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Selachians from the Late Cretaceous (Turonian) Atarque Sandstone Member, Tres Hermanos Formation, Sevilleta Grant, Socorro County, New Mexico

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Introduction

The Cretaceous fish faunas of North America are still poorly known (Applegate, 1970). Selachians, although not uncommon in Cretaceous rocks, are especially poorly understood and in need of extensive study (Cappetta, 1973). Although Marcou described *Ptychodus whipplei* from New Mexico as early as 1858, very little work on New Mexico Cretaceous selachians has been published.

While conducting a geologic study of Upper Cretaceous rocks exposed on the Sevilleta Grant near La Joya, Socorro County, New Mexico (Fig. 1), Bruce Baker discovered a series of fossil-rich lenses in sandstones of the lower part of the Tres Hermanos Formation (Baker, 1981). Baker and Wolberg (1981) provided an interim report on the vertebrates found at the locality. On the Sevilleta Grant, more than 396 m (1,300 ft) of Upper Cretaceous rocks overlie shales of the Dockum Formation (Upper Triassic). The Upper Cretaceous sequence consists largely of shales and sandstones and includes units from the Dakota Sandstone to the Crevasse Canyon Formation (Baker and Wolberg, 1981). The Tres Hermanos Formation overlies the Rio Salado Tongue of the Mancos Shale and underlies the D-Cross Tongue of the Mancos Shale. The fossil-rich lenses that yielded the selachians described below are found in the middle part of the Atarque Sandstone Member, the basal unit of the Tres Hermanos (Fig. 2). The stratigraphic nomenclature for the region has been revised by Hook and others (1983). In the Sevilleta Grant, the Atarque Sandstone Member varies in thickness from 3.4 m (11 ft) to 13 m (42 ft) and can be divided into lower, middle, and upper parts. The basal Atarque consists of light-gray, fine-grained, calcareous sandstones; the middle Atarque consists of yellow-orange, fine-grained, thinly bedded, calcareous sandstone with shale partings; the upper Atarque consists of very fine grained, gray-orange sandstones (Baker, 1981).

Selachians are very abundant in lenses within the middle part of the Atarque. In addition to selachian fossils, turtle shell material, crocodilian armor and teeth, and two plesiosaur teeth have been recovered. Carbonate-cemented mollusk shell material occurs abundantly as well. The vertebrate material was recovered by breaking down the rock matrix with dilute acetic and formic acids followed by washing, screening, and drying the resultant concentrate. Specimens then were picked with and without the use of a binocular microscope. ☞

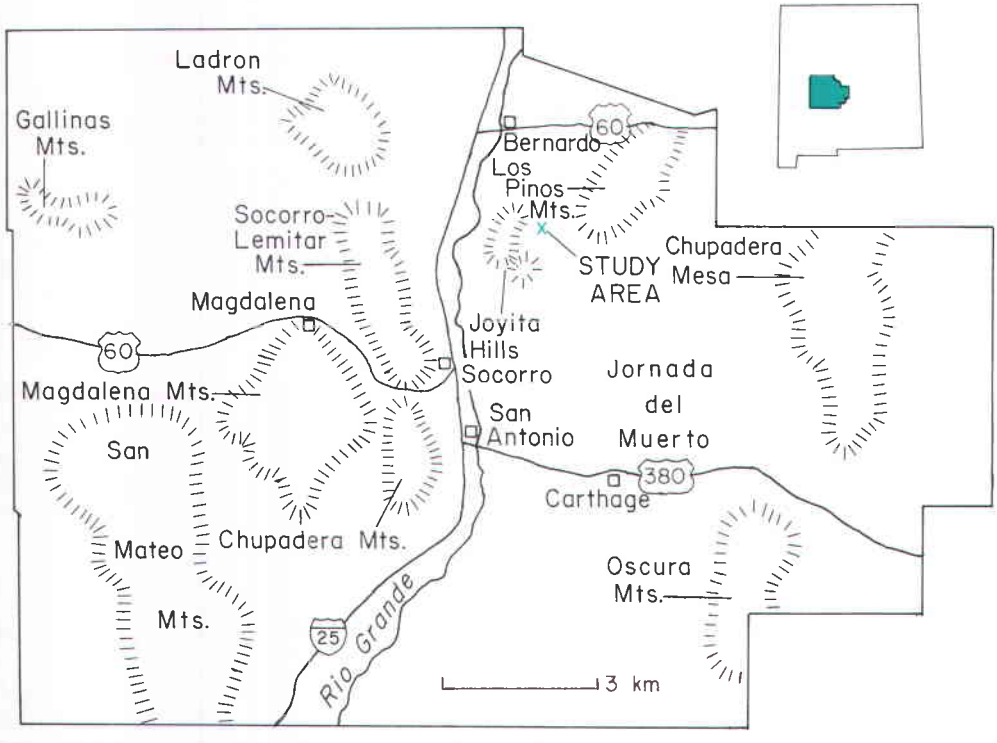

FIGURE 1—Location map of the study area, Socorro County, New Mexico (after Baker, 1981).

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Sediment sorting in gravelly megaripples from the Rio Grande
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This paper is an abbreviated version of a larger work to be published as part of a volume on Late Cretaceous paleontology (NMBMMR, Circular 195), and it attempts to acquaint the reader with the diversity of New Mexico's Cretaceous selachians; economies have been made in taxonomic descriptions and historic data for various taxa. The classification scheme used generally follows Romer (1966), Cappetta (1973), Cappetta and Case (1975), and Cappetta (pers. comm. 1984).

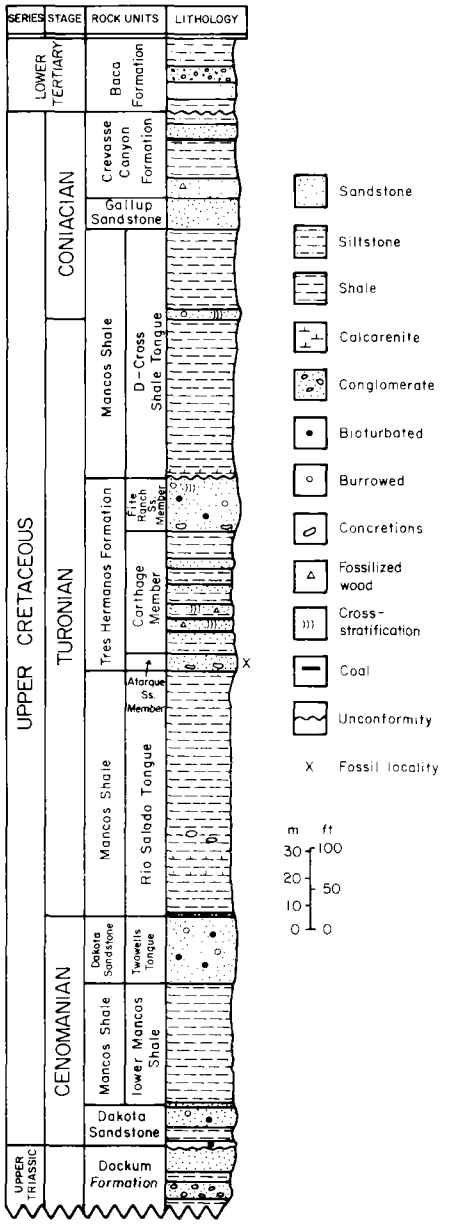

FIGURE 2—Stratigraphy of the Sevilleta Grant, Socorro County, New Mexico (after Baker and Wolberg, 1981).

Systematic paleontology

Class CHONDRICHTHYES
Subclass ELASMOBRANCHI
Order SELACHII
Suborder HYBODONTOIDEA
Family HYBODONTIDAE Owen, 1846
Genus *Hybodus* Agassiz, 1837
Hybodus sp.
Fig. 3–E

The genus *Hybodus* is a common Mesozoic form that is known from the Triassic–Cretaceous in North America (Romer, 1966). *Hybodus* is typical of hybodont sharks, a group that had a Paleozoic origin and were cosmopolitan in distribution. Hybodonts underwent their own adaptive radiation and were not at the origin of modern selachians.

Family PTYCHODONTIDAE Woodward, 1912
Genus *Ptychodus* Agassiz, 1839
Ptychodus whipplei Marcou, 1858
Fig. 3–A

P. whipplei is a very distinctive taxon, and except for *P. anonymus*, not easily confused with other species of *Ptychodus*. *P. whipplei* was first named for specimens found in the Cretaceous of New Mexico. Marcou (1858) reported *P. whipplei* from "the gray sandy marls, three miles north of Galisteo, on the road from Galisteo to Pecos, New Mexico." Distinguished by their raised crown, teeth of *Ptychodus* were adapted to crushing mollusk shells. Although the genus has a cosmopolitan distribution, *P. whipplei*, which occurs commonly when it is found, seems to be restricted to the Late Cretaceous of North America.

Ptychodus anonymus Williston, 1900
Fig. 3–C, D

P. anonymus is similar to *P. whipplei*; both taxa display strongly raised apical crowns. However, the crown of *P. anonymus* is comparatively more elongated than that of *P. whipplei* and is less acutely conical. Like *P. whipplei*, *P. anonymus* is restricted to the Late Cretaceous of North America and was originally described by Williston (1900) from the "Benton" and "Niobrara" of Kansas. It seems likely that these two species are closely related, although the nature of the relationship is as yet unclear.

Bardack (1968) figured a ptychodont from the Boyne member of the Vermillion River Formation in Manitoba, Canada. I concur with Evetts (1979) that this specimen can be referred to *P. anonymus*.

Ptychodus polygyrus Agassiz, 1839
Fig. 3–B

P. polygyrus is a cosmopolitan species known from the Turonian through the Santonian of the English Chalk (Woodward, 1911), the "Niobrara" of Kansas (Williston, 1900), and the Selma Group of Alabama (Applegate, 1970). *P. polygyrus* also is known from Belgium and the U.S.S.R. The abundance and diversity of the ptychodont fauna in the Atarque Member clearly reflects the abundance of the mollusks that formed the food source for these selachians.

Order LAMNIFORMES
Suborder LAMNOIDEI
Family ANACORACIDAE Casier, 1947
Genus *Squalicorax* Whitley, 1939
Squalicorax falcatus (Agassiz), 1843
Fig. 3–P

The trenchant teeth of *S. falcatus* are recognized easily. Bilelo (1969) discussed the genus in north-central Texas. Leriche (1939) reported *S. kaupi* from the Coniacian, Santonian, and early Campanian of Africa. *S. falcatus* is known from the Turonian of Texas (Bilelo, 1969) and South Dakota (Cappetta, 1973). *S. falcatus* also is known from the Cenomanian, Santonian, and Campanian of Europe (Priem, 1912).

S. pristodontus ranges from the late Santonian to the end of the Maestrichtian, although a pre-Campanian age may be doubted on geologic grounds (Bilelo, 1969). *S. pristodontus* has a cosmopolitan distribution. Despite a stratigraphic overlap, the *S. kaupi–S. falcatus–S. pristodontus* sequence forms a suitable evolutionary series. The broad geographic distribution of these taxa enhances their utility for stratigraphic application.

S. falcatus is not abundantly represented in the Joyita Hills fauna. No complete specimens have been recovered yet. *S. falcatus* was an active predator as evidenced by its trenchant, serrated teeth.

Order GALEIFORMES
Suborder ISUROIDEI
Family ISURIDAE Garman, 1913
Genus *Cretolamna* Glikman, 1958
Cretolamna appendiculata Agassiz, 1835
Fig. 3–R–T

C. appendiculata has cosmopolitan distribution and occurs in rocks of Cenomanian to late Paleocene age. The family Isuridae (Lamnidae in older literature) includes the mackerel sharks and consists of large, voracious fish with lunate caudal fins. The

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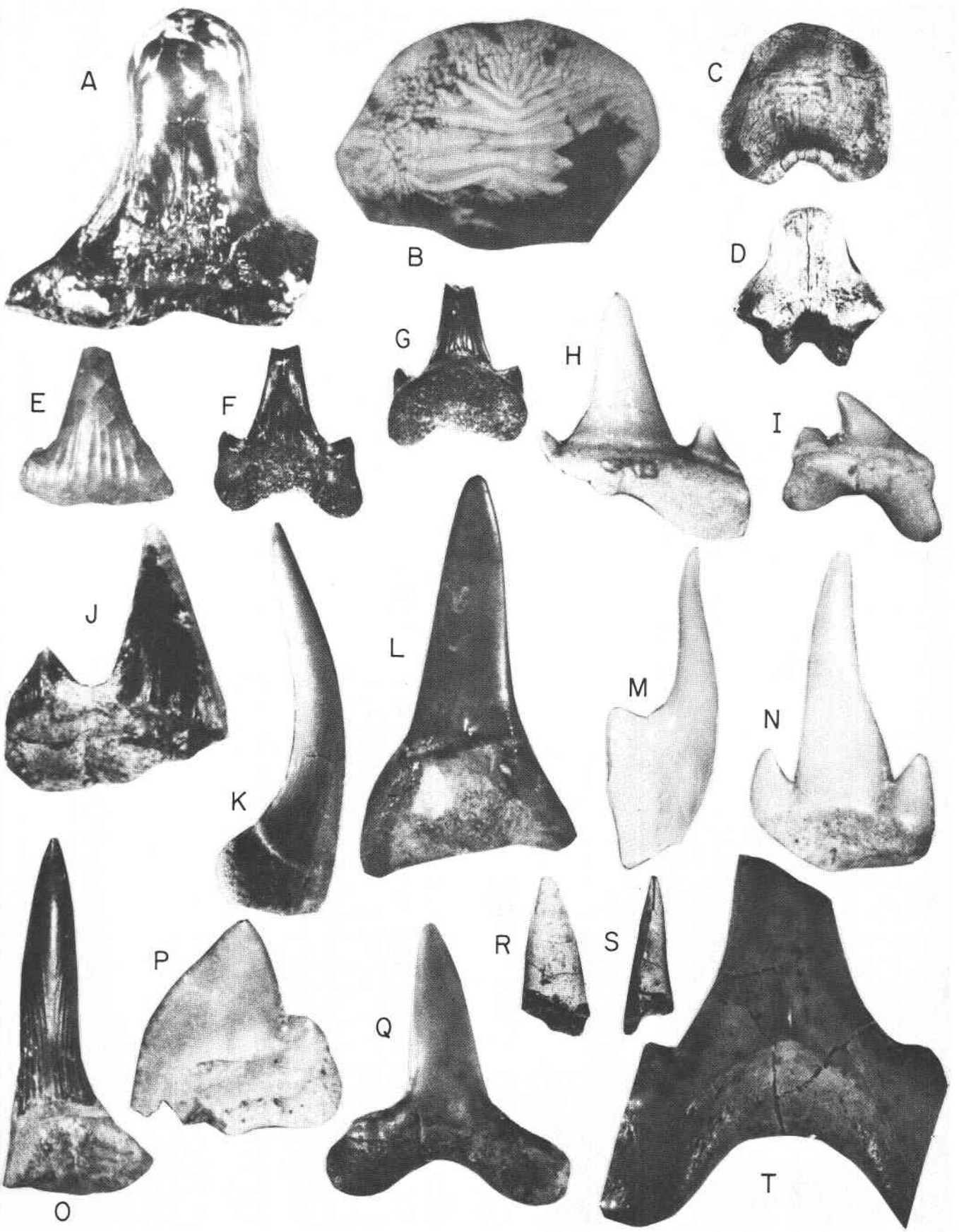

FIGURE 3—**A**, B–0123, *Ptychodus whipplei* Marcou (×4.2); **B**, B–0148, *Ptychodus polygyrus* Agassiz (×4.2); **C–D**, B–0130, *Ptychodus anonymus* Williston, occlusal view (×2.1) and posterior view (×1.7); **E**, B–0009, *Hybodus* sp. (×10); **F–G**, B–0017, *Cretodus semiplicatus* (Agassiz) (×1.7); **H**, B–0031, *Plicatolamna arcuata* (Woodward) (×6.7); **I**, B–0170, *Plicatolamna arcuata* (Woodward) (×6.7); **J**, B–0162, *Cretodus semiplicatus* (Agassiz) (×4.2); **K**, B–0158, *Scapanorhynchus raphiodon* (Agassiz) (×6.7); **L**, B–0153, *Scapanorhynchus raphiodon* (Agassiz) (×6.7); **M**, B–0151, *Odontaspis parvidens* Cappetta (×16.8); **N**, B–0003, *Odontaspis parvidens* Cappetta (×16.8); **O**, B–0111, *Scapanorhynchus raphiodon* (Aggasiz) (×6); **P**, B–0015, *Squalicorax falcatus* (Aggasiz) (×8.4); **Q**, B–0166, *Anomotodon* sp. (×6); **R–S**, B–0128, *Cretolamna appendiculata* (Aggasiz) (×1.25); **T**, B–0200, *Cretolamna appendiculata* (Aggasiz) (×4.2).

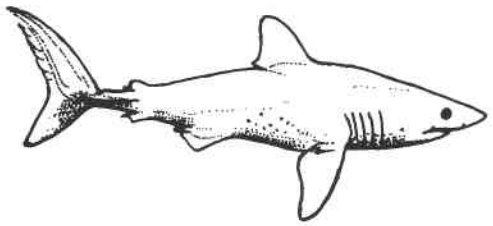

FIGURE 4—A modern representative of the genus *Lamna*, the Porbeagle, *Lamna nasus*. The genera *Cretolamna* and *Cretodus* probably resembled this form.

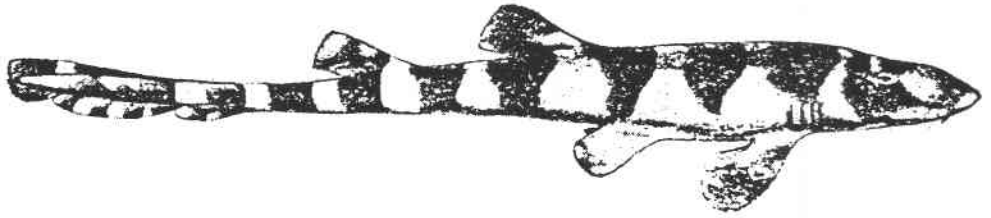

FIGURE 6—A modern catshark, *Chiloscyllium griseum*.

FIGURE 7—A modern goblin shark, *Mitsukurina owstoni*.

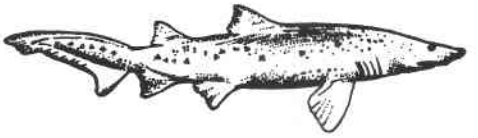

FIGURE 8—A modern representative of the genus *Odontaspis*, the sand shark, *Odontaspis taurus*.

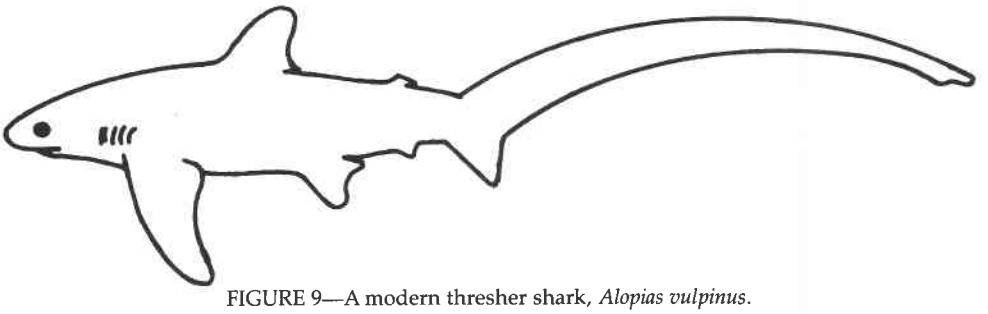

FIGURE 9—A modern thresher shark, *Alopias vulpinus*.

mackerel sharks are aggressive predators and include the modern Great White, *Carcharodon carcharias* (Linnaeus), in addition to the modern genus *Lamna* (Fig. 4). They generally are found near the surface and feed on fish, including other sharks, marine reptiles, and even mammals.

Cretodus semiplicatus (Agassiz, 1843)
Fig. 3–F, G, J

As noted by Cappetta (1973), *C. semiplicatus* is known from Europe where it is found in rocks of Cenomanian to Turonian age. It also is known from the late Turonian of Angola. Evetts (1979) and Cappetta (1973) reported the taxon from the Turonian of the Carlile Shale of South Dakota. *Cretodus semiplicatus* and *Cretolamna appendiculata* are about equally represented in the Atarque fauna.

Family ORECTOLOBIDAE Gill, 1895
Genus *Chiloscyllium* Ogilby, 1906
Chiloscyllium greeni (Cappetta, 1973)
Fig. 5–A, B

First described by Cappetta (1973) from the Carlile Shale (as *Brachaelurus greeni*), *C. greeni* is distinguished easily by its small size, smooth unornamented enamel, and lateral denticles flanking a main cusp. This record of *C. greeni* is only the second record of the species and the first record from New Mexico. Cappetta (1973) suggests that *C. greeni* may be ancestral to *Squatirhina*.

The family Orectolobidae includes the modern nurse sharks, leopard sharks, and catsharks. They are small- to medium-sized sharks that are benthonic, coastal dwelling forms, now found in the warmer waters of the Indo-Pacific. The genus *Chiloscyllium*, the catshark, is still extant and is characterized by strongly developed markings (Fig. 6).

Family MITSUKURINIDAE Jordan, 1898
Genus *Scapanorhynchus* Woodward, 1889
Scapanorhynchus raphiodon (Agassiz, 1843)
Fig. 3–K, L, O

S. raphiodon has cosmopolitan distribution. Some confusion exists in differentiating between *S. raphiodon* and *S. texanus* (*see* Cappetta and Case, 1975), or rather in how some paleontologists have distinguished the taxa. *S. raphiodon* is easily recognized by its long and slender recurved blade, internally ornamented by fine vertical striae.

Scapanorhynchus is included with the goblin sharks and it was long thought that *Scapanorhynchus* was the sole representative of the extinct selachian family Scapanorhynchidae and known only from fossils. Then, in 1898 *Mitsukurina owstoni* was taken from great depths in the Pacific Ocean near Japan (Fig. 7). Since 1898, the modern species has been recorded from Portugal, French Guyana, South Africa, Australia, and the Gulf of Gascogne, France (Cappetta, pers. comm. 1984).

Genus *Anomotodon* Arambourg, 1952
Anomotodon sp.
Fig. 3–Q

This genus is present in the Cretaceous of Morocco (Arambourg, 1952) and Germany. Cappetta (1976) and Case (1980) note the similarity of *Anomotodon* to *Scapanorhynchus* and include the genus within the Mitsukurinidae. In morphology, a strong resemblance is seen to *Scapanorhynchus rapax*, but vertical striae are absent. The Joyita Hills material may represent a new species of *Anomotodon*, but more material is need to make such a determination.

Family ODONTASPIDAE Muller and Henle, 1841
Genus *Odontaspis* Agassiz, 1838
Odontaspis parvidens Cappetta, 1973
Fig. 3–M, N

This species is distinguished from other species of *Odontaspis* by its small size and root morphology. The Joyita Hills specimens are only the second known occurrences of the taxon. *O. parvidens* is a common faunal element.

The Odontaspidae (Carchariidae in older literature) today comprise the sand sharks (Fig. 8). Odontaspids are primarily medium-sized sharks that inhabit shallow waters. They are active swimmers and feed on fish, crustaceans, and cephalopods.

Family CRETOXYRHINIDAE Glikman, 1958
Genus *Plicatolamna* Herman, *in* Cappetta and Case, 1975
Plicatolamna arcuata (Woodward, 1894)
Fig. 3–H, I

P. arcuata was recognized as a distinct species by Herman (*in* Cappetta and Case, 1975) from the Campanian of England. It also is present in the Cenomanian of Lithuania, the Campanian of New Jersey, and the Campanian and Maestrichtian of Belgium.

Family ALOPIIDAE Bonaparte, 1838
Genus *Paranomotodon* Herman, *in* Cappetta and Case, 1975
Fig. 5–Q

Paranomotodon is known from the Cenomanian–Santonian of Europe and the Late Cretaceous of Zaire and Japan. Cappetta and Case (1975) described *Paranomotodon* cf. *angustidens* from the Late Campanian of New Jersey.

Paranomotodon is included within the Alopiidae, or thresher sharks. Modern thresher sharks, distinguished by the extreme development of their caudal fin, are active predators, using their caudal fin to stun prey (Fig. 9). They are cosmopolitan in open ocean waters, but also venture inshore (Castro, 1983).

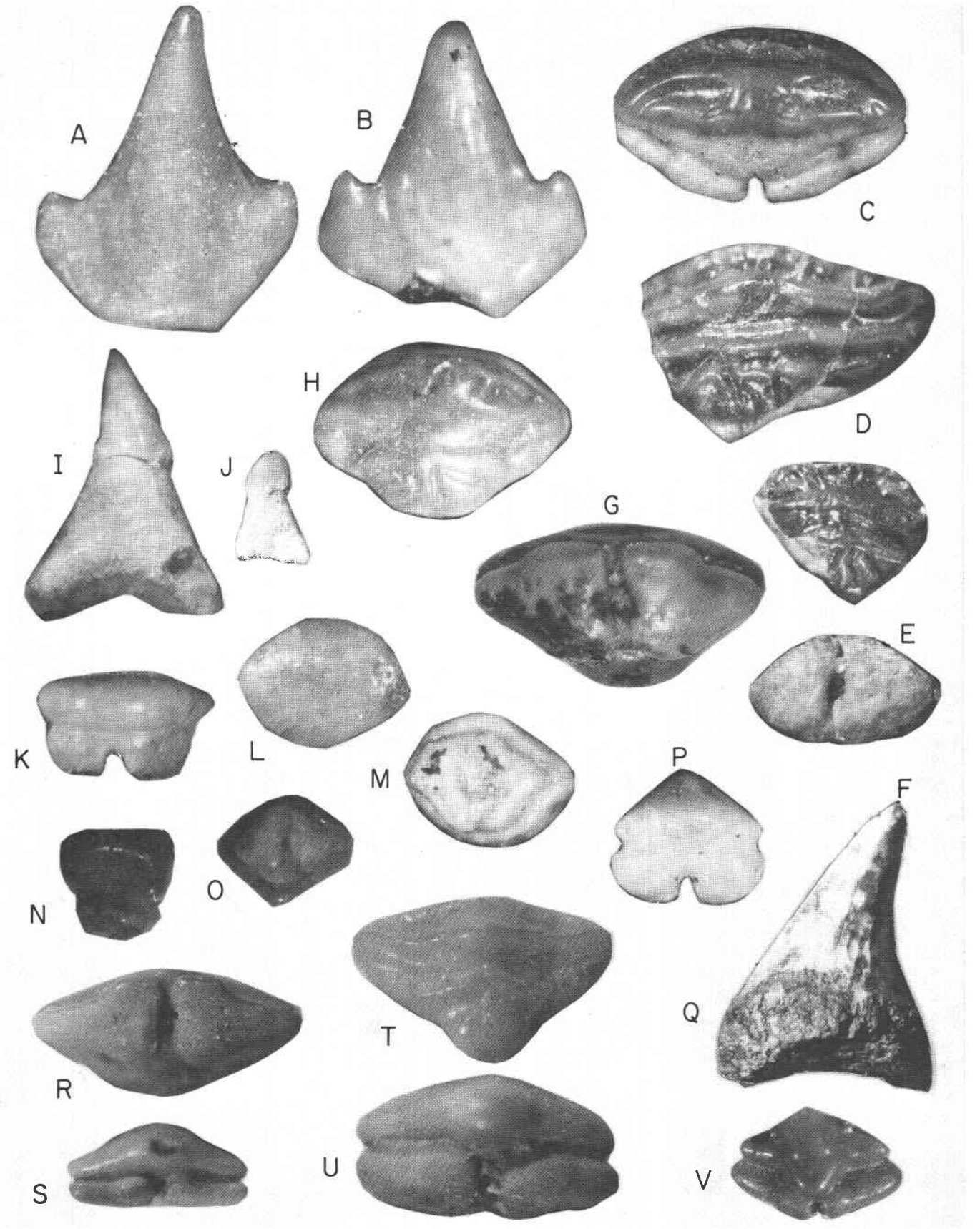

FIGURE 5—**A**, B–0019, *Chiloscyllium greeni* (Cappetta), lateral view (×20); **B**, B–0008, *Chiloscyllium greeni* (Cappetta), lateral view (×20); **C**, B–0100, *Ptychotrygon triangularis* (Reuss), tangential view (×13.5); **D**, B–0173, *P. triangularis* (Reuss), occlusal view (×13.5); **E–F**, B–0171, *P. triangularis* (Reuss), occlusal and basal views (×10); **G**, B–0101, *P. triangularis* (Reuss), basal view (×13.5); **H**, B–0169, *P. triangularis* (Reuss), occlusal view (×13.5); **I**, B–0025, *Ischyrhiza avonicola* Estes (×15); **J**, B–0175, *Ischyrhiza mira* Leidy (×2.5); **K–M**, B–0012, "Batoid indet.," lateral, occlusal, and basal views (×13.5); **N–O**, B–0159, "Batoid indet.," lateral and basal views (×20); **P**, B–0010, *Rhinobatos* sp. (×13.5); **Q**, B–0124, *Paranomotodon* sp., lateral view (×4.2); **R–S**, B–0178, *P. triangularis* (Reuss), basal and posterior views (×20); **T–U**, B–0167, *P. triangularis* (Reuss), occlusal and anterior views (×20); **V**, B–0154, *Ischyrhiza* cf. *I. avonicola* Estes, oblique view of oral tooth (×13.5).

Order RAJIFORMES
Suborder RHINOBATOIDEI
Family RHINOBATIDAE Muller and Henle, 1841
Genus *Rhinobatos* Linck, 1790
Rhinobatos sp.
Fig. 5–P

These very distinctive teeth are characterized by a low, cap-like crown and massive, bulbous roots. Cappetta (1973) reported *Rhinobatos* from the Turonian of South Dakota, and the genus is cosmopolitan in distribution during the Cretaceous. In some respects, the Joyita Hills specimens differ from those reported by Cappetta (1973), Cappetta and Case (1975), and Cappetta (1980). Referral to a species of *Rhinobatos* is not possible at this time.

Rhinobatos is a guitarfish. These fish, which may enter estuaries (Smith, 1953), are moderate-sized, sluggish, bottom-living rays that are common on sandy bottoms. Guitarfish are poor swimmers and frequently conceal themselves beneath the sand (Fig. 10).

Suborder SCLERORHYNCHOIDEI
Family SCLERORHYNCHIDAE Cappetta, 1974
Genus *Ischyrhiza* Leidy, 1856
Ischyrhiza avonicola Estes, 1964
Fig. 5–I, V

I. avonicola was first described from the Lance Formation (Maestrichtian) of Wyoming (Estes, 1964). It also is known from the Early Senonian of Belgium and the Turonian of South Dakota and Texas (Cappetta, 1973). Cappetta noted that the Turonian specimens are significantly smaller than those from the Maestrichtian.

The Sclerorhynchidae were sawfishes, characterized by a long, swordlike rostrum studded with teeth and used for obtaining food. Modern sawfish are found primarily in coastal waters of tropical and subtropical seas. However, they display a broad salinity tolerance and commonly enter brackish or even fresh waters.

Ischyrhiza mira Leidy, 1856
Fig. 5–J

The rostral teeth of *I. mira* are much larger than those of *I. avonicola*. This report of *I. mira* represents a modest range extension of the species. Cappetta and Case (1975) and Slaughter and Steiner (1968) report the range of *I. mira*, in the broad sense, as Late Turonian to Late Maestrichtian (*see* McNulty and Slaughter, 1964). Slaughter and Steiner recognized two subspecies: *Ischyrhiza mira schneideri* (Late Turonian through Coniacian) and *Ischyrhiza mira mira* (basal Campanian through Late Maestrichtian). It seems likely that the Joyita Hills specimens of this report represent *I. mira schneideri*.

Genus *Ptychotrygon* Jaekel, 1894
Ptychotrygon triangularis (Reuss, 1845)
Fig. 5–C–H, R–U

As the figures of *P. triangularis* indicate, the teeth appear to be quite distinctive. This species is represented abundantly in the Joyita Hills collections.

P. triangularis is cosmopolitan in distribution and is known from the Turonian of Czechoslovakia and South Dakota (Cappetta, 1973; Evetts, 1979). Cappetta and Case (1975) reported *P. triangularis* from the Campanian of New Jersey. However, Cappetta (1975) redescribed the New Jersey material as a new species, *Ptychotrygon vermiculata*. Thus, it appears that *P. triangularis* has a stratigraphic range limited to the Turonian.

The Joyita Hills sample differs in some respects from the South Dakota material. The New Mexico specimens display more arcuate crowns, are not as triangular, and show minor differences in ornamentation. More detailed comparisons of larger samples may allow for finer stratigraphic differentiation of the Turonian. Additionally, the Joyita Hills specimens vary in color from almost black to light yellow–brown. The significance of these color variations is unclear, but it may relate to the thermal history of the area.

"Batoids indet."
Fig. 5–K–O

These specimens are small teeth with distinctive, flat, rhomboidal crowns that show a weak medial keel and sloping facets. The margin of the crown is thick and overhangs a well-developed and divided root. In form, these specimens recall *Rhombodus*, but it is impossible to refer these specimens without detailed histological studies. For now, they will be included within the "batoids indet." category.

Conclusions

Selachians frequently compose a significant portion of Cretaceous marine, brackish, and even freshwater faunas of the Western Interior of North America. Only sporadic studies have been conducted on these faunas for the Western Interior as a whole, and even less is known of Cretaceous selachian faunas in the New Mexico record. The locality discovered by Bruce Baker provides an opportunity to study a relatively large and diverse sample of the New Mexico fauna, and it is especially important because it is securely placed in a stratigraphic context by invertebrate data. In this report, 18 selachian taxa are documented in the Atarque Sandstone Member of the Tres Hermanos Formation, and most represent first documented occurrences in New Mexico (Table 1). This fauna compares well with that reported by Cappetta (1973) and Evetts (1979) from the Turonian portion of the Carlile Shale of South Dakota. This fauna also compares well with selachian faunas of similar age from the upper Midwest (Witzke, 1981). Figure 11 shows the distribution of comparable Turonian selachian faunas.

Given more complete samples through the Cretaceous stratigraphic record, selachian

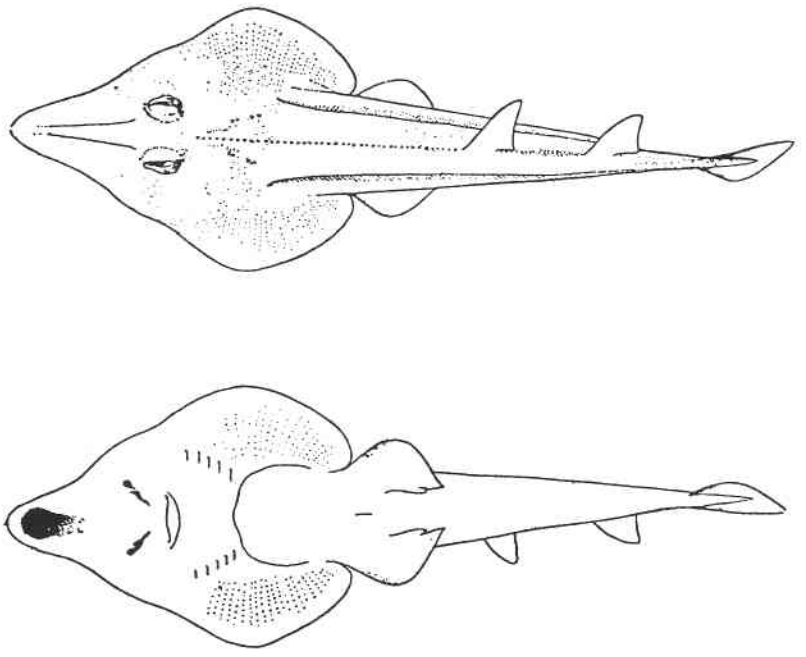

FIGURE 10—A modern species of *Rhinobatos*, the guitarfish, *Rhinobatos schlegeli*.

TABLE 1—Faunal list

Hybodus sp.
Ptychodus whipplei
Ptychodus anonymus
Ptychodus polygyrus
Squalicorax falcatus
Cretolamna appendiculata
Cretodus semiplicatus
Chiloscyllium greeni
Scapanorhynchus raphiodon
Anomotodon sp.
Odontaspis parvidens
Plicatolamna arcuata
Paranomotodon sp.
Rhinobatos sp.
Ischyrhiza avonicola
Ischyrhiza mira
Ptychotrygon triangularis
"Batoids indet."

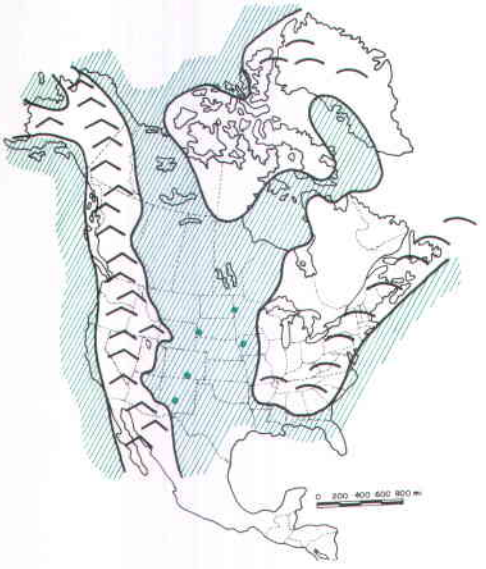

FIGURE 11—Late Early Turonian North American paleogeography. Dots represent comparable selachian faunas (after Williams and Stelck, 1975). Shaded areas indicate water.

faunas, in particular the smaller faunal elements, may offer the possibility of better stratigraphic correlations. Selachian teeth and dermal denticles can occur abundantly and over a wide geographic area, can have limited stratigraphic range, and are identifiable. These attributes lend themselves well to biostratigraphic applications.

In general, the Cretaceous was characterized by a distribution of land and sea that allowed mobile organisms relatively easy access to widely separated geographic areas (Fig. 12). It is this easy dispersion of organisms that highlights the potential for stratigraphic correlations based on selachians. It is also probable that selachian faunas can provide useful paleoenvironmental data. Modern analogs or actually related forms still exist and provide an opportunity for relating fossil selachian taxa to extant taxa.

Based on available data, it seems likely that the Joyita Hills fauna occupied a near-shore environment. The presence of relatively unabraded turtle, crocodile, and dinosaur bone fragments indicates a nearby shoreline and riverine or estuarine habitats. The selachian fauna is relatively unbiased in that both bottom-dwelling forms and active swimmers are well represented.

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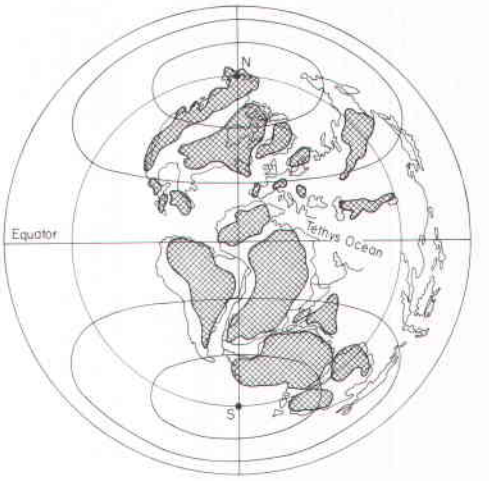

FIGURE 12—Distribution of lands and seas during the Cretaceous (after Kennedy, 1978). Shaded areas indicate land.

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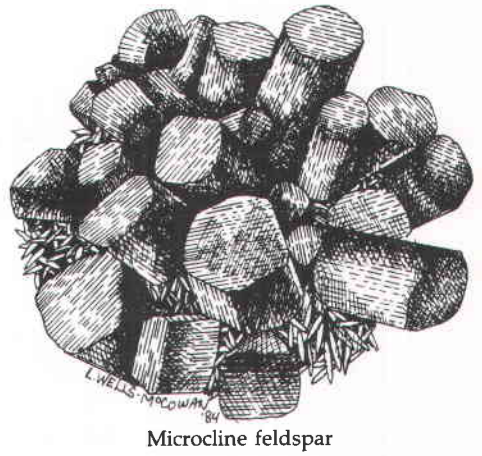

Microcline feldspar