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CHITINOZOANS IN THE SUBSURFACE LOWER PALEOZOIC OF WEST TEXAS

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ABSTRACT

Studies based on both comprehensive sample analysis and electric logs substantially facilitate dating, subdivision, and environmental interpretation of the subsurface pre-Woodford section in West Texas. Acid-insoluble chitinozoans are shown to occur in sufficient quality and quantity to aid in subdividing well sections where the rarely occurring corals, brachiopods, and ostracodes are lacking. About half of the composite cutting samples processed yielded chitinozoans.

Angochitina was found only in the Devonian. *Ancyrochitina,* a long-ranging (Ordovician through Devonian) genus, has distinctive species that can be utilized. A long-necked form seems prevalent at one level in the Silurian and has a widespread though rare occurrence. *Conochitina* and *Rhabdochitina* are restricted to the Middle and Upper Ordovician in West Texas. *Lagenochitina* and *Sphaerochitina* are long-ranging forms needing additional study before species are of much value in correlation. Associated acid-insoluble microfossils are graptolite siculae, scolecodonts, and acritarchs ("hystrichosphaerids").

INTRODUCTION

Very little has been published on the practical zonations and facies framework essential for understanding adequately the regional history of the lower Paleozoic section in the Permian basin of West Texas (Fig. 1). This is due, in part, to uncertainties in correlation resulting from rapid facies changes within some subsurface units and, more especially, to the seeming lack of diagnostic fossils in the sections of micritic limestone, dolomite, chert, and shale. The present report indicates, however, that an integration of sample lithologic and paleontologic analysis with electric-log correlations makes practical the better understanding of the regional framework that is so important in our search for oil and gas.

The objectives of the present study on the subsurface pre-Woodford section of West Texas (Fig. 2), represented mainly by cutting samples, were to interpret the age of the rock units, obtain a zonation that is applicable in sections representing differing depositional environments, and to determine which fossils or groups of fossils are best suited to aid in solving correlation problems in the area.

In the Permian basin, electric logs of several types are used extensively in correlating the pre-Woodford section, and lithology is used to a lesser degree. The main fossils conventionally used in this section are corals, brachiopods, conodonts, stromatoporoids, and ostracodes. These forms are exceedingly useful for dating and interpreting environments of deposition, but many well sections or areas lack them. Thus, problems, such as the precise age of the Devonian chert,

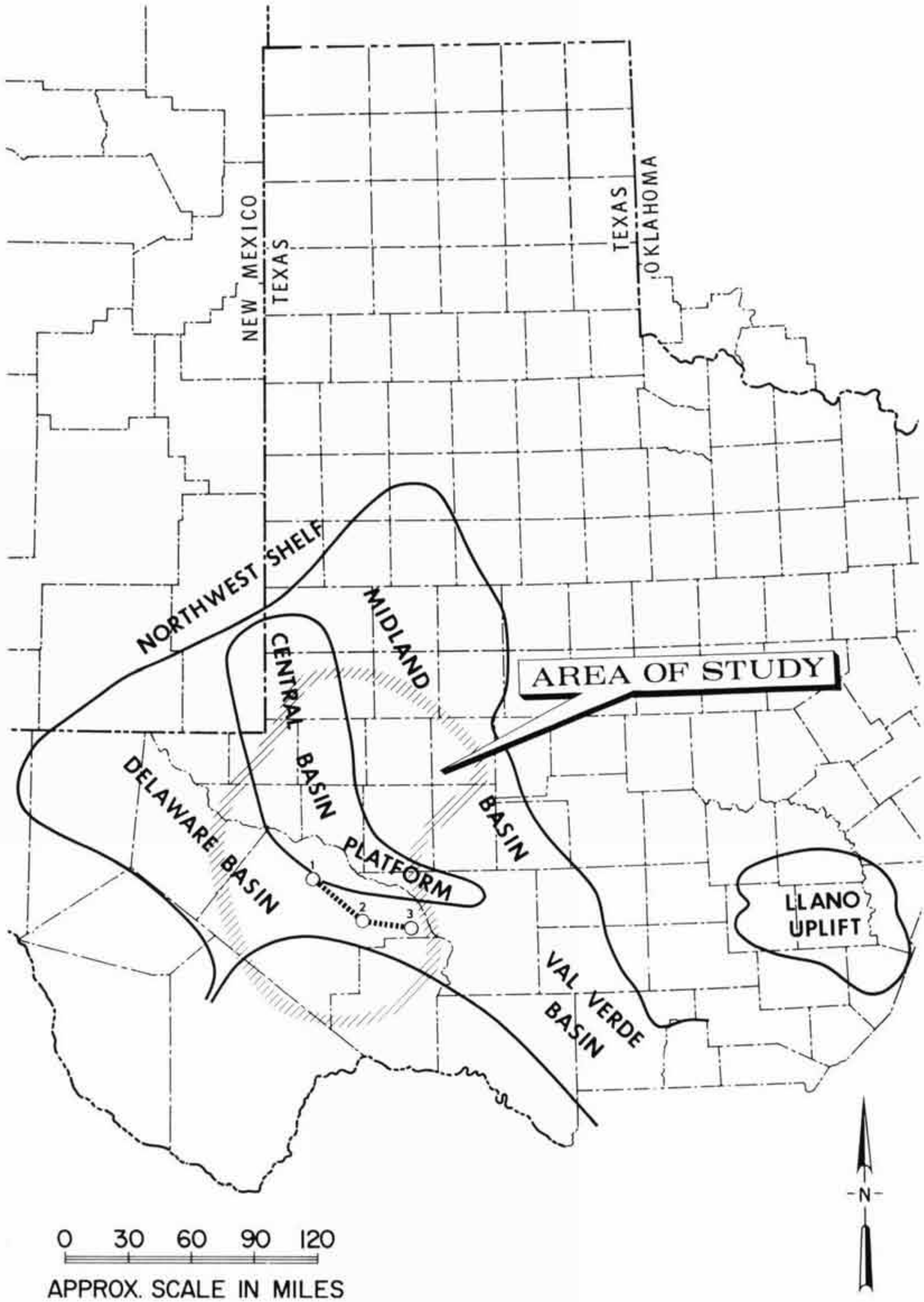


FIG. 1. Area of study, major structural and depositional features, and position of cross section.

SYSTEM	SERIES	GROUP	FORMATION	MEMBER OR ZONE	PAY ZONE
MISSISSIPPIAN	Kinderhook		WOODFORD		
DEVONIAN		HUNTON	DEVONIAN		Devonian
SILURIAN	Middle		SILURIAN SHALE		
			FUSSELMAN		FUSSELMAN
	Lower		"ALEXANDRIAN"		
ORDOVICIAN	Upper	SYLVAN MONTOYA			Montoya
	Middle	SIMPSON	BROMIDE		
			TULIP CREEK	McKEE	McKee sand
			McLISH	WADDELL	Waddell sand
			OIL CREEK	CONNELL	Connell sand
			JOINS		
	Lower	ELLENBURGER			Ellenburger
CAMBRIAN					
PRECAMBRIAN					

FIG. 2. Terminology applied in petroleum exploration to the lower Paleozoic section in the Permian basin, West Texas.

the local presence or absence of Silurian Fusselman, and the position of the Montoya-Simpson contact locally, have persisted for many years.

This sparsity or lack of diagnostic conventional fossils indicated that new approaches were required for resolving subsurface problems. Chitinozoans and associated acid-insoluble microfossils were tried first because JEFFORDS & MILLER (personal communications, 1962-68) had directed attention on the value of these forms as stratigraphic indicators in the subsurface lower Paleozoic of West Texas and Oklahoma. They showed, for example, the advantages of using abundantly occurring chitinozoans rather than the smaller conventional palynomorphs and demonstrated the subsurface occurrence of chitinozoans locally in this area.

Chitinozoans are small, flasklike, cylindrical, spherical, and globose microfossils of uncertain biologic affinities. They are minute, ranging in size from 50 μ to approximately 1 mm, averaging 100-200 μ. These forms are relatively abundant in many types of marine sediments from the Lower Ordovician to the uppermost Devonian. In West Texas, they range from the Middle Ordovician Simpson group through the Upper Devonian. No forms have been found in the Lower Ordovician Ellenburger to date.

The application of chitinozoans to biostratigraphic phases of petroleum exploration is not new (TAUGOURDEAU & JEKHOWSKY, 1960; JODRY & CAMPAU, 1961) but has been most extensive in northern Africa. About 40 genera and several hundred species have been described with about half the studies being published after 1962 (LANGE, 1949, 1952; COLLINSON & SCOTT, 1958; TAUGOURDEAU, 1966; TAUGOURDEAU AND OTHERS, 1967; COMBAZ AND OTHERS, 1967; EISENACK, 1968). Species, however, commonly are rather broadly defined or exceedingly difficult to recognize from published descriptions and their age significance is imprecise (JEFFORDS, 1968). Although chitinozoans have been utilized with evidently some success in several subsurface studies, the "zonations" cannot be applied in other areas without first verifying the ranges of broadly defined species and eliminating factors of purely local significance. As with many rapidly developing groups of fossils, chitinozoans are very useful in the subsurface even though the potentially precise age significance of most species presently is inadequately known. Thus, chitinozoans are not a panacea for subsurface problems in West Texas but must be applied cautiously by skilled workers.

In the present study chitinozoans have been used together with whatever other fossils were found in conjunction with known lithologic intervals and electric logs. These fossils were recovered from most lithologies. Chert, including novaculite and tripolitic types, and dark micritic limestone yield fair assemblages. Dolomite, sandstone, and reef limestone yield poor assemblages. Considering the quality and quantity of some cutting samples, the recovery success seems good. Chitinozoans sufficient for study occur in 50 to 55 percent of the samples processed.

Representative chitinozoans found during the present study are illustrated on Plates 1-16. These identifications are to rather broadly interpreted genera and a few species. Because a principal objective was to determine whether chitinozoans occur in sufficient abundance and adequate quality for application in practical subsurface problems, no detailed systematic treatment is given. Moreover, studies in applied paleontology commonly must be based on cutting samples that are subject to contamination by cavings and generally yield only moderate numbers of specimens that are inadequately preserved for detailed description. Such material, however, can be identified with respect to adequately described assemblages and can be interpreted readily by application of all facets of subsurface data.

Acknowledgment is made to Humble Oil & Refining Company for permission to publish these results. Thanks are given to Messrs. H. P. Bushnell and A. E. Miles for their encouragement; to R. M. Jeffords for editing and other assistance; to T. H. Miller for technical assistance; to J. W. Skinner for photographic assistance; to C. B. Erck, Jr., for assistance in drafting, and, finally to E. R. Olgin, Jr., an able laboratory technician.

All figured specimens are deposited in the files of Humble Oil & Refining Company, Midland, Texas.

PROCEDURES AND TECHNIQUES

Studies were planned to obtain maximum information from available cuttings samples and related records. Although cores are greatly preferred over cuttings in any stratigraphic study, drilling costs and the high-risk potential tend to discourage most coring in the deep (20,000- to 26,000-foot) lower Paleozoic section of West Texas. Thus integrated lithologic, paleontologic, and log studies were made on lower Paleozoic sections represented by cuttings from 60 wells located throughout the Delaware, Val Verde, and Midland basins and the Central Basin platform (Fig. 1). Depending on well location, the thickness of the section studied ranges from 350 to 4,000 feet.

First the lithology and fauna were described and logged systematically for each well. Insofar as possible, age and environment of deposition were interpreted. Sonic or induction logs were checked for additional information. Then composite samples were processed for acid-insoluble microfossils. As only a part of the cutting samples reasonably could be destroyed by processing, composite samples were used. Depending on the amount of samples available, they were grouped into 50- or 100-foot increments; rarely a 200-foot interval was necessary. An average composite sample was about 50 grams. Wherever possible, systemic boundaries were not crossed, and samples from 50 feet above to 50 feet below a contact were not processed. Samples were processed using techniques described by Miller (1967).

Fossils, chiefly chitinozoans, found in the samples processed from the 60 wells were studied empirically and long-ranging forms having little value were disregarded. Useful forms then were color-coded on logs, recorded, and listed on work sheets. The data sheet for each well then was attached to the electric logs, the wells correlated, and cross sections prepared (Fig. 3, 4). Scolecodonts, graptolite siculae, and acritarchs ("hystrichosphaerids") were noted and listed, but these were used only when chitinozoans were lacking.

GENERALIZED STRATIGRAPHY AND OCCURRENCE OF CHITINOZOANS AND OTHER FOSSILS

Units noted in the following discussion of the stratigraphic succession in the subsurface of West Texas are those widely recognized and applied in petroleum exploration of this and adjacent areas (Fig. 2). No attempt has been made to adjust this informal usage to agree with formal nomenclature suggested by the American Commission on Stratigraphic Nomenclature (1961).

PRECAMBRIAN

The basement complex in the subsurface underlies beds ranging in age from Cambrian through Permian. Generally speaking, igneous rocks are found in most of the Permian basin, but metamorphics occur near the extreme southern limits. The igneous rocks range from granites to granodiorite to quartz monzonites. Metamorphic rocks are considered to be in the phyllite to schist range. Precambrian residues lack chitinozoans for all wells examined.

CAMBRIAN

Cambrian rocks, where present, are differentiated readily from the overlying Ellenburger. In the eastern shelf of the Midland basin, the dominant lithology is finely grained, slightly calcareous, slightly hematitic sandstone that probably is Late Cambrian (Riley) in age. South and west of the Midland basin, Cambrian rocks penetrated in wells consist of 100 to 150 feet of medium to coarse sandstone, glauconitic limestone, and green shale. Dolomite also is present at the northern limit of the Val Verde basin. No chitinozoans have been noted in Cambrian lithologies in West Texas.

ORDOVICIAN (ELLENBURGER)

The Ellenburger in West Texas is typically cream, white, buff-brown, and gray, microcrystalline to coarsely crystalline, fractured dolomite that ranges in thickness from 300 to more than 2,000 feet. Vugs, chert, bands of finely to coarsely grained, frosted, quartz sand, and occasional gray and green shale occur. Light-colored micritic limestone is present in wells penetrating this section in the Val Verde basin and at the southern limit of the Midland basin. This limestone extends eastward toward the Llano uplift. A similar limestone is seen in well penetrations in the Northwest shelf. The subsurface Ellenburger yields a sparse fauna consisting of a few mollusks and brachiopods. Although cysts and unidentifiable forms are noted, no chitinozoans have been found during the present study in Ellenburger dolomite or limestone.

ORDOVICIAN (SIMPSON GROUP)

Rocks of Simpson age are found throughout the West Texas area. As generally accepted by operational petroleum geologists, the Simpson Group comprises the Joins Formation (limestone and dolomite); Oil Creek Formation (sandstone, shale, and limestone); McLish Formation (sandstone and limestone); Tulip Creek Formation (sandstone and limestone); and Bromide Limestone. The group ranges in thickness from less than 50 to more than 2,000 feet in the Delaware basin.

Each formation of the Simpson group contains an abundant and varied fauna; ostracodes have a predominant role in subdividing the group. In West Texas only the Bromide and Tulip Creek formations yield chitinozoans. *Conochitina* is the dominant genus and *Cyathochitina* and *Rhabdochitina* occur more rarely.

ORDOVICIAN (JOINS FORMATION)

The Joins is considered to be the basal formation of the Simpson Group. In many cases it is erroneously picked as Ellenburger because of similarity of lithology—dolomite.

The formation consists of thin limestone and shale at the surface; in the subsurface, however, the Joins becomes increasingly dolomitic and resembles the underlying Ellenburger in this respect. Joins dolomites are argillaceous and somewhat sandy, and fossil fragments are noted. In West Texas, the contact between gray-green shale and argillaceous dolomite of the Joins with the underlying clean, light Ellenburger dolomite commonly suggests little or no erosional break.

ORDOVICIAN (OIL CREEK FORMATION)

The Oil Creek Formation in surface and subsurface sections is subdivided into two members, a basal sandstone (Connel Sandstone) and upper member of interbedded limestone and shale. The sandstone is massive, white, and extremely friable; it consists of fine- to medium-grained, rounded to subrounded, frosted quartz grains. Locally in the subsurface, sandstone in the Oil Creek is silicified. Limestone is thinly bedded and contains many ostracodes. Olive-green shale is interstratified or intercalated with limestone; the shale, however, generally occurs in the upper part.

ORDOVICIAN (McLISH FORMATION)

The McLish Formation consists of a basal sandstone (Waddell Sandstone) and an overlying

EXPLANATION OF PLATES

(All figures ×250)

PLATE 1

Acid-insoluble microfossils from the Humble Oil & Refining Company No. 1 Worsham, Pecos County, Texas.——Figures 1-4, *Desmochitina* sp. from core at depth of 12,918 feet; figures 5-7, *Angochitina* sp. from a depth of 12,918 feet; figures 8-12, *Angochitina* sp. cf. *A. mourai* Lange, from core at depth of 12,924 feet; figure 13, scolecodont from same sample as figures 8-12; figure 14, unidentified spore from same sample as figures 8-12.

PLATE 2

Chitinozoans from cores at a depth of 12,926 feet in the same well as Plate 1.——Figures 1-5, *Angochitina* sp. cf. *A. mourai* Lange; figures 6-12, *Sphaerochitina* sp.; figures 13-14, *Desmochitina* sp.

PLATE 3

Chitinozoans from the Humble Oil & Refining Company No. 1 State AP, Andrews County, Texas.——Figure 1, *Ancyrochitina* sp. 1 from depth of 10,550 to 10,600 feet; figures 2-3, 5-6, *Angochitina mourai* Lange, from a depth of 10,700 to 10,780 feet; figure 4, *Lagenochitina* sp. from a depth of 10,700 to 10,780 feet; figures 7-10, *Angochitina devonica* Eisenack, from a depth of 10,700 to 10,780 feet; figure 11, *Angochitina globosa* Collinson & Scott, from a depth of 10,810 to 10,850 feet; figures 12, 15, *Angochitina milanensis* Collinson & Scott, 12 from a depth of 10,810 to 10,850 feet; 15 from a depth of 11,170 to 11,190 feet, and is probably a caved form; figure 13, *Sphaerochitina* sp. from a depth of 10,810 to 10,850 feet; figure 14, *Ancyrochitina cornigera* Collinson & Scott, from a depth of 10,870 to 10,890 feet.

PLATE 4

Chitinozoans from the Humble Oil & Refining Company No. 1 State AP, Andrews County, Texas (figures 1-7), and the Union Oil No. 1 Rape, Glasscock County, Texas (figures 8-9).——Figures 1-7, *Conochitina* spp. from a depth of 11,460 to 11,510 feet; figures 8-9, *Rhabdochitina* sp. from a depth of 10,710 to 10,760 feet.

PLATE 5

Chitinozoans from the Humble Oil & Refining Company No. 1 State BS, Andrews County, Texas (figures 1-11), and the Harrell No. 1 Cook, Glasscock County, Texas (figures 12-17).——Figure 1, *Angochitina milanensis* Collinson & Scott, from a depth of 9,000 to 9,050 feet; figures 2-4, *Angochitina* sp. cf. *A. mourai* Lange, from a depth of 9,100 to 9,200 feet; figure 5, *Desmochitina* sp. from a depth of 9,100 to 9,200 feet; figure 6, *Angochitina* sp. from a depth of 9,300 to 9,350 feet; figures 7-8, *Angochitina globosa* Collinson & Scott, from a depth of 9,300 to 9,350 feet; figures 9-10, *Angochitina* sp. 2, 9, from a depth of 9,300 to 9,350 feet; 10, from a depth of 9,800 to 9,830 feet; figure 11, *Angochitina?* sp. from a depth of 9,800 to 9,830 feet; figure 12, *Angochitina* sp. from a depth of 10,400 to 10,480 feet; figure 13, 15, *Sphaerochitina* sp. from a depth of 10,400 to 10,480 feet; figure 14, *Lagenochitina?* sp. from a depth of 10,400 to 10,480 feet; figures 16-17, *Desmochitina* sp. from a depth of 10,500 to 10,550 feet.

PLATE 6

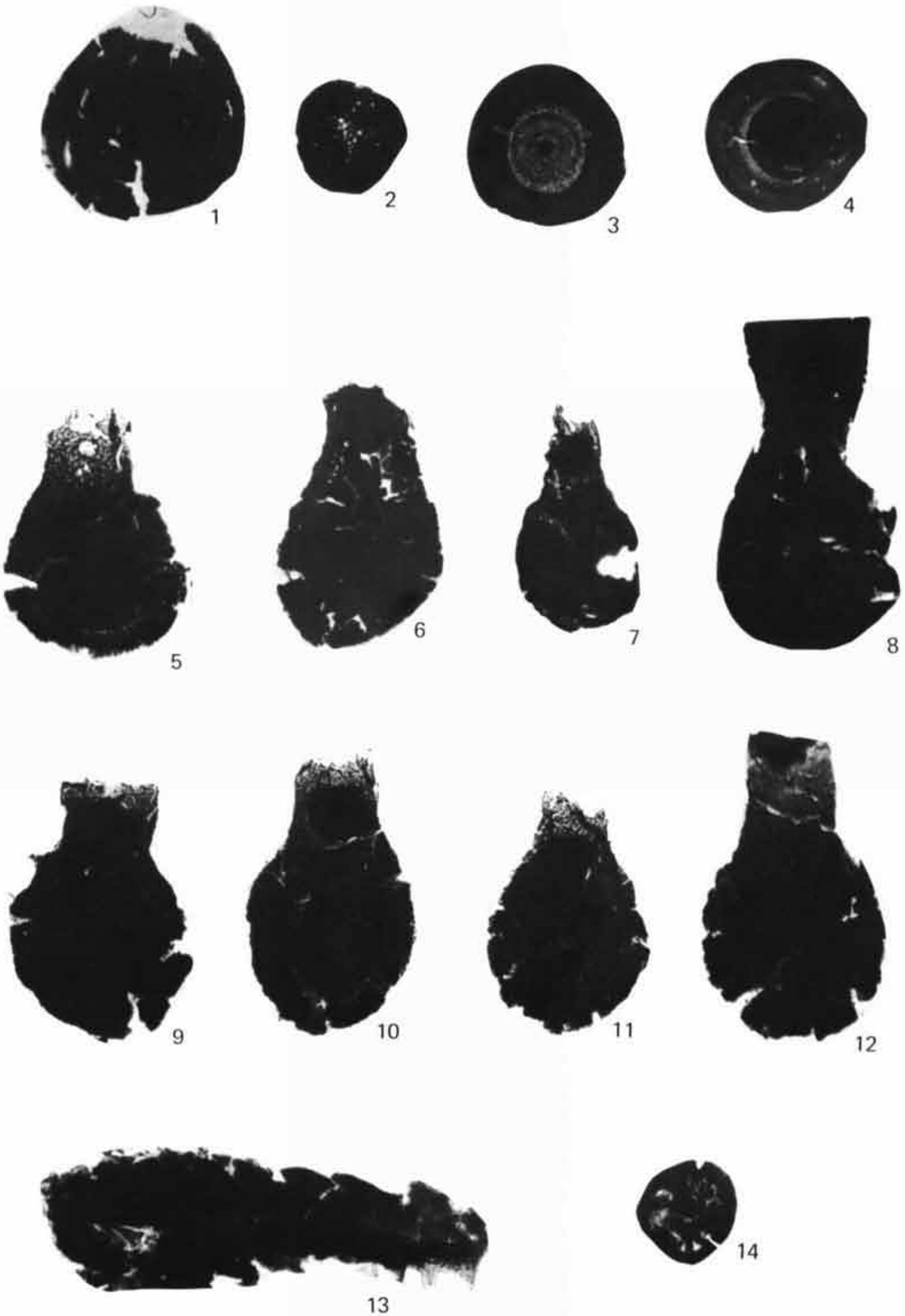
Rhabdochitina from the Harrell No. 1 Cook, Glasscock County, Texas.——Figures 1-6, *Rhabdochitina* sp. from a depth of 10,700 to 10,750 feet.

PLATE 7

Chitinozoans from the El Cinco No. 1 Hoover, Crockett County, Texas.——Figure 1, *Lagenochitina?* sp. from a depth of 12,100 to 12,200 feet; figure 2, *Sphaerochitina* sp. from a depth of 12,100 to 12,200 feet; figures 3-4, *Angochitina* sp. from a depth of 12,100 to 12,200 feet; figure 5, *Ancyrochitina* sp. from a depth of 12,100 to 12,200 feet; figures 6-7, *Conochitina* sp. from a depth of 12,300 to 12,400 feet; figures 8-9, *Rhabdochitina* sp. from a depth of 12,300 to 12,400 feet.

PLATE 8

Chitinozoans from the El Cinco No. 1 Hoover, Crockett County, Texas.——Figures 1-2, *Sphaerochitina* sp. from a depth of 12,300 to 12,400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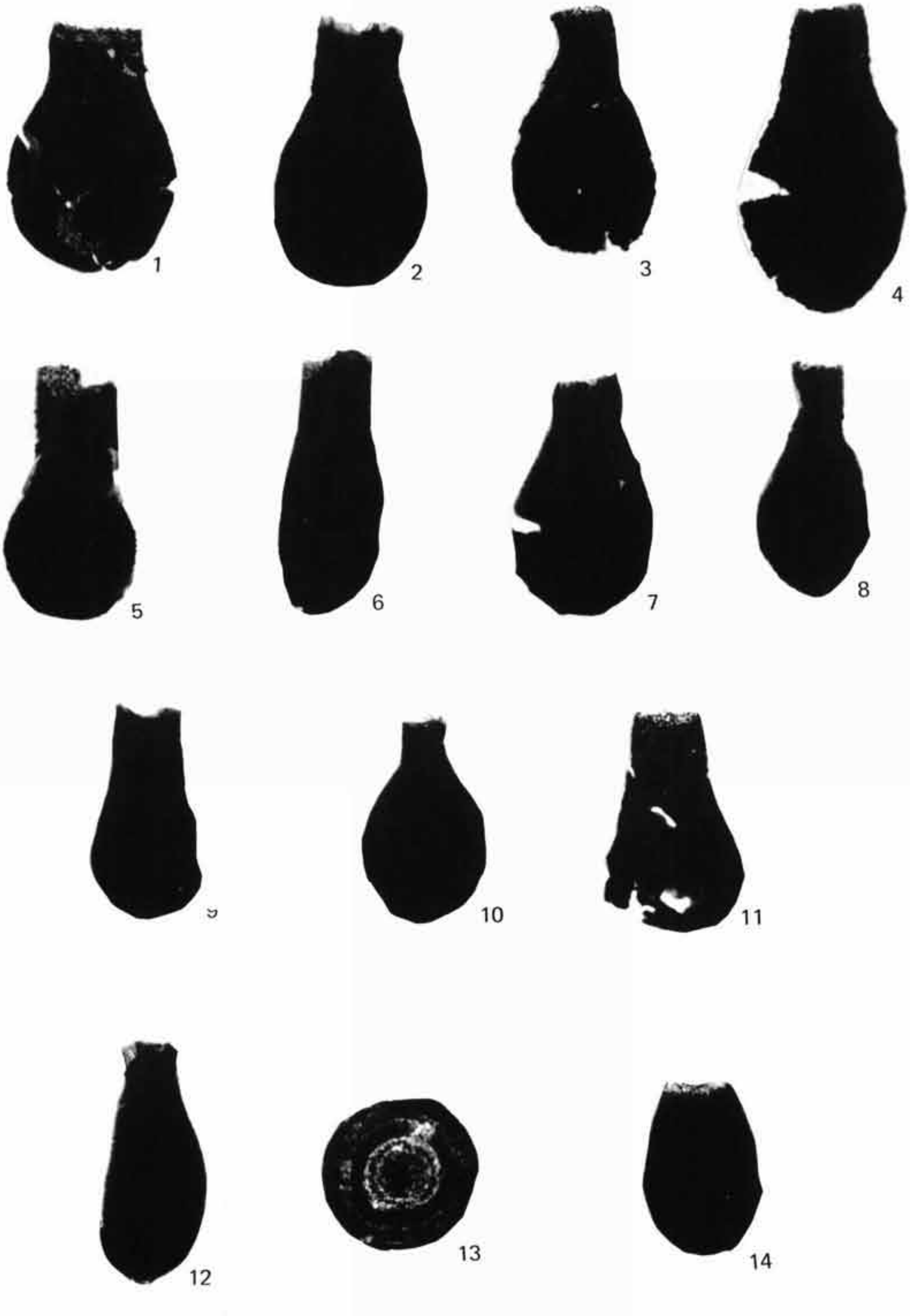
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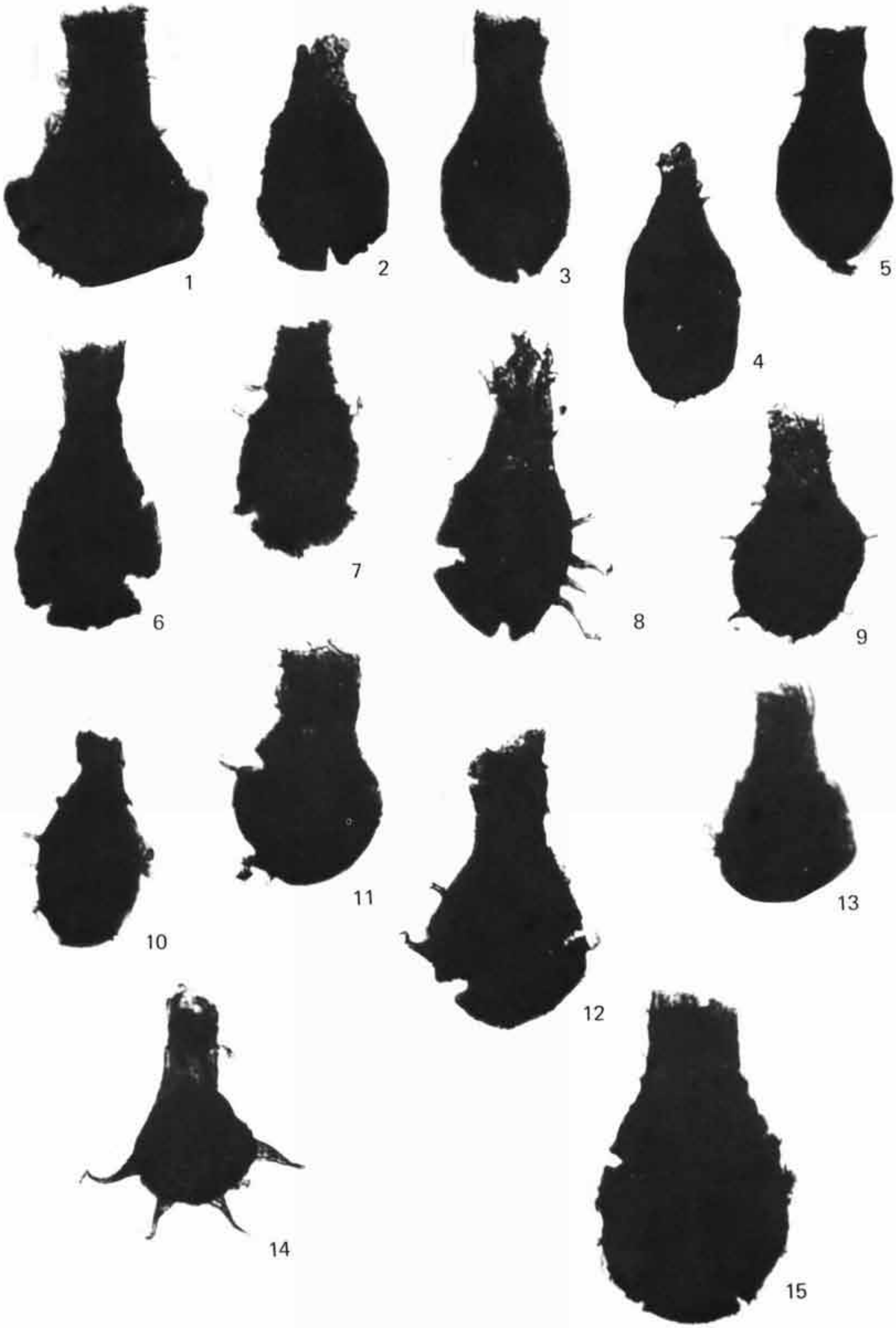
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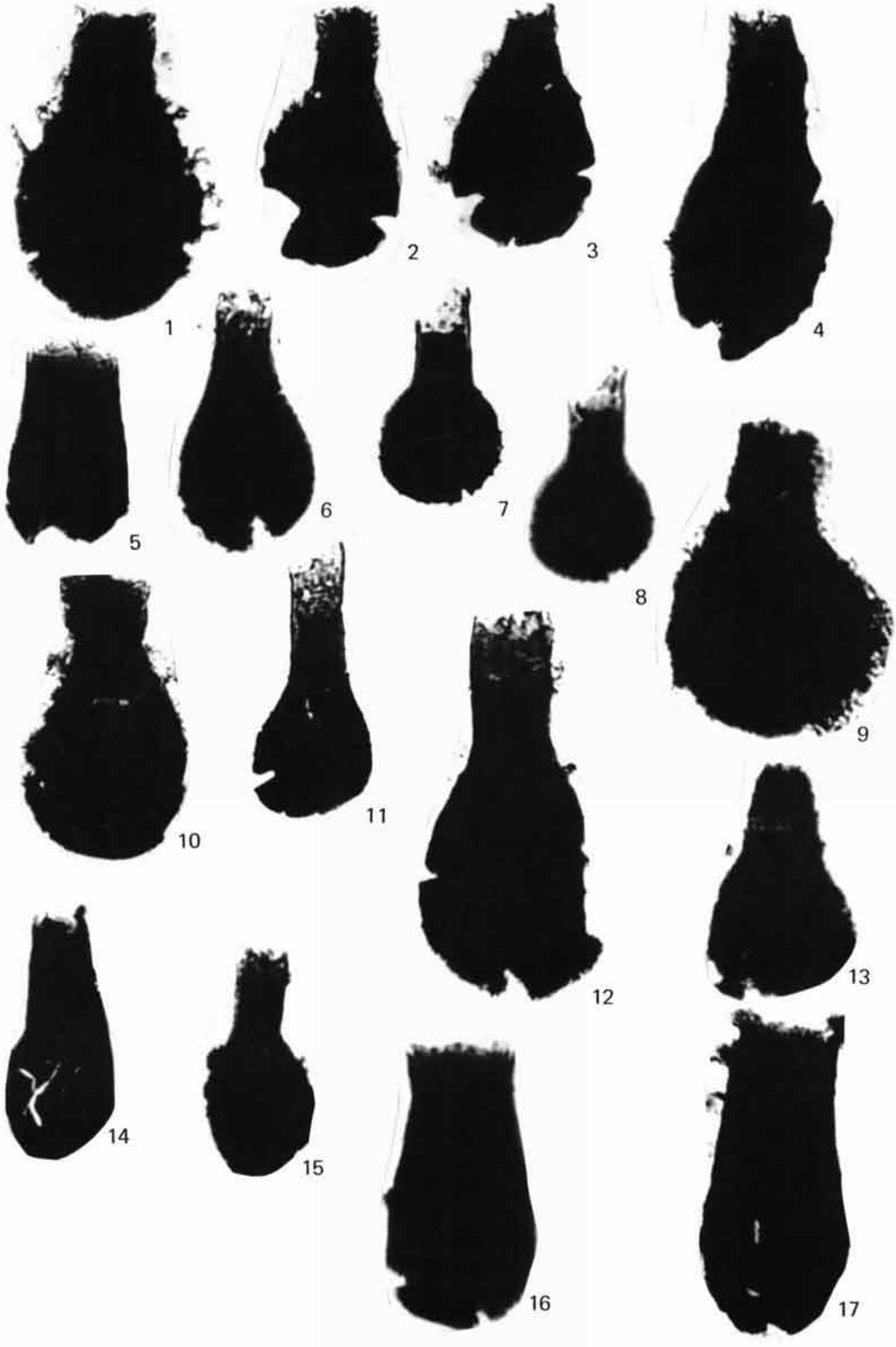
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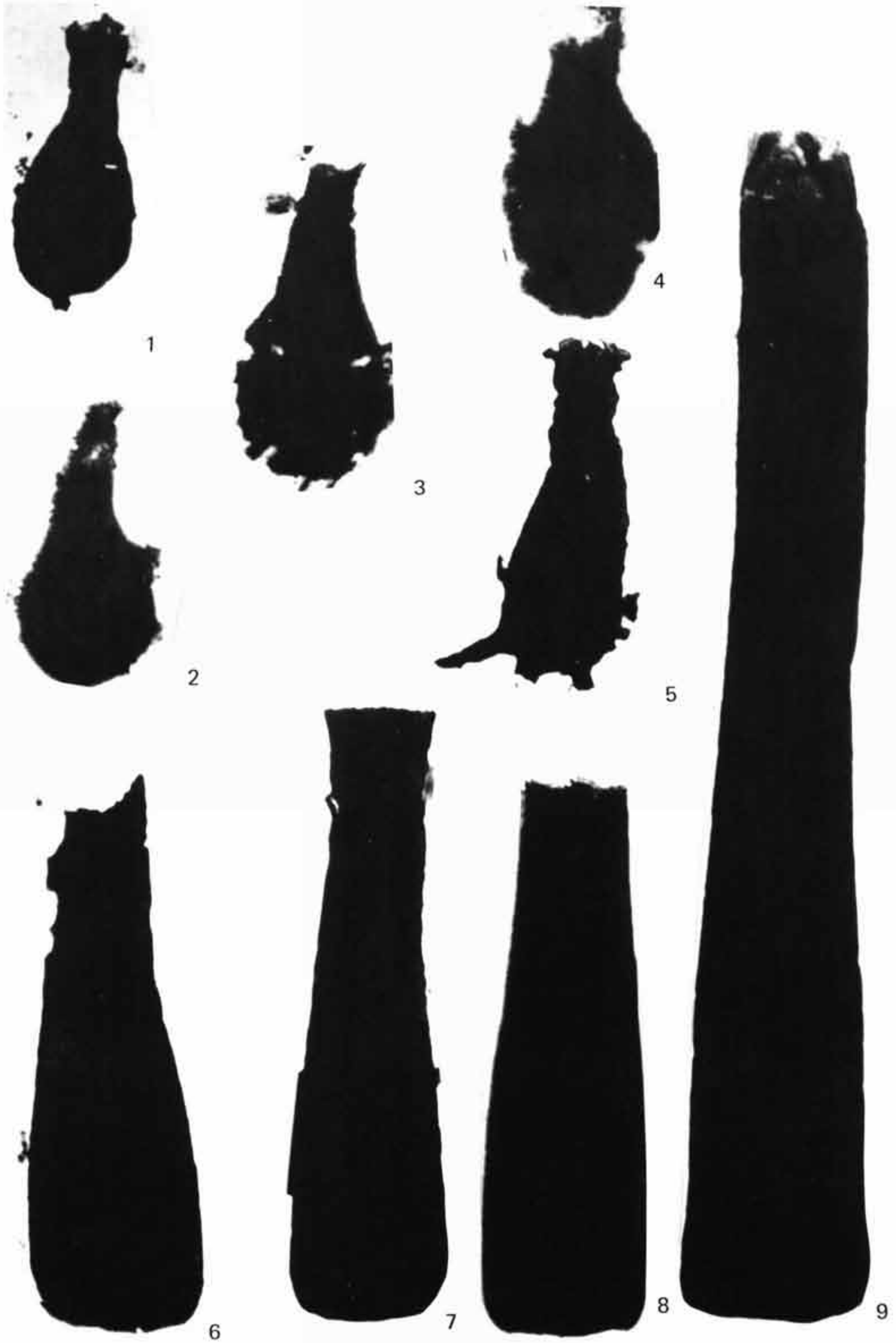
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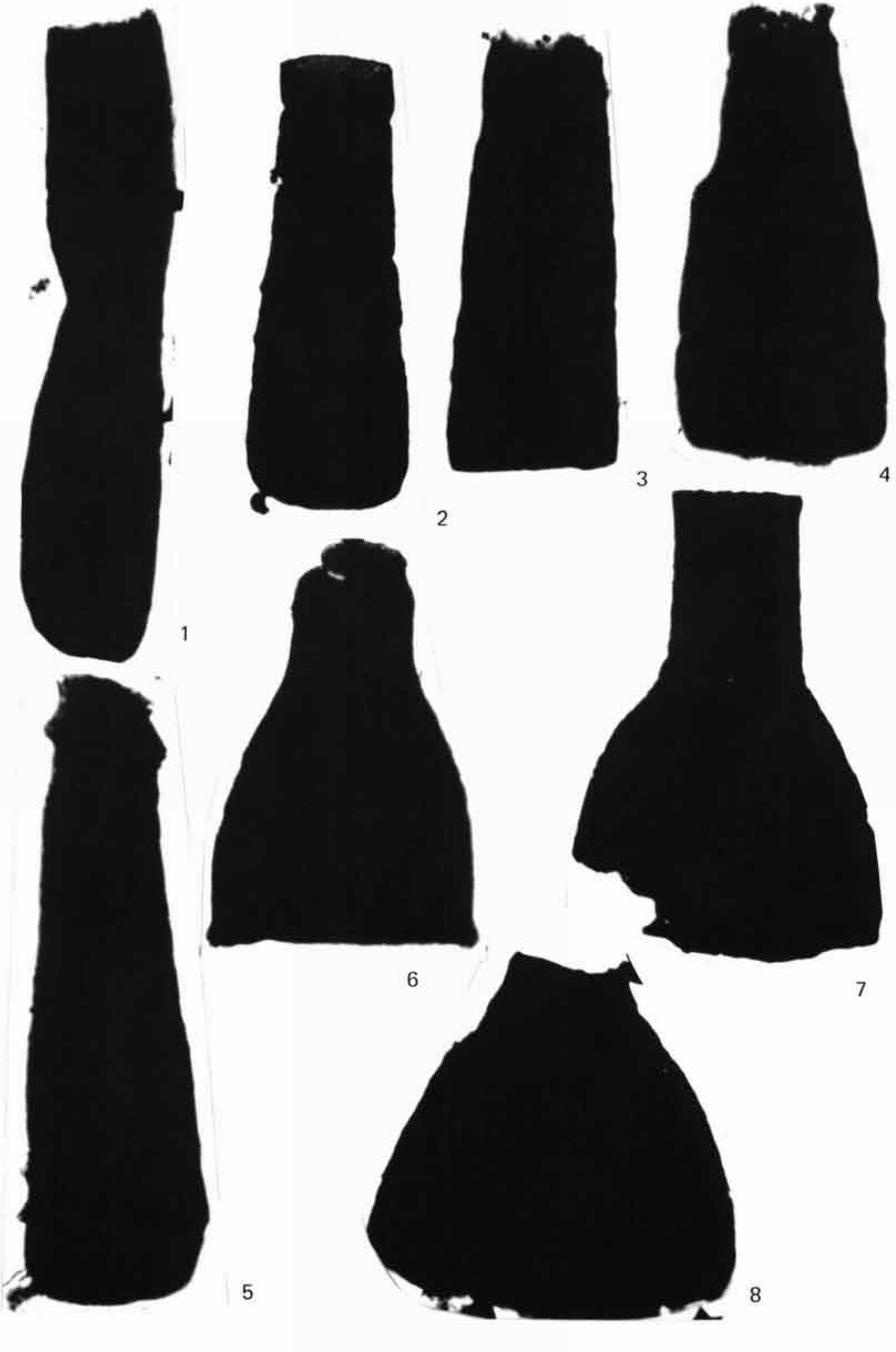
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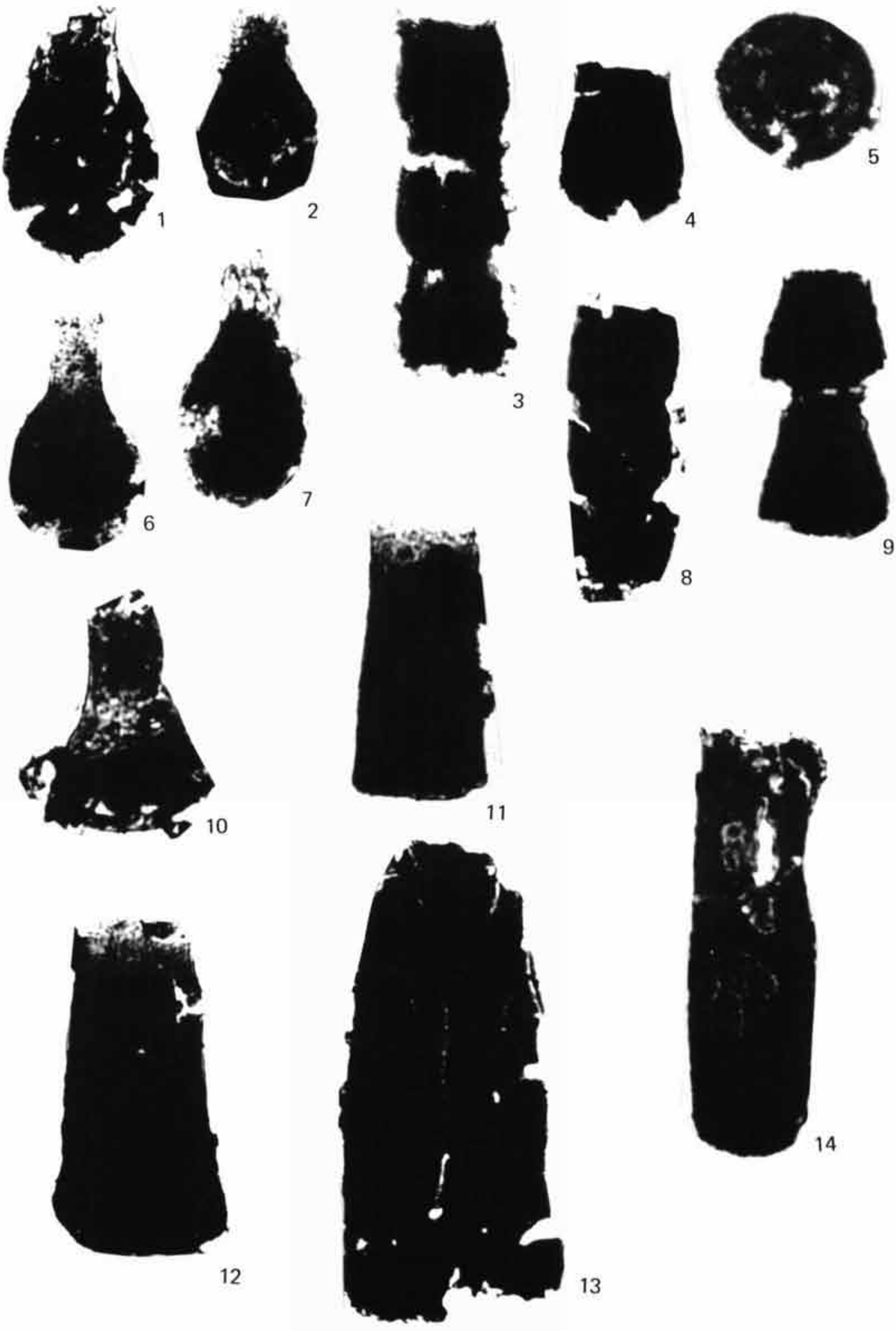
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feet; figures 3-6, *Rhabdochitina* sp. from a depth of 12,300 to 12,400 feet.

PLATE 9

Chitinozoans from the El Cinco No. 1 Hoover, Crockett County, Texas.——Figure 1, *Rhabdochitina* sp. from a depth of 12,300 to 12,400 feet; figures 2-5, *Conochitina* sp. from a depth of 12,300 to 12,400 feet; figures 6-8, *Cyathochitina* sp. from a depth of 12,300 to 12,400 feet.

PLATE 10

Chitinozoans from the Sinclair No. 1 Long (figures 1-3) and the Sinclair No. 1 Hall (figures 4-8), Glasscock County, Texas.——Figure 1, *Rhabdochitina* sp. from a depth of 9,910 to 9,950 feet; figures 2-3, *Conochitina* sp. from a depth of 9,910 to 9,950 feet; figures 4-8, *Desmochitina* sp. from a depth of 10,680 to 10,710 feet.

PLATE 11

Chitinozoans from the Phillips No. 1D Puckett, Pecos County, Texas.——Figures 1-5, *Desmochitina* sp. from a depth of 10,700 to 10,750 feet; figures 6-7, *Conochitina* sp. from a depth of 11,000 to 11,050 feet.

PLATE 12

Chitinozoans from the Standard of Texas No. 1 Montgomery, Pecos County, Texas.——Figure 1, *Angochitina* sp. from a depth of 10,900 to 10,950 feet; figure 2, *Desmochitina* sp. from a depth of 10,900 to 10,950 feet; figure 3, *Sphaerochitina* sp. aff. *S. longicollis* TAUGOURDEAU & JEKHOWSKY, from a depth of 11,100 to 11,130 feet; figures 4, 6, *Conochitina* sp. from a depth of 11,100 to 11,130 feet; figure 5, *Desmochitina* sp. from a depth of 11,100 to 11,130 feet; figures 7-9, *Conochitina* sp. from a depth of 11,150 to 11,200 feet.

PLATE 13

Conochitina from the Standard of Texas No. 1 Montgomery, Pecos County, Texas.——Figures 1-3, *Conochitina* sp. from a depth of 11,150 to 11,200 feet.

PLATE 14

Chitinozoans from the Standard of Texas No. 1 Montgomery, Pecos County, Texas.——Figures 1-4, 8-9, *Conochitina* sp. from a depth of 11,400 to 11,450 feet; figures 5-7, *Conochitina?* sp. from a depth of 11,400 to 11,450 feet; figure 10, *Cyathochitina* sp. from a depth of 11,400 to 11,450 feet; figure 11, *Rhabdochitina* sp. from a depth of 11,400 to 11,450 feet.

PLATE 15

Chitinozoans from the Humble Oil & Refining Company No. 1 Spencer, Terrell County, Texas. ——Figures 1-2, 6-7, *Angochitina* sp. from a depth of 12,500 to 12,600 feet; figures 3-5, 8-9, *Desmochitina* sp. from a depth of 12,500 to 12,600 feet; figure 10, *Ancyrochitina?* sp. from a depth of 12,650 to 12,670 feet; figures 11-14, *Conochitina* sp. from a depth of 12,700 to 12,750 feet.

PLATE 16

Chitinozoans from the Union (Pure) No. 1 Tyrrell, Pecos County, Texas (figures 1-15), and the Humble Oil & Refining Company No. 1 Blackstone-Slaughter, Terrell County, Texas (figures 16-18).——Figures 1-2, 6, *Angochitina* sp.; 1, 2, from a depth of 16,900 to 16,950 feet; 6, from a depth of 17,070 to 17,100 feet; figures 3-4, *Desmochitina* sp. from a depth of 17,070 to 17,100 feet; figures 5, 7-8, 11-13, *Angochitina* sp. cf. *A. mourai* LANGE, 5, 7-8, from a depth of 17,070 to 17,100 feet; 11-13, from cores at a depth of 17,110 feet; figures 9-10, *Lagenochitina?* sp. from a depth of 17,070 to 17,100 feet; figures 14-15, *Conochitina* sp. from a depth of 17,580 to 17,620 feet; figures 16-17, *Desmochitina* sp. from a depth of 9,500 to 9,530 feet; figure 18, *Conochitina* sp. from a depth of 9,900 to 9,950 feet.

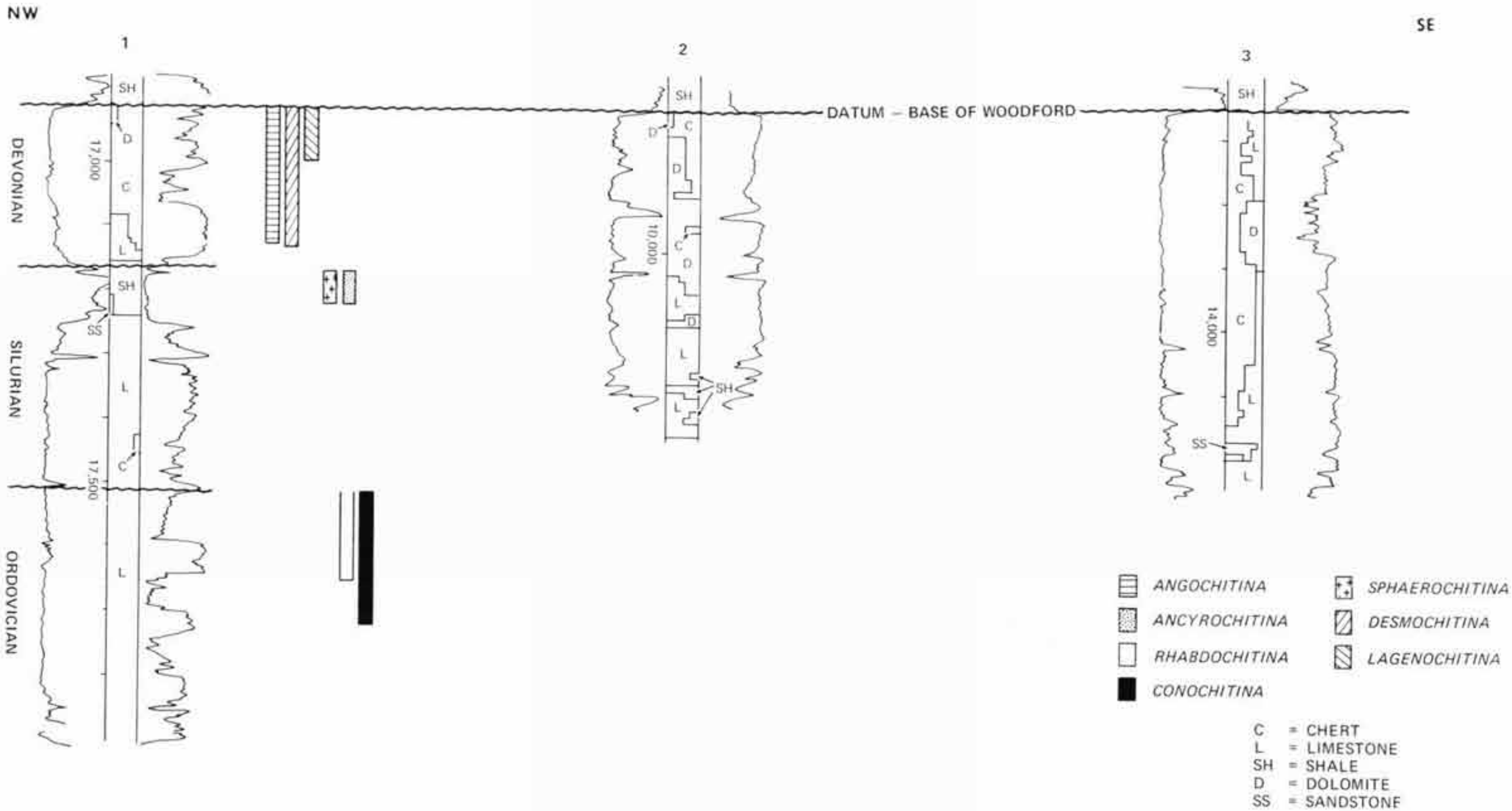

FIG. 3. Problems of correlating widely spaced well sections in the Delaware basin using physical criteria (chiefly electric logs, general lithology, and thickness). Position of section is shown on Figure 1.

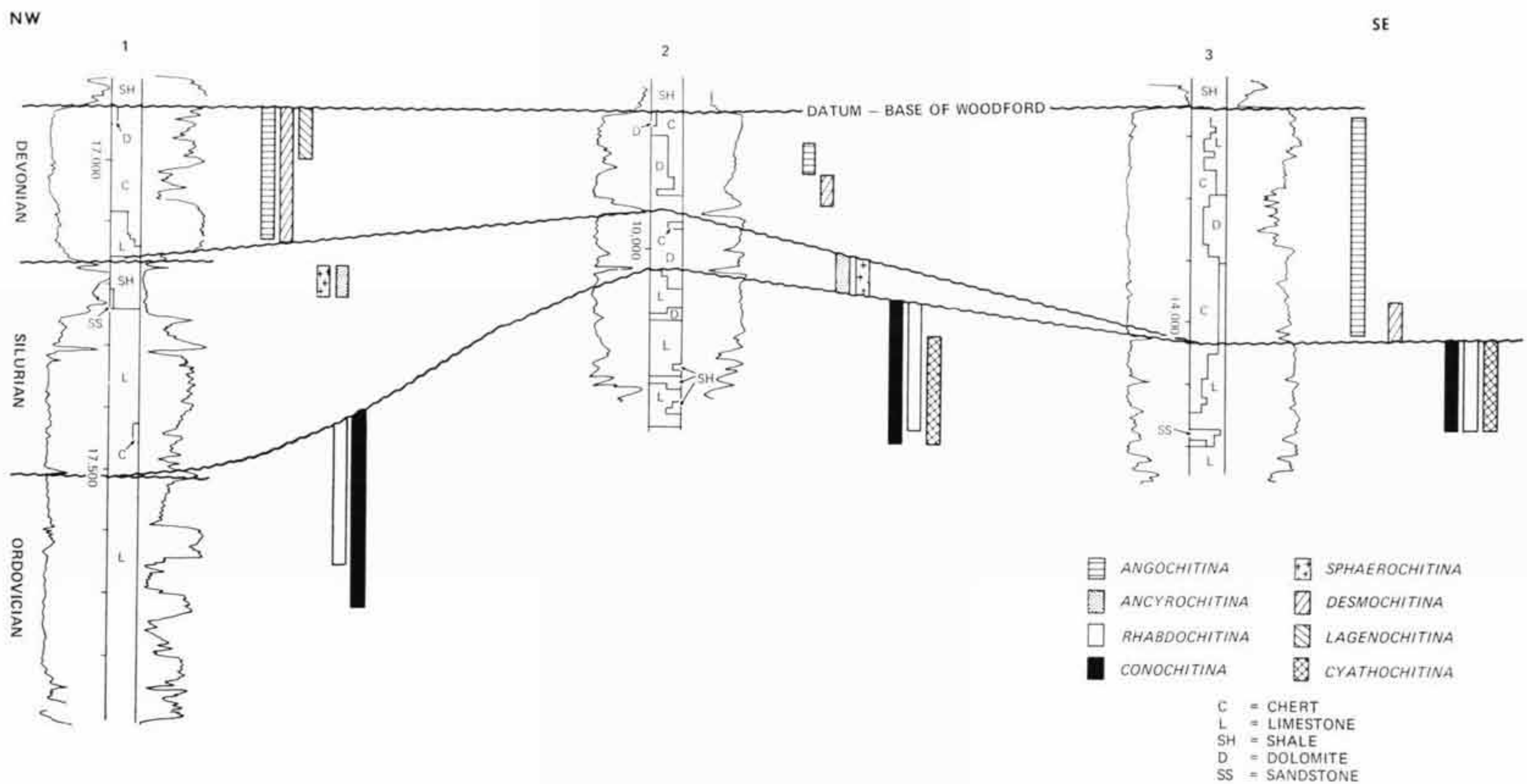

FIG. 4. Correlation of sections shown on Figure 3 based on occurrences of chitinozoans and on physical criteria.

section of thin sandstone, olive and dark green shale, and varied limestone. The sandstone is light green with finely grained, rounded to subrounded, frosted quartz grains. The limestone is gray-white to locally mottled. The "birdseye" limestone of Oklahoma is found in this formation.

ORDOVICIAN (TULIP CREEK FORMATION)

The Tulip Creek Formation consists of a basal sandstone (McKee Sandstone of West Texas and Wilcox Sandstone of Oklahoma) and an overlying section of intercalated shale and limestone. Subsurface Tulip Creek sandstones characteristically display a "salt-and-pepper" stippled appearance, the pepper (darker particles) being conodonts, phosphatic pellets, darkened aragonite, or discolored quartz grains. Olive-green and maroon shale is abundant throughout the formation. Limestone beds are thin and contain abundant schmidtellid ostracodes.

ORDOVICIAN (BROMIDE FORMATION)

The Bromide Formation consists of alternating shale, limestone, and sandstone. The sandstone is thinly bedded to massive and consists of white to buff, fine to coarse, angular to rounded quartz grains. Shales are dark green and slightly more indurated than the shale of other formations in this group.

Limestones vary in thickness and color from light gray to buff and brown, are nodular, and contain abundant ostracode and bryozoan faunas. Other fossils commonly include brachiopods, sponges, and corals.

ORDOVICIAN (MONTOYA GROUP)

In the subsurface, the Montoya is primarily brown to dark-brown micritic to micritic-skeletal limestone. Blue, light-gray, and brown to dark brown chert characteristically is scattered throughout the Montoya section. A recrystallized buff-cream micritic skeletal limestone also is present. The Montoya ranges in thickness from 0 to 600 feet.

This group is the approximate time equivalent of the subsurface Viola Group of Oklahoma and North Texas. The Bigfork chert of the Ouachita facies and Maravillas chert of the Marathon also are facies equivalents of the Montoya. The fauna of the Montoya noted in subsurface rocks includes brachiopods, trilobites, conodonts, siliceous spicules, ostracodes, and questionable radiolarians. Acid-insoluble fossils also are abundant in the Montoya strata, chitinozoan genera nant forms. The equivalent surface Viola Limestone of Oklahoma has yielded a large and varied assemblage of chitinozoans (Jenkins, 1969).

ORDOVICIAN (SYLVAN SHALE)

The Sylvan Shale, topmost unit of the Ordovician in West Texas, is gray to green, or more rarely black, pyritic, phosphatic, and locally dolomitic and cherty. In the subsurface, the Sylvan is generally sandy, dark-green, and gray. Locally this shale is difficult to separate from the overlying "Silurian green shale." In the Ouachita Mountains of Oklahoma, the Sylvan becomes the dark-green and maroon Polk Creek Shale. In the Marathon region, the Sylvan also is equivalent to the Persimmon Gap Shale.

Fossils are rare in the subsurface Sylvan, although graptolites are found abundantly in surface exposures. No chitinozoans were noted.

SILURO-DEVONIAN HUNTON

In West Texas, the terms Devonian, Silurian shale, and Fusselman have been and are still being used for appropriate lithologic parts of this section. The following simple description of the dominant lithologies of the Hunton as used includes the series or lithologic units just noted. Distribution of chitinozoans in the Silurian is variable and in places erratic. No forms were found in the Fusselman Limestone or Dolomite. Chitinozoans are notably lacking in reef facies and are sparse on the shelf to shelf margin. Dark-brown micrites of the basinal facies yield the most diverse assemblages. *Ancyrochitina* is the dominant genus of the Silurian. A small delicate species of *Conochitina* also was noted.

LOWER SILURIAN (ALEXANDRIAN)

The oldest questionable Silurian beds found in this area are isolated patches of oolitic limestone in the southern Midland basin. This section is correlated tentatively with the lower Chimneyhill of Oklahoma, giving this section a questionable Early Silurian (Alexandrian) age.

LOWER SILURIAN (FUSSELMAN FORMATION)

The next oldest Silurian found in the subsurface of West Texas is the lower Niagaran Fusselman Formation. The Fusselman encountered in the subsurface is a light-gray and white, finely to coarsely crystalline limestone or dolomite. Chert occurs sparsely as small nodular masses. The rocks locally have a pink to light-green cast. Fauna is common and consists of crinoid columnals, the corals *Halysites* and *Favosites*, and fragments of brachiopods. Dolomitization where present alters the fossils observed. The section is correlatable with the upper Chimneyhill of Oklahoma.

SILURIAN SHALE

The Silurian shale is considered the topmost unit of the Silurian in the subsurface. Timewise it is late Niagaran and correlates with the Henryhouse of Oklahoma. It is a gray-green calcareous shale with micritic to micritic-skeletal limestone near the base. Bedded chert also occurs at the base. Fossils found in this unit include *Halysites, Favosites*, stromatoporids, ostracodes, and pentamerid brachiopods.

Silurian reefs, where encountered, are characterized typically by light-gray carbonate that contains abundant stromatoporids, corals, crinoid columnals, pentamerid brachiopods, and other microfossils. Parts of these reefs are dolomitic. The inner reefal zone is a dark-brown micritic-skeletal limestone. Shelf dolomitic limestones are light-gray to a darker gray.

DEVONIAN

Devonian cherts are a variation of white to dark-brown novaculites and glassy cherts, changing facies to a buff, partially tripolitic zone, and to a buff, cream, tripolitic chert. Cherty dolomites occur in the Delaware basin. Carbonates are cream, buff, and brown micrites to micritic-crinoidal limestones. Siliceous limestone and dolomite also are present. Age determinations in this section are made using brachiopods, corals, and ostracodes; acid-insoluble fossils are used when no other fauna is present. *Angochitina* is the dominant chitinozoan of the Devonian and locally is found in association with species of *Ancyrochitina, Lagenochitina, Desmochitina*, and *Sphaerochitina*.

APPLICATION OF CHITINOZOANS TO SUPPLEMENT PHYSICAL CRITERIA IN CORRELATION

An example of the problems confronting the subsurface geologist in dating and correlating the subsurface lower Paleozoic of West Texas is shown on the cross section (Fig. 3). This section illustrates the complications encountered in correlations, using only physical criteria (i.e., electric-log patterns and lithology), between well sections lacking paleontologic data (wells No. 2 and No. 3). Well No. 1 is subdivided using both physical and paleontologic data, and even with this amount of control, insufficient clues are provided for detailed correlations to other sections in this area where marked changes occur laterally in log patterns, lithology, and thickness. Cross section (Fig. 4) shows correlation of the wells using occurrences of chitinozoan genera together with lithology and electric-log patterns. It is doubtful that the physical correlations would have been able to indicate a Devonian thickening toward the southeast or a Silurian pinchout as noted between wells No. 2 and No. 3.

SUMMARY AND CONCLUSIONS

An important result of the study here reported has been the demonstration that acid-insoluble microfossils can be recovered in sufficient quantity and quality to aid in correlation and dating.

Chitinozoans were found in most lithologies except sandstone and organic (reef) limestone. Recoveries from dolomite were sparse, although cherty dolomite yields a number of forms. Devonian chert of all types (novaculite, glassy, and tripolitic) is the most prolific in chitinozoan fossils, although tripolitic chert is less so than the other types. Recovery of acid-insoluble fossils from the Silurian is fair but poor in chitinozoans, even though cores were used in this portion of the study. Recovery was excellent in the Middle and Upper Ordovician. Forms were found in the Middle (Simpson Group) through the Upper (Montoya) part of the system. No chitinizoans were found in rocks older than Middle Ordovician.

Angochitina is the dominant genus in the Devonian and is restricted to this portion of the lower Paleozoic. Several species of *Ancyrochitina* are present, a long-necked Silurian form being the most distinctive. *Conochitina* is dominant in the Middle through Upper Ordovician; it is found abundantly in the Montoya and to a lesser degree in the Simpson. *Cyathochitina* is rare, being noted only in two wells where it ranged from the upper Simpson through the lower Montoya. *Rhabdochitina* is common in the Montoya. Its lateral occurrence is unpredictable, but it is found only in the Upper Ordovician. *Desmochitina, Lagenochitina,* and *Sphaerochitina* are long-ranging forms in the Devonian and Ordovician. Detailed description of species within these genera is necessary before they can be used as effective fossils in stratigraphic work. Scolecodonts, graptolite siculae, and hystrichosphaerids were recognized and listed but were used only when chitinozoans were not present.

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