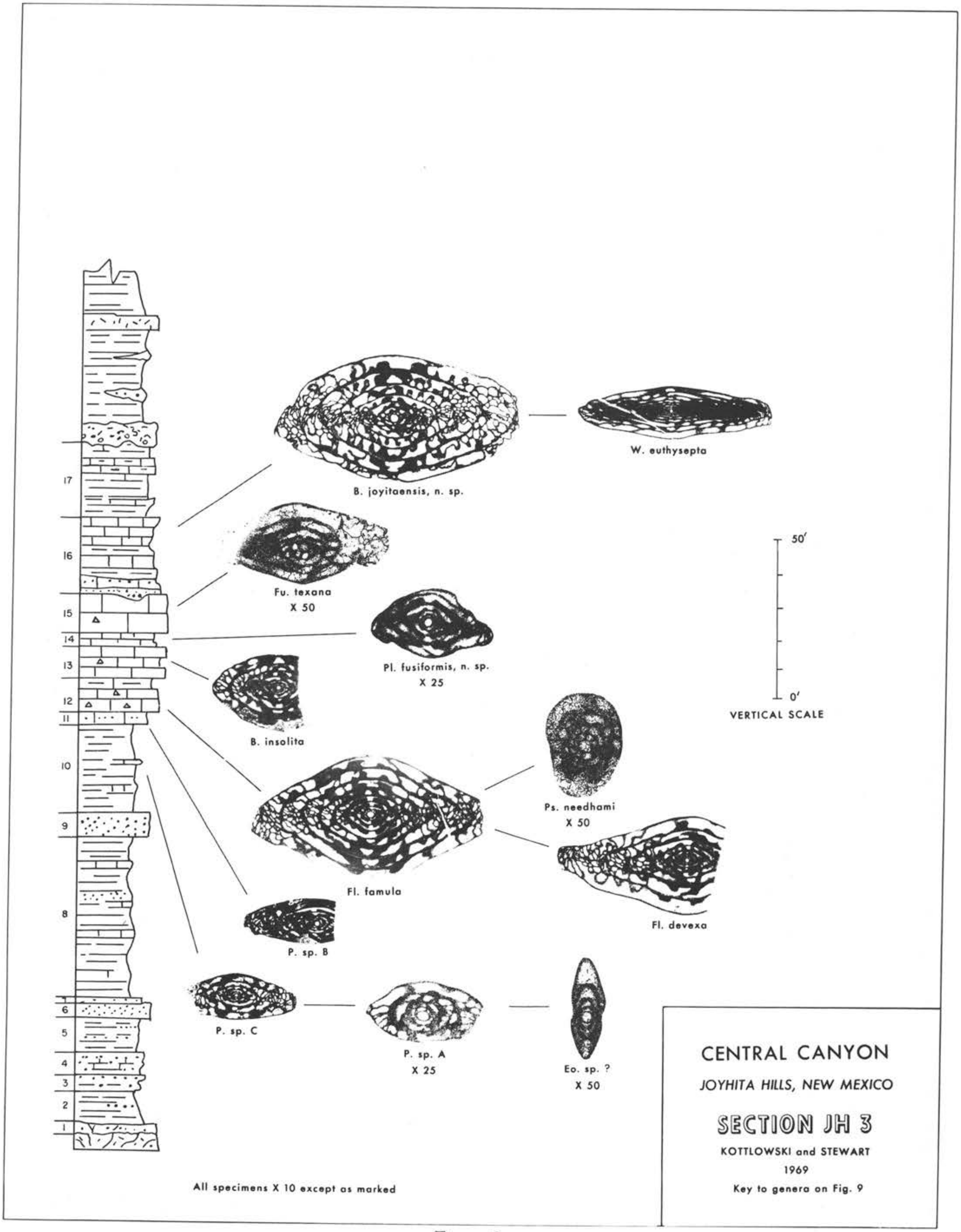
B11; mostly covered; light-gray to reddish-brown *shale;* partly gouge along fault zone; 5-foot-thick (1.5 m) slope. Faulted against upper Atokan limestones.

Central Canyon (Section JH3)

Near Central Canyon, section. JH3, Figure 8, the Missourian beds are poorly exposed on the dip slope. They are overlain with pronounced erosional unconformity by the basal Bursum-facies reddish-brown arkosic breccia-conglomerate. The Missourian beds, unit JH3-17, range from a maximum of 25 feet (7.6 m) in thickness to less than 10 feet (3 m) where they are cut by channels beneath the Bursum facies. The beds are intercalated bluish-gray, limy fossiliferous shale and shaly nodular limestone; red-weathering silicified fossils are mostly brachiopods and crinoid columnals; limestone is light gray to grayish brown, with intraclasts and scattered fossils in a matrix of micrite and sparse sparite; the unit crops out as low ledges on a slope. This unit is probably of early Missourian age, being traced along the outcrop northward to JH2-24. It is equivalent to the beds below the *Eowaeringella* horizons of JH1-25 through JH1-33 and JH2-24 through JH2-28. As JH3-16 contains *Beedeina* and *Wedekindellina,* there is the possibility that the beds of unit JH3-17 are of Desmoinesian age, as their contact appears to be conformable.

East Fork of South Canyon (Section JH4)

Missourian beds along the East Fork of South Canyon, section JH4, were deeply eroded prior to deposition of the overlying Wolfcampian sediments, a maximum of 15 feet (4.6 m) occurring locally. The basal unit, JH4-8, is a 1-foot-thick (0.9 m) ledge of fossiliferous, light-gray limestone, mostly bioclastic micrite with laminae of fine-grained fossiliferous calcarenite and scattered fine-grained "specks" of orange silt. JH4-9 is of bluish-gray, fossiliferous, limy shale containing nodules and thin lenses of fossiliferous, argillaceous micrite; unit is lenticular, averaging about 8 feet (2.4 m) in thickness. At a single outcrop near section JH4, this shale is overlain by a 4-foot-thick (1.2 m), light-gray to pinkish-gray micritic, fossiliferous limestone containing Early Missourian fusulinids. Along the canyon of East Fork, unit JH4-9 is unconformably overlain by purplish and greenish arkose of the



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B. joyitaensis, n. sp.
W. euthysepta
Fu. texana
X 50
Pl. fusiformis, n. sp.
X 25
B. insolita
Ps. needhami
X 50
Fl. famula
Fl. devexa
P. sp. B
P. sp. C
P. sp. A
X 25
Eo. sp. ?
X 50
50′
0′
VERTICAL SCALE
All specimens X 10 except as marked
CENTRAL CANYON
JOYHITA HILLS, NEW MEXICO
SECTION JH 3
KOTTLOWSKI and STEWART
1969
Key to genera on Fig. 9

Figure 8

basal Wolfcampian Bursum facies. Channels 5 feet (1.5 m) deep and 8 feet (2.4 m) wide were cut in the Missourian beds and filled by the Bursum arkose and greenish to reddish-brown, silty shale.

Erosional Thinning of Upper Pennsylvanian Rocks

South of East Fork of South Canyon, Missourian rocks were removed by erosion before deposition of the Bursum facies.

Even the thickest section of Missourian strata in the Joyita Hills, that along Cañada Ancha, has been thinned by erosion. In areas of Pennsylvanian outcrops to the east, south, and west, the Missourian sequence is thicker, but these sections include younger beds. Correlative younger beds were probably deposited in the Joyita Hills area, but later removed by erosion.

No evidence of Virgilian strata has been found in the Joyita Hills area. About 15 miles (24 km) to the west in the southern Ladron Mountains, Virgilian strata are about 375 feet (114 m) thick and mainly of interbedded fossiliferous gray shale and limestone. These appear to be normal marine sediments with only clay and silt clastic materials brought in from outside source areas. Farther to the west and north of the Ladrons (Foster, 1957), however, the Virgilian sequence picks up reddish-brown shales, calcareous sandstones, and arkosic sandstones. This suggests that the clastic material in the Ladron Mountains area was derived from the Zuni uplift to the northwest. The Missourian strata of the southern Ladron Mountains do include thin but significant clastic beds. These are mostly calcareous sandstones and arenaceous calcarenites, but near the top of the Missourian sequence are thin lenses of brown, calcareous, arkosic, pebbly sandstone, containing grains and round to subrounded pebbles of granite, orange-tinted calcite (sometimes mistakenly identified as feldspar), weathered feldspar, quartz, and limestone intraclasts. As the Missourian includes much more siliciclastic material to the west and north, the detritus is believed derived mostly from the Zuni uplift.

East of the Joyita Hills in Los Piños Mountains, on Turret Mesa (11 miles, 18 km, to the east) and on Sierra Montosa (16 miles, 26 km, to the east), the Virgilian strata are 200 to 23o feet (61-7o m) thick, with the uppermost Virgilian fusulinid zones absent, and consist of gray cliff-forming noncherty limestones with interbeds of light-gray, reddish-brown, and greenish-gray shales and some olive micaceous sandstones. Reddish-brown shales and the sandstone beds are thicker and more numerous at Sierra Montosa in the Virgilian sequence, the Virgilian on Turret Mesa (5 miles, 8 km, closer to the Joyita Hills) containing only a few thin silty sandstone beds.

Missourian strata, in contrast, thicken from 2oo feet (61 m) at Sierra Montosa to 33o feet (100 m) on Turret Mesa; this increase in thickness in a southwest direction is due mostly to thickening of lower light-gray and greenish-gray shales and upper reddish-brown shales, as well as thickening of medial arkosic sandstones. Basal Missourian strata in both sections include thin, pebbly arkoses and limestone conglomerates.

About 15 miles (24 km) south of the Joyita Hills in the Cerros de Amado area, the Virgilian sequence is thin, about 13o feet (40 m) thick, and consists of interbedded massive limestones and gray shale with several beds of reddish-brown, calcareous arkose. In the upper part of the section, which lacks youngest Virgilian fusulinid zones, are intertongued, laminated, carbonaceous, and calcareous shales that grade laterally into recrystallized, nodular, dark-gray micrites. These suggest a quiet, stagnant lagoonal environment.

The Virgilian sequences in the areas surrounding the Joyita Hills appear to be shallow-water marine sequences with minor detrital material brought in from the west and from the east. The progressive withdrawal of the sea in late. Pennsylvanian time left several areas of low relief exposed, while to the east and south several sections appear to be truncated by erosion beneath the overlying Wolfcampian clastic beds. It is possible that a marine Virgilian section was deposited in the Joyita Hills area and was removed by erosion during early Wolfcampian time or during latest Virgilian time.

FUSULINID BIOZONES

PROFUSULINELLA

The genus *Profusulinella* defines the Lower Atoka in central New Mexico. Its lowest occurrence in the form of primitive species marks the top of the Morrow Series where present. Transitional forms with an erratic diaphanotheca replacing a primathecal layer (Stewart, 1966) in the wall overlaps the lowest forms of the genus *Fusulinella* near the division between the upper and lower Atokan zones.

FUSULINELLA

The *Fusulinella* biozone marks the Upper Atoka in central New Mexico with the species *Fusulinella iowaensis* (Thompson, 1934) representing the highest occurrence of the genus.

The genera *Eostaffella, Millerella,* and *Pseudostaffella* occur abundantly throughout the Atoka Series in New Mexico, but are not restricted to this series.

BEEDEINA AND WEDEKINDELLINA

The limits of the biozones of the two genera *Beedeina* and *Wedekindellina* coincide in central New Mexico and represent the lower half of the Des Moines Series. Several other genera, such as *Plectofusulina, Frumentella, Pseudostaffella,* and *Eostaffella,* occur within this biozone, but are not restricted to it. The base of the biozone is represented by the species *Beedeina insolita* (Thompson, 1948).

EOWAERINGELLA

The biozone of *Eowaeringella* is one of the best defined and most restricted of all fusulinid zones in North America (Stewart, 1968). Its lowest occurrence is near the base of the Missouri Series where advanced species of the genus *Plectofusulina* and *Fusiella texana* (Stewart, 1958) are the only fusulinids presently found below the genus in rocks assigned to the Missouri Series. The upper occurrence of *Eowaeringella* is near the first appearance of the primitive species of the genus *Triticites.* The genus *Eowaeringella* is widespread in New Mexico and is found where the lower Missourian rocks are present as a result of shallow shelf-facies deposition.

TRITICITES

The biozone of *Triticites* starts in the Lower Missouri Series and extends well into the Wolfcamp Series of the

Lower Permian. Recognizable species are used to further define biozones in the Upper Pennsylvanian. These species are described and discussed in Part II of this study. Only the lowermost part of the biozone of *Triticites* is present in the Joyita Hills. The Bursum facies flanking the study area contain species of *Triticites,* suggesting only the uppermost part of the biozone to be represented in the Permian sediments.

WOLFCAMPIAN STRATA

Wolfcampian rocks in central New Mexico have been referred to the Bursum Formation and the gradationally overlying Abo Redbeds. The type Bursum Formation near the Oscura Mountains, about 25 miles (4o km) southeast of the Joyita Hills, is part of an intertongued red-bed and marine limestone sequence with the lower beds being of Virgilian age (in the upper arkosic member of the Madera Limestone of Wilpolt and Wanek, 1951, or in the Virgilian Bruton Formation of Thompson, 1942a). The Virgilian beds appear to grade up into the Bursum Formation, although locally a thick, lenticular arkose and limestone-cobble conglomerate occurs at the base of the Bursum. However, similar arkoses also are present in the Bruton Formation and higher in the Bursum Formation, as well as in the overlying Abo Redbeds.

Bursum "Formation" thus has been used to label outcrops of interbedded limestones and red beds, ranging from Virgilian to early Wolfcampian in age, that occur at or near the Pennsylvanian-Permian boundary. Locally this boundary between systems appears to be gradational as in the northern Oscura Mountains (Wilpolt and Wanek, 1951) and northern Sacramento Mountains (Pray, 1961; Otte, 1959). Detailed geologic mapping (Oppel, 1959) suggests at least some disconformity even in these areas. In many areas the Bursum beds are erosionally unconformable on underlying Pennsylvanian strata. Northeast and northwest of the Joyita Hills, the Bursum facies appears to tongue-out amid basal reddish elastic rocks of the Abo Redbeds.

The Bursum Formation is a mappable unit in such areas as the Oscura Mountains. Southward from the southern Oscura Mountains into the northern and central San Andres Mountains, however, tongues of the marine Hueco gray limestone and shale occur in the lower part of the Wolfcampian and thicken southward at the expense of the Abo. At the southern tip of the San Andres Mountains, 130 miles (210 km) south of the Joyita Hills, the Abo consists of only a few lenses of red beds in the upper part of the Hueco Formation. Thus the Wolfcampian red-bed sequence in north-central New Mexico grades southward and intertongues with the Hueco marine deposits of southern New Mexico.

The Bursum facies, of intertongued Wolfcampian limestone and red beds, southward moves up in the Wolfcampian section, and in the central and southern San Andres Mountains (Kottlowski et al., 1956) this lithic sequence is at the contact of the southward-thickening Hueco and southward-thinning Abo.

Some geologists have regarded the Bursum as a time zone, rather than as a lithogically defined formation, and label the earliest Wolfcampian as being of Bursum "age." The faunas of this limestone-red-bed sequence are probably more related to its environment of deposition rather than its precise age, thus usage of Bursum should be confined to its outcrops, or to nearby subsurface occurrences, where it is a lithic mappable unit. Bursum facies is a more appropriate term than Bursum zone; it should be considered as a basal facies of the Abo Redbeds and the northward extension of Hueco marine sediments.

This is well illustrated in the Joyita Hills area. In Los Piños Mountains and other Permian outcrops to the south and southeast, the Bursum is a well-defined mappable unit. In the Joyita Hills, only locally does the Bursum facies contain limestone lenses, and in most places is split off from the Abo Redbeds only on the basis of greenish-gray, elastic beds. In the southern part of the Joyita Hills, this green, gray, purplish, and reddish-brown Bursum facies sequence pinches out against hills of Precambrian granite gneiss, and even part of the lower Abo appears to abut against the Precambrian.

Outside of central New Mexico, the term Bursum facies should be used to refer to interbedded limestone-red-bed type of lithology. Use of Bursum to refer to the early Wolfcampian faunal zones, such as those where *Triticites* and *Schwagerina* occur, is not recommended, because these faunas also occur in lower beds of the Hueco Formation, as for example, in the San Andres Mountains and the excellent Wolfcampian section in the Robledo Mountains.

Wolfcampian sections near the Joyita Hills do contain significant thicknesses of the Bursum facies, and are mappable as the Bursum Formation.

Cañoncito de la Uva Section

In the Cañoncito de la Uva area (NE¼ sec. 8, T. 2 S., R. 2. E.), 9 miles (15 km) southeast of the Joyita Hills, the basal Bursum beds, erosionally unconformable on thinned Virgilian strata, are either a greenish-gray to reddish-brown, silty shale or an intertongued brown, limy, lenticular sandstone, 10 to 30 feet (3-9 m) thick. Locally, filling channels and pockets cut into the upper Pennsylvanian strata, is as much as 15 feet (4.5 m) of limestone-cobble conglomerate that includes some clasts as large as boulders several feet in diameter. Within the conglomerate are scattered subrounded quartz pebbles, but no fragments of granite or feldspar. The conglomerate, where present, grades up into the brown, calcareous sandstone.

Above these basal beds, the Bursum, in ascending order, consists of (r) 3o to 5o feet (9-15 m) of red to greenish-gray shale, the upper beds gray to purplish with lenses of dark-gray shale, (2) 3 to Io feet (1-3 m) of gray to reddish-brown, nodular, fossiliferous limestone, (3) about 40 feet (12 m) of red to bluish-purple shale with lenses of nodular limestone, (4) lenses, 5 to 15 feet (1.5-4.5 m) thick, of nodular limestone and arkosic calcarenite containing minor 6-inch-thick (r 5 cm) lenses of coarse-grained arkose, (5) 25 feet (7.5 m) of gray, reddish-brown, and bluish-purple shale with limestone nodules, and (6) lenses as much as 5 feet (1.5 m) thick of calcarenite and limestone conglomerate. This upper unit contains some angular fragments of feldspars and granite. The limestone pebbles are mostly subrounded and smaller than 0.5 inch (r 3 mm) in diameter. Scattered amid the clastic granules are a few bone fragments. Gradationally above are the reddish-brown sandstone and shale of the Abo Redbeds, as well as some lenses of reddish, impure limestone.

In the Cañoncito de la Uva area, the Wolfcampian Bursum facies thus is unconformable on the Pennsylvanian. The basal limestone conglomerate is locally derived, with the quartz pebbles as a resistant fraction obtained from a distant source. The angular granite and subrounded limestone clasts in the upper Bursum appear to have been eroded from a source perhaps 5 to 1o miles (8-16 km) distant. The mixture of marine fossils and vertebrate bone fragments suggest nearshore conditions or an alternation of marine and terrestrial environments.

Palo Duro Canyon Section

West of Palo Duro Canyon in the foothills of the southwestern Los Piños Mountains (sec. 13, T. i S., R. 2 E., projected) about 8 miles (3 km) east of the southern Joyita Hills, the Bursum facies overlies Pennsylvanian limestones on a relatively even surface. Virgilian beds beneath the Bursum are only 200 to 23o feet (60-70 m) thick, with uppermost Virgilian faunal zones absent. The Bursum facies is about 125 feet (38 m) thick; it is composed mostly of bluish-purple and greenish shales with lenses of nodular fossiliferous limestone. At and near the base are lenses of brown, calcareous, arkosic sandstone with some thin beds of limestone-pebble conglomerate. About 4o feet (12 m) above the base is a medium-bedded, fossiliferous limestone, averaging 10 feet (3 m) in thickness, which contains jasperized brachiopods and crinoid stems as well as numerous fusulinids. The specimens include *Schwagerina emaciata, S. jewetti, S. grandensis,* S. cf. *pinosensis, Stewartina* spp. (Garner L. Wilde, unpub. ms.), and a new species of *Triticites*. A 1-foot (3o cm) limestone bed in the middle of the Bursum is locally a fusulinid coquina, composed of *Schwagerina grandensis, S. emaciata, Triticites hugesensis, T. ventricosus,* T. n. sp., *Stewartina* spp., and *Oketaella?*.

Above the medial limestone, several lenses of sandstone and of fossiliferous limestone crop out, and both contain limestone-pebble and limestone-cobble conglomerates. Clasts in these conglomerate lenses are dominantly of limestone, but also of clay balls, feldspar fragments, and some granite. The overlying reddish-brown shale and sandstone of the Abo Redbeds are comformable on the Bursum facies.

The lower Bursum along Palo Duro Canyon thus contains minor amounts of feldspar washed in from afar and minor amounts of locally derived limestone conglomerate, but is mainly of nearshore shales and marine limestones. The upper Bursum includes similar shales and marine limestones, but a higher percentage of locally derived limestone clasts, as well as granite and feldspar. Many of the feldspar and granite grains are subangular, easily broken material that appears to have been partly rounded during transport. Most of the erosive effect, however, resulted in smaller and smaller angular pieces, rather than rounded clasts.

Eastern Los Piños Section

About 15 miles (24 km) northeast of the Joyita Hills on the east side of Los Piños Mountains east of Sierra Montosa (sec. 33, T. 2 N., R. 4 E.), the Bursum facies is about 200 feet (6o m) thick and consists of reddish-brown, bluish-purple, and green shales with interbeds of fossiliferous limestone. Near the base are several lenses of arkose and limestone-pebble conglomerate, and near the top of the Bursum is a bed of arkosic conglomerate.

Ladron Mountains Outcrops

West of the Rio Grande, the nearest outcrops of Bursum-like beds occur on the southwest flank of the Ladron Mountains, 18 miles (29 km) west-northwest of Joyita Hills (Kottlowski, 196o, p. 32). Part of the formation is missing owing to faults. Basal beds are purplish limy shales, apparently disconformably on Virgilian limestones. These grade up into argillaceous nodular fossiliferous limestones, which are in turn overlain by reddish-brown limy conglomerates with clasts of limestone, fossils, quartz, and pinkish siltstone. Above the fault zone, brown limestones are conformably overlain by reddish-brown siltstones of the Abo Redbeds.

Regional Relationships

Thus all known sections of the Bursum facies surrounding the Joyita Hills appear to be made up of: ( ) basal lenses of limestone conglomerate and arkose, (2) a dominant facies of bluish-purple to greenish-gray shale with interbeds of marine limestone, and (3) lenses of limestone conglomerate and arkose in the upper part of the unit. The limestone clasts in the conglomerates are mainly of Pennsylvanian limestones, although some of the cobbles in the upper conglomerates are from penecontemporaneously eroded Bursum limestones. Whereas the lower limestone conglomerates were derived from the Pennsylvanian units directly below the erosion surface below the Bursum, the upper limestone clasts must have been derived from some source area not covered by the lower Bursum beds, and where Pennsylvanian limestones were exposed to erosion during early Wolfcampian time. This eroded area was the southern part of the Joyita Hills as shown by: (1) the thinness and the lithology of the Joyita Hills Bursum facies, (2) southward truncation of Pennsylvanian units in the Joyita Hills, (3) similarity of clasts of Precambrian rocks in the upper Bursum conglomerates to the Precambrian rocks of the southern Joyita Hills area, and (4) onlap of Bursum facies and lower Abo onto Precambrian rocks to the south.

The Bursum facies in the Joyita Hills is about 3o feet (9 m) thick and includes basal lenticular conglomerates of two types: (1) greenish limestone-granule to -pebble conglomerate, and (2) dark reddish-brown quartz-pebble conglomerate. The greenish limestone conglomerate is made up mostly of angular to rounded fragments of Pennsylvanian limestones with some clasts of quartz, feldspar, and granite, in a quartz-sand matrix. The reddish quartz conglomerate is hard, well cemented by silica and calcite, and contains angular clasts, dominantly of quartz, but also of feldspars, granite, red chert, and silicified limestone. Some of the quartz clasts are shaped like slivers, and could not have been transported much farther than the 0.25 mile (400 m) distance from the nearest Precambrian outcrop. Reddish-brown and bluish-purple siltstones, shales containing limestone nodules and fossil fragments, and thin lenses of argillaceous limestone make up the upper part of the Bur-sum; they grade up into the Abo Redbeds.

Section Near Coal Mine Canyon

South of Cañada Ancha and northwest of Coal Mine Canyon, the Bursum facies is unconformable on the underlying middle (?) Missourian limestones, with the basal bed, JH

Pb1 (on Figure 5, Pb is above JH1-37, the uppermost Pennsylvanian unit), being a lenticular 4-foot-thick (1.2 m) grayish-brown quartz-breccia conglomerate containing lenses of greenish-gray limestone-pebble conglomerate. Above, unit JH1-Pb2 is poorly exposed reddish-brown to yellowish-brown silty shale, forming a 1-foot-thick (0.9 m) slope. JH1-Pb3 is an irregular ledge of grayish-brown arkosic conglomeratic sandstone, containing many angular to subrounded quartz pebbles and some rounded limestone pebbles; unit is 4 feet (I.2 m) thick. JH 1-Pb4 is partly covered in the strike valley (formed throughout the Joyita Hills in the upper part of the Bursum facies) but scattered exposures are of interbedded grayish-green, reddish-brown, and bluish-purple shale, reddish-brown, friable arkose, and sparse nodules or thin, short lenses of limy siltstone or silty dense limestone; upper shales contain numerous lenses of purplish-gray calcareous argillaceous nodules; pink orthoclase and brown to light-gray plagioclase feldspars occur not only in the arkosic lenses but also scattered throughout the shales; sparse subrounded pebbles of granite gneiss occur in the local quartz-limestone conglomerate lenses; unit is about 57 feet (17 m) thick. Above, the basal Abo is of dark reddish-brown silty shale, 17 feet (5 m) thick, overlain by a lenticular, hard, well-cemented, reddish-brown arkose, I to 5 feet (0.3-1.5 m) thick.

Southwest of Coal Mine Canyon in the Bursum strike valley, deep channels as much as 20 feet (6 m) deep, have been cut into the Missourian strata and filled by reddish-brown quartz conglomerate and arkose. Cobbles and pebbles in the conglomerate are of subangular to subrounded quartz, granite gneiss, and chert, with scattered limestone clasts. The channels appear to be oriented almost east-west, and cross-bedding suggests current directions from the east-southeast.

Cañoncito Colorado (Section JH2)

On the north side of Cañoncito Colorado, section JH2, the basal Bursum facies is unconformable on underlying Missourian strata. The Bursum facies and lower Abo beds are as follows in ascending order:

JH2-30; *arkose,* greenish-gray, friable, crosslaminated, coarse-grained with lenses of quartz pebbles; maximum of 4 feet (1.2 m) thick, ledges.

JH2-31; *shale,* reddish-brown to purplish-gray with greenish-gray lenses and laminae; silty, lenticular; 7 feet (2 m) thick, slope.

JH2-32; *arkose,* greenish-gray to pinkish-gray, medium-grained, cross-laminated, lenticular; lenses of quartz-pebble conglomerate; ledges, 6 feet (1.8 m) thick.

JH2-33; interbedded greenish-gray to reddish-brown silty *shale* and friable grayish-green to dark reddish-brown lenticular *arkose,* fine- to coarse-grained; scattered throughout both shale and arkose are many subrounded to rounded pebbles of quartz, limestone, and silicified limestone; 12 feet (3.7 m) thick, slope.

JH2-34; *arkose,* friable, medium-grained, greenish-gray to tan and pinkish-gray; lenticular; sparse, scattered quartz and feldspar pebbles; grains subrounded to subangular; rubbly ledge, 6 feet (1.8 m) thick.

JH2-35; *shale* partly covered; lower part reddish- to greenish-gray, upper dark reddish-brown; in lower third are lenses of bluish nodular calcareous siltstone and silty dense limestone; thickness on slope is about 31 feet (9 m).

JH2-36; *arkose,* coarse-grained, crosslaminated; lenticular, brown to reddish-brown ledges; pebbly lenses of quartz, limestone, and silicified limestone; 7 feet (2.1 m) thick; overlain by dark reddish-brown shales and sandstones of typical Abo Redbeds.

Central Canyon (Section JH3)

Along Central Canyon, section JH3, Missourian shales and limestones are unconformable beneath the basal Bursum facies, unit JH3-18, a lenticular, reddish-brown breccia-conglomerate, 5 to 8 feet (1.5-2.4 m) thick, containing angular fragments, 0.5 to 2 inches (1-5 cm) in diameter, of quartz, siliceous limestone, and sparse granite gneiss. Above, unit JH3-19 is partly covered on the dip slope, consisting of interbedded greenish-gray, reddish-brown, and purplish-gray, clayey shale with scattered lenses of brown coarse-grained arkosic sandstone, greenish-gray coarse-grained pebbly sandstone containing many limestone clasts, and nodular masses of fossiliferous, medium-grained, gray calcarenite containing fragments of brachiopods and crinoid columnals; unit is about 33 feet (10 m) thick. JH3-2o is typical Abo arkose, lenticular, hard, coarse-grained, dark reddish-brown ledge, 2 to 5 feet (0.6-i.5 m) thick.

East Fork of South Canyon (Section JH4)

In section JH4, East Fork of South Canyon (fig. 9), the Bursum facies fill channels cut in the lower Missourian strata; a typical channel is 5 feet deep (1.5 m) and 8 feet (2.4 m) wide. The basal Wolfcampian is friable, purplish-gray, and greenish-gray arkose, r to 7 feet (0.3-2.1 m) thick, that fills the channels and overlaps them. Above is 22 feet (6.7 m) of intercalated greenish to reddish arkose, siltstone, and shale, partly covered on a dip slope. The overlying unit is a lenticular ledge of nodular, crinoidal, silty, gray limestone, maximum of

foot (0.3 m) thick, which is overlain by 11 feet (3.4 m) of reddish-brown, silty shale and friable arkose, the basal Abo facies. This is overlain by a massive, well-cemented, dark reddish-brown arkose forming a prominent lenticular 1-foot-thick (0.9 m) ledge, which is beneath a thick sequence of dark reddish-brown Abo shales.

South Fork of South Canyon (Section **JH5)**

At section JH5, South Fork of South Canyon, thinned Late Atokan limestones are overlain by a greenish-gray limestone-conglomerate, 2 to 5 feet (0.6-1.5 m) thick; next is 7 to 1o feet (2.1-3 m) of brown arkose with lenses of quartz pebbles, some of which are angular shards. Above is a thick sequence of dark reddish-brown Abo shale. About 100 feet (31 m) to the south, the basal Bursum facies fills a channel cut down into Early Atokan beds, and consists of interbedded greenish-gray and reddish-brown arkosic conglomerate as much as 20 feet (6 m) thick. The reddish conglomerate is hard, well cemented, with angular clasts, 0.5 to 2 inches (1-5 cm) in diameter, mainly of quartz but including much feldspar, granite gneiss, red chert, and silicified limestone. The greenish-gray lenses contain a large percentage of limestone grains and pebbles, along with quartz, feldspar, and granite gneiss.

Section JH6 (Near Hill 5r 29)

At section JH6, 1900 feet (58o m) southwest of section JH5, unconformable on Precambrian granite gneiss, or locally on remnant silicified lenses of the basal Pennsylvanian quartzite, is lenticular reddish-brown arkose, friable, with scattered angular quartz pebbles, about 3 feet (o.9 m) thick. Above is

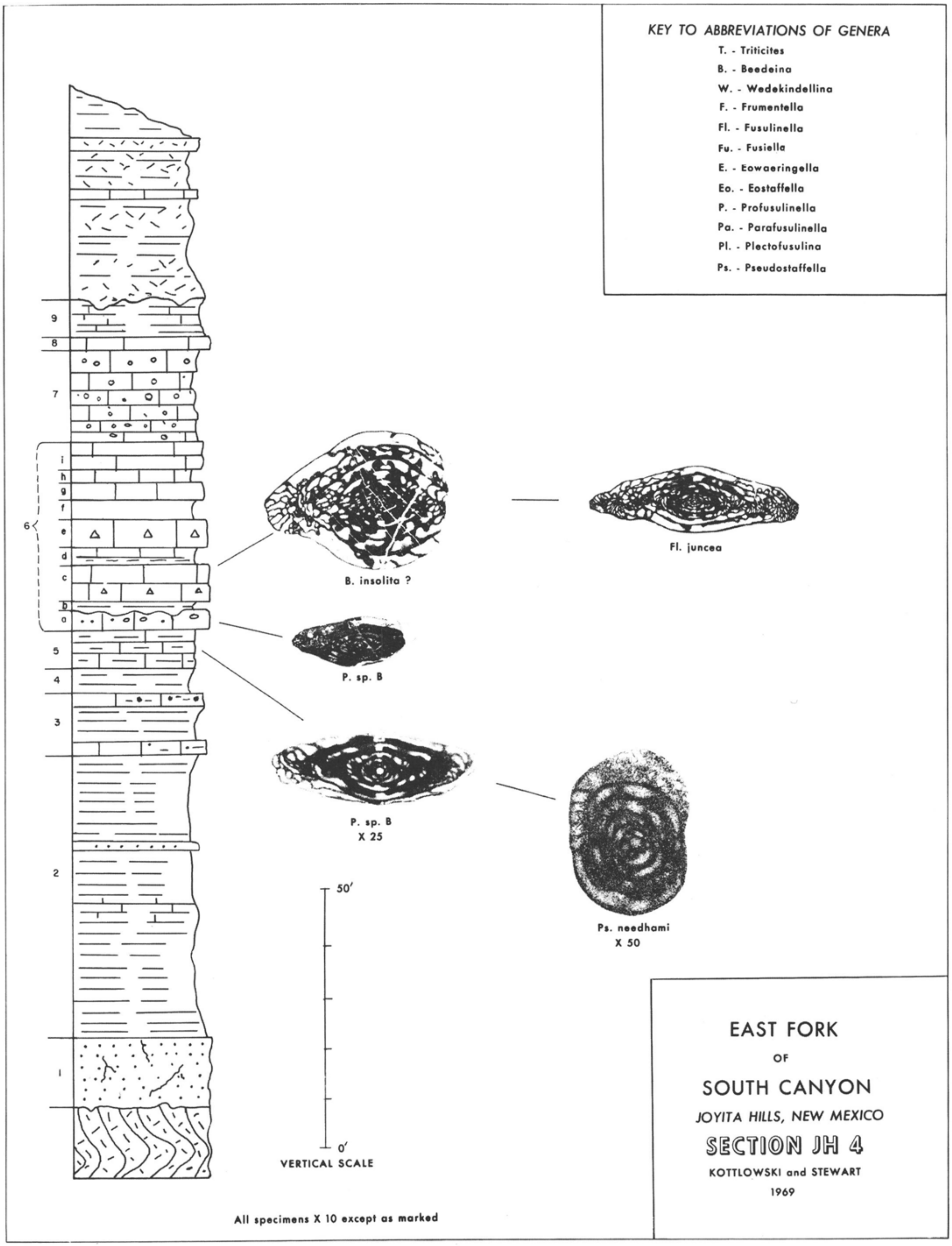
KEY TO ABBREVIATIONS OF GENERA
T. - Triticites
B. - Beedeina
W. - Wedekindellina
F. - Frumentella
Fl. - Fusulinella
Fu. - Fusiella
E. - Eowaeringella
Eo. - Eostaffella
P. - Profusulinella
Pa. - Parafusulinella
Pl. - Plectofusulina
Ps. - Pseudostaffella
9
8
7
i
h
g
f
6
e
d
c
b
a
5
4
3
2
1
B. insolita ?
Fl. juncea
P. sp. B
P. sp. B
X 25
Ps. needhami
X 50
50′
0′
VERTICAL SCALE
All specimens X 10 except as marked
EAST FORK
OF
SOUTH CANYON
JOYITA HILLS, NEW MEXICO
SECTION JH 4
KOTTLOWSKI and STEWART
1969

Figure 9

a very lenticular arkosic, arenaceous calcarenite, 1 to 5 feet (o.3-1.5 m) thick, gray to reddish-brown, medium- to coarse-grained, containing angular to rounded grains of limestone, calcite, fossil fragments, quartz, and minor feldspar. Overlying reddish-brown arkose, dark reddish-brown shale, and pale reddish-brown calcareous sandstone are typical of the Abo Redbeds.

North Fork of Rosa de Castillo Arroyo (Section JH7)

Along the North Fork of Rosa de Castillo Arroyo, section JH7, the beds are unconformable on the Precambrian and appear to be of the Abo facies. They are laterally equivalent (traceable along the outcrop) to lower Abo units to the north. The basal unit (I) is lenticular reddish-brown to light-brown arkose with lenses of angular to rounded quartz pebbles and cobbles; some of the quartz clasts are angular shardlike fragments; unit is absent to 3 feet (0.9 m) thick; (2) lenticular, partly covered silty dark reddish-brown shale slope, 12 to 17 feet (3.7-5.5 m) thick; (3) gray to reddish-gray, calcareous, medium-grained, friable sandstone, 2 feet (o.6 m) thick; (4) more than 5o feet (1 5 m) of dark reddish-brown shale with scattered lenses of limestone-pebble conglomerate, brown platy sandstone, and nodular limy pale reddish-brown siltstone.

In this area, Wilpolt and Wanek (1951) had mapped the Abo Redbeds as being in fault contact with the Precambrian granite gneiss. The contact is a depositional one with the basal Abo almost conformable on the gneiss. The contact surface has been tipped to dip to the west about 12 degrees; on the cleaned dip surface of the Precambrian gneiss are small patches of Abo arkose.

Location of the Joyita Axis

South of section JH7, the Paleozoic rocks are overlapped by sands and sandstones of the Cenozoic Santa Fe Group, and only the main ridge of Precambrian rocks extends uncovered to and south of the canyon of Rosa de Castillo Arroyo. In the canyon banks, reddish-brown Abo conglomerate is plastered unconformably on the Precambrian granite gneiss, consisting of angular quartz and gneiss cobbles in an arkosic matrix.

The southern extent of this relationship of Abo Redbeds resting directly on Precambrian is controlled by a relatively complete Pennsylvanian sequence underlying the Bursum facies in Cerritos del Coyote and Cerros de Amado about 1o miles (6 km) to the south-southeast. The Palo Duro Canyon section, 8 miles (13 km) to the east of this southernmost tip of the Joyita Hills, has a thick Pennsylvanian section below the Bursum and Abo facies. These distances do leave room for a considerable mass of Precambrian rocks to have been exposed to erosion during early Wolfcampian time, and locate the true Joyita axis in central New Mexico. In the Joyita Hills, along the 2.5 miles (4 km) from its northern tip southward to the South Fork of South Canyon, the basal Wolfcampian Bursum facies (fig. o) rests unconformably on the

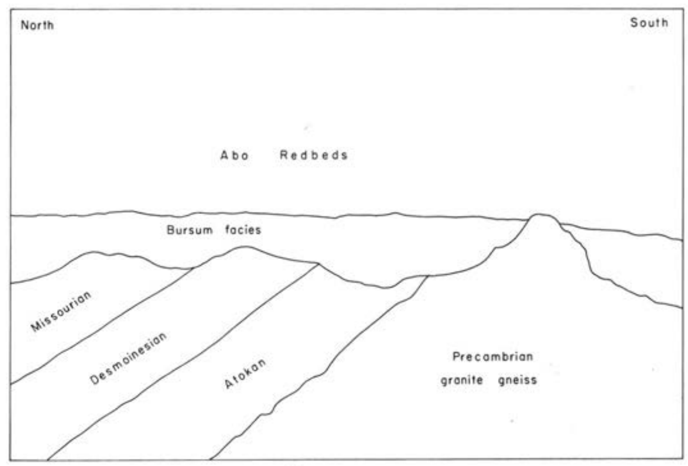

Figure 10

DIAGRAMMATIC SECTION OF BURSUM FACIES IN JOYITA HILLS

Pennsylvanian, the erosion surface truncating the Missourian, Desmoinesian, and Atokan strata southward, and being in turn overlapped by lower Abo Redbeds. Similar relationships probably occur on the west, south, and east sides of these hills of Precambrian rocks, the Bursum facies and Abo Redbeds overlapping eroded Pennsylvanian units.

Geologic History

During Devonian time the Joyita Hills area, with most of northern and central New Mexico, was part of the Peñasco dome (Armstrong, 1967), from which all pre-Devonian rocks were stripped down to the Precambrian core. Shorelines of this huge dome were to the south near Roswell and Truth or Consequences (fig. i i) and to the northwest near Chaco Canyon ruins. Central and northern New Mexico provided erosional detritus to the northwest and south as the quartz sands and green clays in the Four Corners' Aneth, Elbert, and lower Ouray units, and the clays, quartz silt, and fine-grained sand of southern New Mexico's Percha-Woodford black shale facies. Post-Devonian erosion removed some of the Devonian strata, particularly along the Pennsylvanian-Permian Pedernal uplift.

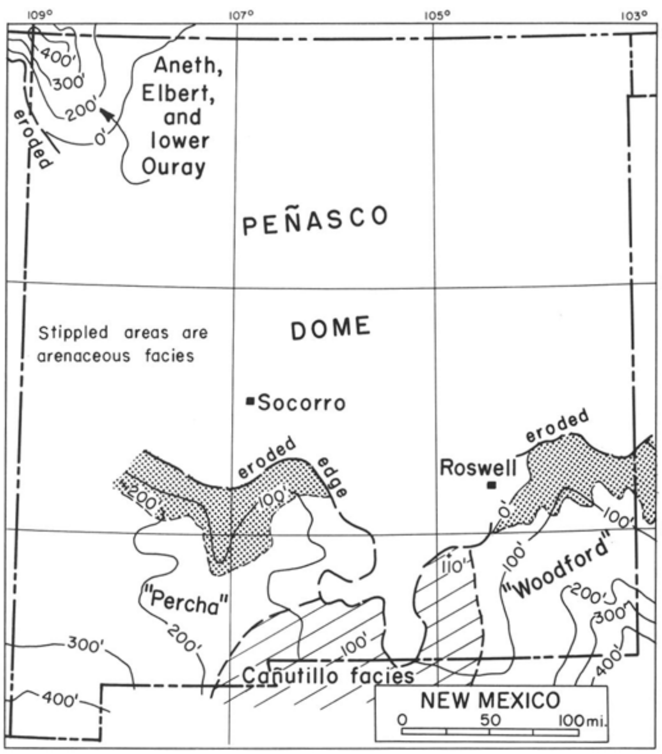

Figure 11
ISOPACH MAP OF DEVONIAN STRATA IN NEW MEXICO

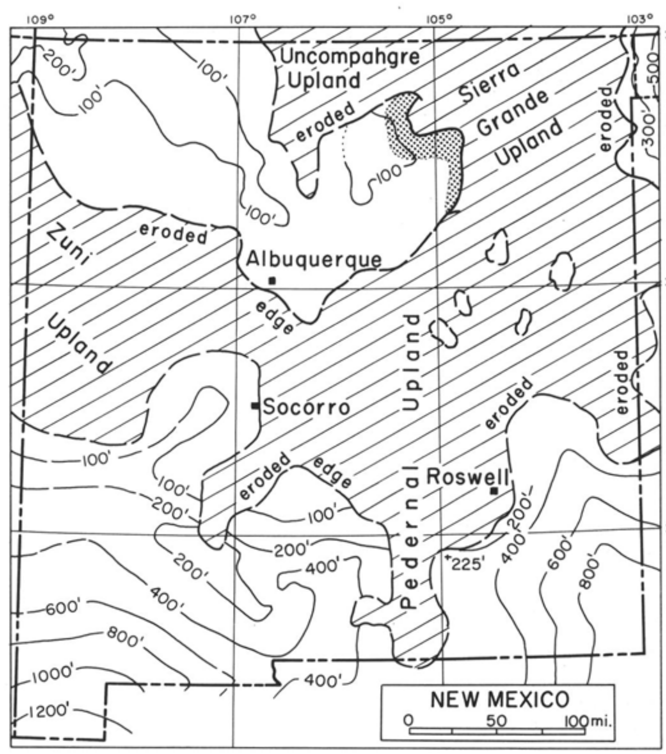

Figure 12
ISOPACH MAP OF MISSISSIPPIAN STRATA IN NEW MEXICO

Most of New Mexico, including the Joyita Hills area, was covered by Early and Middle Mississippian limestones. Basal Mississippian beds in central New Mexico unconformably overlie Precambrian rocks (Kottlowski, I 963a). Locally, as in the Magdalena Mountains, the basal Mississippian is reddish-brown arkosic calcarenite. Erosion of the Mississippian rocks during late Mississippian and early Pennsylvanian stripped the Mississippian, except for local remnants, from most of central New Mexico as shown on Figure 12.

Shorelines of the Late Mississippian seas were to the south near 32°3o' N. Lat. where the Chesterian Helms, Paradise, and Barnett Formations were deposited. The Precambrian rocks in central New Mexico were eroded during Chesterian time to provide some of the elastic detritus for these nearshore and shallow-marine sediments.

In northeastern New Mexico, the Sierra Grande upland appears to have stood above the Mississippian seas, as there the Middle Mississippian Arroyo Peñasco Formation includes basal sandstones and conglomerates that lap northeastward onto hills of Precambrian rocks.

Beginning with the Morrow Series of earliest Pennsylvanian time, the early and middle Paleozoic pattern of a low landmass (the Peñasco dome in central and northern New Mexico), fringed by a shallow southern sea, vanished. North-south structural trends arose, and the resulting uplifts and basins (fig.) dominated the processes of erosion and deposition during Pennsylvanian time. Morrowan elastic sediments were deposited in the Delaware basin (Meyer, 1966) to the southeast, in the Orogrande basin (Pray, 1961) to the south, in the Rowe-Mora basin (Taos trough of Sutherland, in Miller et al., 1963) to the north-northeast, and locally in the Paradox basin (Wengerd, 1962) to the northwest and Pedregosa basin (Zeller, 1965) to the southwest.

Morrowan strata appear to be absent in central New Mexico, although, as in the Joyita Hills, basal beds do not contain diagnostic fossils. Thus most of central New Mexico, including the Joyita Hills area, appears to have been a low upland during earliest Pennsylvanian time.

By Atokan time, the north-south core of the Pedernal uplift was well defined, lying about 45 miles (72 km) east of the Joyita Hills. Some siliciclastic sands and minor gravels were shed from the Pedernals to the east and from the Zuni uplift to the northwest, but much of the detritus was clay. Some of the elastic material was derived from local hills and shoals. Relatively thick deposits of quartz and clay were deposited in the Estancia, Lucero, and San Mateo basins, as well as in the other Pennsylvanian basins in the State.

PENNSYLVANIAN PALEOENVIRONMENTS

Thus the Joyita Hills area was slightly higher than adjoining regions during Morrowan and Atokan time with a possible shallow, broad upland exposed in the Morrowan. The thin Atokan sequence appears to have been deposited in shallow, stagnant, marine waters, with the sparse pebbles and cobbles derived locally from small areas awash amid lagoonal seas. The carbonaceous shales and bone coal laminae suggest local marshy, paludal areas crowded with vegetation. Gypsum laminae indicate local evaporite pools and supratidal flats.

The basal quartzitic sandstone in the Joyita Hills is reworked local detritus of lenticular deposition filling depressions and lapping up onto small hillocks of Precambrian granite gneiss. Poorly preserved crinoid columnals, algal filaments, and brachiopods attest to the marine environment of deposition as the early Atokan seas transgressed over the area.

The overlying black shale unit contains intertongued sandstone and arenaceous calcarenite in lower beds, bone coal and gypsum laminae near the middle, and interbeds of black silty calcilutite and coarse-grained calcarenite in upper beds. These suggest stagnant lagoonal waters, with sand supplied during eustatic deposition, then marsh and evaporite flats, partly subaerial, amid the fetid lagoons. Later crinoidal banks scattered throughout the area indicate deeper, low-energy shelf seas.

The brownish-black silty calcilutite with upper laminae of yellow and pale-red siltstones suggest less stagnant shallow waters, more silt and less clay brought in as detritus, and possible short periods of subaerial exposure of the silty sediments of an intertidal environment.

The upper Atokan limestones of Early and Late Atokan age are slightly oolitic, algal, contain normal marine faunas, and much chert, being marine deposits typical of shallow shelf environments. Considering the entire area of the Joyita Hills, the units are lenticular and locally disconformable, suggesting periods of nondeposition, if not of some slight submarine and subaerial erosion. The oolites, fusulinids, and skeletal calcarenites represent short periods of higher energy interspersed between periods of shallow-water, lower energy shelf conditions exhibited by the algal lime muds.

During Desmoinesian time, most of New Mexico was at least periodically beneath extensive seas. Sandy shaly deltaic facies were deposited near the low exposed uplifts, such as those on both sides, west and east, of the Pedernals. However, in middle Desmoinesian time, various areas throughout New Mexico were uplifted and eroded, so that in many places, such as near Roswell, in the Joyita Hills, and in the Oscura Mountains, Missourian elastic strata unconformably to dis conformably overlie middle and early Desmoinesian strata.

The lower part of the Early Desmoinesian sequence in the Joyita Hills is of normal low-energy, shallow-marine conditions. In most areas the basal strata are conformable to unconformable on underlying Late Atokan beds and consist of fossiliferous micrite and calcarenitic micrite, with essentially no siliciclastic detritus nor any apparent intraclasts derived from the Atokan beds. Along Cañada Ancha, however, probable basal Desmoinesian rocks are lenses of arenaceous calcarenite containing scattered subrounded pebbles of quartz, granite gneiss, and detrital chert. This suggests some nearshore conditions produced by a local uplift and erosion near the northern part of the Joyita Hills during latest Atokan or earliest Desmoinesian time.

The elastic strata of Early Desmoinesian age that conformably to erosionally unconformably overlie the lower Early Desmoinesian limestones contain mostly reworked limestone clasts, but do include much quartz and some feldspar. They are higher energy, very shallow-water deposits and suggest some small nearby shoreline areas of quartz-and-feldspar-bearing rocks, such as the Precambrian granite gneiss, were exposed to erosion during this episode of Early Desmoinesian time. Algal banks, fusulinid-bearing micrites, and skeletal calcarenites are common. During Late Desmoinesian time the Joyita Hills area was probably slightly above sea level as evidenced by a hiatus with the Late Desmoinesian missing. Also the Early Desmoinesian sediments become more arenaceous and include pebble conglomerates near the unconformity of the overlying early Missourian strata.

During Missourian and Virgilian time, appreciable amounts of red-bed materials, red clays and red silts with feldspar grains, were derived from the Pennsylvanian uplifts, the Pedernal uplift to the east and the Zuni uplift to the northwest in central and west-central New Mexico. The Missourian strata in the Joyita Hills are interbedded argillaceous marine limestones and calcareous fossiliferous shale with several beds of fusulinid-bearing micrites. These normal-marine low-energy shelf lime-mud deposits are mixed with eroded and reworked fine-grained detritus. The upper part of the Missourian has been removed by erosion during late Paleozoic time, but the sequence is thinner than most Missourian sections in the region. This again suggests that the Joyita Hills area was a relatively broad shallow area of deposition during the Early Missourian.

Virgilian strata are absent in the Joyita Hills. Sequences of Virgilian rocks in nearby areas appear to be shallow-water marine deposits containing minor amounts of siliciclastic detritus brought in from the west and the east, grading upward into marginal marine to nonmarine red beds. It is possible that a thin marine Virgilian sequence was deposited in the Joyita Hills area, but it was removed by erosion during latest Virgilian and early Wolfcampian time.

EARLY PERMIAN WOLFCAMPIAN PALEOENVIRONMENTS

During Early Wolfcampian time, beginning in late Virgilian time, many of the Pennsylvanian uplifts were rejuvenated and shed vast amounts of erosional elastics into adjoining basins and troughs. In the Orogrande basin west of the Pedernal uplift, an estimated 1810 cubic miles (755o

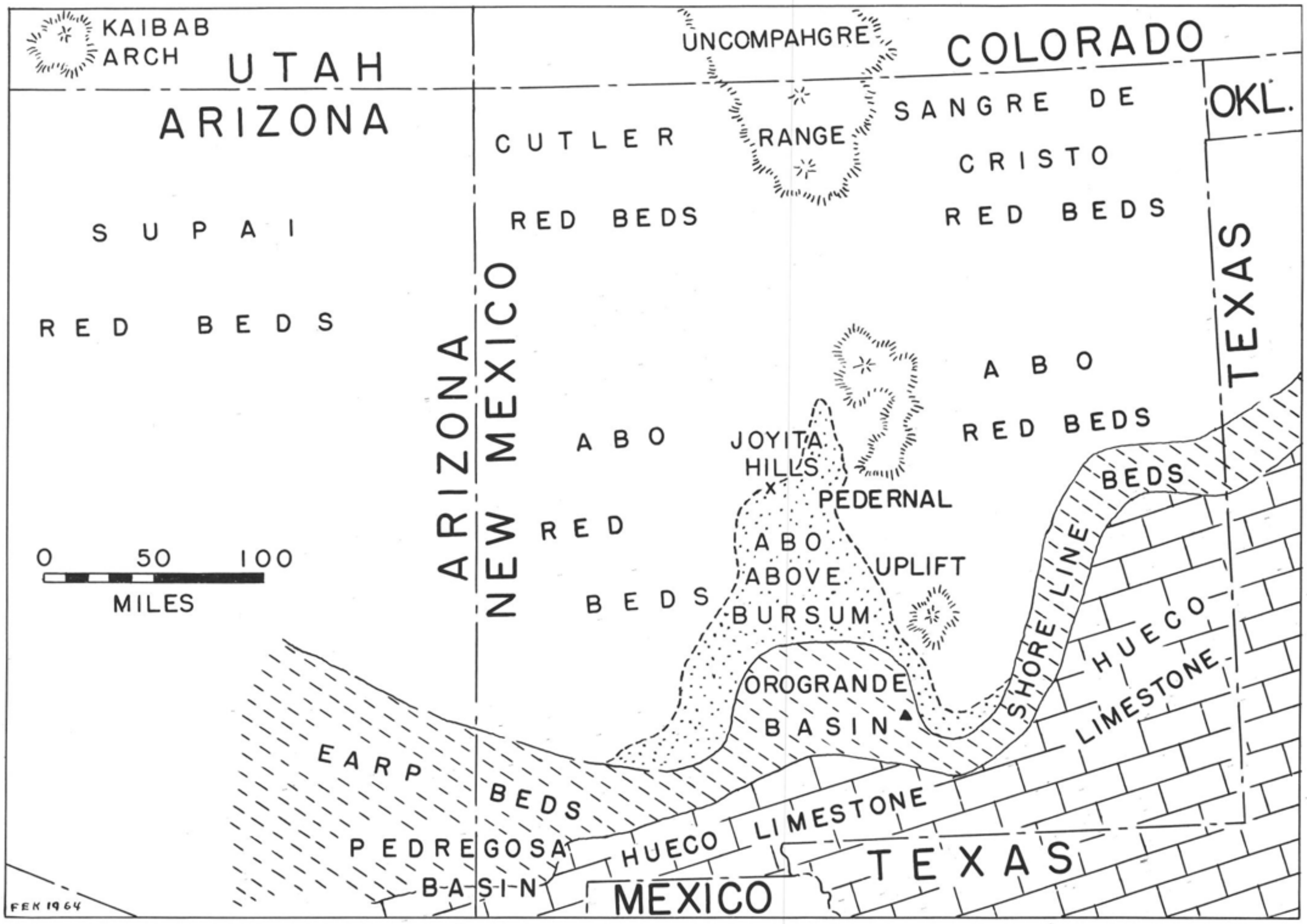

Figure 13
Wolfcampian paleogeologic map of New Mexico

cu. km) of siliciclastic material were derived from the Pedernals during late Virgilian time. This amount, with the detritus swept eastward into the Delaware basin, required the 8500-square-mile (22,000 sq. km) mass of the Pedernals to be eroded about 1300 feet (400 m), more than 0.25 mile. Early Wolfcampian sediments derived from the western Pedernals include quartzite and granite cobble-conglomerates, arkosic sandstone, and red shales, with about 800 cubic miles (334o cu. km) of siliciclastic detritus deposited in the Orogrande basin. Similar but smaller amounts filled the Estancia basin to the northeast of the Joyita Hills.

By middle Wolfcampian time, reddish clastic fragments from the Uncompahgre uplift of northern New Mexico and southern Colorado flooded southward in stream channels and adjacent floodplains to bury most of the Pennsylvanian-early Wolfcampian islands. Southward these Abo Redbeds interfingered with northward-extending tongues of Hueco limestone and marine shale; the Bursum facies of central New Mexico is the intertonguing of the Abo and Hueco (fig. 13).

In the southern part of the Joyita Hills, the small Joyita uplift rose above the early Wolfcampian seas, Pennsylvanian strata were truncated by erosion during this early Wolfcampian (and late Virgilian?) episode, and the basal Wolfcampian siliciclastics, the Bursum facies, were laid down across the various Pennsylvanian units. The wedgeout of the Bursum facies from north to south under the Abo facies in the area of study further supports the presence of the Early Wolfcampian Joyita uplift. Angular shards of quartz, and large fresh clasts of feldspar and granite gneiss attest to the nearness of the local uplift. The highest parts of the exposed gneiss hills stood above the early Wolfcampian shoreline seas, and were covered only by the middle beds of the Abo Redbeds. It appears that the earliest part of the Wolfcamp Series is not present in the Joyita Hills since only the upper part of the Tri*ticites* biozone is present.

By late Wolfcampian time, the small Joyita uplift, the Zuni uplift to the northwest, and most of the Pedernal uplift to the east were buried beneath the Abo Redbeds. Only locally as at the present-day Pedernal Hills and Pajarita Mountain, did remnant Precambrian-rock mountains (fig. 13) rise above the red-clastic flood. These higher remnants supplied minor detritus to the sandy lagoonal seas of early Leonardian time, and were in turn buried by the Leonardian Yeso Formation sands, dolomitic limestones, and gypsum beds.

The relationships of Pennsylvanian and Wolfcampian rocks so well shown in the Joyita Hills are similar to those described by Pray (1961) in the Sacramento Mountains. In the northern part southeast of Tularosa (Otte, 1959), a complete Virgilian sequence is relatively conformable beneath Wolfcampian strata, composed of shoreline sediments bordering the west edge of the Pedernal uplift. Bursum and Hueco facies strata, the Laborcita Formation of early Wolfcampian age, grade up into the main mass of the Abo Redbeds. Southeastward toward the edge of the Pedernal uplift, this Bur-sum facies thins, grades laterally into the lower part of the Abo Redbeds, and truncates pre-Permian strata. Oil tests drilled on top of the Pedernal uplift encountered Abo Red-beds above the Precambrian core of the buried landmass.

The Bursum facies of early Wolfcampian age, most often considered as the marine interbeds bearing a *Schwagerina-Triticites* fauna, is unconformable on Virgilian and older Pennsylvanian beds in central New Mexico near and in the Joyita Hills. Thus the Joyita uplift is a documented key to the widespread orogeny of late Virgilian and early Wolfcampian time. Minor uplift during middle and late Desmoinesian time may have been an event forecasting the major later movement, erosion, and arkosic red-bed deposition.

PART II

FUSULINIDS OF THE JOYITA HILLS
SOCORRO COUNTY, CENTRAL NEW MEXICO

WENDELL J. STEWART

Abstract

Fusulinids occur in great abundance throughout the interval of Pennsylvanian sediments in the Joyita Hills. A new genus *Parafusulinella* is described with two new species, P. *propria* from the Joyita Hills, and P. *mexicana* from the Boca Grande Mountains of northwestern Mexico. Other new species described from the Joyita Hills include *Plectofusulina rotunda*, P. *coelocamara*, *P. fusiformis*, *Beedeina joyitaensis*, *Wedekindellina elongata*, *W. alveolata*, *Triticites riograndensis*, and *T. liosepta*.

Introduction

The stratigraphic occurrence of the fusulinids, their biozones and paleoecological significance have been discussed in Part I of this study. Additional discussion concerning stratigraphy, faunal assemblages, taxonomy, systematic descriptions and phylogeny follows. All specimens and types are filed in the Texaco Inc. paleontological collections (see appendix).

Systematic Descriptions

Superfamily FUSULINACEA VON MÖLLER, 1878

Family OZAWAINELLIDAE

THOMPSON AND FOSTER, I 937

Genus EOSTAFFELLA

RAUSER-CHERNOUSOVA , I 948

Eostaffella spp.
Plate 1, figures 1-4

Diagnosis—Test small, discoidal, mostly involute with rounded equatorial periphery and an average axial length of 0.135 mm, an equatorial width of 0.415 mm with a form ratio of 5:0.32. The proloculus is small, spherical and averages 4o microns in outside diameter.

The chomata are indistinct, asymmetrical, low relief and border a tunnel with an average angle of 12 degrees. The spirotheca is of uniform thickness throughout the test and is composed of a tectum, a primatheca (Stewart, 1966) and rare outer tectorial layers.

The septa number 9 to 17 from the first to the fourth volutions with a maximum of four volutions. The coiling inflates progressively with each volution.

Remarks—It seems impossible at this time to attempt to speciate this genus since over ninety-five species and many subspecies or varieties have been published (Kahler and Kahler, 1966-1967). Most of these publications of species are in the Russian language and are unavailable to the writer.

Occurrence—The genus *Eostaffella* occurs abundantly in the Morrowan sediments of New Mexico and decreases in its occurrence upward in the section until it disappears in the Lower Permian. Collected from beds JH1-11 JH2-13, JH2-17, JH3-10, and JH4-6h.

Family FU SU LINIDAE VON MÖLLER, 1878

Subfamily SCHUBERTELLINAE SKINNER, 1931

Genus FUSIELLA LEE AND CHEN, 1930

Fusiella texana Stewart

Plate 1, figures 12-16; table

Fusiella texana Stewart, 1958, Journal of Paleontology, v. 32, no. 6, p.1055, plate 137, figs. 14, 15.

Diagnosis—The test is small, ovate to endothyroid in the juvenile stages, and fusiform with pointed polar extremities in the mature volutions. The average length is o.6o mm, the width 0.3o mm and an average form ratio of 1:2.0. The small, spherical proloculus ranges between 3o and 4o microns.

The thin spirotheca is composed of a tectum, primatheca and upper tectorium and ranges in thickness from 6 to 14

TABLE 1. MEASUREMENTS OF *FUSIELLA TEXANA* STEWART

Volution	Half Length 1	Half Length 2	Half Length 3	Half Length 4	Radius Vector 1	Radius Vector 2	Radius Vector 3	Radius Vector 4	Form Ratio 1	Form Ratio 2	Form Ratio 3	Form Ratio 4
0	0.020	0.018			0.020	0.018			1.0	1.0		
1	0.042	0.050			0.033	0.032			1.3	1.5		
2	0.074	0.148			0.052	0.080			1.4	1.8		
3	0.168	0.251			0.089	0.117			1.9	2.1		
4	0.242	0.330			0.138	0.180			1.7	1.8		

Volution	Tunnel Angle (degrees) 1	Tunnel Angle (degrees) 2	Tunnel Angle (degrees) 3	Tunnel Angle (degrees) 4	Wall Thickness 1	Wall Thickness 2	Wall Thickness 3	Wall Thickness 4	Septal Count 5	Septal Count 6	Septal Count 7	Septal Count 8
0	—	—			0.006	0.007			—	—	—	
1	—	—			0.006	0.011			9	7	8	
2	15°	21°			0.008	0.015			12	12	12	
3	19°	27°			0.013	0.014			15	11	12	

TABLE 2. MEASUREMENTS OF *PSEUDOSTAFFELLA NEEDHAMI* THOMPSON

Volution	Half Length 1	Half Length 2	Half Length 3	Half Length 4	Radius Vector 1	Radius Vector 2	Radius Vector 3	Radius Vector 4	Form Ratio 1	Form Ratio 2	Form Ratio 3	Form Ratio 4
0	0.028	0.022	0.026	0.064	0.028	0.019	0.028	0.023	1.0	1.1	.93	1.0
1	0.055	0.062	0.040	0.052	0.110	0.057	0.054	0.050	.45	1.1	.74	1.0
2	0.094	0.126	0.076	0.070	0.153	0.130	0.110	0.081	.61	.97	.69	.86
3	0.152	0.167	0.142	0.108	0.200	0.228	0.158	0.137	.76	.73	.90	.79
4	0.224		0.178	0.142	0.286		0.237	0.200	.78		.75	.71

Volution	Tunnel Angle (degrees) 1	Tunnel Angle (degrees) 2	Tunnel Angle (degrees) 3	Tunnel Angle (degrees) 4	Wall Thickness 1	Wall Thickness 2	Wall Thickness 3	Wall Thickness 4	Septal Count 5	Septal Count 6	Septal Count 7	Septal Count 8
0	—	—	—	—	0.008	0.009	0.008	0.007	—	—	—	—
1	17°	—	19°	—	0.017	0.012	0.017	0.009	8	9	7	9
2	22°	24°	19°	19°	0.015	0.017	0.012	0.012	11	11	8	11
3	30°		12°	16°	0.017	0.014	0.012	0.011	15	14	13	16
4	28°				0.019		0.011	0.010	17		17	

microns from the proloculus to the fourth volution. The tunnel is wide, irregular, and ranges from 15 to 33 degrees. The chomata are well developed, asymmetrical to flowing, and extend from one-half to the entire height of the chamber. Secondary infilling is developed along the straight axis of coiling. The septa are unfluted except in the polar extremities and number from 8 to 15 for the four volutions.

Occurrence—*Fusiella texana* is not found in great abundance, but occurs more commonly in the beds assigned to the Lower Missouri Series in New Mexico. Rare specimens are found in the upper biozones of *Beedeina* and *W edekindellina*. It is the only fusiform fusulinid found between the highest occurrence of *Beedeina* and the lowest occurrence of the genus *Eowaeringella*. Rare specimens are found in the same collections with the latter genus from strata assigned to the Lower Missouri. Collected from beds: J H1-17, J H1-34, JH 1-35, JH3-15 and JH4-8.

Subfamily FUSULININAE **VON MÖLLER, I 878**

Genus PSEUDOSTAFFELLA

THOMPSON, I 942 *Pseudostaffella needhami* Thompson

Plate 1, figures 5-I I; table *2*

Pseudostaffella needhami Thompson, 1942, American Journal Science, v. 240, no. 6, p. 411-413, pl. 1, figs. 15-20, pl. 3, figs. 10-14

Diagnosis—*Test* small, subspherical to ellipsoidal, depressed in axial regions with greater growth expansion in the equatorial dimension. Mature specimens of three to four volutions measure 0.24 to 0.45 mm in length, 0.40 to 0.46 mm in width with form ratios 1:0.78 to I:1.0 from the first to last volutions. The inner one or two volutions are coiled at different angles to the mature axis of coiling, some as great as 90 degrees. The proloculus is spherical and measures 44 to 56 microns in outside diameter.

The spirotheca is thin and averages about 14 microns in thickness in the mature stages. It is composed of a tectum, a primatheca and an upper tectorium. The septa are thin and unfluted with counts ranging from 8 to 17 from the first to last volutions.

The tunnel is very irregular, ranges from 17 to 28 degrees from the immature to mature whorls, and is bounded by well-developed irregularly shaped chomata. The chomata reach one-half to two-thirds the height of the chambers.

Occurrence—*In* the Joyita Hills the genus *Pseudostaffella* occurs in the Upper Atokan and Lower Desmoinesian strata. Only two specimens were found in the Central Canyon section (JH3), but this is believed to be an oversight due to random collecting. The above species is found in the following beds: RI I-1 2, JH1-19, JH2-19, JH3-12, JH4-5 and JH4-6i.

Genus PLECTOFUSULINA STEWART, 1958

Since the type species, *Plectofusulina franklinensis,* was published in 1958, many specimens and species have been found in the Pennsylvanian sediments of western Texas, New Mexico, Arizona, Utah and Colorado. The present range of the genus extends from the Upper Atoka, through the Des Moines and into the Lower Missouri Series in the biozone of the fusulinid genus *Eowaeringella*. Several authors have erroneously referred species of *Plectofusulina* to the genus *Oketaella*.

Some significant morphologic changes occur with the advancement of the genus *Plectofusulina* through geologic time. Epithecal tectorial deposits are heavier, along with better developed chomata, in the more primitive species. The diaphanotheca becomes thicker and more distinct with advancement, as the tectoria and chomata tend to disappear. Perhaps with such significant phylogenetic advancement, other genera or subgenera should be distinguished, and the entire group with small tests and coiling of this nature should be taxonomically distinguished as a subfamily.

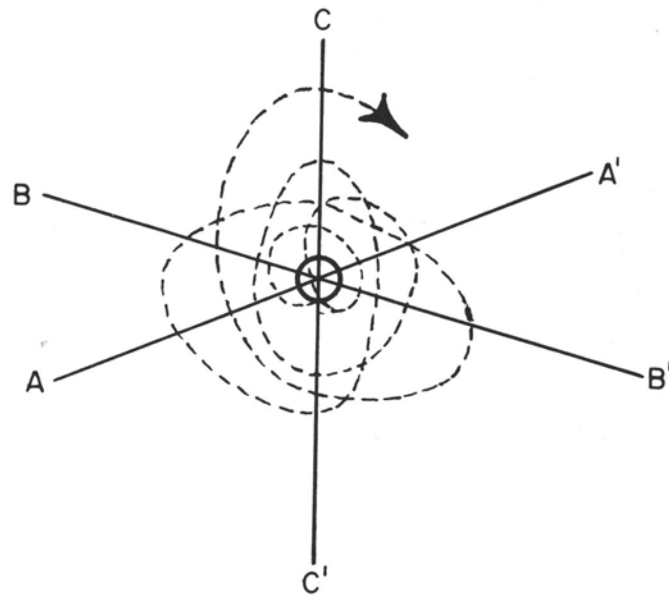

Figure 14

PLECTOID COILING IN PLECTOFUSULINA

A–A′ and B–B′ are in the horizontal plane, C–C′ is in the vertical plane. Large circle around the intersection of the three axes represents the proloculus and the arrow path follows the center of the tunnel for each chamber as growth progresses.

The type of coiling in the above genus is described as *plectoid* from the Greek word *plektos,* meaning twisted. The axis of coiling may differ for each stage of development or as each new chamber is added. The coiling plane always extends through the center of the proloculus, but then may rotate or twist in each new growth stage in any of the 36o degrees from the vertical or horizontal planes. Figure 14 illustrates plectoid coiling.

Plectofusulina franklinensis Stewart

Plate 2, figures 16, 17, 19

Plectofusulina franklinensis Stewart, 1958, Journal of Paleontology, v. 32, no. 6, p. 1056, pl. 132, figs. 1-10

Diagnosis—*Test* small, subspherical to ovate, with lengths from 0.82 to 1.o2 mm, widths from 0.62 to 0.70 mm and an average form ratio of 1:1.3. The axis of coiling for each volution is plectoid, and continues through the plane of the center of the proloculus as a point of common leverage, but then tends to gyrate or revolve around this central point in both horizontal and vertical directions. The four to four and one-half volutions exhibit an average septal count of 8, 14, and 15 from the first to last volutions with a slight flaring in the later chambers of mature individuals.

The spirotheca is composed of a tectum, thin to faint diaphanotheca, and an upper and lower tectoria which comprise most of the wall. The relatively large and ovate proloculus averages 100 microns in outside diameter. The chomata are well developed, asymmetrical and extend from one-half to two-thirds the height of the chambers. Some tend to slightly overhang the erratic tunnel of 17 to 34 degrees from the first to last volutions consecutively.

Occurrence—The genus *Plectofusulina* extends from within the upper biozone of the genus *Fusulinella* well up into the biozone of the genus *Eowaeringella.* Its present range would include the Upper Atoka Series, all of the Des Moines Series and part of the lowermost Missouri Series.

Plectofusulina franklinensis occurs in the middle to upper part of the biozone and is found in the following units of the Joyita Hills: JH1-13, JH 9, JH1-35, JHz-1 3 and JH2-19.

Plectofusulina rotunda Stewart, n. sp.
Plate r, figures 17-21; table 3

Diagnosis—Shell subspherical to ovate, very rounded apical extremities, length ranging from 0.57 to o.63 mm, width ranging from 0.50 to 0.54 mm and a form ratio of r :1.1 to 1:1.2. The four volutions are loosely plectoid and coil around a gyrating or varying axis for each volution both vertically and horizontally.

The proloculus is small, spherical and measures 5o to 68 microns in outside diameter. The chomata are well developed, symmetrical to asymmetrical and border a very irregular tunnel with average angles of 8 to 18 degrees from the first to last volutions.

The spirotheca is thin and composed of a tectum, thin diaphanotheca and upper and lower tectoria. It measures 9 microns in the proloculus to 15 microns in the fourth volution including the epithecal layers. The septa exhibit little or no fluting except in the apical extremities and number 9, 13, 15 and 18 from the first to last volutions.

Remarks—Plectofusulina rotunda is differentiated from other species of this genus by its smaller and rounder shape, its smaller proloculus, and the slightly flowing, asymmetrical chomata.

Occurrence—This species is found in the uppermost biozone of *Fusulinella* and in the lower biozones of *Beedeina* and *Wedekindellina,* or in the Upper Atoka and in the Lower Des Moines Series. In the Joyita Hills it has been found in beds: JH1-17, JH2-9, JH2-13, JH3-12 and JH3-14.

Plectofusulina coelocamara Stewart, n. sp.
Plate 2, figures 1-3, 5, 6; table 4

Diagnosis—Shell of average size for the genus, ovate fusiform in shape with lengths from 0.816 to 0.840 mm, widths from 0.530 to 0.786 mm and form ratios of 1 : 1.0 to :1.6. Mature individuals exhibit four loosely coiled or vaulted volutions with septal counts of 7, 10, 13, and 14 from the first to last with a slight flaring or rapid expansion in the last several chambers of the fourth whorl. The axis of coiling is plectoid. All measurements were made from axial sections orientated in the axial plane of the last volution.

The proloculus is of average size, spherical and measures 64 to 15z microns in outside diameter. The chomata are asymmetrical, extend one-third the height of the chamber and are faint or absent in the last volution in the inflated chambers. The tunnel is irregular, due to the plectoid coiling and poorly defined as a result of the faint chomata. Angles where measurable range from 7 to 13 degrees from the proloculus to the last volution present.

The spirotheca is composed of a tectum, thick diaphanotheca and a very thin upper and lower tectoria. The wall is uniform in thickness throughout each volution as seen in the axial section and ranges from 9 to 17 microns from the proloculus to the fourth whorl. The septa are unfluted throughout the central portions of each volution with only subtle fluting in the axial extremities.

Remarks—Plectofusulina coelocamara derives its specific name from the Greek *koilas* (hollow) and *kamara* (vaulted chamber). It differs from other species by the presence of loosely coiled vaulted chambers, the advanced spirotheca with very thin tectoria and thick diaphanotheca, and the lack of chomata in the latter volutions.

Species of similar phylogenetic development found in the Lower Missouri have been erroneously referred to the genus *Oketaella.*

TABLE 3. MEASUREMENTS OF *PLECTOFUSULINA ROTUNDA* STEWART, N. SP.

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.032	0.028	0.025	0.034	0.027	0.024	0.028	0.038	1.20	1.15	0.90	0.90
1	0.071	0.058	0.049	0.068	0.060	0.060	0.080	0.068	1.20	0.97	0.61	1.00
2	0.089	0.093	0.082	0.120	0.082	0.102	0.110	0.103	1.10	0.93	0.75	1.16
3	0.179	0.213	0.172	0.236	0.168	0.164	0.178	0.680	1.10	1.30	0.97	1.30
4	0.284	0.317	0.288	0.298	0.252	0.260	0.270	0.262	1.10	1.20	1.07	1.14
	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	—	—	—	0.009	0.009	0.009	0.009	—	—	—	—
1	23°	28°	23°	20°	0.014	0.012	0.011	0.013	9	8	9	8
2	24°	19°	28°	35°	0.015	0.014	0.010	0.014	14	12	14	12
3	25°	30°	30°	28°	0.016	0.014	0.014	0.013	14	13	15	14
4					0.015	0.015	0.012	0.013		18		

TABLE 4. MEASUREMENTS OF *PLECTOFUSULINA COELOCAMARA* STEWART, N. SP.

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.042	0.034	0.076	0.032	0.038	0.035	0.079	0.033	1.1	0.97	0.96	0.97
1	0.078	0.064	0.139	0.067	0.082	0.069	0.146	0.069	0.95	0.93	0.95	0.97
2	0.167	0.130	0.233	0.120	0.153	0.109	0.228	0.120	1.1	1.30	1.0	1.00
3	0.286	0.262	0.342	0.224	0.246	0.169	0.308	0.169	1.17	1.50	1.1	1.30
4	0.417	0.408		0.420	0.383	0.272		0.265	1.10	1.50		1.60
	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	32°	—	—	—	0.013	0.009	0.009	0.009	—	—	—	
1	16°	27°	—	23°	0.012	0.014	0.014	0.010	9	7	8	
2	28°	29°	—	24°	0.013	0.013	0.015	0.015	10	9	10	
3	—	37°	—	28°	0.023	0.017	0.015	0.015	13	12	13	
4					0.017	0.014		0.015	14			

Occurrence—This is not only the most advanced species phylogenetically, but it occurs higher in the geologic section. To date it has been found in the lowermost Missouri Series in the *Eowaeringella* biozone. In the Joyita Hills it is found in bed JH1-35.

Plectofusulina fusiformis Stewart, n. sp.

Plate 2, figures 4, r 2-15, 18; table 5

Diagnosis—Shell inflated-fusiform with pointed to slightly rounded apical extremities, lengths of 0.84 to o.88 mm, widths from 0.42 to 0.57 mm and from ratios of 1 :1.5 to 1 : 1.9. The four volutions are loosely coiled with a slight tendency to flare in -the last. The septa exhibit very slight irregularities or folds in the central portion of the test, but never develop loops. The septal count ranges from 8 to 15 from the first to last volution. The axis of coiling is less plectoid than in most of the species of the genus.

The proloculus is subspherical and ranges in size from 64 to 7o microns in outside diameter. The wall of the proloculus is thin as it is in the first two volutions. The spirotheca in the first two volutions is composed of a tectum, primatheca, and upper tectorium, while in the last two volutions it is composed of a tectum, diaphanotheca and an upper and lower tectorium. It measures 8, 8, 12 and 19 microns for the volutions.

The chomata are well developed, extend half the chamber height, are asymmetrical and flow towards the apical areas. The tunnel is irregular to straight with angles of 18, 25, and 3o degrees for the last three volutions.

Remarks—This species may be differentiated by its fusiform shape, flowing chomata and more primitive spirotheca.

Occurrence—The range of this species is not known over New Mexico, even though it has been noted in other sections. In the area of study it is found near the base of the Des Moines Series in beds: JH1-13, JH2-13 and JH3-14.

Genus FRUMENTELLA STEWART, 1958

This genus was originally assigned by the author to **the** subfamily Schubertellinae, but after careful study of many more specimens it is here placed under the subfamily Fusulininae. Thompson (1964) considered the above genus to be a synonym of *Pseudowedekindellina* (Sheng, 1958), but significant differences exist to validate the genus *Frumentella* The latter genus is considerably smaller, has fewer volutions, larger form ratio, less secondary chamber filling, less, if any, septal fluting and a more erratic axis of coiling. Both genera have a spirotheca consisting of a tectum, primatheca and an upper tectorium. However, the genus *Frumentella* exhibits a well-developed primatheca of uniform thickness and a most erratically developed upper tectorium, while *Pseudowedekindellina* has both deposits above and below the tectum developed as layers of unequal thickness throughout each volution.

TABLE 5. MEASUREMENTS OF *PLECTOFUSULINA FUSIFORMIS* STEWART, N. SP.

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.032	0.035	0.032	0.032	0.032	0.030	0.030	0.032	1.00	1.17	1.07	1.0
1	0.072	0.070	0.068	0.054	0.062	0.070	0.051	0.060	1.16	1.00	1.33	9.0
2	0.130	0.125	0.120	0.146	0.104	0.115	0.072	0.095	1.25	1.10	1.67	1.54
3	0.273	0.256	0.216	0.255	0.169	0.175	0.145	0.140	1.60	1.46	1.49	1.82
4	0.435	0.439	0.420		0.207	0.285	0.220		1.62	1.54	1.90	
	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	23°	27°	—	0.008	0.009	0.008	0.009	—	—		
1	20°	24°	18°	19°	0.008	0.008	0.008	0.010	8	10		
2	19°	29°	26°	24°	0.012	—	0.014	0.015	13	13		
3	22°	30°	23°		0.015	0.015	0.015	0.012	14	15		
4					0.019	0.013	0.019					

TABLE 6. MEASUREMENTS OF *FRUMENTELLA EXEMPLA* STEWART

Volution	Half Length 1	Half Length 2	Half Length 3	Half Length 4	Radius Vector 1	Radius Vector 2	Radius Vector 3	Radius Vector 4	Form Ratio 1	Form Ratio 2	Form Ratio 3	Form Ratio 4
0	0.031	0.035	0.029	0.032	0.030	0.033	0.028	0.029				
1	0.070	0.055	0.057	0.043	0.061	0.055	0.045	0.055				
2	0.121	0.089	0.148	0.070	0.105	0.087	0.097	0.070				
3	0.342	0.199	0.246	0.138	0.174	0.129	0.147	0.152				
4	0.602	0.385	0.401	0.271	0.265	0.215	0.199	0.149				

Volution	Tunnel Angle (degrees) 1	Tunnel Angle (degrees) 2	Tunnel Angle (degrees) 3	Tunnel Angle (degrees) 4	Wall Thickness 1	Wall Thickness 2	Wall Thickness 3	Wall Thickness 4	Septal Count 5	Septal Count 6	Septal Count 7	Septal Count 8
0	—	—	—	—	0.009	0.007	0.009	0.009	—	—	—	—
1	20°	—	22°	—	0.012	0.008	0.009	0.008	9	8	8	8
2	28°	26°	26°	18°	0.015	0.008	0.013	0.009	12	13	12	13
3	35°	27°	27°	29°	0.015	0.013	0.015	0.015	16	14	17	17
4					0.008	0.012	0.009	0.014				

Frumentella exempla Stewart

Plate 2, figures 7-11; table 6

Frumentella exempla Stewart, 1958, Journal of Paleontology, v. 32, no. 6, p. 1055, pl. 133, figs. 1-10

Diagnosis—The shell of four volutions is minute and fusiform with the length ranging from 0.58 to **1.2 mm,** widths from 0.3o to 0.53 mm and an average form ratio of 1:2.5. The axis of coiling is slightly curved, and the axial extremities are pointed to slightly rounded. The proloculus is spherical to subspherical and ranges in outside diameter from 58 to 6o microns.

The spirotheca is thin, uniform in thickness, ranges from 9 to 14 microns throughout the test and is composed of a rectum, primatheca and upper tectorium. The chomata are well developed, asymmetrical and flow slightly towards the axial extremities. The irregular tunnel angle averages 20 degrees in the first to around 3o degrees in the last volution.

The septa are unfluted except in the extreme axial area of each volution where large dissepiments and small amounts of secondary deposits are irregularly developed.

Occurrence—Frumentella exempla occurs in the middle and upper Des Moines sediments over much of New Mexico. Its lower limits are within the upper biozone of the genus *Wedekindellina* and its upper limit coincides with that of the highest occurrence of the genus *Beedeina.* In the Joyita Hills it has been identified from the following beds: JH1-13, JH1-17, JH2-13 and JH3-16.

Genus PROFUSULINELLA RAUSER-CHERNOUSOVA AND BELYAEV, 1936

Remarks—Many specimens of the genus Pro *fusulinella* were found in detrital and arenaceous units in the Joyita Hills. It is believed that most of these forms have been reworked due to their surfaces being badly abraded and eroded, their occurrence with the genus *Fusulinella* and their erratic distribution. It is difficult to speciate these forms due to the above nature of their occurrence.

The presence of the genus in detrital sediments suggests the erosion of shallow exposures of earlier Atokan deposits during the transgressive cycle in late Atokan time.

Profusulinella sp. A

Plate 2, figures 20-25; table 7

Diagnosis—Shell is small, inflated fusiform with a maximum length of 1.306 mm, a maximum width of 0.858 mm and *a* form ratio of I :1.5. The apical areas are sub-rounded with a maximum of six volutions noted in the largest specimen.

The proloculus is spherical, small and measures 5o to 70

TABLE 7. MEASUREMENTS OF *PROFUSULINELLA* SP. A.

Volution	Half Length 1	Half Length 2	Half Length 3	Half Length 4	Radius Vector 1	Radius Vector 2	Radius Vector 3	Radius Vector 4	Form Ratio 1	Form Ratio 2	Form Ratio 3	Form Ratio 4
0	0.025	0.035	0.035		0.029	0.032	0.032		0.86	1.1	1.1	
1	0.040	0.078	0.081		0.058	0.080	0.082		0.70	0.97	0.99	
2	0.157	0.135	0.186		0.090	0.123	0.133		1.75	1.10	1.40	
3	0.223	0.252	0.382		0.138	0.179	0.225		1.62	1.40	1.70	
4	0.356	0.404	0.521		0.216	0.252	0.330		1.65	1.60	1.57	
5	.526	0.506			0.312	0.325			1.70	1.56		
6	.653				0.429				1.52			

Volution	Tunnel Angle (degrees) 1	Tunnel Angle (degrees) 2	Tunnel Angle (degrees) 3	Tunnel Angle (degrees) 4	Wall Thickness 1	Wall Thickness 2	Wall Thickness 3	Wall Thickness 4	Septal Count 5	Septal Count 6	Septal Count 7	Septal Count 8
0	18°	—	—		0.009	0.008	0.009		—	—	—	
1	18°	18°	18°		0.008	0.010	0.009		10	8	10	
2	24°	22°	24°		0.010	0.009	0.013		15	11	18	
3	16°	18°	21°		0.016	0.013	0.020		20	18	20	
4	19°	21°			0.018	0.015	0.019		25		19	
5	23°				0.015	0.011						
6					0.018							

TABLE 8. MEASUREMENTS OF *PROFUSULINELLA* SP. B

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.042	0.040	0.052		0.042	0.039	0.052		1.0	1.0	1.0	
1	0.078	0.075	0.126		0.065	0.068	0.105		1.2	1.1	1.2	
2	0.136	0.183	0.254		0.110	0.131	0.159		1.2	1.4	1.6	
3	0.249	0.403	0.420		0.150	0.214	0.230		1.6	1.9	1.8	
4	0.423	0.679	0.682		0.221	0.295	0.321		1.9	2.3	2.7	
5	0.720	1.123	0.964		0.293	0.389	0.460		2.4	2.0	2.1	
6			1.246				0.555				2.2	

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	22°	—	17°		0.010	0.011	0.012		—			
1	18°	14°	17°		0.013	0.010	0.013		8			
2	20°	20°	23°		0.012	0.014	0.015		13			
3	19°	30°	22°		0.015	0.014	0.015		17			
4	20°	26°	22°		0.017	0.016	0.016		17			
5					0.011	0.014	0.016		22			
6							0.014		22			

microns in outside diameter. The well-developed chomata are asymmetrical, extend half the height of the chamber and flow laterally into the outer epithecal layer of the wall. Fluting is mainly restricted to the axial extremities with slight folds in some equatorial areas. The straight tunnel exhibits angles of 18, 18, 23, 20, and 23 degrees.

The spirotheca is composed of a tectum, thin primatheca and a thicker outer tectorium. It measures 9 microns in the proloculus and 9, 1o, 13, 16, 15 and 18 microns progressively for the following six volutions. The septal count averages 9, 14, 19 and 25 for the three specimens measured. Secondary filling is erratically developed, but mainly restricted to the lateral slopes and slightly fluted apical areas.

Occurrence—Species A is found in beds: JH1-10, JH2-9, JH3-10, and JH4-6c.

Profusulinella sp. B

Plate 3, figures 1-3, 5-7; table 8

Diagnosis—Shell elongate fusiform with bluntly pointed poles and lengths of 1.44 to 2.49 mm, widths of o.586 to 1. r r mm and form ratios of I:2.2 to 1:2.9. Mature forms exhibit a straight axis of coiling for five to six volutions with the septal count in one sagittal specimen being 8, 13, 17, 17, 22 and 22 for six volutions. The spherical proloculus measures 8o to 104 microns in outside diameter. Fluting is absent in central area of shell and weakly developed in the apical areas.

The spirotheca consists of a tectum, primatheca and outer tectorium which ranges in thickness from 10 to 14 microns. The chomata are heavy, asymmetrical and flow laterally as they reach one-half the chamber height. The straight tunnel averages 19, 16, 21, 26 and 24 degrees from the proloculus through the fifth volution. Secondary fill is present lateral to the chomata and extends into the apical areas.

Occurrence—Species B is found in beds: JH 1, JH3-11, JH4-5, JH4-6a, and JH4-6c.

Profusulinella sp. C

Plate 3, figures 4, 8-13; table 9

Diagnosis—Shell slightly inflated to elongate fusiform with a straight to irregular axis of coiling and bluntly pointed polar extremities. Lengths range from 2.13 to 2.5o mm, widths from o.86 to r.16 mm and the form ratios from 1:2.0 to 1 :2.8. Mature specimens have five to six volutions with an average septal count of r o, 15, 18, 2.1 and 22 for five volutions. The

TABLE 9. MEASUREMENTS OF *PROFUSULINELLA* SP. C

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.042	0.051	0.045	0.051	0.040	0.050	0.046	0.048	1.0	1.0	1.0	1.1
1	0.056	0.109	0.113	0.127	0.060	0.103	0.082	0.080	0.93	1.1	1.4	1.6
2	0.110	0.220	0.215	0.276	0.081	0.153	0.138	0.149	1.4	1.4	1.6	1.8
3	0.219	0.423	0.356	0.574	0.158	0.240	0.190	0.218	1.4	1.8	1.9	2.6
4	0.318	0.770	0.656	1.040	0.239	0.346	0.276	0.371	1.3	2.2	2.4	2.8
5	0.586	1.063	1.189	1.246	0.337	0.521	0.430	0.542	1.7	2.0	2.8	2.3
6	1.131				0.578				2.0			

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	14°	—	26°	0.010	0.011	0.015	0.015	—	—		
1	15°	19°	14°	26°	0.009	0.014	0.017	0.011	10	10		
2	23°	24°	19°	28°	0.012	0.016	0.016	0.018	17	14		
3	20°	27°	22°	35°	0.017	0.021	0.017	0.022	20	17		
4	24°	25°	29°	26°	0.018	0.024	0.024	0.021	22	19		
5	35°		37°		0.019	0.018		0.019	25			
6					0.013							

septa are very slightly fluted in the central portion of the shell, and are well fluted in the apical areas.

The spirotheca is composed of a tectum, a primatheca and an outer tectorium equal in thickness to the primatheca. The total wall average thickness measures 12, 13, 15, 20, 21, and 13 from the proloculus through the fifth volution.

The chomata are asymmetrical and extend from one-half to two-thirds the height of the chamber. They tend to flow slightly or extend laterally a short distance from the tunnel into minor amounts of secondary infilling. The tunnel is slightly erratic with average angles of 15, 19, 23, 26, 27 and 36 degrees from the proloculus outward to the fifth volution. The proloculus is small, spherical and measures 84 to 102 microns in outside diameter for four specimens.

Occurrence-Species C is found in beds: JH1-9, JH3-10 and JH4-3.

Profusulinella sp. D

Plate 3, figures 14-16; table 10

Diagnosis-Shell small, ovate to inflated fusiform with rounded polar extremities. Lengths range from 0.68 to 0.95 mm, widths from 0.48 to 0.62 mm and the form ratio from 1:1.4 to 1:2.0. Five volutions exhibit an average septal count of 15, 18, 22 and 27 for the first through the fourth. The juvenarium, or first two volutions, is very tightly coiled and at different angles to the adult stages. Perhaps many of these specimens represent microspheric individuals. The proloculus is small, spherical and ranges in size from 32 to 56 microns in outside diameter.

The spirotheca is very thin and measures around 5, 6, 13, 14, 15 and 9 microns from the proloculus through the fifth volution. It is composed of a tectum, a thin primatheca and a thin outer tectorium which is covered by thick deposits of the flowing chomata and some additional lateral infilling. The erratic or irregular tunnel exhibits angles of 12, 12, 14 and 13 degrees from the first to the last volution. Little or no fluting is visible throughout the test.

Occurrence-Species D has been found at one locality only, in bed JH1-9.

Genus FUSULINELLA MÖLLER, 1877

Fusulinella juncea Thompson

Plate 3, figures 18, 19, 21-25; table

Fusulinella juncea Thompson, 1948, University of Kansas Paleontological Contribution, Protozoa, Art. 1, p. 93, pl. 37, figs. 1-18

Diagnosis-Shell small, elongate fusiform with bluntly pointed poles and lengths from 1.83 to 2.96 mm, widths from 0.87 to 1.19 mm and an average form ratio of :3.3. Six to seven volutions in mature individuals are tightly coiled around a straight axis with an average septal count of 11, 15, 18, 22, 22, 25 and 26 for the first through the seventh volution.

The proloculus is small, spherical to slightly ovate and ranges in size from 68 to 104 microns in outside diameter. The chomata are well developed, asymmetrical, flow laterally, are not bilaterally symmetrical and extend from one-half to three-fourths the height of the chamber. The tunnel is slightly irregular with average angles of 21, 16, 22, 24, 26, 28, and 30 degrees from the proloculus through the sixth volution.

The thin spirotheca is composed of a tectum, diaphanotheca and an upper and lower tectorium. Thickness measurements average 11, 10, 12, 14, 20, 23, 23, and 27 from the proloculus through the seventh volution. The septa are slightly fluted in the central area and increase to dissepimental fluting in the apical areas.

Occurrence-*Fusulinella juncea* is found in beds: JH2-9, JH2- and JH4-6c.

Fusulinella cf. *F. acuminata* Thompson

Plate 3, figures 17, 20

Fusulinella acuminata Thompson, 1936, Journal of Paleontology, v. o, no. z, p. 101, pl. 13, figs. 5-7.

Several specimens of the genus *Fusulinella* were found in bed JH3-10, which is the lowest occurrence of the genus in the Joyita Hills area. These individuals are here referred to the species *Fusulinella acuminata* Thompson due to similar biometrics; however, too few were found and studied to give an accurate comparison.

TABLE 10. MEASUREMENTS OF *PROFUSULINELLA* SP. D

Volution	Half Length 1	Half Length 2	Half Length 3	Half Length 4	Radius Vector 1	Radius Vector 2	Radius Vector 3	Radius Vector 4	Form Ratio 1	Form Ratio 2	Form Ratio 3	Form Ratio 4
0	0.016	0.028	0.020		0.018	0.025	0.018		0.89	1.1	1.1	
1	0.033	0.056	0.054		0.044	0.058	0.056		0.75	0.97	0.96	
2	0.087	0.110	0.083		0.057	0.080	0.080		1.5	1.4	1.0	
3	0.151	0.168	0.162		0.116	0.150	0.136		1.3	1.1	1.2	
4	0.235	0.268	0.286		0.167	0.212	0.192		1.4	1.3	1.5	
5	0.341	0.445	0.475		0.239	0.310	0.242		1.4	1.4	1.4	

Volution	Tunnel Angle (degrees) 1	Tunnel Angle 2	Tunnel Angle 3	Tunnel Angle 4	Wall Thickness 1	Wall Thickness 2	Wall Thickness 3	Wall Thickness 4	Septal Count 5	Septal Count 6	Septal Count 7	Septal Count 8
0	—	—	—		0.005	0.005	0.005		—	—		
1	—	12°	—		0.006	0.007	0.006		16	14		
2	8°	15°	12°		0.013	0.013	0.012		19	18		
3	14°	14°	14°		0.015	0.014	0.013		23	22		
4	10°	13°	15°		0.017	0.014	0.016		27			
5					0.007	0.013	0.009					

TABLE 11. MEASUREMENTS OF *FUSULINELLA JUNCEA* THOMPSON

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.034	0.051	0.052	0.052	0.030	0.050	0.048	0.047	1.1	1.0	1.1	1.1
1	0.078	0.080	0.132	0.096	0.058	0.058	0.078	0.089	1.3	1.4	1.7	1.1
2	0.152	0.128	0.236	0.216	0.100	0.110	0.108	0.142	1.5	1.2	2.2	1.5
3	0.324	0.292	0.339	0.406	0.150	0.146	0.162	0.241	2.2	2.0	2.1	1.7
4	0.452	0.470	0.936	0.548	0.232	0.207	0.241	0.330	1.9	2.3	3.9	1.7
5	0.575	0.936	1.309	0.885	0.330	0.281	0.336	0.420	1.7	3.3	3.9	2.1
6	0.906	1.060	1.462	1.415	0.448	0.403	0.434	0.513	2.0	2.6	3.4	2.8
7	1.950	1.981			0.597	0.550			3.3	3.6		

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	—	—	21°	0.009	0.013	—	0.012	—	—	—	—
1	19°	11°	14°	22°	0.011	0.009	0.012	0.009	10	—	12	11
2	25°	13°	23°	19°	0.011	0.011	0.014	0.016	15	15	15	15
3	24°	22°	27°	22°	0.011	0.015	0.016	0.019	17	18	18	18
4	17°	21°	32°	30°	0.021	0.015	0.021	0.020	23	22	22	20
5	22°	34°	32°	24°	0.020	0.023	0.026	0.024	24	21		20
6	22°	35°			0.024	0.026	0.021	0.019	25	22		
7					0.026	0.028			26			

Fusulinella cf. *F. famula* Thompson

Plate 3, figures 26-28

Fusulinella famula Thompson, 1948, University of Kansas Paleontological Contributions, Protozoa, Art. I, p. 91-93, pl. 32, figs. 4, 5; pl. 38, figs. 1-8.

Several specimens, here referred to the species *Fusulinella famula* Thompson, were found in beds JH1-11c and JH3-I2. Too few of these forms were found to allow adequate study and comparison; however, it exhibits advanced characteristics for the genus and occurs with *Fusulinella iowaensis* near the top of the section assigned to the Atoka Series.

Fusulinella devexa Thompson

Plate 4, figures 1-3; table 12

Fusulinella devexa Thompson, 1948, University of Kansas Paleontological Contributions, Protozoa, Art. x, p. 94, pl. 35, figs. 1-15

Dia2nosis—Shell elongate fusiform, slightly inflated in eauatorial region, sharply to bluntly pointed polar extremities and lengths from 3.97 to 4.72 mm, widths from 1.21 to 2.41 mm and an average form ratio of 1 :3.o. Seven volutions are coiled around a straight axis with an average septal count of Io, 14, 17, 19 and 23.

The proloculus is small for the genus, spherical, and ranges in outside diameter from 82 to 108 microns. The chomata are well developed, asymmetrical, extend one-half the height of the chamber and exhibit little lateral extension. The irregular tunnel angle averages 16, 18, 2o, 22, 22, 29 and 32 degrees from the proloculus to the sixth volution. Fluting is mainly confined to the apical areas.

The spirotheca is thin and composed of a tectum, diaphanotheca and thin upper and lower tectoria. Its average thickness ranges from 13 to 35 microns from the proloculus to the seventh volution.

Occurrence—Fusulinella devexa is found in the following beds: JH3-12, JH3-13 and JJH4-6c.

TABLE 12. MEASUREMENTS OF *FUSULINELLA DEVEXA* THOMPSON

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.041	0.041	0.053	0.054	0.041	0.041	0.052	0.056	1.0	1.0	1.0	0.97
1	0.102	0.127	0.153	0.178	0.078	0.110	0.103	0.110	1.3	1.2	1.5	1.6
2	0.213	0.213	0.276	0.393	0.138	0.160	0.178	0.172	1.5	1.3	1.6	2.3
3	0.339	0.387	0.538	0.546	0.228	0.228	0.287	0.247	1.7	1.7	1.9	2.2
4	0.632	0.603	0.976	0.862	0.337	0.339	0.424	0.358	1.9	1.8	2.3	2.4
5	1.126	0.765	1.400	1.392	0.525	0.452	0.586	0.491	2.2	1.7	2.4	2.8
6	1.631	1.582	2.183	1.986	0.716	1.689	0.608	0.638	2.3	2.3	3.6	3.1
7	2.361	2.293			1.208	0.918			1.9	2.5		

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	17°	—	21°	16°	0.013	0.019	0.013	0.013	—			
1	20°	12°	14°	18°	0.015	0.013	0.014	0.013	10			
2	17°	20°	20°	20°	0.013	0.019	0.019	0.014	14			
3	21°	23°	17°	23°	0.016	0.019	0.019	0.019	17			
4	24°	23°	21°	22°	0.028	0.021	0.021	0.021	19			
5	24°	29°	32°	30°	0.032	0.029	0.029	0.030	23			
6	26°	49°			0.028	0.032	0.035	0.015				
7					0.013	0.048						

Fusulinella iowaensis Thompson

Plate 4, figures 4-1o; table 13

Fusulinella iowaensis Thompson, 1934, University of Iowa Studies, N. S., no. 284, v. 16, no. 4, p. 296, pl. 20, figs. 28-30

Diagnosis-Shell very obese or inflated fusiform with bluntly pointed polar extremities. Lengths range from 2.11 to 2.67 mm, widths from 1.56 to 1.83 and the form ratio from I :1.5 to I :1.7. Eight or nine volutions for mature specimens exhibit a straight axis of coiling with an average septal count of 10, 16, 18, 23, 27, 28, and 42 for seven volutions.

The proloculus is of average size, spherical and measures 112 to 120 microns in outside diameter. The chomata are dense and massive, asymmetrical, flow laterally and extend to within a few microns of the chamber ceiling. The tunnel is straight and narrow with average angles of 12, 13, 13, 14, 15, 16, 16 and 18 degrees from the proloculus through the seventh volution. Septal fluting is weakly developed in the central portion of each chamber, but tends to become better developed in apical regions. The only secondary infilling noted is an extension laterally of the chomata.

The spirotheca is composed of a tectum, a thin diaphanotheca, a thin inner tectorium and a thicker outer tectorium. The wall thickness averages 13, I I, 15, 16, 17, 21, 22, 24 and 25 microns from the proloculus to the eighth volution.

Occurrence-Fusulinella iowaensis occurs at the top of the biozone for this genus in New Mexico, and generally marks the top of the Atoka Series in most of North America. It is a very distinctive species and has been referred by Russian workers to the genus *Dagmarella*. The validity of such taxonomic consideration is beyond the present scope of this paper. The above species is found in the Joyita Hills from beds: JH1-11c, JH2-9, JH2-10 and JH2-11.

Genus BEEDEINA GALLOWAY, 1933, emend. Ishii, 1957

Ishii (1957, 1958) and Stewart (1968) discussed the validity of the genus *Beedeina* and its significant differences with the genus *Fusulina*. Certainly the forms of Eurasia belonging to the *Fusulina cylindrica* group are greatly different from those belonging to the *Fusulina* girtyi group. Most of the Early Pennsylvanian species of North. America assigned to the genus *Fusulina* should be assigned to the genus *Beedeina,* with the exception of *Fusulina fallsensis* Thompson, Verville and Lokke. The latter species occurs with *Eowaeringella* and has been assigned to beds of the Lower Missouri Series (Stewart, 1968).

Beedeina insolita (Thompson)

Plate 4, figures I I-19; table 14

Fusulina? insolita Thompson, 1948, University of Kansas Paleontological Contributions, Protozoa, Art. 1, p. 96, pl. 38, figs. 9-13

Beedeina insolita (Thompson), Ishii, 1958, Journal of the Institute of Polytechnics, Osaka City University, Ser. G, v. 4, p. 41

Diagnasis-Shell inflated fusiform to obese with bluntly pointed poles, seven to eight volutions around a straight axis of coiling and a septal count of 9, 13, 16, and 20 for the first four volutions. The maximum dimensions measured were: length 4.32 mm, width 2.81 mm and a form ratio of 1:1.5. Average lengths mean very little, since many forms are microspheric and digress too far from the normal.

The proloculus is medium in size, spherical and measures around 130 microns in outside diameter for the megalospheric forms. It is small, spherical and measures less than 6o microns for the microspheric forms. The chomata are massive, symmetrical to asymmetrical with some tending to overhang the tunnel and a few noted with lateral flowage. The tunnel is straight to slightly irregular with average angles of 18, 20, 20, 21, 22, 25 and 38 degrees from the proloculus through the seventh volution.

The spirotheca is composed of a tectum, diaphanotheca and a moderately thick inner and outer tectorium. Its average thickness ranges 16, 17, 21, 24, 26, 32, 36, 45 and 26 microns from the proloculus through the eighth volution. The septa are moderately fluted across the entire shell with a more intense development in the apical extremities.

TABLE 13. MEASUREMENTS OF *FUSULINELLA IOWAENSIS* THOMPSON

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.060	0.056	0.056	0.056	0.063	0.054	0.054	0.052	0.95	1.0	1.1	1.2
1	0.151	0.120	0.152	0.181	0.097	0.082	0.097	0.086	1.5	1.4	1.6	2.1
2	0.202	0.154	0.229	0.195	0.154	0.138	0.154	0.131	1.3	1.1	1.5	1.5
3	0.345	0.320	0.304	0.300	0.229	0.195	0.195	0.198	2.0	1.6	1.6	1.5
4	0.450	0.386	0.424	0.442	0.337	0.262	0.285	0.288	1.3	1.5	1.5	1.5
5	0.641	0.522	0.583	0.606	0.468	0.360	0.415	0.409	1.4	1.4	1.4	1.5
6	0.895	0.776	0.817	0.861	0.592	0.505	0.544	0.590	1.5	1.5	1.5	1.5
7	1.254	1.057	1.180	1.140	0.798	0.706	0.701	0.780	1.6	1.5	1.7	1.5
8		1.555	1.333			0.916	0.870			1.7	1.5	
	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	12°	—	22°	20°	0.018	0.013	0.013	0.011	—	—	—	—
1	13°	14°	13°	13°	0.012	0.013	0.010	0.010	10	10	13	10
2	12°	11°	13°	15°	0.015	0.014	0.018	0.018	12	16	19	15
3	15°	11°	15°	12°	0.016	0.015	0.018	0.017	17	18	22	18
4	16°	12°	16°	14°	0.017	0.016	0.019	0.018	26	22	25	23
5	16°	16°	16°	16°	0.021	0.022	0.023	0.019	33	24	28	25
6	19°	16°	16°	16°	0.024	0.021	0.023	0.020	37	24		20
7		20°	16°		0.018	0.028	0.024	0.024	42			
8						0.030	0.022					

TABLE 14. MEASUREMENTS OF *BEEDEINA INSOLITA* (THOMPSON)

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.034	0.067	0.060	0.052	0.031	0.067	0.061	0.062	1.1	1.0	0.97	1.0
1	0.120	0.152	0.132	0.080	0.086	0.139	0.090	0.086	1.4	1.1	1.5	1.0
2	0.187	0.258	0.236	0.172	0.191	0.202	0.152	0.134	0.98	1.2	1.5	1.3
3	0.386	0.446	0.379	0.292	0.215	0.336	0.246	0.209	1.8	1.3	1.5	1.4
4	0.589	0.724	0.587	0.509	0.346	0.490	0.349	0.318	1.7	1.5	1.7	1.6
5	0.829	0.949	0.864	0.658	0.503	0.694	0.510	0.439	1.6	1.4	1.7	1.5
6	1.240	1.361	1.037	0.883	0.727	0.851	0.700	0.600	1.7	1.6	1.5	1.5
7	1.572			1.280	1.143			0.732	1.4			1.7
8	2.160				1.409				1.5			

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	17°	18°	20°	—	0.019	0.017	0.013	—	—	—	
1	24°	19°	18°	—	0.014	0.021	0.015	0.014	9	9	9	
2	18°	22°	21°	19°	0.020	0.025	0.020	0.020	14	13	13	
3	17°	22°	23°	17°	0.019	0.028	0.024	0.024	14	16	16	
4	22°	24°	21°	21°	0.026	0.028	0.019	0.028	21	19	21	
5	29°	19°	25°	25°	0.037	0.032	0.029	0.038				
6	25°				0.040	0.038	0.032	0.035				
7	38°				0.048			0.037				
8					0.026							

Microspheric forms have unfluted septa, heavy flowing chomata, an endothyroid juvenarium and are about one-half the size of the megalospheric forms.

Remarks—Beedeina insolita is considered to be a transitional form between the genus *Fusulinella* and the genus *Beedeina.* It exhibits some morphologic characteristics of each. The microspheric forms were assigned to this species since they are the only other form of fusulinid found in the same beds with *Beedeina insolita.*

Occurrence—The stratigraphic position of this species gives support to its being considered as a transitional form between the above genera. It is sometimes found in New Mexico with advanced species of the genus *Fusulinella* and sometimes with primitive species of the genus *Beedeina.* It would then span the biozone between these two stratigraphically important genera. In the Joyita Hills this species is found in beds: JH2- 12, JH3-13, JH3-14, JH4-6c, and JH4-6i.

Beedeina pristina (Thompson)

Plate *5,* figures 1-3, 5, 6; table 15

Fusulina pristina Thompson, 1945, State Geological Survey of Kansas, Bull. 6o, Pt. z, p. 6i, pl. 5, figs. 7-18

Diagnosis—Shell small, inflated fusiform, with bluntly pointed polar extremities. The length ranges from 2.64 to 2.94 mm, width ranges from 1.19 to 1.71 mm and the form ratio from 1: 1.6 to I :2.5. The volutions exhibit an average septal count of I I, 15, 59, 22, 26, and 3o consecutively for six volutions. The lateral slopes tend to be slightly indented to concave. The axis of coiling is straight.

The proloculus is small and spherical and ranges in outside diameter from 90 to 150 microns. Septal fluting is moderately developed with a higher intensity in the apical areas and only minor amounts in the equatorial region.

The spirotheca is thin and consists of four layers, a tectum, diaphanotheca and an upper and lower tectorium. The dia-

TABLE 15. MEASUREMENTS OF *BEEDEINA PRISTINA* (THOMPSON)

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.075	0.048	0.060	0.045	0.071	0.050	0.057	0.045	1.1	0.96	1.1	1.0
1	0.157	0.079	0.086	0.067	0.123	0.075	0.062	0.074	1.3	1.1	1.4	0.90
2	0.345	0.152	0.180	0.150	0.213	0.125	0.100	0.118	1.6	1.2	1.8	1.3
3	0.665	0.273	0.282	0.307	0.333	0.194	0.156	0.193	2.0	1.4	1.8	1.6
4	0.800	0.450	0.481	0.495	0.487	0.294	0.250	0.298	1.6	1.5	1.9	1.7
5	1.083	0.835	0.870	0.736	0.663	0.440	0.386	0.452	1.6	1.9	2.3	1.6
6	1.327	1.472	1.235	1.060	0.855	0.593	0.573	0.650	1.6	2.5	2.2	1.6
7			1.453	1.321			0.795	0.846			1.8	1.6

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	16°	—	—	—	0.024	0.019	0.013	—	—	—		
1	14°	15°	16°	20°	0.024	0.024	0.012	0.019	14	9		
2	19°	15°	18°	19°	0.034	0.021	0.015	0.020	19	13		
3	26°	28°	21°	17°	0.036	0.025	0.025	0.032	18	21		
4	28°	29°	21°	25°	0.031	0.034	0.031	0.036	24	21		
5	26°	29°	34°	28°	0.032	0.031	0.035	0.041	28	25		
6			28°	25°	0.041	0.033	0.040	0.045	32			
7							0.035	0.024				

phanotheca and upper and lower tectorium are of equal thickness. The average thickness of the wall is 19, 21, 23, 26, 32, 35, 4o and 35 microns from the proloculus through the seventh volution.

The chomata are very erratic, symmetrical to asymmetrical, and extend from one half to the full height of the chamber. The very asymmetrical shapes tend to hook or overhang the tunnel. The tunnel is very irregular and ranges from 16 to 28 degrees from the proloculus through the sixth volution. No secondary filling is present in any area of the test.

Remarks—So many species have been described under the genus *Beedeina (Fusulina* of authors) that it is very difficult at present to properly speciate a population of individuals. However, the forms referred here to *Beedeina pristina* compare favorably in most morphologic characteristics to the types of that species, the minor difference being a slightly larger proloculus in the above forms. This is a primitive species of the genus.

Occurrence—Specimens of *Beedeina pristina* have been found in the Joyita Hills from one horizon only, in beds JH1-13 and JH2-13.

Beedeina cf. *B. socorroensis* (Needham)

Plate 5, figures 4, *7-10*; table 16

Fusulina socorroensis Needham, 1937, New Mexico School of Mines, Bull. 14, p. 22, pl. II, figs. 6-1 o

Diagnosis—Shell small, fusiform with sharp to bluntly pointed poles. Lengths range from 1.77 to 2.63 mm, widths from 1.26 to 1.35 mm and form ratios from r :2.o to 1:3.o. The six volutions are loosely coiled around a straight axis and exhibit an average septal count of r I, 15, 18, 18 and 20 for the last five whorls.

The proloculus is small, spherical and ranges in outside diameter from 1 I o to 126 microns. The septa are intensely fluted throughout each chamber with individual loops being symmetrical to bulbous in shape.

The thin spirotheca is composed of four layers and is uniform in thickness across each volution. The four layers consist of a tectum, diaphanotheca and an upper and lower tectorium. The latter three layers are of equal thickness. The average wall thickness from the proloculus through the sixth volution is 16, 18, 21, 25, z8, 31 and 36 microns.

Chomata are developed throughout most of the test with some pseudochomata present. The chomata are symmetrical and extend from one-half to two-thirds the vault of the chamber with a slight tendency to overhang the tunnel. The tunnel is straight to slightly irregular in its path and exhibits average angles of 11, 16, 18, 24, 3o, 32 and 3o degrees from the proloculus through the sixth volution. No secondary filling is present.

Remarks—This species is compared to *Beedeina socorroensis* since it is similar in all characteristics with the exception of its smaller size. Most of the specimens studied are encased in arenite-size quartz and carbonate detritus and exhibit great amounts of surface abrasion that may account for fewer volutions and the smaller size.

Occurrence—Beedeina cf. B. *socorroensis* is found in beds JH1-21 and JH2-23.

Beedeina cf. *B. novamexicana* (Needham)

Plate 5, figures 11, 15; table 17

Fusulina novamexicana Needham, 1937, New Mexico School of Mines, Bull. 14, p. 23, pl. II, figs. I 1-15

Diagnosis—Shell obese to very inflated fusiform with bluntly pointed poles and average lengths of 2.46 to 2.95 mm, widths of 1.64 to 1.8o mm and form ratios of 1:1.5 to :1.6. Seven volutions are the most observed on any individual, but may be less than the maximum for an adult form due to the eroded surface of each specimen. No definite saggital specimens were found, so a septal count is not available. The axis of coiling is straight and the lateral slopes tend to be slightly concave.

The proloculus is of medium size for the genus and is spherical with the outside diameter measuring from 112 to 156 microns. Septal fluting is very intense and extends the height of the chamber and completely across its lateral extent. The spirotheca is composed of a tectum, a thin diaphanotheca, and thick inner and outer tectoria, and measures an

TABLE 16. MEASUREMENTS OF *BEEDEINA* CF. *B. SOCORROENSIS* (NEEDHAM)

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.055	0.060	0.063	0.057	0.052	0.048	0.061	0.053	1.1	1.2	1.0	1.1
1	0.095	0.078	0.151	0.084	0.084	0.073	0.105	0.076	1.1	1.1	1.4	1.1
2	0.208	0.147	0.402	0.199	0.130	0.119	0.170	0.115	1.6	1.2	2.3	1.9
3	0.465	0.330	0.812	0.328	0.211	0.178	0.274	0.187	2.2	1.9	3.0	1.8
4	0.746	0.559	1.255	0.614	0.312	0.227	0.439	0.284	2.4	2.5	2.9	2.2
5	1.010	0.887	1.815	1.059	0.445	0.449	0.613	0.479	2.3	2.0	3.0	2.2
6	1.580			1.509	0.630	0.678		0.675	2.5			2.2

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	11°	—	—	—	0.014	0.020	0.019	0.017	—	—		
1	17°	16°	22°	12°	0.015	0.019	0.020	0.019	10	12		
2	18°	16°	26°	18°	0.021	0.021	0.020	0.021	14	17		
3	22°	24°	27°	31°	0.021	0.027	0.025	0.028	17	20		
4	32°	27°	32°	34°	0.028	0.028	0.028	0.028	17	19		
5	29°	34°		36°	0.031	0.027	0.031	0.036	21	19		
6	30°				0.040	0.032		0.028				

TABLE 17. MEASUREMENTS OF *BEEDEINA* CF. *B. NOVAMEXICANA* (NEEDHAM)

Volution	Half Length 1	2	3	4	Radius Vector 1	2	3	4	Form Ratio 1	2	3	4
0	0.078	0.056	0.068	0.039	0.074	0.058	0.068	0.038	1.1	0.97	1.0	1.0
1	0.126	0.144	0.138	0.137	0.118	0.106	0.111	0.079	1.1	1.4	1.2	1.7
2	0.256	0.198	0.204	0.198	0.207	0.188	0.198	0.131	1.2	1.1	1.0	1.5
3	0.499	0.326	0.369	0.341	0.307	0.262	0.291	0.219	1.6	1.2	1.3	1.6
4	0.723	0.492	0.573	0.572	0.439	0.366	0.402	0.349	1.6	1.3	1.4	1.6
5	1.066	0.721	0.921	0.758	0.635	0.504	0.532	0.479	1.7	1.4	1.7	1.6
6	1.231	0.987		1.113	0.821	0.679		0.661	1.5	1.5		1.7
7		1.472		1.478		0.898		0.901		1.6		1.6

Volution	Tunnel Angle (degrees) 1	2	3	4	Wall Thickness 1	2	3	4	Septal Count 5	6	7	8
0	9°	11°	10°	—	0.021	0.019	0.022	0.014	—	—	—	—
1	15°	15°	15°	19°	0.029	0.017	0.023	0.019			none found	
2	21°	16°	17°	14°	0.032	0.025	0.025	0.015				
3	17°	18°	17°	18°	0.029	0.026	0.029	0.023				
4	15°	12°	17°	18°	0.033	0.029	0.030	0.025				
5	21°	15°		21°	0.036	0.037	0.035	0.029				
6		17°			0.039	0.029		0.034				
7						0.030		0.019				

average thickness of 19, 20, 25, 27, 30, 35, 36 and 3o from the proloculus to the last volution.

Chomata are well developed, very asymmetrical and overhang the tunnel. They extend from three-fourths to the complete height of the chamber. The tunnel is straight and narrow with average angles of s o, 15, 17, 18, 16, 20 and 17 degrees from the proloculus through the sixth volution.

Remarks—These specimens are comparable to the species *Beedeina novamexicana* (Needham) in all characteristics with the exception of size. They exhibit less volutions, shorter length and width, but the same form ratio. Most of the specimens are eroded, which may account for the above.

Occurrence—Beedeina cf. *B. novamexicana* is found only in bed JH1-19.

Beedeina pattoni (Needham)

Plate 5, figures 12-14, 16-19; table 18

Fusulina pattoni Needham, 1937, New Mexico School of Mines, Bull. 14, p. z6, pl. III, figs. 3-5

Diagnosis—Shell small and fusiform in shape with bluntly pointed polar extremities. Lengths range from 2.46 to 2.93 mm, widths from 1.09 to 2.04 and form ratios from 1:1.8 to 1:2.5. All specimens studied have six volutions and an average septal count of 9, 12, 14, 17 and 20 consecutively. The whorls are loosely coiled around a straight axis.

The proloculus is small, spherical to ovate and ranges *in* outside diameter from 58 to 72 microns. The septa are moderately to slightly fluted in the equatorial region with an increase in fluting intensity toward apical areas.

The spirotheca is thin and not too well preserved in most specimens. It is composed of four layers with a tectum, a diaphanotheca and an inner and outer tectorium. The tectoria are thinner than the diaphanotheca. The total wall has an average thickness of 9, 10, 15, 21, 25, 3o and 17 microns from the proloculus through the sixth volution.

The chomata are well developed in each volution, are asymmetrical in shape and extend from one-half to two-thirds the height of the vault of the chamber. The tunnel is straight to slightly irregular and exhibits average angles of 19, 17, 23, 27, 3o and 35 degrees from the proloculus through the fifth

TABLE 18. MEASUREMENTS OF *BEEDEINA PATTONI* (NEEDHAM)

Volution	Half Length 1	2	3	4	Radius Vector 1	2	3	4	Form Ratio 1	2	3	4
0	0.029	0.036	0.029	0.030	0.026	0.037	0.025	0.030	1.1	0.97	1.2	1.0
1	0.057	0.061	0.051	0.052	0.071	0.071	0.045	0.057	0.81	0.86	1.1	0.91
2	0.103	0.116	0.101	0.099	0.108	0.115	0.086	0.093	0.95	1.0	1.2	1.1
3	0.346	0.242	0.202	0.206	0.182	0.173	0.145	0.152	1.9	1.4	1.4	1.4
4	0.557	0.401	0.516	0.338	0.309	0.264	0.242	0.236	1.8	1.5	2.1	1.4
5	0.936	0.767	0.945	0.619	0.437	0.421	0.364	0.350	2.1	1.8	2.6	1.8
6	1.360	1.468	1.231	0.853	0.546	0.583	1.021	0.486	2.5	2.5	1.2	1.8

Volution	Tunnel Angle (degrees) 1	2	3	4	Wall Thickness 1	2	3	4	Septal Count 5	6	7	8
0	—	19°	—	—	0.009	0.009	0.009	0.009	—	—		
1	18°	18°	15°	17°	0.009	0.010	0.008	0.010	9	—		
2	20°	30°	25°	17°	0.018	0.015	0.015	0.019	12	12		
3	28°	27°	33°	20°	0.024	0.021	0.024	0.019	14	15		
4	33°	30°	29°	26°	0.026	0.023	0.026	0.024	16	18		
5	32°	39°	37°	29°	0.027	0.031	0.032	0.027	20	21		
6					0.027	0.019	0.017	0.017				

volution. Traces of secondary deposits are noted in the apical areas of a few specimens.

Occurrence-Beedeina pattoni is found in common occurrence in bed JH1-17.

Beedeina joyitaensis Stewart, n. sp.

Plate 6, figures 1-8; table 19

Diagnosis-Shell of average size with slightly inflated fusiform shape, bluntly rounded polar extremities and slightly concave lateral slopes. The length averages from 5.46 to 6.98 mm, the width from 2.37 to 2.54 mm and the form ratio from 1:2.3 to 1:2.8. The seven to eight volutions exhibit an average septal count of 14, 19, 22, 25, 29, 32 and 4o around a straight axis of coiling.

The proloculus is small for the genus, is spherical and ranges in outside diameter 134 to 182 microns. The septal fluting is very erratic, but characteristic for the species. Smaller loops are intensely developed in the apical areas and extend into the equatorial area as broader, erratically shaped loops and folds decreasing in intensity.

The spirotheca is thin, but uniform in thickness laterally throughout most of each volution, with a slight thinning indicated immediately adjacent to the polar extremities. The four layers consist of a tectum, a clear, thin diaphanotheca, a thin outer tectorium and a thicker inner tectorium for the mature volutions. The latter chambers of the last volution consist of a tectum and diaphanotheca while the earlier three to four volutions of the immature stages exhibit only three layers. The spirotheca exhibits average thicknesses of 21, 19, 24, 28, 3o, 40, 38 and 21 microns.

Chomata are well developed in the immature volutions and are dense, symmetrical to asymmetrical and extend one-half the height of the chamber vault. In the latter mature volutions, pseudochomata (Stewart, 1958) replace the true chomata and are erratically developed and tend to overhang the tunnel. The irregular tunnel measures an average of 18, 17, 17, 19, 24, 25, 27 and 4o degrees from the first to last volutions. No secondary filling is present, except in the pseudochomata structures.

Remarks-This species has an affinity to *Beedeina rockymontana* (Roth and Skinner), but differs mainly in having pseudochomata in the mature volutions, a more irregular tunnel and a thinner spirotheca. Such a combination of the above morphologic characteristics serve to differentiate this species.

Occurrence-Beedeina joyitaensis occurs abundantly in beds JH1-12, JH1-21 and JH3-16.

Genus WEDEKINDELLINA

DUNBAR AND HENBEST, 1933

Wedekindellina elongata Stewart, n. sp.

Plate 7, figures 1-7; table **20**

Diagnosis-Shell very elongate fusiform to cylindrical in shape with pointed to bluntly pointed apical extremities. Lengths range from 3.98 to 5.98 mm, widths from o.8o to 1.03 mm and form ratios from :4.2 to :6.5. Mature individuals of seven to eight volutions exhibit a straight axis of coiling and an average septal count of 10, 16, 19, **21, 21,** 24 and 23 for the first through the seventh volution. The volutions are tightly coiled throughout the test.

The proloculus is subspherical, ovate in the axial dimension and averages 58 microns in outside diameter. Fluting is tenuous with slight undulations in the equatorial area of the test and a few dissepiments in the apical area, which increase in number from the juvenile to mature volutions.

The four-layered spirotheca is of uniform thickness for each volution and is composed of a tectum, thick diaphanotheca and a thin to intermittent upper and lower tectorium. It averages in thickness 9, 8, **12, 14, 16, 19, 21,** and 20 from the proloculus through the seventh volution.

The chomata are small, symmetrical and extend one-fourth

TABLE 19. MEASUREMENTS OF *BEEDEINA JOYITAENSIS* STEWART, N. SP.

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.075	0.067	0.078	0.092	0.071	0.068	0.078	0.094	1.1	1.0	1.0	0.98
1	0.126	0.086	0.091	0.122	0.116	0.125	0.124	0.139	1.1	0.69	0.73	0.88
2	0.262	0.270	0.352	0.312	0.187	0.188	0.199	0.218	1.4	1.4	1.8	1.4
3	0.394	0.488	0.465	0.524	0.268	0.330	0.319	0.330	1.5	1.5	1.5	1.6
4	0.517	0.810	0.834	0.956	0.379	0.477	0.475	0.498	1.4	1.7	1.8	1.9
5	0.952	1.320	1.511	1.895	0.535	0.699	0.682	0.715	1.8	1.9	2.2	2.7
6	1.523	1.952	2.123	2.841	0.749	0.950	0.908	0.972	2.0	2.1	2.3	2.9
7	2.558	2.899	2.732	3.495	1.029	1.269	1.183	1.228	2.5	2.3	2.3	2.8
8	3.082				1.241				2.5			

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	18°	17°	23°	0.021	0.021	0.021	0.030	—	—	—	—
1	17°	14°	16°	20°	0.020	0.019	0.023	0.015	14	12	14	13
2	17°	16°	18°	19°	0.026	0.026	0.023	0.022	18	19	20	18
3	19°	19°	20°	19°	0.026	0.032	0.029	0.026	22	21	26	26
4	18°	24°	26°	27°	0.029	0.029	0.031	0.031	24	23	26	29
5	27°	23°	25°	33°	0.035	0.040	0.045	0.045	28	28	29	35
6	22°	—	27°	30°	0.039	0.039	0.032	0.046	24	30	35	28
7	40°				0.041	0.021	0.031	0.020	36			42
8					0.050							

TABLE 20. MEASUREMENTS OF *WEDEKINDELLINA ELONGATA* STEWART, N. SP.

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.029	0.029	0.029	0.029	0.023	0.031	0.029	0.031	1.3	0.93	1.0	0.93
1	0.117	0.110	0.112	0.134	0.048	0.059	0.049	0.056	2.4	1.9	2.3	2.4
2	0.277	0.222	0.224	0.273	0.065	0.085	0.084	0.092	4.3	2.6	2.7	3.0
3	0.452	0.362	0.578	0.368	0.114	0.129	0.116	0.129	4.0	2.8	5.0	2.9
4	0.818	0.674	0.682	0.524	0.167	0.184	0.161	0.182	4.9	3.7	4.2	2.9
5	1.841	0.964	1.024	0.764	0.240	0.248	0.218	0.240	7.4	3.9	4.7	3.2
6	1.977	1.533	1.626	1.695	0.324	0.308	0.290	0.340	6.1	5.0	5.6	5.0
7	2.422	1.695	2.092	2.991	0.427	0.410	0.399	0.462	5.7	4.2	5.3	6.5
8		1.994				0.517				3.8		
	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	—	—	13°	0.008	0.009	0.009	0.009	—	—	—	—
1	14°	—	16°	28°	0.007	0.008	0.008	0.008	10	10	10	—
2	23°	25°	17°	33°	0.009	0.013	0.013	0.010	22	16	15	15
3	27°	17°	24°	26°	0.011	0.019	0.015	0.011	24	19	16	16
4	37°	19°	24°	30°	0.016	0.018	0.017	0.016	21	22	22	17
5	44°	28°	25°	40°	0.020	0.017	0.024	0.018	21	22	21	22
6	39°	35°	43°	38°	0.024	0.019	0.019	0.022	22	26	22	26
7		33°			0.016	0.016	0.020	0.024	22	24	22	23
8						0.019						

to one-third the vault of the chamber. They do not extend laterally into secondary infilling as do many species of the genus. The tunnel is regular to irregular and expands rapidly in the last several volutions with angles averaging 13, 16, 23, 25, 3o, 4o and 35 degrees from the proloculus through the sixth volution. Secondary infilling is concentrated along the axis of coiling only, is not present in the equatorial area and rarely present at all in the last volution.

Remarks—Wedekindellina elongata is characterized by an unusual elongation of the length, absence of axial filling in the last volution, wide tunnel angle and small symmetrical chomata.

Occurrence—This species is abundant in beds JH1-12 and JH I-2 r with *Beedeina joyitaensis,* and in bed JH2-23.

Wedekindellina alveolata Stewart, n. sp.

Plate 7, figures 8-12, 15; table 21

Diagnosis—Shell of average size for the genus, fusiform to cylindrical shape with bluntly pointed to rounded apical extremities. Lengths range from 2.42 to 3.38 mm, widths from 0.84 to 1.11 mm and form ratios from i:2.8 to r:3.2 for the eighth and ninth volutions. In the sixth and seventh volutions the form ratio averages I :4.5 and diminishes to 1:3.2 in the eighth and ninth. This reflects the equatorial expansion and

TABLE 21. MEASUREMENTS OF *WEDEKINDELLINA ALVEOLATA* STEWART, N. SP.

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.031	0.025	0.031	0.025	0.030	0.026	0.025	0.024	1.0	1.0	1.2	1.0
1	0.050	0.048	0.048	0.052	0.047	0.040	0.055	0.049	1.1	1.2	0.87	1.1
2	0.083	0.097	0.151	0.163	0.071	0.064	0.074	0.060	1.2	1.5	2.0	2.7
3	0.225	0.126	0.397	0.313	0.100	0.096	0.106	0.089	2.3	1.3	4.0	3.5
4	0.426	0.421	0.472	0.486	0.135	0.122	0.147	0.120	3.2	3.4	3.2	4.0
5	0.539	0.567	0.836	0.673	0.181	0.169	0.190	0.163	3.0	3.3	4.4	4.1
6	0.952	0.901	1.279	0.996	0.229	0.219	0.279	0.230	4.2	4.1	4.6	4.3
7	1.178	1.243	1.450	1.093	0.322	0.299	0.401	0.352	3.7	4.2	3.6	3.1
8	1.322	1.309	1.212	1.342	0.419	0.429	0.429	0.463	3.2	3.0	2.8	2.9
9		1.689				0.557				3.0		
	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	—	—	—	0.009	0.008	0.007	0.007	—	—	—	
1	—	—	—	16°	0.008	0.008	0.008	0.007	—	9	9	
2	8°	16°	—	15°	0.009	0.008	0.009	0.009	7	13	17	
3	11°	21°	—	21°	0.010	0.014	0.014	0.012	12	19	15	
4	18°	25°	32°	19°	0.015	0.013	0.015	0.010	18	20	19	
5	30°	20°	29°	16°	0.020	0.015	0.019	0.012	14	25	21	
6	34°	25°	30°	28°	0.021	0.020	0.016	0.020	21	23	21	
7	—	22°	—	—	0.020	0.024	0.015	0.015				
8		—			0.021	0.019		0.018				
9						0.021						

vaulting in the chamber for the last two volutions and tighter coiling in the earlier volutions, which is one of the characteristics of this species. The eight to nine volutions exhibit a slightly bowed axis of coiling. The septal count averages 9, 12, 15, 19, 21 and 22 for the first six volutions.

The average-size proloculus is spherical and ranges in outside diameter from 5o to 62 microns. Septal fluting is totally absent throughout the test. Axial filling is well developed in all but the last two volutions where all secondary infilling is absent. The volutions with axial filling are tightly coiled.

The spirotheca is uniform in thickness throughout each volution and is composed of a tectum and a diaphanotheca with extremely thin upper and lower tectoria. In some specimens the tectorial layers are difficult to distinguish, giving the appearance that the tectum and diaphanotheca compose the entire wall.

Chomata are moderately developed, asymmetrical to overhanging in shape and extend upward to one-half the chamber vault. The chomata are better developed in volutions where secondary infilling is absent or present in minor amounts. In many specimens the chomata are not present in the last volution.

The tunnel is irregular and averages 16, 15, 21, 25, 28, 3o and 22 degrees from the first through the seventh volution and may not be distinguished in the eighth and ninth volutions due to the absence of chomata.

Remarks-This species is characterized by the tight inner volutions with axial filling and expanding last two volutions, which are void of any fluting or secondary filling. The name W. *alveolata* means "hollowed out" and is descriptive here in reference to the last two volutions void of any structures.

Occurrence-Wedekindellina alveolata is common in beds JH1-13, JH 1-17, JH2-17, and JH2-18.

Wedekindellina excentrica (Roth and Skinner)

Plate 7, figures 13, 14, 16-18

Wedekindella excentrica Roth and Skinner, 1930, Journal of Paleontology, V. 4, no. 4, p. 340-341, pl. 30, figs. 1-3

Wedekindellina excentrica (Roth and Skinner), Thompson, 1936, Journal of Paleontology, v. 10, no. 2, p. 105-106, pl. 15, figs. 6, 9-11

Diagnosis-Shell ovate fusiform with rounded apical extremities. The length ranges from 3.70 to 4.42 mm, the width from 1.48 to 1.55 mm and the form ratio from 1:2.4 to 1 :3.o. The nine volutions are tightly coiled around a straight axis with an average septal count of 11, 16, 19, 21, 24, 24, 27, 32 and 28 from the first through the ninth volution. Secondary in-filling is very dense throughout most of the test except for the tunnel and immediately adjacent areas. It is so dense in some specimens that the apical extremities for each volution are obscured.

The proloculus is small, spherical and averages 64 microns in outside diameter. The septa are straight across the equatorial portion of the shell and obscured by secondary infilling in the apical areas.

The protheca is of uniform thickness throughout the adult volutions. The spirotheca is composed of a tectum, diaphanotheca and upper and lower tectoria. The average spirotheca thickness measures 9, 11, 12, 14, 19, 21, 24, 27, 27 and 19 microns from the proloculus through the ninth volution.

The chomata are asymmetrical, slightly flowing and extend one-half the chamber height. The tunnel is very irregular and averages 15, 14, 19, 20, 21, 21, 20, 22 and 27 degrees from the proloculus through the eighth volution.

Occurrence-Wedekindellina excentrica is common in occurrence in beds JH1-13, JH 7, JH1-19, JH I-20, JH 1-21, R2-13, JH2-17, and JH2-18.

Wedekindellina cf. W. *minuta* (Henbest)

Plate 9, figures 6-8

Fusulinella minuta Henbest, 1928, Journal of Paleontology, v. 2, no. 1, p. 81-8z, pl. 8, figs. z-5.

Wedekindellina minute (Henbest), Dunbar and Henbest, 1942, Illinois Geological Survey, Bull. 67, p. 100-101, pl. 10, figs. 1-6.

Several small specimens of *Wedekindellina* were found in beds JH1-17 and JH2-19 which appear to be near the same stratigraphic horizon. Too few specimens were found to allow adequate speciation, however most observed compare closely with W. *minuta* (Henbest) as it is figured and described.

Wedekindellina euthysepta (Henbest)

Plate 9, figures 1-5

Fusulinella euthusepta Henbest, 1928, Journal of Paleontology, v. 2, p. 80-81, pl. 8, figs. 6-8, pl. 9, figs. I, 2

Wedekindella euthysepta (Henbest), Dunbar and Henbest, 1930, American Journal of Science, v. 20, p. 357-364

Wedekindella euthysepta (Henbest), Dunbar and Henbest, 1931, American Journal of Science, v. 21, p. 458

Wedekindellina euthysepta (Henbest), Dunbar and Henbest, 1933, In Cushman, Cushman Laboratory for Foraminiferal Research Spec. Pub. 4, p. 134, key plate 10, figs. 13-15

Diagnosis-Shell elongate fusiform with sharp to bluntly pointed apical extremities. Average lengths are 4.5o mm, widths are 1.15 mm and an average form ratio of 1:3.9. The nine volutions are tightly coiled around a straight axis with heavy axial infilling.

The proloculus is spherical to ovoid and averages 72 microns in outside diameter. Septal fluting is rarely visible and when present is only slight undulations.

The four-layered spirotheca is composed of a tectum, thick diaphanotheca and a thin lower and upper tectorium. It is uniform in thickness throughout each volution.

The chomata are developed throughout the test and are asymmetrical, slightly flowing and reach one-half to two-thirds the height of the chamber. The tunnel is regular to straight with average angles of 12 to 31 degrees for the first through the eighth volution.

Occurrence-This species occurs abundantly in beds JH 1-17, JH 1-19, JH 1-21, JH2-18 and JH3-16.

Genus PARAFUSULINELLA STEWART, n. gen.

Type species: *Parafusulinella propria* Stewart, n. sp.

Diagnosis-Shell small and fusiform with pointed to bluntly pointed apical extremities. Lateral slopes are concave, depressed to slightly irregular. Form ratio ranges from :2.5 to

1:3.o for mature specimens of six to seven volutions. Coiling is moderate to tight around a slightly irregular axis.

The proloculus is small to average in size and is subspherical to spherical in shape. The juvenarial area is most characteristic for the genus. Some forms appear endothyroid or tightly coiled normal to the later whorls. Some forms exhibit tight coiling in the first and second whorls askew to the later axis of coiling, but not normal or at right angles to it. In all specimens of both species studied, the juvenarium exhibits a very low form ratio or an ovoid shape. Normally in the third volution the axial dimension or length extends rapidly to an elongate fusiform shape. The septa are slightly undulated across the equatorial area and increase to slight fluting in the apical areas.

Chomata are well developed in all but the last volution, they are asymmetrical and tend to slightly overhang the central tunnel. In some forms they extend laterally from the tunnel to the apical area and develop in the vertical dimension about one-half the chamber vault.

The tunnel is not visible in the first two volutions due to the erratic coiling. It is irregular and expands rapidly and progressively in the third through the sixth volutions.

Secondary infilling is erratically developed throughout the test. In some cases it is continuous with the chomata on the lateral slopes of the preceding whorl and in other cases it is spotty in the apical areas, but not concentrated along the axis.

The spirotheca is thin and uniform in thickness for each volution. It is composed mainly of three layers: a tectum, primatheca and an upper tectorium. In rare specimens a thin lower tectorium is suggested, but the primatheca remains dense and less transmittal to light than the diaphanotheca of more advanced genera.

Generic Comparisons—Parafusulinella has an affinity to several other genera, but is significantly different from them to require new taxonomic consideration. Comparison is given below on the major morphologic differences among the genera.

Wedekindellina—This genus differs from *Parafusulinella* in that it has a four-layered spirotheca, tight coiling, heavy axial fill, flowing chomata and a normal juvenarium without askew or endothyroid coiling.

Waeringella—The larger size, tight coiling, heavy axial infilling, normal juvenarium, flowing chomata and narrow tunnel angle distinguish this genus.

Pseudowedekindellina—This genus differs in having a large proloculus, normal juvenarium, heavy axial fill, apical fluting, tighter coiling in early volutions and very elongate fusiform shape.

Frumentella—The much smaller size, larger proloculus, smaller chomata and thinner spirotheca distinguish this genus.

Fusiella—This genus differs from *Parafusulinella* in having no visible fluting, smaller size, thinner spirotheca, some axial infilling and less developed chomata.

Pseudo fusulinella—Most species of this genus are larger than the new genus and have more axial fluting, a four-layered spirotheca with a well-developed diaphanotheca, a normal juvenarium and much more massively developed chomata.

Parafusulinella propria Stewart, n. sp.

Plate 7, figures 19-29; plate 8, figures 1, 2; table 22

Diagnosis—Shell small and fusiform to slightly inflated fusiform in shape with pointed to bluntly pointed apical extremities. Lateral slopes are concave to irregularly depressed. Lengths range from 1.85 to 2.34 mm, widths from 0.78 to o.88 mm with an average form ratio of 1:2.7. The six volutions are moderately to tightly coiled around a slightly irregular axis and exhibit an average septal count of I o, 13, 16, 18, 20 and 19.

The proloculus is small and subspherical to spherical in shape with an outside diameter range of 44 to 62 microns. The juvenarium is tightly coiled and normal or erratic to the adult axis of coiling in over half of the specimens studied, and is ovoid in shape. From the third volution outward the form ratio changes abruptly from I : I.0 to :2.3. Fluting is almost absent throughout the test, with only slight evidence in the apical areas.

The spirotheca is uniformly thin throughout the test and is composed of a tectum, a primatheca and an upper tec-

TABLE 22. MEASUREMENTS OF *PARAFUSULINELLA PROPRIA* STEWART, N. GEN., N. SP.

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.022	0.027	0.031	0.025	0.023	0.028	0.031	0.026	0.96	0.96	1.0	0.96
1	0.089	0.040	0.076	0.051	0.053	0.049	0.069	0.042	1.7	0.87	1.1	1.2
2	0.213	0.071	0.223	0.168	0.079	0.071	0.099	0.073	2.7	1.0	2.3	2.3
3	0.308	0.182	0.389	0.308	0.134	0.105	0.146	0.107	2.3	1.7	2.7	2.9
4	0.626	0.466	0.642	0.483	0.219	0.159	0.212	0.170	2.9	2.9	3.0	2.8
5	1.052	0.723	0.823	0.690	0.321	0.288	0.304	0.250	3.3	2.5	2.7	2.8
6	1.169	0.925	1.141	1.063	0.441	0.339	0.426	0.389	2.7	2.7	2.7	2.7

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	—	—	—	0.008	0.008	0.011	0.009	—	—	—	
1	—	13°	—	20°	0.008	0.007	0.009	0.007	9	10	—	
2	33°	13°	17°	31°	0.010	0.008	0.010	0.012	12	13	13	
3	24°	17°	32°	27°	0.015	0.011	0.015	0.017	16	15	18	
4	31°	31°	27°	39°	0.019	0.018	0.014	0.017	19	17	18	
5	—	26°	—	35°	0.012	0.019	0.021	0.018	19	20	20	
6					0.009	0.009	0.009	0.009	22	16		

torium. It averages in thickness 8, 8, 10, 15, 18, 18 and 9 microns from the proloculus through the sixth volution.

Chomata are well developed, asymmetrical, overhang the central tunnel, extend one-half the chamber height and diminish in the last volutions. Some extend laterally into the upper tectorium.

The tunnel is irregular and expands from an average angle of 13 degrees in the second or third volution to 31 degrees in the fifth and sixth volution. Due to the askew coiling in the juvenarium, the tunnel and chomata are rarely visible in axial section in the first several volutions.

Secondary infilling is erratically developed along the lateral slopes and in the apical areas.

Remarks—Comparisons are made with *Parafusulinella mexicana* under the description of that species.

Occurrence—Parafusulinella propria has been found in rocks of the Lower Des Moines Series in several exposures in New Mexico. In the Joyita Hills it is from beds JH 1-13, 7, JH2-17, and JH2-18.

Parafusulinella mexicana Stewart, n. sp.

Plate 8, figures 3-16; table 23

Diagnosis—Shell small, fusiform to slightly inflated fusiform with pointed to bluntly pointed apical extremities and concave lateral slopes. Lengths range from 2.04 to 2.90 mm, widths from 0.74 to 1.15 mm and form ratios from 1:25 to I :3o. The six to seven volutions exhibit tighter coiling in the first four whorls and expansion in the fifth, sixth, and seventh, with an average septal count of 7, 9, I I, 14, 15, 16 and 20 consecutively. The axis of coiling is straight to slightly irregular.

The proloculus is spherical and of average size for a small test. It ranges in outside diameter from 64 to 84 microns. The juvenarium is coiled askew or at various angles to the coiling in the adult stage, and is more inflated in the equatorial dimension. From the third volution outward, the greatest expansion is in the axial dimension. The septa are slightly undulated in the equatorial area of the test and increase to dissepimental fluting in the apical areas.

The spirotheca is composed of three layers, with a tectum, a primatheca and an upper tectorium. In rare specimens a most discontinuous thin laver of secondary deposits may be seen below the primatheca in some volutions. It is rare and not believed to be synonymous with a lower tectorium. The entire wall averages in thickness 8, 7, 9, 12, 16, 18, 20 and 9 microns from the proloculus through the seventh volution.

The chomata are well developed, asymmetrical to slightly overhanging, rise one-half the chamber vault and decrease in size in the last volution. They do not flow laterally.

The tunnel is irregular and expands rapidly from an average of 20 degrees in the second volution to as much as 56 degrees in the sixth. It is not visible in the juvenarium due to the erratic coiling in the first two volutions. Secondary filling is insignificant to absent.

Remarks—Parafusulinella mexicana differs from *P. propria* in its overall larger size, larger proloculus, absence of secondary fill, less flowing chomata, and more fluting in the apical areas.

Occurrence—At present this species has been found only in the Big Hatchet Mountains of southwestern New Mexico and in the Boca Grande Mountains across the border in Mexico where it occurs in the lower biozone of the genus *Beedeina*. Location of collection is half way up the north slope of Boca Grande Peak along longitude 108 degrees west, approximately eight miles northwest of the Boca Grande Ranch, northwest corner of Chihuahua, Mexico.

Genus EOWAERINGELLA
SKINNER AND WILDE, I 967,
emend. STEWART, 1968

Eowaeringella joyitaensis Stewart

Plate 9, figures 15, 16

The types for this species are from the Joyita Hills and

TABLE 23. MEASUREMENTS OF *PARAFUSULINELLA MEXICANA* STEWART, N. SP.

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.042	0.033	0.032	0.032	0.038	0.032	0.034	0.034	1.1	1.1	0.94	0.94
1	0.050	0.051	0.062	0.048	0.050	0.054	0.069	0.049	1.0	0.94	0.90	0.98
2	0.118	0.132	0.134	0.107	0.081	0.087	0.100	0.079	1.5	1.5	1.3	1.4
3	0.227	0.324	0.211	0.209	0.124	0.132	0.133	0.116	1.8	2.5	1.6	1.8
4	0.421	0.566	0.463	0.412	0.172	0.198	0.211	0.169	2.4	2.9	2.2	2.4
5	0.507	0.832	0.599	0.626	0.254	0.266	0.315	0.250	2.0	3.1	1.9	2.5
6	1.053	1.020	0.954	1.075	0.337	0.380	0.423	0.369	3.1	2.7	2.3	2.9
7	1.449		1.458		0.569		0.579		2.5		2.5	

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	—	—	—	0.008	0.008	0.009	0.007	—	—	—	—
1	—	16°	—	—	0.007	0.007	0.006	0.008	7	7	—	—
2	18°	28°	19°	20°	0.009	0.009	0.009	0.009	10	9	7	11
3	23°	32°	20°	25°	0.012	0.013	0.012	0.010	13	11	11	11
4	27°	35°	32°	36°	0.017	0.014	0.016	0.018	15	15	12	14
5	30°	36°	42°	40°	0.022	0.018	0.015	0.016	15	19	11	15
6	48°		56°		0.024	0.019	0.017	0.022	16	22	16	16
7					0.009		0.017			20		

were described and figured by Stewart (1968). The above species occurs abundantly in bed JH2-29.

Eowaeringella kottlowskii Stewart
Plate 9, figures 9, 10

This species was also described and figured by Stewart (1968) and occurs abundantly in bed JH2-29.

Eowaeringella ultimata var. *magna* Stewart
Plate 9, figures 11, 12

This variety was described and figured by Stewart (1968) and occurs in bed JH1-34.

Eowaeringella ultimata var. *inflata* Stewart
Plate 9, figures 13, 14

This variety was described and figured by Stewart (1968) and occurs in bed JH1-34.

Subfamily SCHWAGERININAE DUNBAR AND HENBEST, 1930

Genus TRITICITES GIRTY, 1904

Triticites riograndensis Stewart, n. sp.
Plate 10, figures 1-4; table 24

Diagnosis—Shell elongate fusiform with bluntly pointed to rounded and slightly irregular polar extremities. Average lengths range from 3.86 to 4.86 mm, widths from 2.45 to 1.62 mm and form ratios from 1:2.9 to 1:3.2. The six to seven volutions are loosely coiled around a straight axis, with a septal count averaging 12, 15, 17, 18 and 19 from the first through the fifth volution.

The spherical proloculus is small in size for the genus and ranges in outside diameter from 84 to 124 microns. Septal fluting is rare to undulating in the equatorial region of the chamber and becomes erratically dissepimental in the apical region.

The spirotheca is of uniform thickness throughout each volution in axial section and varies less in thickness than most species from the proloculus through the last volution. Average thicknesses of the spirotheca from the proloculus through the seventh volution are 11, I I, 14, 24, 3^1, 4^0, 44 and 45 microns. It is composed of a tectum and a finely alveolar keriotheca.

The chomata are erratically developed, asymmetrically shaped from mounds and over-changing shapes to slightly flowing symmetry. They tend to disappear in the last volution. The tunnel is regular to irregularly developed and exhibits average angles of 24, 26, 32, 38, 45 and 51 degrees from the proloculus through the fifth volution. It is not definitive in the last volutions due to the absence of chomata.

Remarks—Triticites riograndensis differs mainly from other species of the genus by the absence of good fluting in the equatorial region of the test, the erratic chomata, the uniformly thick wall throughout each chamber and the irregular polar extremities.

Occurrence—This species is rare to common throughout most of bed JH1-37.

Triticites nebraskensis Thompson
Plate 10, figures 5-7, i o

Fusulina exigua Staff, 1910, Zoologica, v. 22, pt. 58, p. 39, fig. 25.
Fusulina exigua Staff, 1912, Palaeontolographica, v. 59, p. 179, text fig. 10, pl. 15, fig. 4.
Triticites exiguus (Schellwien and Staff), Dunbar and Condra, 1927, Nebraska Geological Survey, Bull. II, second series, p. 111-113, pl. 8, fig. 1-5.
Triticites nebraskensis Thompson, 1934, University of Iowa Studies, v. 16, no. 4, p. 281-282.

Diagnosis—Small elongate fusiform test with bluntly pointed polar extremities. Lengths range from 3.60-4.54 mm, widths from 1.42 to 1.7o mm and the form ratios from 1 :2.5 to 1 :2.6. The six to eight volutions are medium to tightly coiled around a straight axis, with a septal count averaging 11, 14, 17, 19 and 19 for the first five volutions.

The proloculus is small, spherical and measures 66 to 74 microns in outside diameter. Septal fluting is absent with

TABLE 24. MEASUREMENTS OF *TRITICITES RIOGRANDENSIS* STEWART, N. SP.

Volution	Half Length 1	2	3	4	Radius Vector 1	2	3	4	Form Ratio 1	2	3	4
0	0.042	0.047	0.050	0.062	0.044	0.047	0.048	0.061	0.96	1.0	1.0	1.0
1	0.123	0.106	0.109	0.118	0.090	0.068	0.075	0.083	1.4	1.6	1.5	1.4
2	0.303	0.176	0.182	0.219	0.151	0.122	0.113	0.128	2.0	1.4	1.6	1.7
3	0.526	0.434	0.382	0.461	0.248	0.194	0.174	0.216	2.1	2.2	2.2	2.1
4	1.227	0.978	0.897	0.986	0.371	0.277	0.281	0.298	3.3	3.5	3.2	3.3
5	1.946	1.327	1.732	1.542	0.560	0.492	0.421	0.488	3.5	2.7	4.1	3.2
6	2.431	1.932	1.996	2.179	0.787	0.745	0.619	0.724	3.1	2.6	3.2	3.0
7			2.362				0.811				2.9	

Volution	Tunnel Angle (degrees) 1	2	3	4	Wall Thickness 1	2	3	4	Septal Count 5	6	7	8
0	25°	—	—	23°	0.011	0.012	0.012	0.011	—	—		
1	30°	22°	25°	26°	0.010	0.011	0.012	0.011	12	12		
2	38°	30°	32°	30°	0.013	0.014	0.014	0.014	14	16		
3	38°	37°	39°	38°	0.023	0.024	0.025	0.025	17	18		
4	50°	44°	45°	44°	0.032	0.031	0.032	0.030	18	18		
5	50°	47°	52°	51°	0.041	0.039	0.040	0.041	20	18		
6			—		0.042	0.045	0.045	0.044				
7							0.045					

dissepimental fluting present in the apical areas with many septal pores. The spirotheca is composed of a tectum and a finely alveolar keriotheca, with thinning toward the apical areas. The chomata are mound-shaped to slightly overhanging, symmetrical to asymmetrical and extend from one-half to the entire height of the chamber.

The tunnel is straight and increases in magnitude in the adult stages with average angles of 19, 21, 28, 35, 43 and 48 degrees from the proloculus through the fifth volution.

Occurrence—These specimens are rare in the middle and upper part of bed JH 1-37.

Triticites sp. A
Plate 10, figures 8, 9, II; table 25

Diagnosis—Too few specimens were found to allow proper orientation and measurements necessary for species identification. However, a summary follows on the specimens studied.

The shell is small, inflated fusiform in shape, with slightly concave lateral slopes and bluntly pointed apical extremities. Lengths range from 2.00 to 2.09 mm, widths from 1.36 to 1.45 mm and form ratios from 1:1.4 to 1:1.5 for adult specimens of six volutions. In the first three volutions the axial length is less than the width, giving form ratios less than one to one. The six volutions are loosely coiled around a straight axis and exhibit an average septal count of 10, 13, 15, and 18 for the first four whorls.

The proloculus is small, spherical and measures in outside diameter from 72 to 76 microns. Septal fluting is mainly concentrated in the apical areas, with slight undulations in the equatorial regions. The wall is composed of a tectum and finely alveolar keriotheca in the mature stages, but appears to have thin tectorial deposits in the juvenile wall. The spirotheca thickness averages 11, 19, 20, 24, 27, 37 and 39 microns from the proloculus through the sixth volution.

The chomata are dense, asymmetrical to overhanging and reach three-fourths the chamber height. The tunnel is slightly irregular and averages 14, 21, 17, 25 and 28 degrees from the first through the fifth volution.

Remarks—These forms differ from comparable species in the inflated width being greater in dimension than the length in the early volutions.

Occurrence—Triticites sp. A is rare in bed JH1-37.

Triticites liosepta Stewart, n. sp.
Plate 10, figures 12-16, 19; table 26

Diagnosis—Shell irregular in shape, mostly cylindrical to elongate fusiform with very irregular polar extremities. Lengths range from 3.0o to 4.64 mm, widths from 1.10 to 1.4o mm and form ratios from :2.7 to 1:3.3. The 5½ to 6 volutions are coiled around a very irregular axis which tends to bend slightly at each end near the apical extremity. Coiling is rather loose, with an average septal count of 11 , 14, 16, 18 and 19 from the first through the fifth volution.

The proloculus is small, slightly ovoid and elongated in axial dimension, and ranges in outside diameter from 78 to 96 microns. Fluting is absent throughout the chamber, except for thin-walled dissepiments in the apical areas. These dissepiments contribute to the irregularity of the polar extremities.

The spirotheca tends to thin slightly from the equatorial to the axial portion of each chamber and is composed of a tectum and a weakly alveolar keriotheca. The wall appears to have the above characteristics throughout the test. The thickness averages 13, 16, 20, 28, 33, 38 and 42 from the proloculus through the sixth volution.

The chomata are symmetrically shaped mounds, extend one-half the chamber height and decrease in size in the last volution. The tunnel is straight to slightly irregular, wide and averages 27, 28, 39, 45 and 53 degrees from the proloculus through the fourth volution. No secondary filling is present.

Remarks—This new species is best characterized by the smooth or unfluted septa, wide tunnel angle, mound-shaped chomata, irregular polar extremities and irregular axis of coiling. The species name comes from *leios* (smooth) and *septum* (partition) referring to the smooth and unfluted septa.

Triticites liosepta is comparable to the form figured by

TABLE 25. MEASUREMENTS OF *TRITICITES* SP. A

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.038	0.036			0.036	0.037			1.1	0.98		
1	0.079	0.064			0.084	0.079			0.94	0.81		
2	0.129	0.097			0.148	0.121			0.87	0.80		
3	0.276	0.200			0.207	0.243			1.3	0.82		
4	0.386	0.347			0.304	0.317			1.3	1.1		
5	0.789	0.877			0.459	0.474			1.7	1.9		
6	1.004	1.046			0.681	0.727			1.5	1.4		

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	—	—			0.010	0.012			—	—	—	
1	13°	14°			0.020	0.019			11	10	9	
2	20°	22°			0.018	0.021			13	12	13	
3	14°	20°			0.025	0.024			15	16	15	
4	25°	25°			0.025	0.029			18	19	18	
5	30°	27°			0.036	0.039						
6					0.035	0.041						

Dunbar and Condra (1927) plate 8, figure 9, which was identified as *Triticites irregularis* (Schellwien and Staff, 1912). However, the form figured by Dunbar and Condra as T. ir*regularis* is not believed to be conspecific with the form figured by Schellwien and Staff on their plate 17, figure 10. Thompson (1936) on page 681 designated the form published by Staff (1912) on plate 17, figure 1 o, as the lectotype for *Triticites irregularis;* therefore the form of Dunbar and Condra is without a name and is here referred to *Triticites liosepta.*

Occurrence—This species occurs in the middle of bed JH1-37.

Triticites sp. B

Plate 10, figures 17, 18

Several specimens were found in the *Triticites* biozone that are here referred to as T. sp. B. These forms are extremely small, inflated fusiform in shape with lengths around 0.96 mm, widths around 0.50 and form ratios of :1.9. Several specimens have endothyroid juvenaria, others have small spherical proloculi measuring up to 6o microns in outside diameter. Chomata are asymmetrical and reach one-half the chamber vault. Fluting is of a low degree and secondary filling is absent. A maximum of four volutions are visible beyond the endothyroid juvenarium.

The wall is very thin and appears to be composed of a tectum and a structureless keriotheca on prothecal layer. The tunnel is narrow and ranges from Io to 35 degrees from the first to the third volution.

Remarks—Insufficient specimens were found to adequately describe this species, but no forms similar to the above morphologic features have been described from the Lower Missouri Series of North America.

Occurrence—Rare specimens found in bed JH1-37.

TABLE 26. MEASUREMENTS OF *TRITICITES LIOSEPTA* STEWART, N. SP.

Volution	Half Length				Radius Vector				Form Ratio			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0.040	0.039	0.048	0.048	0.040	0.040	0.042	0.048	1.0	0.97	1.1	1.0
1	0.199	0.072	0.099	0.108	0.085	0.061	0.080	0.089	2.7	1.2	1.2	1.2
2	0.421	0.253	0.178	0.214	0.165	0.103	0.148	0.156	2.5	2.5	1.2	1.4
3	0.957	0.421	0.553	0.496	0.302	0.186	0.249	0.271	3.2	2.2	2.2	1.8
4	1.752	0.621	0.952	1.223	0.478	0.274	0.376	0.433	3.7	2.3	2.5	2.8
5	2.323	1.042	1.500	1.949	0.698	0.400	0.549	0.639	3.3	2.6	2.7	3.0
6		1.830				0.583				3.1		

Volution	Tunnel Angle (degrees)				Wall Thickness				Septal Count			
	1	2	3	4	1	2	3	4	5	6	7	8
0	41°	—	22°	27°	0.012	0.014	0.012	0.015	—	—		
1	30°	20°	29°	28°	0.015	0.012	0.014	0.026	10	12		
2	42°	39°	40°	26°	0.025	0.021	0.019	0.016	12	16		
3	58°	39°	37°	50°	0.025	0.038	0.026	0.031	14	19		
4	56°	56°	50°	54°	0.038	0.035	0.025	0.032	17	18		
5					0.040	0.035	0.038	0.045	19	19		
6						0.042						

References

Armstrong, Augustus K. (1958) *The Mississippian of west-central New Mexico:* N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Mem. 5, 34 p.

——— (1967) *Biostratigraphy and carbonate facies of the Mississippian Arroyo Peñasco Formation, north-central New Mexico*: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Mem. 20, 80 p.

Dunbar, C. O., and Condra, G. E. (1927) *The Fusulinidae of the Pennsylvanian System of Nebraska:* Nebr. Geol. Surv., Bull. II, Second Series, 135 p., 15 pls.

Foster, Roy W. (1957) *Stratigraphy of west-central New Mexico*: Four Corners Geol. Soc. Guidebook of southwestern San Juan Basin, p. 62-72.

Herber, Lawrence J. (1963) *Precambrian rocks of La Joyita Hills*: N. Mex. Geol. Soc. Guidebook of the Socorro Region, p. 180-184.

Ishii, K. (1957) *On the so-called* Fusulina: Proc. Japan Acad., v. 33, n. 10, p. 652-656.

——— (1958) *On the phylogeny, morphology and distribution of* Fusulina, Beedeina *and allied fusulinid genera:* Jour. Inst. Polytechnics, Osaka City Univ., Ser. G., v. 4, p. 29-70, pls. 1-4.

Kahler, F., and Kahler, G. (1966-1967) *Fossilium catalogus, 1:* animalia (Ed. F. Westphal), Pans 111-114, Teil 1-4, Fusulinida (Foraminiferida).

Kelley, Vincent C. (1952) *Tectonics of the Rio Grande depression of central New Mexico*: N. Mex. Geol. Soc. Guidebook of central New Mexico, p. 93-105.

Kottlowski, Frank E. (1960) *Summary of Pennsylvanian sections in southwestern New Mexico and southeastern Arizona*: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Bull. 66, 187 p.

——— (1963a) *Paleozoic and Mesozoic strata of southwestern and south-central New Mexico*: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Bull. 79, 100 p.

——— (1963b) *Pennsylvanian rocks of Socorro County, New Mexico:* N. Mex. Geol. Soc. Guidebook of Socorro region, p. 102-111.

———, Flower, Rousseau H., Thompson, M. L., and Foster, Roy W. (1956) *Stratigraphic studies of the San Andres Mountains, New Mexico*: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Mem. 1, 132 p.

———, and Stewart, Wendell J. (1966) *Joyita uplift: a key to Wolfcampian orogeny* (abst.): Geol. Soc. Am., Spec. Paper 101, p. 114.

Meyer, Richard F. (1966) *Geology of Pennsylvanian and Wolfcampian rocks in southeast New Mexico*: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Mem. 17, 123 p.

Miller, John P., Montgomery, Arthur, and Sutherland, Patrick K. (1963) *Geology of part of the southern Sangre de Cristo Mountains, New Mexico*: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Mem. 11, 106 p.

Needham, C. E. (1937) *Some New Mexico Fusulinidae:* N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 14, 88 p., 12 pls.

Northrop, Stuart A., and Wood, Gordon H. (1946) *Geology of Nacimiento Mountains, San Pedro Mountain, and adjacent plateaus in parts of Sandoval and Rio Arriba Counties, New Mexico:* U.S. Geol. Surv. Oil and Gas Inv. Prelim. Map 57.

Oppel, Theodore W. (1959) *The Pennsylvanian-Permian contact in lower Fresnal Canyon, Sacramento Mountains, New Mexico*: Roswell Geol. Soc. Guidebook of Sacramento Mountains, p. 186-195.

Otte, Carel, Jr. (1959) *Late Pennsylvanian and early Permian stratigraphy of the northern Sacramento Mountains, Otero County, New Mexico*: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Bull. 50, 111 p.

Pray, Lloyd C. (1961) *Geology of the Sacramento Mountains escarpment, Otero County, New Mexico*: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Bull, 35, 144 p.

Read, Charles B., and Wood, Gordon H. (1947) *Distribution and correlation of Pennsylvanian rocks in late Paleozoic sedimentary basins of northern New Mexico*: Jour. Geol., v. 55, p. 220-236.

Roth R., and Skinner, J. (1930) *The fauna of the McCoy Formation, Pennsylvanian, of Colorado:* Jour. Paleo., v. 4, n. 4, p. 332-352, pls. 28-31.

Sheng, J. C. (1958) *Fusulinids from the Penchi Series of the Taitzeho Valley, Liaoning:* Palaeontologia Sinica, whole n. 143, N.S.B., n. 7, p. 56-119, 16 pls.

Staff, H. von (1910) *Die anatomie und physiologie der Fusulinen*: Zoologica, v. 22, pt. 58, 93 p., 2 pls.

——— (1912) *Monographie de Fusulinen, Teil III, Die Fusulinen (Schellwienien) Nordamerikas:* Palaeontographica, v. 58, p. 157-192, pls. 15-20.

Stark, John T., and Dapples, Edward C. (1946) *Geology of the Los Piños Mountains, New Mexico*: Geol. Soc. Am. Bull., v. 57, p. 1121-1172.

Stewart, W. J. (1958) *Some fusulinids from the upper Strawn, Pennsylvanian, of Texas:* Jour. Paleo. v. 32, n. 6, p. 1051-1070, pls. 132-137.

——— (1966) *New species of the fusulinid genus* Thompsonella *and a proposed change in wall terminology:* Jour Paleo., v. 40, n. 2, p. 354-358, pl. 41.

——— (1968) *The stratigraphic and phylogenetic significance of the fusulinid genus* Eowaeringella, *with several new species:* Cush. Found. Foram. Res., Spec. Publ. n. 10, 29 p., 7 pls.

Thompson, M. L. (1934) *The fusulinids of the Des Moines Series of Iowa*: Univ. Iowa Studies, new series, n. 284, v. 16, n. 4, p. 277-332, pls. 20-23.

——— (1936) *Pennsylvanian fusulinids from Ohio:* Jour. Paleo., v. 10, n. 8, p. 673-683, pls. 90, 91.

——— (1942a) *Pennsylvanian System in New Mexico:* N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Bull. 17, 92 p.

——— (1942b) *New genera of Pennsylvanian fusulinids:* Am. Jour. Sci., v. 240, n. 6, p. 403-420, pls. 1-3.

——— (1948) *Studies of American fusulinids:* Univ. Kans. Contr. Paleontology, Protozoa, Art. 1, 184 p., 38 pls.

——— (1964) *Fusulinacea:* In Treatise on invertebrate paleontology, Part C, Protista 2, v. 2. p. C358-C436.

Wengerd, Sherman A. (1959) *Regional geology as related to the petroleum potential of the Lucero region, west-central New Mexico*: N. Mex. Geol. Soc. Guidebook of west-central New Mexico, p. 121-134.

——— (1962) *Pennsylvanian sedimentation in Paradox basin, Four Corners region*: *in* Pennsylvanian System in the United States, Amer. Assoc. Petroleum Geologists, p. 264-330.

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

———, and Wanek, Alex A. (1951) *Geology of the region from Socorro and San Antonio east to Chupadera Mesa, Socorro County, New Mexico*: U.S. Geol. Surv. Oil and Gas. Inv. Map OM 121.

Zeller, Robert A., Jr. (1965) *Stratigraphy of the Big Hatchet Mountains area, New Mexico*: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res., Mem. 16, 128 p.

PLATES 1-10

PLATE 1

(All figures x100 except 16)

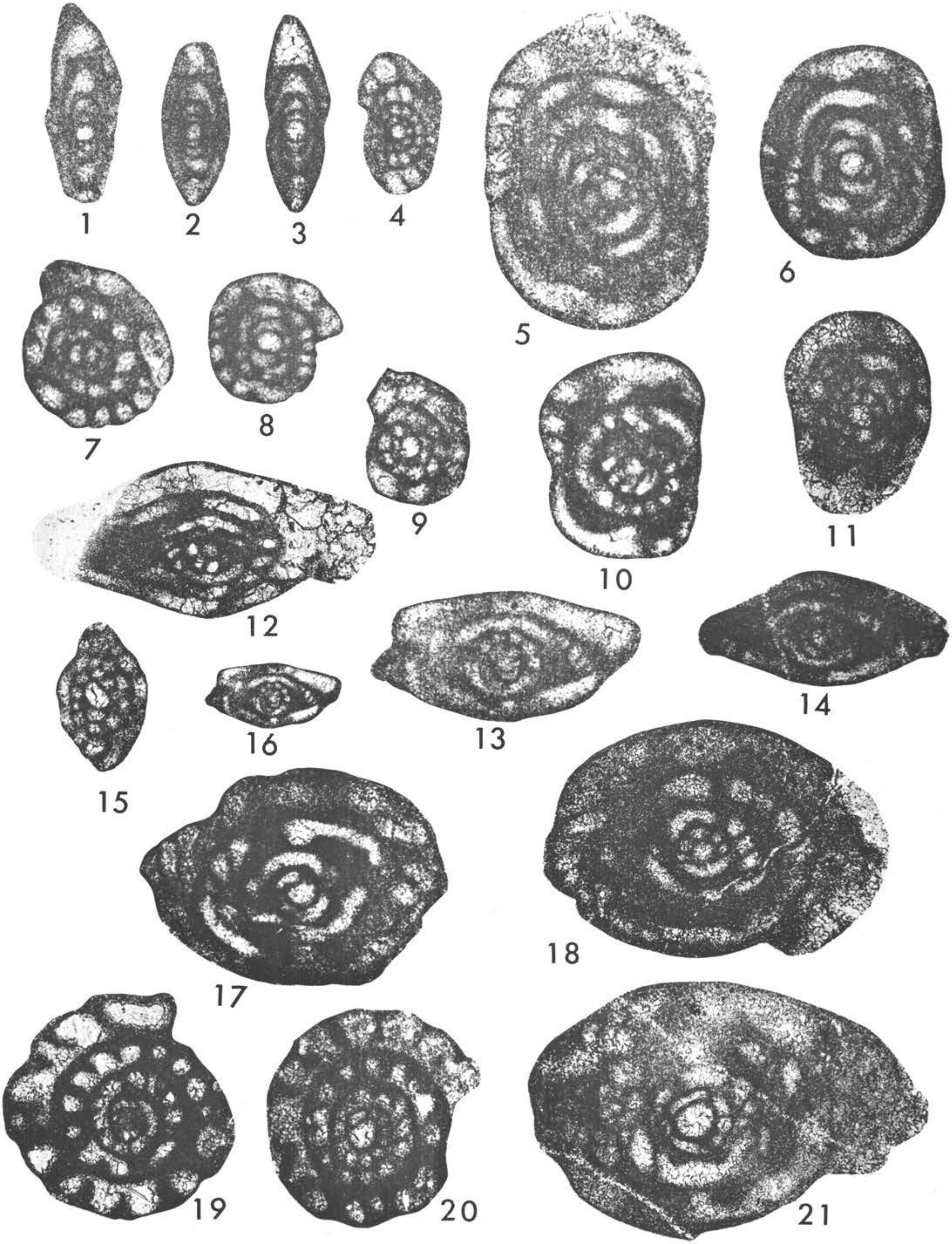
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PLATE 2

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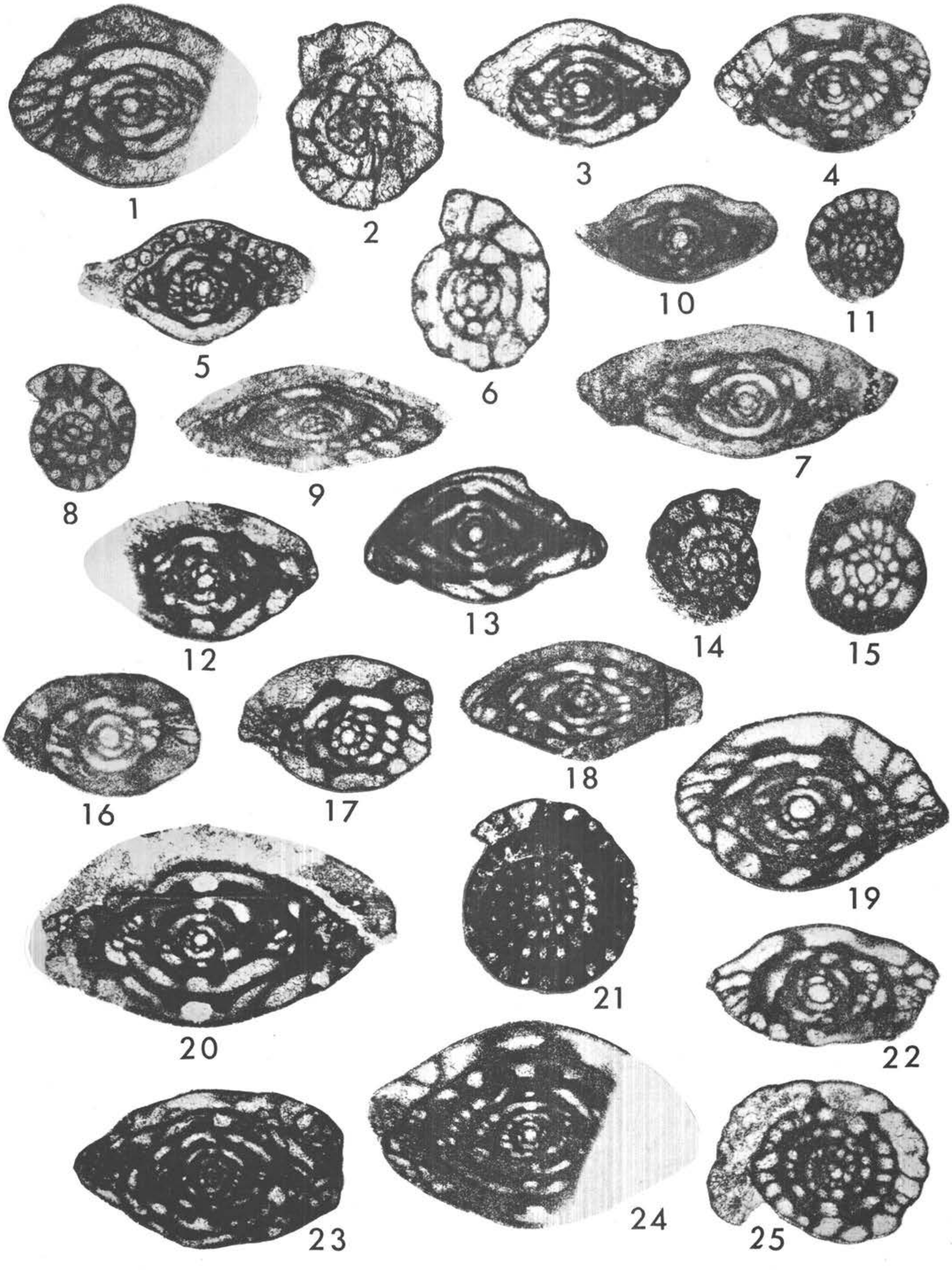
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PLATE 3

(All figures x20 except 1, 14-16)

Figures		Page
1-3, 5-7	*Profusulinella* sp. B 1, axial section x50; 2, 6, axial sections; 3, 5, 7, sagittal sections.	41
4, 8-13	*Profusulinella* sp. C 4, 8, 9, 12, 13, axial sections; 10, 11, sagittal sections.	41
17, 20	*Fusulinella* cf. *F. acuminata* Thompson 17, axial section; 20, sagittal section.	42
14-16	*Profusulinella* sp. D 14, 15, axial sections x50; 16, sagittal section x50.	42
18, 19, 21-25	*Fusulinella juncea* Thompson 18, 19, 22, 23, 25, axial sections; 21, 24, sagittal sections near the plane of the tunnel.	42
26-28	*Fusulinella* cf. *F. famula* Thompson 26, 28, axial sections; 27, oblique sagittal section.	43

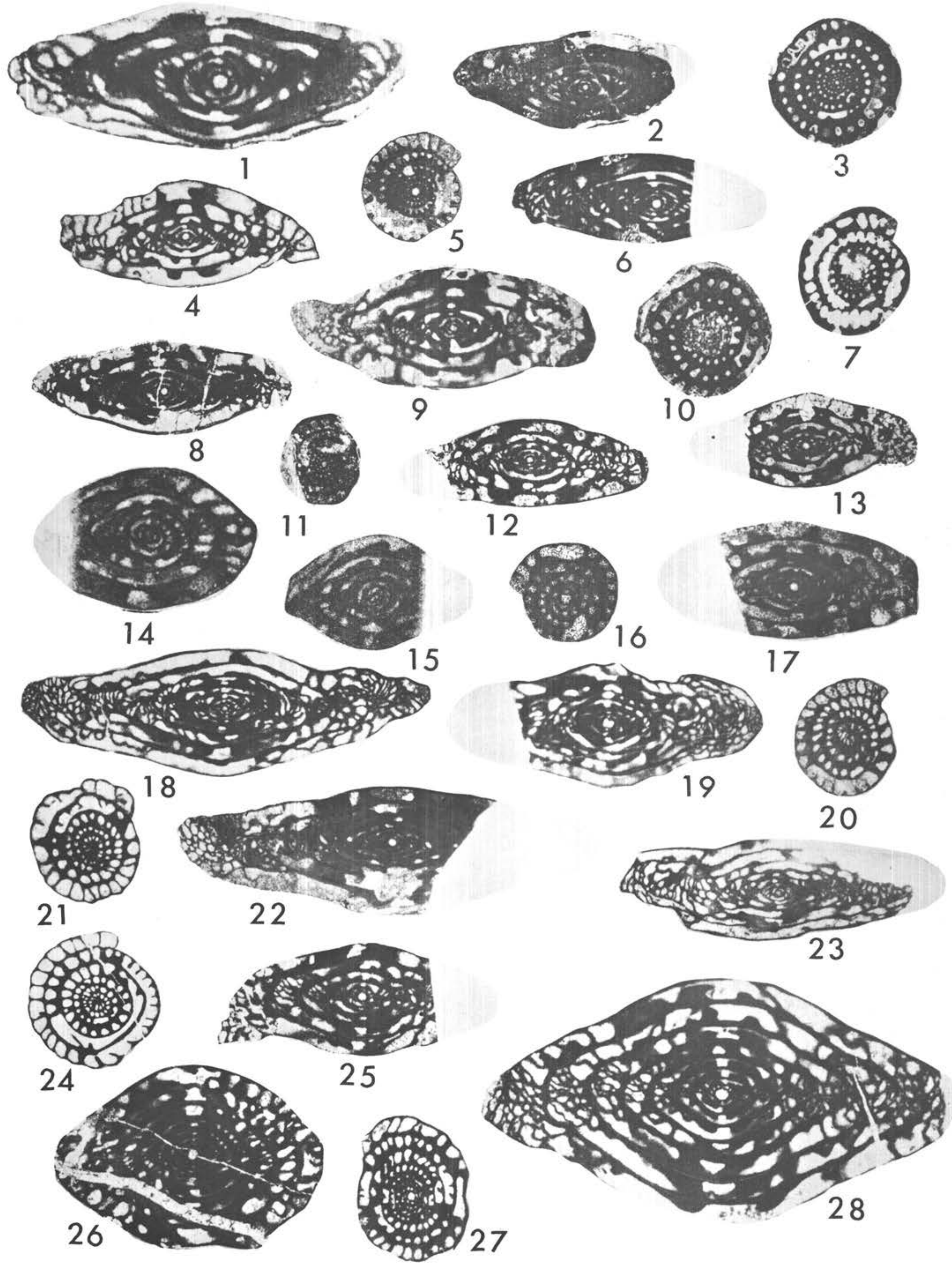
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PLATE 4

(All figures x20 except 19)

Figures		*Page*
1-3	*Fusulinella devexa* Thompson 1, 2, axial sections; 3, sagittal section.	43
4-10	*Fusulinella iowaensis* Thompson 4-6, 8, axial sections; 7, 9, 10, sagittal sections.	44
11-19	*Beedeina insolita* (Thompson) 11, 12 sagittal sections; 13, 15, 16, 18, axial sections; 14, axial section questionably referred to this species; 17, sagittal section questionably referred to this species; 19, axial section of a microspheric form questionably referred to this species, x50.	44

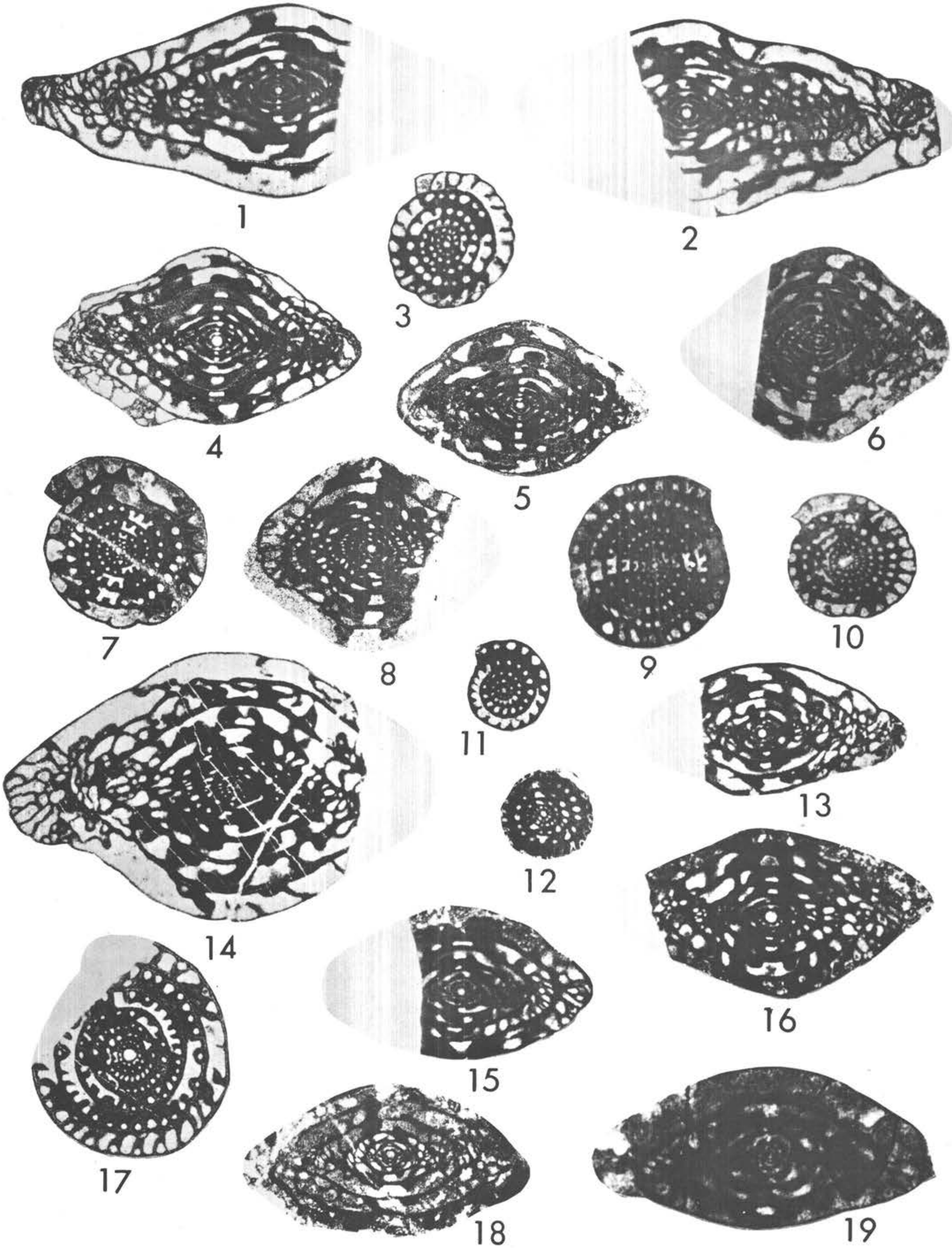
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PLATE 5

(All figures x20)

Figures		Page
1-3, 5, 6	*Beedeina pristina* (Thompson) .... 1, 3, 6, axial sections; 2, 5, sagittal sections, 2 is near the plane of the proloculus.	45
4, 7-10	*Beedeina* cf. *B. socorroensis* (Needham) .... 4, 7, 8, 10, axial sections; 9, sagittal section.	46
11, 15	*Beedeina* cf. *B. novamexicana* (Needham) .... 11, 15, axial sections.	46
12-14, 16-19	*Beedeina pattoni* (Needham) .... 12-14, 17, 19, axial sections; 16, 18, sagittal sections, 18 is not in the plane of the proloculus.	47

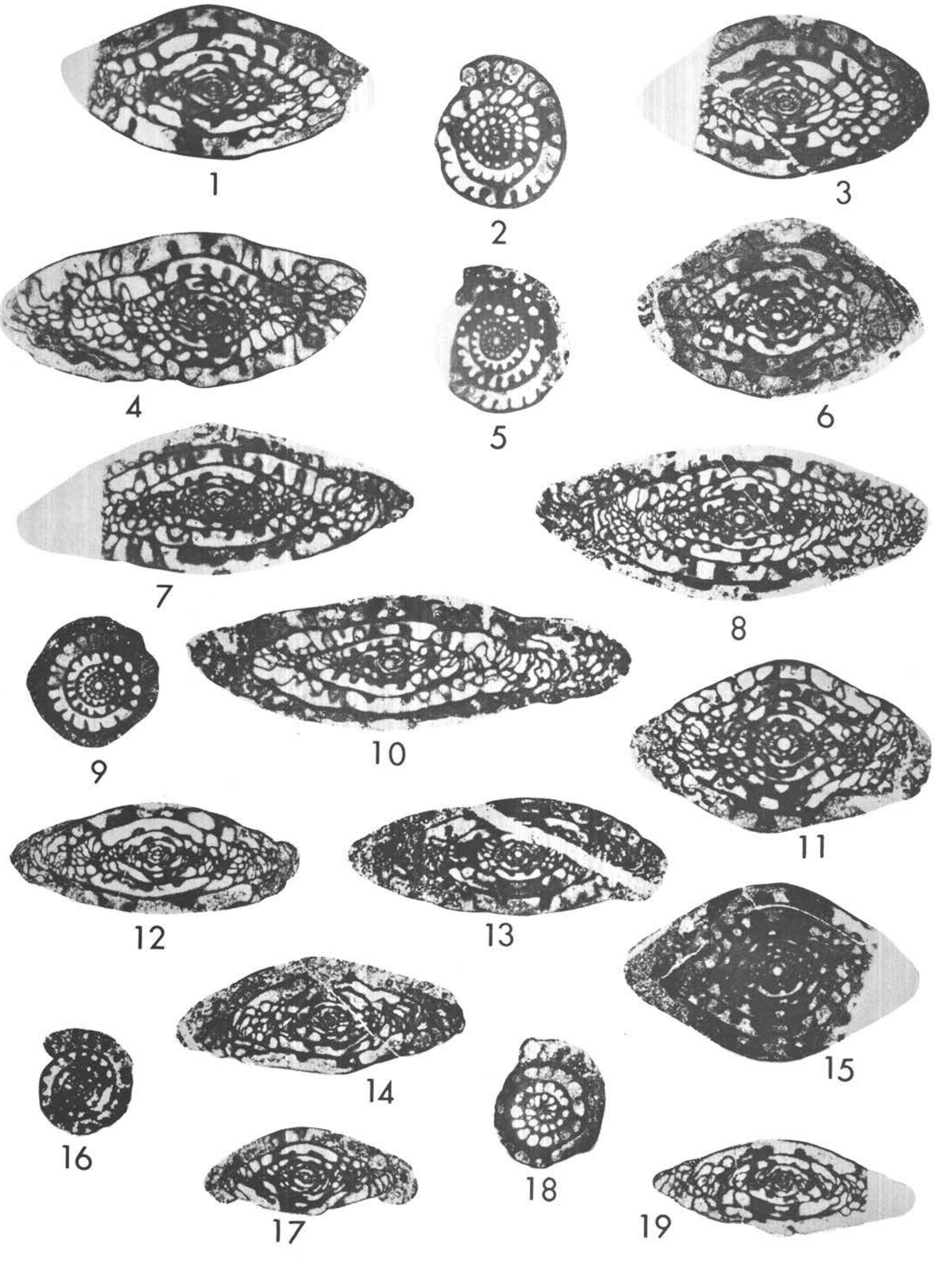
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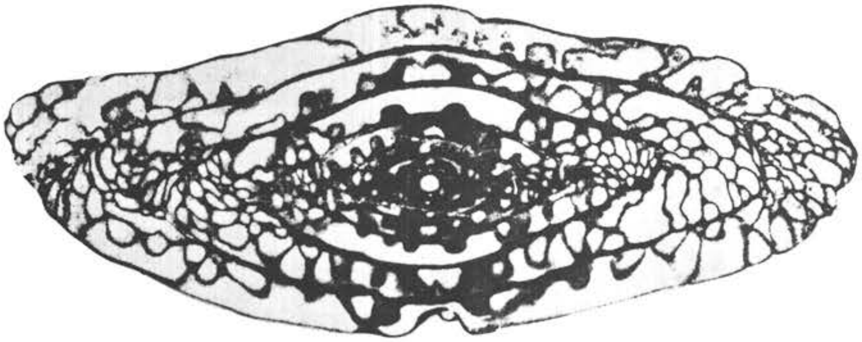
PLATE 6

(All figures x20)

Figures		*Page*
1-8	*Beedeina joyitaensis* Stewart, n. sp.	48
	1, axial section of the holotype; 4, 5, 8, axial sections of paratypes; 2, 3, 6, 7, sagittal sections of paratypes. Figures 5 and 8 represent the more obese variations of the species. Figure 8 was properly oriented for sectioning with the last volution; however, the axis of coiling for the earlier volutions appears to be aberrant.	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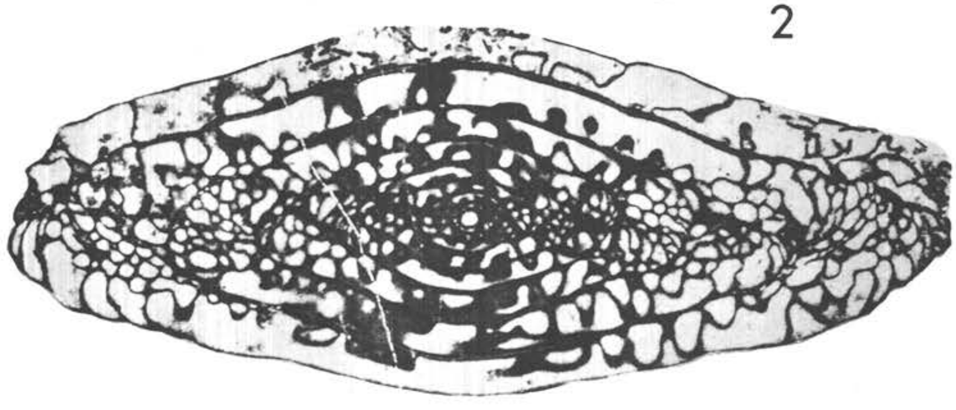
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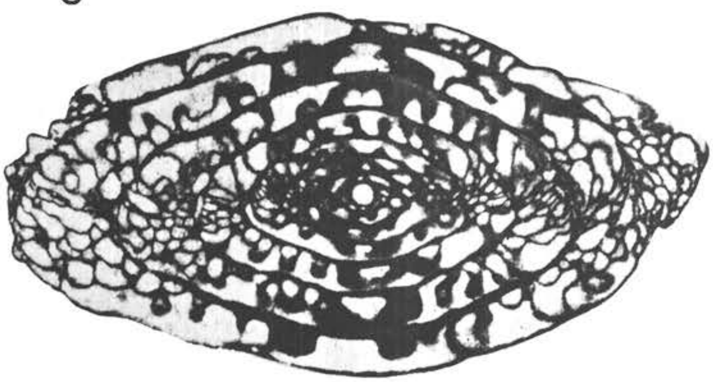
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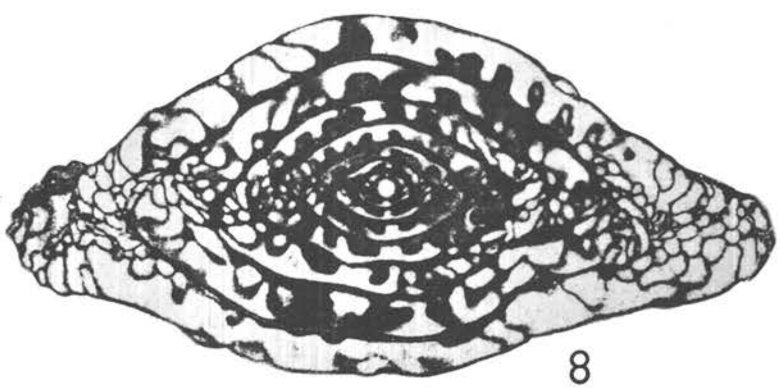
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PLATE 7

(All figures x20)

Figures		Page
1-7	*Wedekindellina elongata* Stewart, n. sp. .... 1, axial section of the holotype; 2, 4, 6, axial sections of paratypes; 3, 5, 7, sagittal sections of paratypes.	48
8-12, 15	*Wedekindellina alveolata* Stewart, n. sp. .... 9, axial section of the holotype; 8, 10, 15, axial sections of paratypes; 11, 12, sagittal sections of paratypes.	49
13, 14, 16-18	*Wedekindellina excentrica* (Roth and Skinner) .... 13, 16, 17, axial sections; 14, 18, sagittal sections.	50
19-29	*Parafusulinella propria* Stewart, n. gen., n. sp. .... 19, axial section of the type species and the holotype; 21, 24-29, axial sections of paratypes; 20, 22, 23, sagittal sections of paratypes.	51

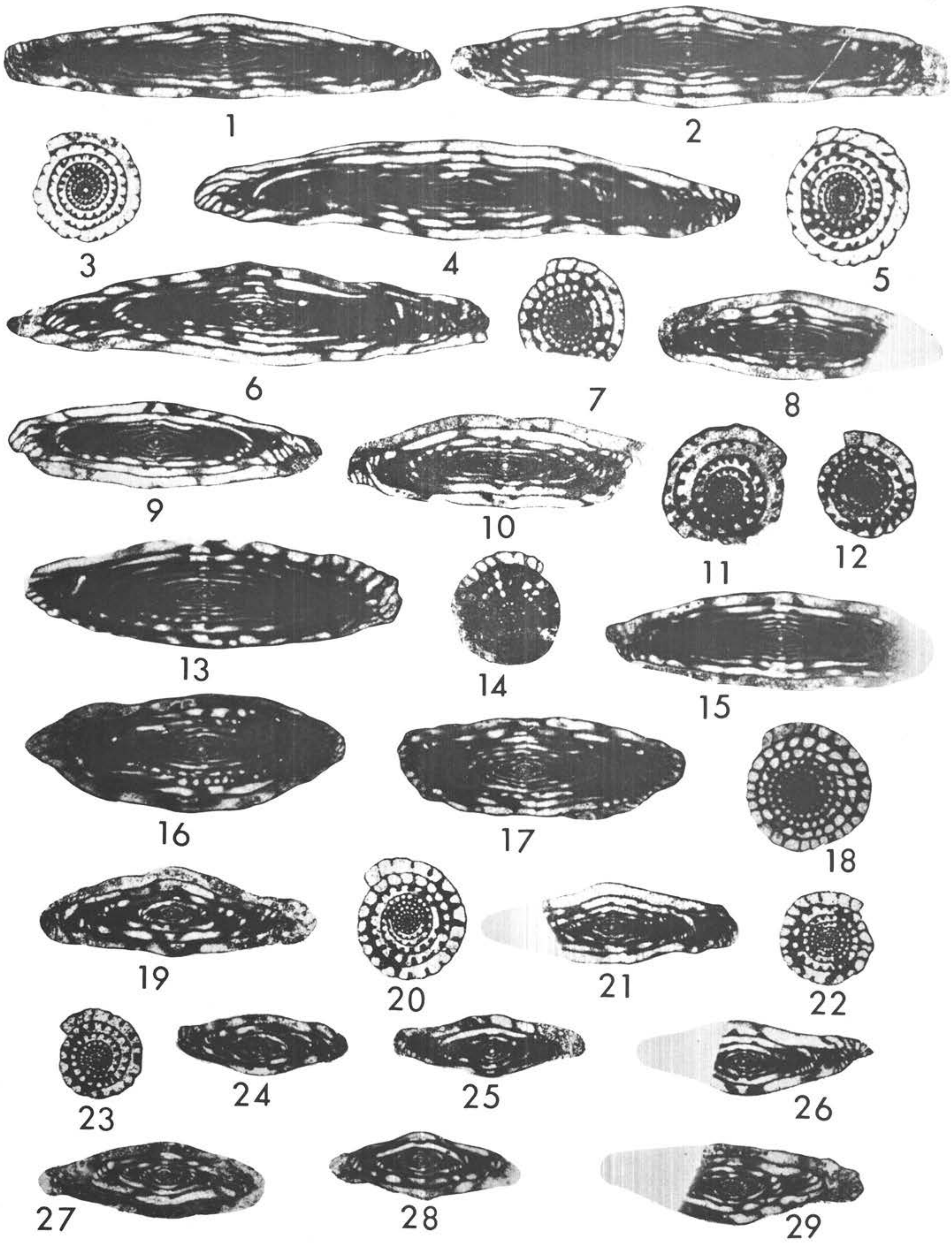
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PLATE 8

(All figures x20 except 1, 2, 13-16)

Figures		*Page*
1, 2	*Parafusulinella propria* Stewart, n. gen., n. sp. .... 1, axial section of the holotype enlarged x50; 2, detail of the equatorial region of the holotype and type species to illustrate the layers of the spirotheca, x75.	51
3-16	*Parafusulinella mexicana* Stewart, n. sp. .... 3, 13, axial section of the holotype, x20 and x50; 6, 7, 9-12, axial sections of paratypes; 4, 5, 8, sagittal sections of paratypes; 14, detail of the equatorial region of the holotype illustrating the layers of the spirotheca, x75; 15, detail of the equatorial region of an axial section of a paratype, x75; 16, detail of a sagittal section of a paratype, x75.	52

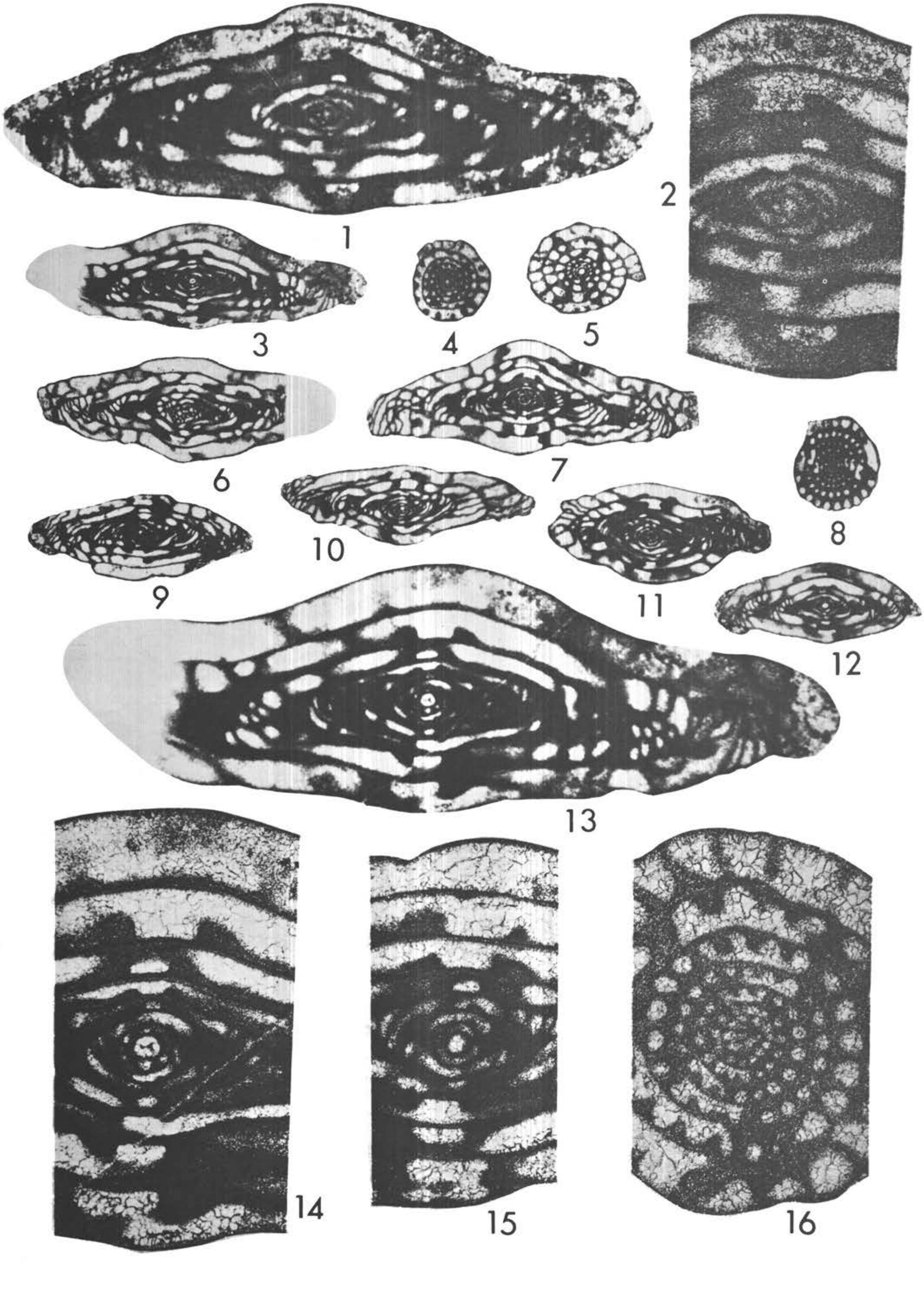
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PLATE 9

(All figures x20 except 6, 7)

Figures		Page
1-5	*Wedekindellina euthysepta* (Henbest) 1, 4, 5, axial sections; 2, 3, sagittal sections.	50
6-8	*Wedekindellina* cf. *W. minuta* (Henbest) 6, axial section exhibiting erratic coiling and juvenarium, x50; 7, axial section closely resembling the holotype after Henbest, x50; 8, axial section exhibiting an endothyroid juvenarium, may be a microspheric form of another species.	50
9, 10	*Eowaeringella kottlowskii* Stewart 9, axial section of the holotype; 10, sagittal section of a paratype.	53
11, 12	*Eowaeringella ultimata* var. *magna* Stewart 11, sagittal section of a paratype; 12, axial section of the holotype.	53
13, 14	*Eowaeringella ultimata* var. *inflata* Stewart 13, axial section of the holotype; 14, sagittal section of a paratype.	53
15, 16	*Eowaeringella joyitaensis* Stewart 15, sagittal section of a paratype; 16, axial section of the holotype.	52

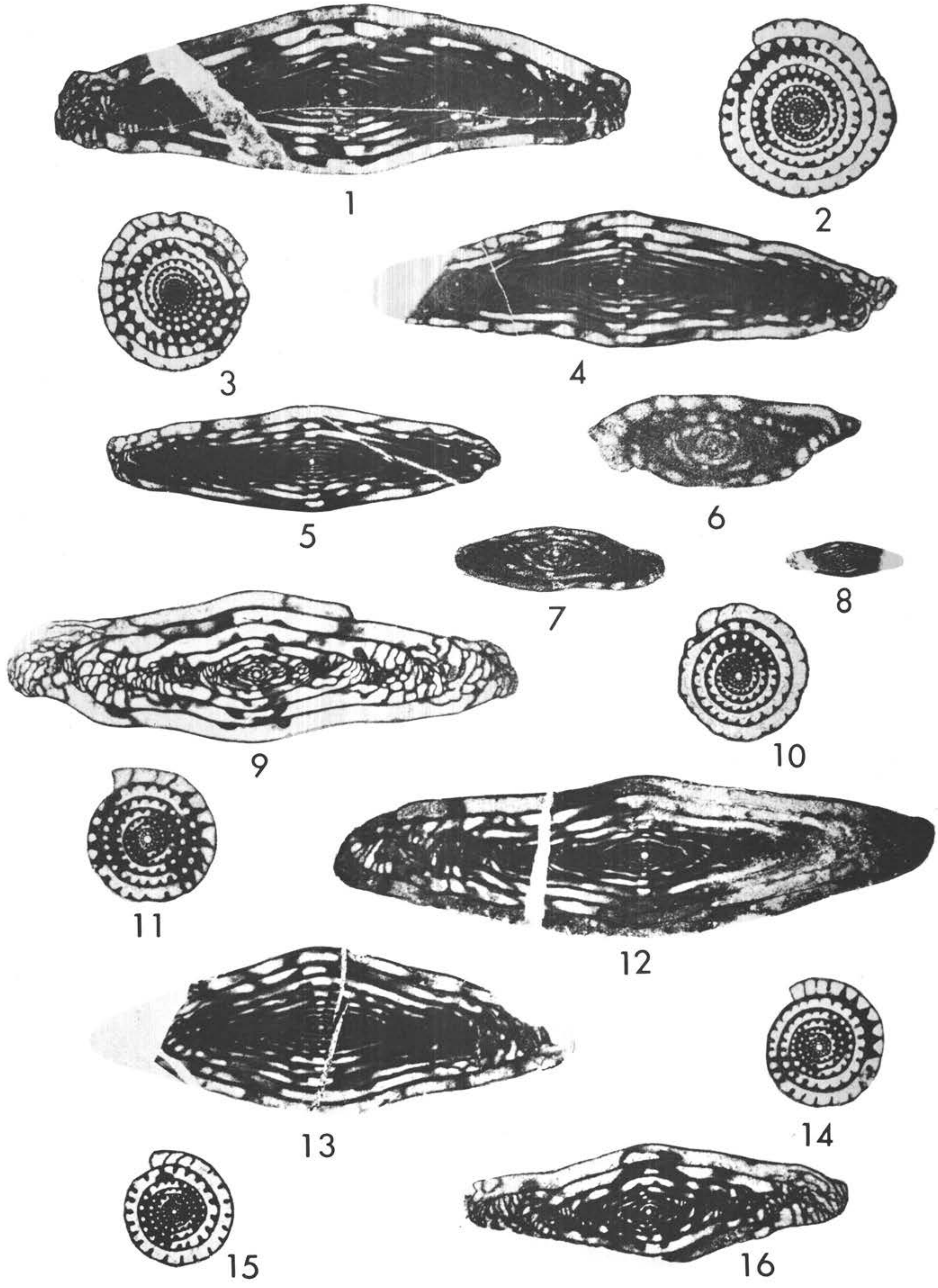
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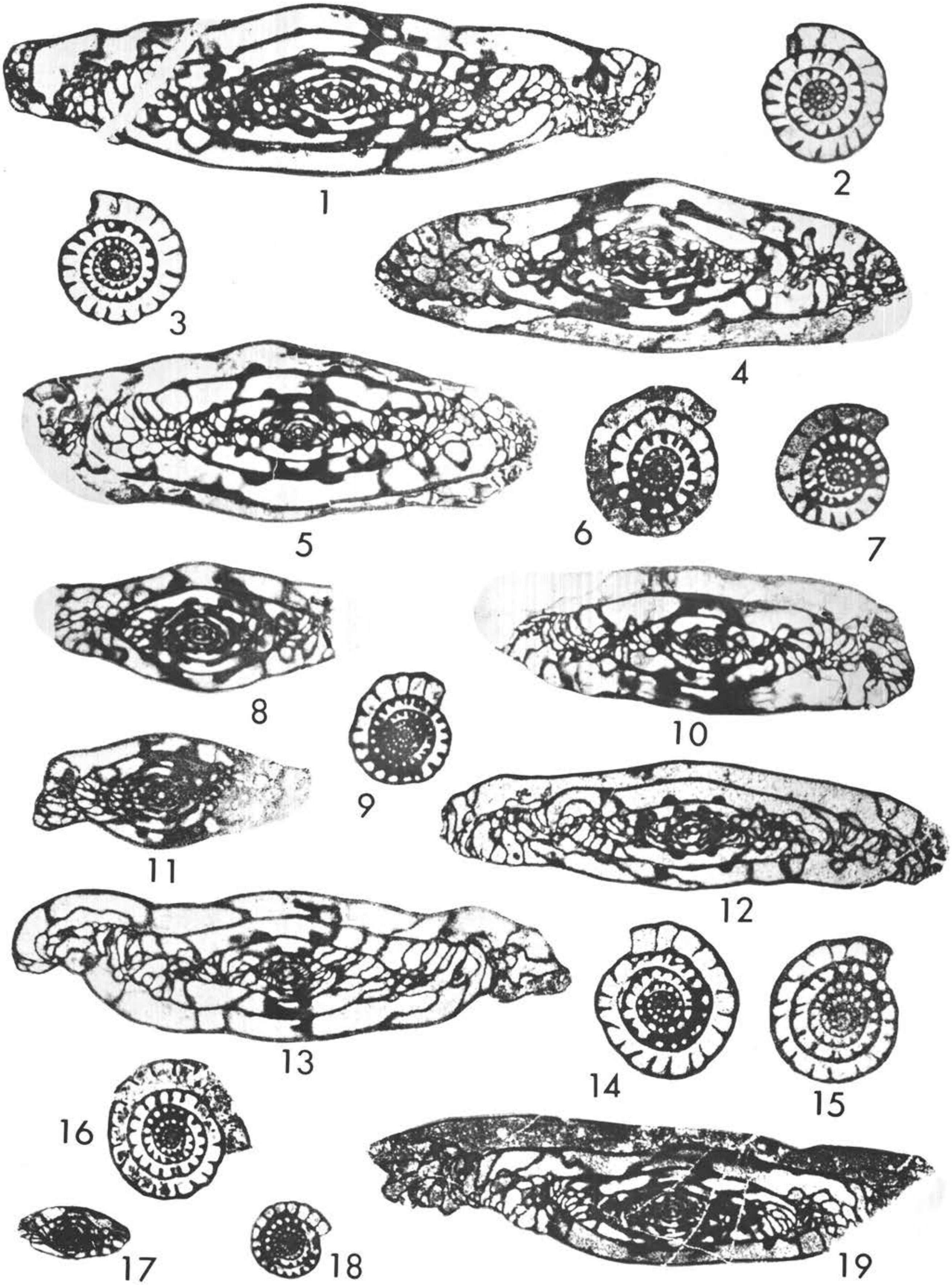
PLATE 10

(All figures x20)

Figures		*Page*
1-4	*Triticites riograndensis* Stewart, n. sp. .... 1, axial section of the holotype; 2, 3, sagittal sections of paratypes; 4, axial section of a paratype.	53
5-7, 10	*Triticites nebraskensis* Thompson .... 5, 10, axial sections; 6, 7, sagittal sections.	53
8, 9, 11	*Triticites* sp. A .... 8, 11, axial sections; 9, sagittal section.	54
12-16, 19	*Triticites liosepta* Stewart, n. sp. .... 12, axial section of the holotype; 13, 19, axial sections of paratypes; 14-16, sagittal sections of paratypes.	54
17, 18	*Triticites* sp. B .... 17, axial section; 18, sagittal section.	55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Appendix

CATALOG OF ILLUSTRATED SPECIMENS

The following is a list of the catalog numbers of the specimens illustrated in this report. All specimens are in the paleontological collections of Texaco Inc., Divisional Paleontological Laboratory, Midland, Texas. Type specimens are identified as H or P, for holotype or paratype, respectively. Occurrences given in the column labeled "bed" refer to figures 6-9 in the text.

CATALOG NO.	TYPE	PLATE & FIGURE		BED
Beedeina insolita (Thompson)				
TT Co. 1009-84		4	11	
TT Co. 1009-85		4	12	
TT Co. 1009-86		4	13	
TT Co. 1009-87		4	14	JH4-6c
TT Co. 1009-88		4	15	JH3-13
TT Co. 1009-89		4	16	
TT Co. 1009-90		4	17	
TT Co. 1009-91		4	18	
TT Co. 1009-92		4	19	
Beedeina joyitaensis Stewart, n. sp.				
TT Co. 1009-112	H	6	1	JH1-21
TT Co. 1009-113	P	6	2	
TT Co. 1009-114	P	6	3	
TT Co. 1009-115	P	6	4	
TT Co. 1009-116	P	6	5	JH3-16
TT Co. 1009-117	P	6	6	
TT Co. 1009-118	P	6	7	
TT Co. 1009-119	P	6	8	
Beedeina cf. *B. novamexicana* (Needham)				
TT Co. 1009-103		5	11	JH1-19
TT Co. 1009-104		5	15	
Beedeina pattoni (Needham)				
TT Co. 1009-105		5	12	JH1-17
TT Co. 1009-106		5	13	
TT Co. 1009-107		5	14	
TT Co. 1009-108		5	16	
TT Co. 1009-109		5	17	
TT Co. 1009-110		5	18	
TT Co. 1009-111		5	19	
Beedeina pristina (Thompson)				
TT Co. 1009-93		5	1	JH1-13
TT Co. 1009-94		5	2	
TT Co. 1009-95		5	3	
TT Co. 1009-96		5	5	
TT Co. 1009-97		5	6	JH2-13
Beedeina cf. *B. socorroensis* (Needham)				
TT Co. 1009-98		5	4	JH2-23
TT Co. 1009-99		5	7	
TT Co. 1009-100		5	8	JH1-21
TT Co. 1009-101		5	9	
TT Co. 1009-102		5	10	
Eostaffella spp.				
TT Co. 1009-1		1	1	
TT Co. 1009-2		1	2	JH2-19
TT Co. 1009-3		1	3	JH3-10
TT Co. 1009-4		1	4	
Eowaeringella joyitaensis Stewart				
TT Co. 1009B-1	H	9	16	
TT Co. 1009B-4	P	9	15	
Eowaeringella kottlowskii Stewart				
TT Co. 1009A-1	H	9	9	JH2-29
TT Co. 1009A-2	P	9	10	
Eowaeringella ultimata var. *inflata* Stewart				
TT Co. 1009A-9	H	9	13	JH1-34
TT Co. 1009A-11	P	9	14	
Eowaeringella ultimata var. *magna* Stewart				
TT Co. 1009A-5	H	9	12	JH1-34
TT Co. 1009A-6	P	9	11	
Frumentella exempla Stewart				
TT Co. 1009-26		2	7	JH1-13
TT Co. 1009-27		2	8	
TT Co. 1009-28		2	9	
TT Co. 1009-29		2	10	
TT Co. 1009-30		2	11	
Fusiella texana Stewart				
TT Co. 1009-12		1	12	JH3-15
TT Co. 1009-13		1	13, 16	JH1-17
TT Co. 1009-14		1	14	
TT Co. 1009-15		1	15	
Fusulinella cf. *F. acuminata* Thompson				
TT Co. 1009-59		3	17	
TT Co. 1009-60		3	20	
Fusulinella devexa Thompson				
TT Co. 1009-74		4	1	JH3-12
TT Co. 1009-75		4	2	
TT Co. 1009-76		4	3	
Fusulinella cf. *F. famula* Thompson				
TT Co. 1009-71		3	26	JH1-11c
TT Co. 1009-72		3	27	
TT Co. 1009-73		3	28	JH3-12
Fusulinella iowaensis Thompson				
TT Co. 1009-77		4	4	JH2-10
TT Co. 1009-78		4	5	
TT Co. 1009-79		4	6	JH1-11c
TT Co. 1009-80		4	7	
TT Co. 1009-81		4	8	
TT Co. 1009-82		4	9	
TT Co. 1009-83		4	10	
Fusulinella juncea Thompson				
TT Co. 1009-67		3	22	JH2-11
TT Co. 1009-68		3	23	
TT Co. 1009-69		3	24	
TT Co. 1009-70		3	25	
Parafusulinella mexicana Stewart, n. sp.				
TT Co. 1143V-149	H	8	3, 13, 14	
TT Co. 1143V-150	P	8	4	
TT Co. 1143V-151	P	8	5	
TT Co. 1143V-152	P	8	6	
TT Co. 1143V-153	P	8	7	
TT Co. 1143V-154	P	8	8	
TT Co. 1143V-155	P	8	9, 15	
TT Co. 1143V-156	P	8	10	
TT Co. 1143V-157	P	8	11	
TT Co. 1143V-158	P	8	12	
TT Co. 1143V-159	P	8	16	

CATALOG NO.	TYPE	PLATE & FIGURE		BED
Parafusulinella propria Stewart, n. gen., n. sp.				
TT Co. 1009-138	H	7	19	JH1-17
		8	1, 2	
TT Co. 1009-139	P	7	20	
TT Co. 1009-140	P	7	21	
TT Co. 1009-141	P	7	22	
TT Co. 1009-142	P	7	23	
TT Co. 1009-143	P	7	24	
TT Co. 1009-144	P	7	25	JH2-17
TT Co. 1009-145	P	7	26	
TT Co. 1009-146	P	7	27	
TT Co. 1009-147	P	7	28	
TT Co. 1009-148	P	7	29	
Plectofusulina coelocamara Stewart, n. sp.				
TT Co. 1009-21	H	2	1	JH1-35
TT Co. 1009-22	P	2	2	
TT Co. 1009-23	P	2	3	
TT Co. 1009-24	P	2	5	
TT Co. 1009-25	P	2	6	
Plectofusulina franklinensis Stewart				
TT Co. 1009-37		2	16	JH1-13
TT Co. 1009-38		2	17	JH2-13
TT Co. 1009-39		2	19	JH1-19
Plectofusulina fusiformis Stewart, n. sp.				
TT Co. 1009-31	H	2	13	JH3-14
TT Co. 1009-32	P	2	4	JH2-13
TT Co. 1009-33	P	2	12	JH1-17
TT Co. 1009-34	P	2	14	
TT Co. 1009-35	P	2	15	
TT Co. 1009-36	P	2	18	
Plectofusulina rotunda Stewart, n. sp.				
TT Co. 1009-16	H	1	17	JH2-13
TT Co. 1009-17	P	1	18	
TT Co. 1009-18	P	1	19	
TT Co. 1009-19	P	1	20	
TT Co. 1009-20	P	1	21	
Profusulinella sp. A				
TT Co. 1009-40		2	20	JH1-10
TT Co. 1009-41		2	21	
TT Co. 1009-42		2	22	JH3-10
TT Co. 1009-43		2	23	
TT Co. 1009-44		2	24	JH2-9
TT Co. 1009-45		2	25	
Profusulinella sp. B				
TT Co. 1009-46		3	1	JH4-5
TT Co. 1009-47		3	2	JH4-6a
TT Co. 1009-48		3	3	
TT Co. 1009-49		3	5	
TT Co. 1009-50		3	6	JH3-11
TT Co. 1009-51		3	7	
Profusulinella sp. C				
TT Co. 1009-52		3	4	JH1-9
TT Co. 1009-53		3	8	
TT Co. 1009-54		3	9	
TT Co. 1009-55		3	10	
TT Co. 1009-56		3	11	
TT Co. 1009-57		3	13	
TT Co. 1009-58		3	12	JH3-10
Profusulinella sp. D				
TT Co. 1009-61		3	14	JH1-9
TT Co. 1009-62		3	15	
TT Co. 1009-63		3	16	

CATALOG NO.	TYPE	PLATE & FIGURE		BED
Pseudostaffella needhami Thompson				
TT Co. 1009-5		1	5	JH4-5
TT Co. 1009-6		1	6	JH2-19
TT Co. 1009-7		1	7	
TT Co. 1009-8		1	8	
TT Co. 1009-9		1	9	
TT Co. 1009-10		1	10	JH2-9
TT Co. 1009-11		1	11	JH3-12
Triticites liosepta Stewart, n. sp.				
TT Co. 1009-179	H	10	12	JH1-37
TT Co. 1009-180	P	10	13	JH1-37
TT Co. 1009-181	P	10	14	JH1-37
TT Co. 1009-182	P	10	15	JH1-37
TT Co. 1009-183	P	10	16	JH1-37
TT Co. 1009-184	P	10	19	JH1-37
Triticites nebraskensis Thompson				
TT Co. 1009-172		10	5	JH1-37
TT Co. 1009-173		10	6	JH1-37
TT Co. 1009-174		10	7	JH1-37
TT Co. 1009-175		10	10	JH1-37
Triticites riograndensis Stewart, n. sp.				
TT Co. 1009-168	H	10	1	JH1-37
TT Co. 1009-169	P	10	2	JH1-37
TT Co. 1009-170	P	10	3	JH1-37
TT Co. 1009-171	P	10	4	JH1-37
Triticites sp. A				
TT Co. 1009-176		10	8	JH1-37
TT Co. 1009-177		10	9	JH1-37
TT Co. 1009-178		10	11	JH1-37
Triticites sp. B				
TT Co. 1009-185		10	17	JH1-37
TT Co. 1009-186		10	18	JH1-37
Wedekindellina alveolata Stewart, n. sp.				
TT Co. 1009-127	H	7	9	JH2-18
TT Co. 1009-128	P	7	8	JH1-17
TT Co. 1009-129	P	7	10	
TT Co. 1009-130	P	7	11	
TT Co. 1009-131	P	7	12	
TT Co. 1009-132	P	7	15	
Wedekindellina elongata Stewart, n. sp.				
TT Co. 1009-120	H	7	1	JH2-23
TT Co. 1009-121	P	7	2	JH1-21
TT Co. 1009-122	P	7	3	
TT Co. 1009-123	P	7	4	
TT Co. 1009-124	P	7	5	
TT Co. 1009-125	P	7	6	
TT Co. 1009-126	P	7	7	
Wedekindellina euthysepta (Henbest)				
TT Co. 1009-160		9	1	
TT Co. 1009-161		9	2	
TT Co. 1009-162		9	3	
TT Co. 1009-163		9	4	JH1-21
TT Co. 1009-164		9	5	JH3-16
Wedekindellina excentrica (Roth and Skinner)				
TT Co. 1009-133		7	13	JH2-17
TT Co. 1009-134		7	14	
TT Co. 1009-135		7	16	JH1-13
TT Co. 1009-136		7	17	JH2-13
TT Co. 1009-137		7	18	
Wedekindellina cf. *W. minuta* (Henbest)				
TT Co. 1009-165		9	6	
TT Co. 1009-166		9	7	
TT Co. 1009-167		9	8	

Index

Numbers in **boldface** indicate main sections.