SPECIAL PAPERS IN PALAEONTOLOGY · 39

Late Cenomanian and Turonian Ammonite faunas from north-east and central Texas

THE PALAEONTOLOGICAL ASSOCIATION

PRICE £30

SPECIAL PAPERS IN PALAEONTOLOGY NO. 39

LATE CENOMANIAN AND TURONIAN AMMONITE FAUNAS FROM NORTH-EAST AND CENTRAL TEXAS

BY

WILLIAM JAMES KENNEDY

with 24 plates and 39 text-figures

THE PALAEONTOLOGICAL ASSOCIATION
LONDON

JULY 1988

Printed in Great Britain

CONTENTS

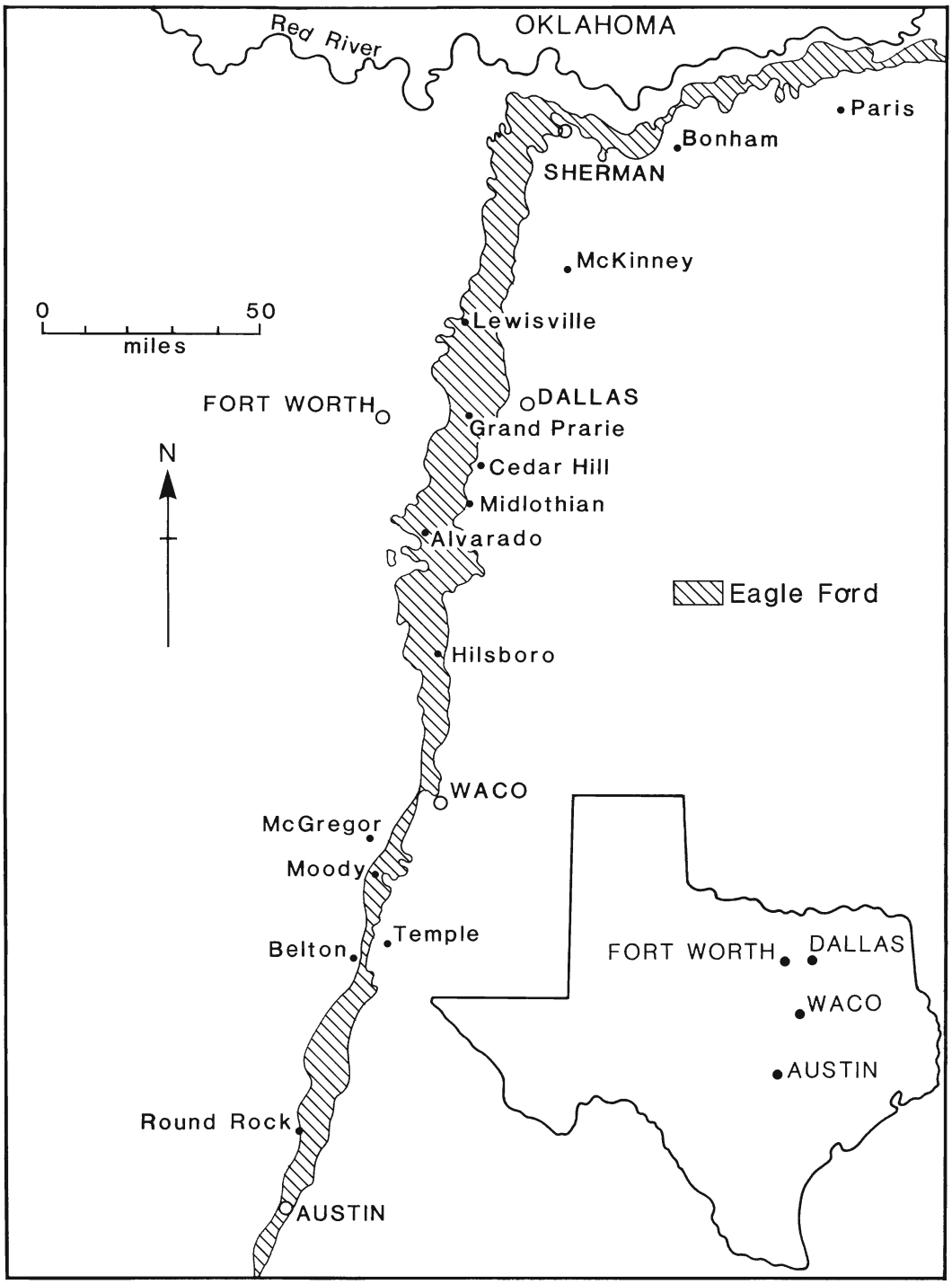
ABSTRACT. The late Cenomanian *Sciponoceras gracile* Zone ammonite fauna of the Britton Formation of the Eagle Ford Group in north-central Texas comprises twenty-seven species referred to seventeen genera, of which one genus and five species are new. The fauna consists of: *Borissiakoceras orbiculatum* Stephenson, 1955, *B. auriculatum* sp. nov., *B. desmoceratoides* sp. nov., *Desmoceras* (*Moremanoceras*) *scotti* (Moreman, 1942), *Placenticeras cumminsi* Cragin, 1893, *Metengonoceras acutum* Hyatt, 1903, *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822), *Eucalycoceras* sp., *Pseudocalycoceras angolaense* (Spath, 1931), *Tarrantoceras* (*Sumitomoceras*) *conlini* Wright and Kennedy, 1981, *T.* (*S.*) *crassum* sp. nov., *T.* (*S.*) *proteus* sp. nov., *T.* (*S.*) *bentonianum* (Cragin, 1893), *Euomphaloceras septemseriatum* (Cragin, 1893), *Metoicoceras geslinianum* (d'Orbigny, 1850), *Nannometoicoceras* gen. nov. *acceleratum* Hyatt, 1903, *Metaptychoceras reesidei* (Cobban and Scott, 1973), *Puebloites corrugatus* (Stanton, 1894), *Anisoceras* sp. nov. aff. *plicatile* (J. Sowerby, 1819), *Allocrioceras dentonense* (Moreman, 1942), *A. larvatum* (Conrad, 1855), *A. annulatum* (Shumard, 1860), *A. conlini* sp. nov., *Allocrioceras* sp., *Sciponoceras gracile* (Shumard, 1860), *Worthoceras vermiculus* (Shumard, 1860), and *Yezoites delicatulus* (Warren, 1930). Dimorphism is recognized in *Placenticeras*, *Metoicoceras*, *Nannometoicoceras* gen. nov., *Allocrioceras*, *Sciponoceras*, *Worthoceras*, and *Yezoites*. *Nannometoicoceras* gen. nov. is interpreted as a dwarf offshoot of *Metoicoceras*.

The Turonian ammonite faunas of the upper part of the Eagle Ford Group from the Texas/Oklahoma border 400 km (250 miles) south to Austin comprises twenty-eight species referred to eighteen genera of which one genus and seven species are new. The fauna consists of: *Puzosia* (*Puzosia*) *serratocarinata* Kennedy and Cobban, 1988*a*, *Parapuzosia* (*Austiniceras*) *seali* Clark, 1960, *Tragodesmoceras* sp., *Watinoceras reesidei* Warren, 1930, *W. coloradoense* (Henderson, 1908), *Romaniceras* (*Romaniceras*) *mexicanum* Jones, 1938, *incertae sedis*, *Spathites* (*Spathites*) *puercoensis* (Herrick and Johnson, 1900*a*), *Mammites* sp., *Collignoniceras woollgari* (Mantell, 1822) *regulare* (Haas, 1946), *Prionocyclus hyatti* (Stanton, 1894), *P. macombi* Meek, 1876*b*, *P. bosquensis* sp. nov., *P. wyomingensis* Meek, 1876*a*, *Prionocyclites mite* gen. et sp. nov., *Hoplitoides sandovalensis* Cobban and Hook, 1980*a*, *Coilopoceras springeri* Hyatt, 1903, *C. inflatum* Cobban and Hook, 1980*a*, *Metaptychoceras crassum* sp. nov., *M. annulatum* sp. nov., *Metaptychoceras* sp. A., *Metaptychoceras* sp. B., *Baculites yokoyamai* Tokunaga and Shimizu, 1926, *Scaphites* (*Scaphites*) *carlilensis* Morrow, 1935, *S.* (*S.*) *larvaeformis* Meek and Hayden, 1859, *S.* (*Pteroscaphites*) *inaffectus* Crick, 1979, *Worthoceras minor* sp. nov., and *Y.* cf. *delicatulus* (Warren, 1920).

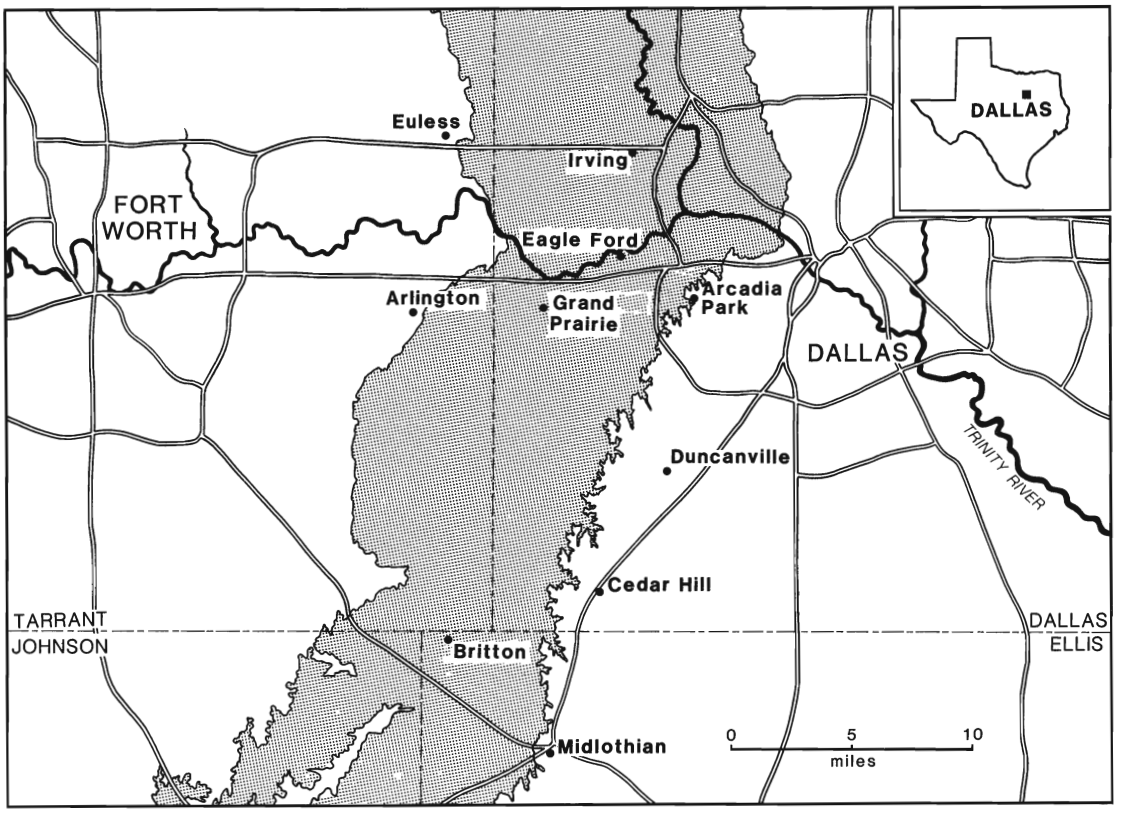
The faunas can be placed in the standard zonal scheme for the southern US Western Interior recognized by Cobban (1984*a*). In the Dallas area there is a marked unconformity just below the base of the Arcadia Park Formation, with Upper Cenomanian *Sciponoceras gracile* Zone Britton Formation overlain by a thin 2·5 m sequence of *Pseudaspidoceras flexuosum* and *Vascoceras* (*Greenhornoceras*) *birchbyi* Zone age that also belongs to the Britton. There is no evidence for the lower *Collignoniceras woollgari woollgari* Subzone of the *C. woollgari* Zone, but the basal Kamp Ranch Limestone Member of the Arcadia Park and, at some localities at least, the Britton shales below belong to the *regulare* Subzone. Above, the bulk of the Arcadia Park Formation is *Prionocyclus hyatti* Zone, the top just extending into the *P. macombi* Zone and overlain unconformably by Coniacian Austin Chalk. To the north of Dallas, the top of the Eagle Ford extends to the *P. wyomingensis* Zone and perhaps higher. In the Waco area, the upper part of the Lake Waco Formation is *P. hyatti* Zone, the succeeding South Bosque Formation spanning the upper *P. hyatti* Zone to the *Scaphites whitfieldi* Zone, overlain unconformably by Coniacian Austin Chalk. In the Austin area, the Eagle Ford Condensed Zone yields a *P. hyatti* Zone fauna and rests unconformably on *C. woollgari* Zone sediments referred to as South Bosque Formation in recent publications.

INTRODUCTION

THE Eagle Ford Group was named by Hill (1887) for the settlement of Eagle Ford on the south bank of the West Fork of the Trinity River. Early descriptions are given by Hill (1887), Taff and Leverett (1893), and others, reviewed by Adkins (1928, 1933), Moreman (1927, 1933, 1942), Adkins and Lozo (1951), Brown and Pierce (1962), Norton (1965), McNulty (1965, 1966), Pessagno (1969*a*, *b*), and Smith (1981). The rich macrofaunas of the succession were described by Conrad (1855), Shumard (1860), Cragin (1893), Hyatt (1903), Scott (1927), and Moreman (1927, 1942); microfaunas and microfloras are reviewed by Pessagno (1969*a*, *b*), Smith (1981), and Valentine (1984). I here



TEXT-FIG. 1. Locality map of the study area showing the outcrop of the Eagle Ford Group, and some of the more important localities.



TEXT-FIG. 2. Locality map of the study area in north-east Texas, showing the outcrop of the Eagle Ford Group, principal highways and some important localities (see Norton 1965 for more precise locality map).

described the diverse Upper Cenomanian *Sciponoceras gracile* Zone fauna that occurs in the Britton Member in the Dallas–Fort Worth area, and the succeeding Turonian ammonites of the uppermost Britton, the Arcadia Park Formation and its correlatives in the area from the Texas/Oklahoma border south 270 km to Austin. The study area is indicated in text-fig. 1, which also shows some of the more important localities mentioned in the text; text-fig. 2 shows the type and other localities in the Dallas–Fort Worth area in detail.

AMMONITE ZONES

A detailed Cenomanian–Turonian ammonite zonation is recognized in the southern US Western Interior as follows (modified after Cobban 1984*a*, 1986).

	Zone
Coniacian (part of)	*Forresteria/Inoceramus deformis* *Forresteria/Inoceramus rotundatus*
Upper Turonian	*Prionocyclus quadratus* *Scaphites whitfieldi* *Prionocyclus wyomingensis* *Prionocyclus macombi*

	Zone
Middle Turonian	*Prionocyclus hyatti*
	Prionocyclus percarinatus
	Collignoniceras woollgari
Lower Turonian	*Mammites nodosoides*
	Vascoceras birchbyi
	Pseudaspidoceras flexuosum
Upper Cenomanian	*Neocardioceras juddii*
	Vascoceras cauvini
	Sciponoceras gracile
	Metoicoceras mosbyense
	Calycoceras canitaurinum
Middle Cenomanian	*Plesiacanthoceras* aff. *wyomingense*
	Acanthoceras amphibolum
	Conlinoceras tarrantense

Cobban (1984*a*) suggested that the *gracile* Zone might be divided into *V. diartianum* Subzone below and *Euomphaloceras septemseriatum* Subzone above. His subsequent work (pers. comm. 1986) shows that the fauna of the *diartianum* Subzone is significantly older than the *gracile* Zone and that *E. septemseriatum* ranges throughout the *gracile* Zone, which thus cannot be so subdivided in the interior.

Note that the *Prionocyclus percarinatus* Zone is known with certainty only from north-east Nebraska and south-east and south-west South Dakota; the index species may, however, be represented by poorly preserved ammonites from the Mancos Shale of west-central New Mexico. The *Collignoniceras woollgari* Zone can be divided into subzones of *C. w. woollgari* below and *C. w. regulare* above; the *P. hyatti* Zone into subzones of *Hoplitoides sandovalensis* below and *Coilopoceras springeri* above; the *P. macombi* Zone into subzones of *C. colleti* below and *C. inflatum* above; and the *P. wyomingensis* Zone into subzones of *Scaphites warreni* below and *S. ferronensis* above.

Zonation of the Texas sequence is far less satisfactory. Early schemes were proposed by Scott (1927), Moreman (1927), Adkins (1928, 1933), and Moreman (1942). The latter proposed the following for the Arcadia Park Formation:

Zone	*Subzone*
Alectryonia lugubris	
Prionocyclus aff. *woollgari*	*Prionocyclus meekianus*
	Coilopoceras eaglefordensis
	Romaniceras sp.
	Prionotropis hyatti
	Prionotropis graysonensis

As is discussed below, the bulk of the Arcadia Park belongs to the *Prionocyclus hyatti* Zone.

For the Britton Formation, Moreman proposed:

Zone	*Subzone*
Metoicoceras whitei	*Barroisiceras trinodosum*
	Worthoceras vermiculum
	Allocrioceras pariense
Metoicoceras irwini	*Neocardioceras septemseriatum*
	Eucalycoceras bentonianum
	Epengonoceras acutum
	Tragodesmoceras scotti

As shown below, *Metoicoceras whitei*, *M. irwini*, and *Barroisiceras trinodosum* are all synonyms of *M. geslinianum*, while all of the index species occur at the same horizon in both Texas and the US Western Interior.

Adkins and Lozo (1951) proposed the following:

Zone 9: *Alectryonia lugubris.*
Zone 8: *Coilopoceras austinense–Coilopoceras* n. sp.
Zone 7: *Coilopoceras eaglefordense.*
Zone 6*c*: *Metaptychoceras–Worthoceras.*
Zone 6*b*: *Romaniceras.*
Zone 6*a*: Salmurian. Unknown in the area.
Zone 5: *Neocardioceras.*
Zone 4: *Eucalycoceras bentonianum–Mantelliceras* n. sp.

Zone 4 is Middle Cenomanian, Zone 5 corresponds to the *Sciponoceras gracile* Zone.

Young and Powell (1978) recognized the following sequence:

Coniacian	*Peroniceras haasi* Zone
Turonian	*Prionocyclus hyatti* Zone
	Coilopoceras eaglefordense Zone
	Metoicoceras whitei Zone

The most recent zonation was proposed by Young and Powell (1978):

	Zone
Turonian	*Prionocyclus hyatti*
	Coilopoceras eaglefordense
	Metoicoceras whitei
Upper Cenomanian	*Kanabiceras septemseriatum*
	Acanthoceras alvaradoense
	Eucalycoceras bentonianum
	Conlinoceras tarrantense

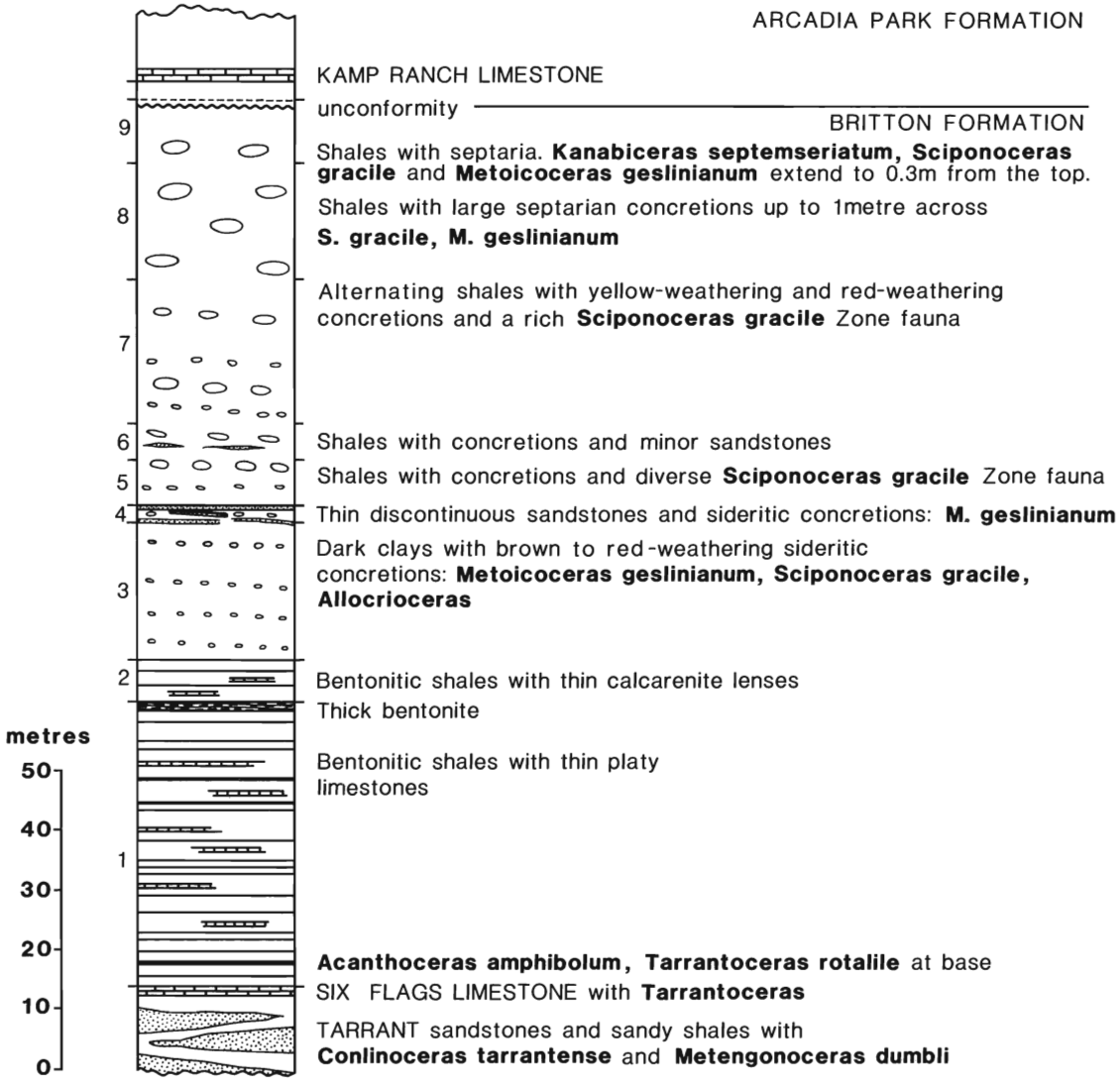
Metoicoceras whitei is a synonym of *M. geslinianum*, while it, *Euomphaloceras* [*Kanabiceras*] *septemseriatum*, and *Tarrantoceras* (*Sumitomoceras*) [*Eucalycoceras*] *bentonianum* all co-occur. *Coilopoceras eaglefordense* is a synonym of *C. springeri* Hyatt, 1903 (*fide* Cobban and Hook, 1980*a*) and occurs with *P. hyatti* in the upper part of the latter's range.

The latest observations are by Kauffman *et al.* (1977), who compared the succession in northern Texas with successions described from Cimarron County, Oklahoma. These authors pointed out that the greater part of the upper Britton Member belonged to their *S. gracile* Zone and the uppermost 4·5 to 6·0 m (15 to 20 ft.) to their *Mytiloides opalensis* Zone and possibly part of their *M. mytiloides* Zone, that is to say the *Pseudaspidoceras flexuosum* to *Mammites nodosoides* Zones in ammonite terms. They also correlate the Arcadia Park Formation with the Carlile Shale of Kansas, of *Prionocyclus hyatti* Zone age.

As will be shown below, the central Texas Turonian can be divided into the same zonal succession as that recognized by Cobban in the southern US Western Interior, and that scheme is used here.

STRATIGRAPHY

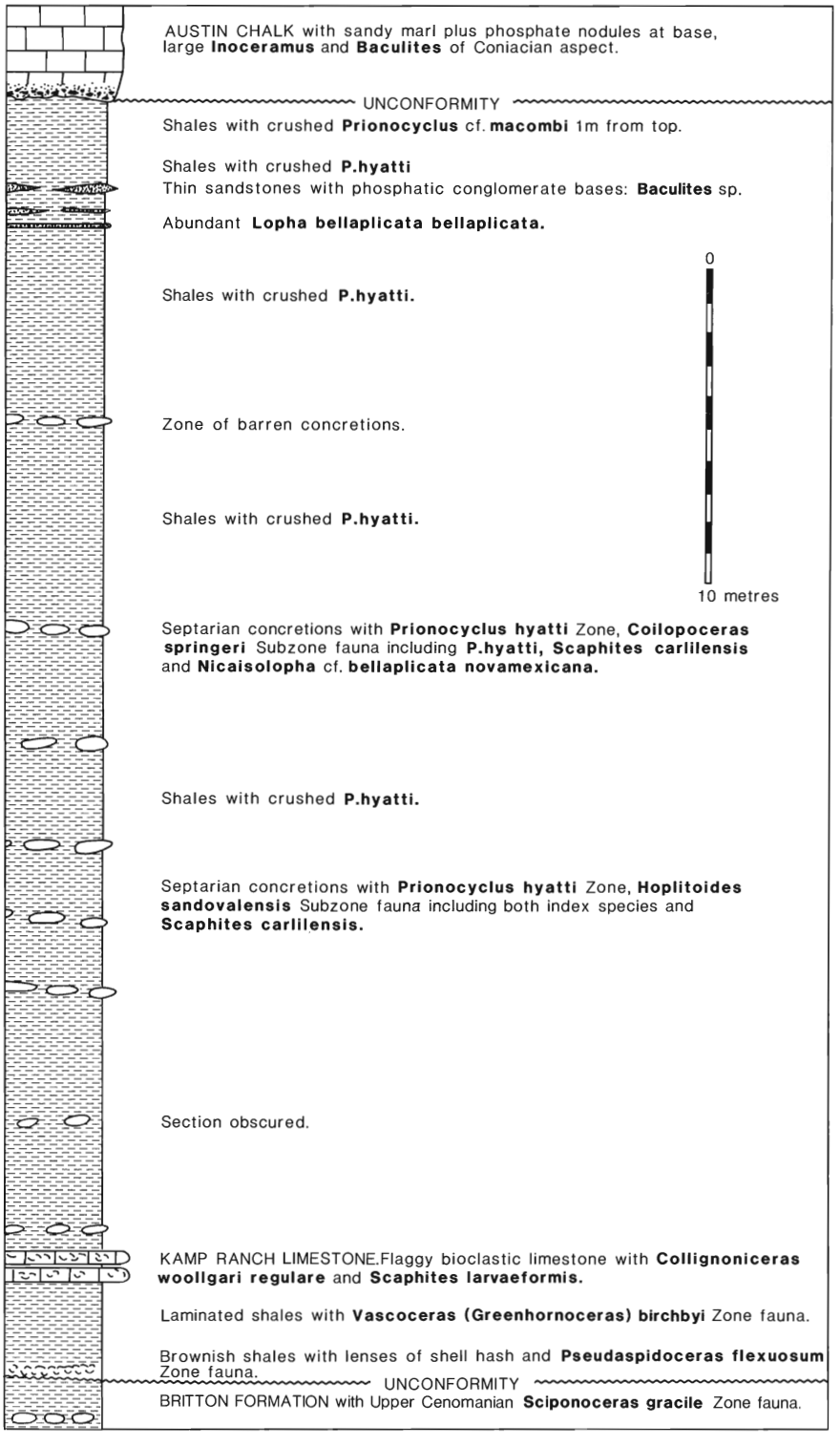
Dallas area. The Eagle Ford Group is a predominantly argillaceous sequence that takes its name from the settlement of Eagle Ford on the south bank of the West Fork of the Trinity River in Dallas County. Ferdinand Roemer (1852) refers to 'black Eagle Ford shales', but the unit was named formally by Hill (1887). It ranges from 144·5 m (475 ft.) in the north of Dallas County to 122 m (400 ft.) in the south. Early descriptions are given by Hill (1887), Taff and Leverett (1893) among



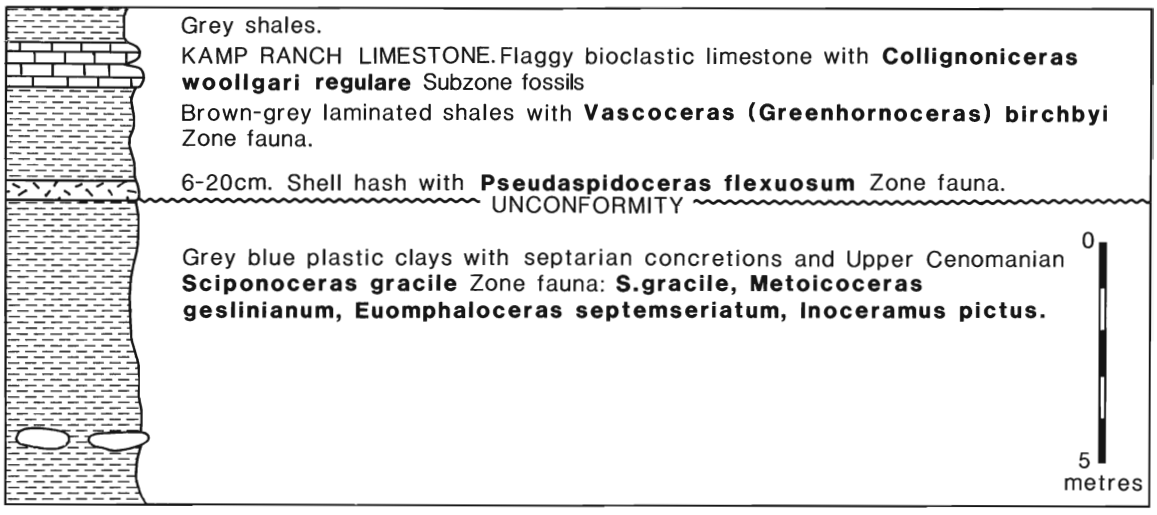
TEXT-FIG. 3. Generalized succession in the Britton Formation in the Dallas area, based on Brown and Pierce (1962), Norton (1965), and personal observations.

others, reviewed by Moreman (1927, 1942), Brown and Pierce (1962), Norton (1965), McNulty (1965, 1966), and Smith (1981). Moreman (1933, 1942) recognized three divisions in the Eagle Ford: the Tarrant, Britton, and Arcadia Park Formations, and these are used here. Considerable controversy attaches to the recognition or not of the Tarrant Formation as a separate entity, but this is not relevant to the present faunas and will be addressed in a further publication on the mid-Cenomanian faunas of the area.

All of the *gracile* Zone material described here comes from a limited area of Dallas, Tarrant, Grayson, Ellis, and Denton Counties (text-fig. 2), and the detailed cored section from close to the type locality of the Eagle Ford described by Brown and Pierce (1962) provides a typical Britton sequence, shown in text-fig. 3; text-fig. 4 shows the Arcadia Park succession. I was able to study



TEXT-FIG. 4. Generalized succession in the Arcadia Park Formation in the Dallas–Fort Worth area.



TEXT-FIG. 5. The unconformable Britton/Arcadia Park Formation junction on Loop 12, north of Arcadia Park in Dallas County.

outcrops in the Dallas area in the company of J. M. Hancock, R. Parish, and P. Scholle in 1973–1974; these observations are incorporated into the following account.

The lower part of the Tarrant Formation underlying the Britton yields a diverse fauna, with *Conlinoceras tarrantense* (Adkins, 1928) and *Metengonoceras dumbli* (Craigin, 1893) as the commonest ammonites; the sharp base appears to be a minor discontinuity surface. Powell (1968) described a section across the Britton/Tarrant boundary between the northbound and southbound carriageways of Texas Highway 360 between Randol Mill Road and the Dallas–Fort Worth Turnpike and Six Flags Park in north-east Arlington, between Dallas and Fort Worth. Tarrant sandstones are overlain by sandy clays; quartzose calcarenites appear 2·75 m (9 ft.) above the top of the Tarrant sands and are conspicuous 3·6 m (12 ft.) above; Norton (1965) named them the Six Flags Limestone Member; they yield abundant poorly preserved *Tarrantoceras* sp. Above, 5·5 m (18 ft.) of bentonitic shales were exposed. Powell's collections, now in the USGS Collections, Denver, include *Acanthoceras* cf. *amphibolum* Morrow, 1935 and *T. rotatile* Stephenson, 1955 (Pl. 3, figs. 1–3) from bentonitic shales at this locality, while Kauffman *et al.* (1977, p. 26) note a conspicuous bentonite 1·5 m (5 ft.) above the Six Flags Limestone, 27·5 to 30·5 cm (0·9 to 1 ft.) thick; they state that it is biostratigraphically at the level of the key X bentonite of the Western Interior. The clays above have yielded no diagnostic macrofossils that I has seen until Unit 3, some 36·5 m (120 ft.) above the Six Flags Limestone, where the *gracile* Zone fauna first appears. Norton (1965) records *Metoicoceras irwini*, *S. gracile*, and *Allocrioceras pariense*; the zonal fauna extends up into Unit 9 of Norton. The celebrated Horton's Mill and California Crossing localities fall into Unit 5.

Norton (1965) suspected that there was an unconformity between the Britton and the overlying Arcadia Park, placing it at the base of a distinctive flaggy limestone, termed the Kamp Ranch Flags, while Pessagno (1969*a*, *b*) inferred a paraconformity between the two on the basis of an absence of early Turonian Foraminifera. In 1973 J. M. Hancock and I observed this contact in temporary exposures on Loop 12, 400 m south of Route 80 and east of Furlong Road, north of Arcadia Park (text-fig. 5). There is an unconformity 2·5 m below the Kamp Ranch Limestone, the latter being the mappable base of the Arcadia Park Formation. Plastic grey clays and concretions of the Britton Formation yielded *E.* cf. *septemseriatum*, *M. geslinianum*, *Placenticeras* sp., *S. gracile*, and *Inoceramus* of the *pictus* group 0·3 m below the break, which is overlain by a 6–20 cm thick calcareous silt with abundant shelly debris and shale partings. Poorly preserved ammonites are abundant, and

correspond to the *Gauthiericeras* aff. *bravaisi* of Moreman (1927, p. 96, pl. 14, fig. 2). Wright and Kennedy (1981, p. 49, pl. 9, fig. 11) thought Moreman's specimen to be a *Neocardioceras juddi* (Barrois and Guerne, 1878) of the Upper Cenomanian. The new specimens in some cases show inner and outer ventrolateral but no siphonal tubercles, and are *Watinoceras*, comparable to *W. reesidei* Warren, 1930. They occur with *Mytiloides columbianus* (Heinz, 1935), the association indicating the Lower Turonian *Pseudaspidoceras flexuosum* Zone. Above, laminated shales and shell plasters 0·5–2·0 m above the break yielded *Placenticeras* sp., *W.* cf. *reesidei*, *W. coloradoense* (Henderson, 1908), *Mammites* sp., *Metaptychoceras* sp. A, *Baculites yokoyamai* Tokunaga and Shimizu, 1926, and *Mytiloides columbianus*, indicating the *V.* (*Greenhornoceras*) *birchbyi* Zone.

The Kamp Ranch Limestone (Norton, 1965) yields abundant *Collignoniceras woollgari* (Mantell, 1822) *regulare* (Haas, 1946) juveniles, *Scaphites larvaeformis* Meek and Hayden, 1859, and *Mytiloides* sp. indet. The *Collignoniceras* are mostly too small to determine whether or not they belong to the nominate subspecies or to *C. w. regulare* (Haas, 1946), but larger specimens from this unit elsewhere are *regulare*. I have no material from the clays and shales immediately below the Kamp Ranch Limestone at this locality, but the J. D. Powell Collection (now in then USGS Collections, Denver) includes specimens of *C. w. regulare* from shales below the limestone at USGS Mesozoic Locality D9444, along Mansfield Road in south-west Dallas County between Mountain Creek Bridge and the White Rock Escarpment just west of Cedar Hills, and specimens in shales from USGS Mesozoic Locality D9446, road cuts on Kiest Boulevard 0·5 mile west of Ledbetter Drive, just east of Mountain Creek Lake, and at Dallas Baptist College, western Dallas County.

As already noted, Norton (1965, p. 76) suggested there might be an unconformity below the Kamp Ranch Limestone in Dallas County, but the presence of *C. w. regulare* both below and in the limestone at some localities speaks against this being of wide extent. However, the absence of *C. w. woollgari* Subzone and *Mammites nodosoides* Zone macrofaunas and absence of early Turonian microfaunas and microfloras in the Socony Mobil Dallas Core (Brown and Pierce 1962; Pessagno 1969*a*, *b*) suggest that the unconformity just below the Britton/Arcadia Park junction may vary in magnitude or that there may be more than one unconformity in the interval between the top of the Britton and the base of the Kamp Ranch Limestone.

There are 36·5 m (120 ft.) of clays and shales with concretions (sometimes septarian) and thin calcarenite stringers between the top of the Kamp Ranch Limestone and the base of the Austin Chalk (text-fig. 4) in the Dallas area, with flaggy sandstones with phosphatic conglomerate bases prominent in the top few metres. Fossiliferous concretions 10–13 m above the top of the Kamp Ranch Limestone on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, yielded a distinctive fauna of the *Prionocyclus hyatti* Zone, *H. sandovalensis* Subzone: *P. hyatti* (Stanton, 1894), *H. sandovalensis* Cobban and Hook, 1980*a*, and *S. carlilensis* Morrow, 1935. The position of the base of the *hyatti* Zone was not determined. The top 15 m (50 ft.) of the Arcadia Park were studied in sections at the intersection of Chalk Hill Road and Route 80, to the west of Dallas. Shales and septarian concretions 15 m (50 ft.) below the base of the Austin yielded *P. hyatti* and *S. carililensis* indicating the *P. hyatti* Zone, but inadequate for reference to *sandovalensis* versus *springeri* Subzones, and *Nicaisolopha* cf. *bellaplicata novamexicana* (Kauffman, 1965), an exclusively *H. sandovalensis* Subzone species (Kauffman *et al.* 1978). Thin calcareous sandstones 3 m (9·9 ft.) below the Austin have thin phosphatic conglomerate bases and yield *Baculites* sp. but no age-diagnostic ammonites. This level corresponds to the Fish Bed Conglomerate of Taff and Leverett (1893, pp. 299–304). It yields abundant *N. b. bellaplicata* (Shumard, 1860) (Pl. 23, figs. 26 and 27) in Dallas County (see Kauffman 1965, pl. 3). This is restricted to the upper *C. springeri* Subzone of the *hyatti* Zone (Kauffman *et al.* 1978).

Shales immediately above and below these conglomerates and sandstones yield *P. hyatti*. The highest ammonite found was a juvenile *Prionocyclus* from 1 m (3 ft.) below the base of the Austin Chalk (OUM KT 3703) (text-fig. 13E). It is identified as *P.* cf. *macombi* Meek, 1876*b*, suggesting that the top of the Arcadia Park Formation just extends into the base of the *P. macombi* Zone.

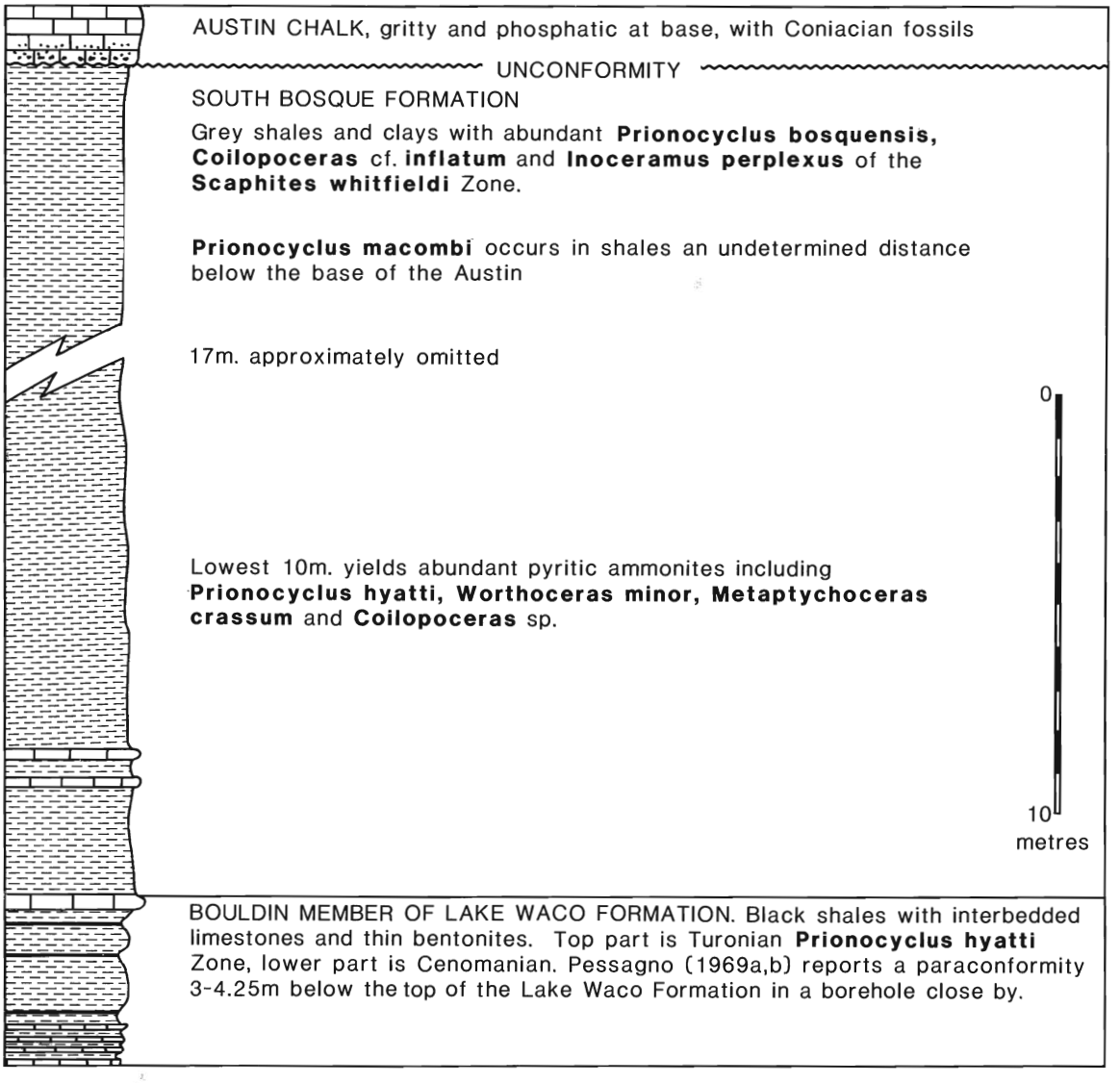
There is a marked unconformity at the base of the overlying Atco Member of the Austin Chalk (Pessagno 1969*a*, *b*; Smith 1981), which is piped down into the top of the Eagle Ford in arthropod

burrows. The bottom of the Austin is a sandy marl with abundant phosphatic nodules, termed Eagle Ford Condensed Zone by Smith (1981); chalks 1 m (3 ft.) above the base yielded large *Baculites* and *Inoceramus* of Coniacian aspect. Pessagno (1969*a*, *b*) initially thought the base of the Austin was Santonian in the Dallas area, but Smith (1981, p. 19, fig. 14) referred the basal Atco Member to the Coniacian *Lucianarhabdus cayeuxii* nannofossil Zone, a view supported here.

Smith (1981) gives details of the Austin/Eagle Ford contact at Cedar Hill (p. 9, fig. 5) and Arcadia Park (p. 10, fig. 6) close by that are in complete agreement with my own observations. It is clear from this and from ammonites in old collections that all or the greater part of the *P. macombi*, *P. wyomingensis*, *S. whitfieldi*, and *P. quadratus* Zones of the Turonian are missing in the Dallas area.

Fannin, Collins, and Grayson Counties. The Eagle Ford Group is thought to have a thickness of 106 m (350 ft.) in northern Collins County and throughout Grayson and Fannin Counties (Adkins 1933, p. 428). *C. woollgari* juveniles occur in shales and thin sandstones at USGS Mesozoic Locality D9484, section exposed on Mill Creek at and upstream of bridge on US Highway 82, just west of Bells, Grayson County, and in shales at D9493, Sowell's Bluff on the south side of the Red River, under bridge on Highway 78, 12 miles north of Bonham, Fannin County. The most striking difference from the succession in the Dallas area is the development of a major sandstone unit within the sequence. This was named the Fish Bed Conglomerate by Taff and Leverett (1893) and described in detail by Stephenson (1918). It can be traced down dip into the subsurface, where it has been termed Sub-Clarksville Sand. McNulty (1954) proposed the name Lake Crockett Sandstone Member for this unit and named the shale above it and below the Austin the Lake Crockett Shale, subsequently replaced (McNulty 1966) by Bells Sandstone Member and Maribel Shale Member respectively. The base of the Bells Sandstone is gradational, and McNulty measured 14·2 m (46·6 ft.) at Bells, noting that the sequence thickens eastwards. Of significance are records of *N. bellaplicata* 2·7 m (9 ft.) below the top of the Member in east-central Grayson County (McNulty 1966) suggesting the *P. hyatti* Zone. This is confirmed by the presence of *P. hyatti*, *Placenticeras* sp., and *S.* cf. *puercoensis* (Herrick and Johnson, 1900*a*) at USGS Mesozoic Locality D9485, gully north of US Highway 82, 1 mile west of Bells, Grayson County. The top of the member yields *Prionocyclus wyomingensis* Meek, 1876*a* in the uppermost bed in northern Collins and southern Grayson County, indicating a much higher horizon in the Turonian than is preserved around Dallas. I have seen no ammonites from the overlying Maribel Shale Member. Smith (1981, p. 11, fig. 7) studied the junction with the Austin Chalk on Choctaw Creek in Grayson County; it is described by him as conformable and corresponding to the base of the Coniacian *L. cayeuxii* nannofossil Zone.

The Waco Area. Waco is 130 km south-south-west of Dallas (text-fig. 1). The Eagle Ford Group is 61 m (199 ft.) thick in the Waco borehole studied by Brown and Pierce (1962) and Pessagno (1969*a*, *b*); Adkins (1933) and Adkins and Lozo (1951) summarize early work, the latter erecting a detailed lithostratigraphy and providing many detailed sections. A generalized succession is shown in text-fig. 6. Brown and Pierce (1962) succinctly summarize the differences between the succession at Waco and that around Dallas, pointing out that sands and silts are conspicuously absent at Waco, where carbonates dominate in the lower part of the sequence. The Eagle Ford rests with a marked break on Pepper Shale of Cenomanian age. The base of the Eagle Ford varies. At Bird Creek in Bell County (Adkins and Lozo 1951, p. 130, figs. 8 and 13) there is a 45 cm (1·5 ft.) black shale at the bottom of the Bluebonnet Member, overlain by a phosphatic pebble/shell coquina with the celebrated *Acanthoceras bellense* fauna of Adkins (1928). Elsewhere the Bluebonnet yields diverse *Tarrantoceras* and other fossils of the *A. amphibolum* Zone (Cobban 1984*a*). Silver (1963) describes lateral variations in the Bluebonnet which he regards as a lagoonal facies and gives thicknesses of up to 6·1 m (20 ft.). The junction with the succeeding Cloice Member appears to be conformable. This is a predominantly shale sequence, 10·8 m (35·5 ft.) thick at the type locality (Adkins and Lozo 1951, p. 140, figs. 10 and 18). I have seen no ammonites from this unit. The succeeding Bouldin Member consists of interbedded shales and limestones, 4·1 m (13·5 ft.) thick on Cloice Branch (Adkins and Lozo 1951, p. 142), where Adkins and Lozo (1951, p. 142) record '*Eucalycoceras*, *Metoicoceras* and mantelliceratidae'. Pessagno (1969*a*, *b*) demonstrated that there was a major discontinuity in the



TEXT-FIG. 6. The upper part of Eagle Ford Group succession in the Waco area.

upper part of the Lake Waco Formation, his *Rotalipora cushmani-greenhornensis* Zone extending to 10–14 ft. from the top of that unit, and overlain directly by his *Whitinella archaeocretacea* Subzone of the *Marginotruncana helvetica* Zone, the *M. sigali* Subzone being absent. This is supported by evidence from the Blue Cut section, 3·8 km north-north-west of Moody in McLennan County (Adkins and Lozo 1951, p. 136) where flaggy limestones in the Lake Waco/South Bosque transition yield *P.* cf. *hyatti* with no trace of Lower or Middle Turonian ammonites.

The succeeding South Bosque Formation (Prather 1902; Adkins and Lozo 1951) is 36·5 m (120 ft.) thick in the area of South Bosque, 10 km approximately south-west of Waco. There were formerly numerous working pits in the area that showed the top of this unit and the contact with the overlying Austin Chalk, visible from Route 84, while I have also seen collections of pyritic micromorphs and

nuclei from anthills in the South Bosque area now in the collections of the Texas Memorial Museum in Austin, Texas. These are related to a waterfall-forming limestone that I take to be the top of the Lake Waco Formation. Details are as follows: from 60 cm (2 ft.) above the limestone on Tater Creek: *Prionocyclus* sp. juv., *Worthoceras minor* sp. nov; from 5·33 m (17·5 ft.) above on Cloice Branch: *P.* sp. juv. cf. *hyatti*, *Coilopoceras* sp. juv., *Metaptychoceras crassum* sp. nov., and *W. minor*; from 6·1 m (20 ft.) above on Cement Plant Creek: *P.* sp. juv. cf. *hyatti*, *M. crassum*, and *W. minor*; from 10·2 m (33·5 ft.) above *P.* sp. juv. cf. *hyatti*, *M. crassum*, and *W. minor*.

M. crassum and *W. minor* occur in the *P. hyatti* Zone, *C. springeri* Subzone at Chispa Summit in Trans-Pecos Texas, while the minute *Prionocyclus* have in some cases strong inner and outer ventrolateral tubercles to 3 mm whorl height, and I conclude that at least the lowest 10 m of the South Bosque Formation belongs to the *C. springeri* Subzone of the *P. hyatti* Zone. I have been unable to place the *hyatti/macombi* Zone boundary in this area, but a temporary exposure in an aggregate pit near South Bosque yielded crushed *P. macombi* Meek, 1876*b*, an undetermined distance below the base of the Austin. The top 7 m of shales and clays yield abundant *P. bosquensis* sp. nov. at a second aggregate pit approximately 10 km south-west of Waco, the species extending to 1 m from the contact. Much rarer are *C.* cf. *inflatum* Cobban and Hook, 1980*a* and a heteromorph (Pl. 14, fig. 7). Associated *I. perplexus* Whitfield, 1877, indicate the *S. whitfieldi* Zone.

The base of the Austin Chalk is a marked unconformity, gritty phosphatic chalk piping down into the shales below. There are numerous black and brown phosphates at the base of the Austin, some of which are worn moulds of *B. yokoyamai* Tokunaga and Shimizu, 1926. Unphosphatized macrofossils show the base of the Austin to be Coniacian, with *Cremnoceramus deformis* (Meek, 1876*a*) early form of Kauffman (in litt.) 2 m above the base.

Austin area. The Eagle Ford thins markedly southwards from Waco across a structural high known as the San Marcos Arch. Adkins (1933, p. 434) records 10·6–12·2 m (35–40 ft.) at outcrop and 7·3–13·7 m (24–45 ft.) in wells near Austin, and gives the following generalized succession:

(D) 8, 7, 6, 5, 4. Condensed zone. Eagle Ford clay containing angular boulders up to 18 inches long of both chalky limestone and laminated Eagle Ford limestone, corroded by groundwater but not rolled; some phosphatic pebbles; *Alectryonia lugubris* (Conrad), *Prionocyclus* sp., *Prionotropis* spp., *Coilopoceras chispaense*, *C. eaglefordense*, *C.* n. sp., *Romaniceras* sp., *Pseudaspidoceras* 2 spp., *Proplacenticeras* (?) n. sp., *Neocardioceras* spp., *Scaphites* n. sp., pelecypods, fish teeth; about 1·5 feet.

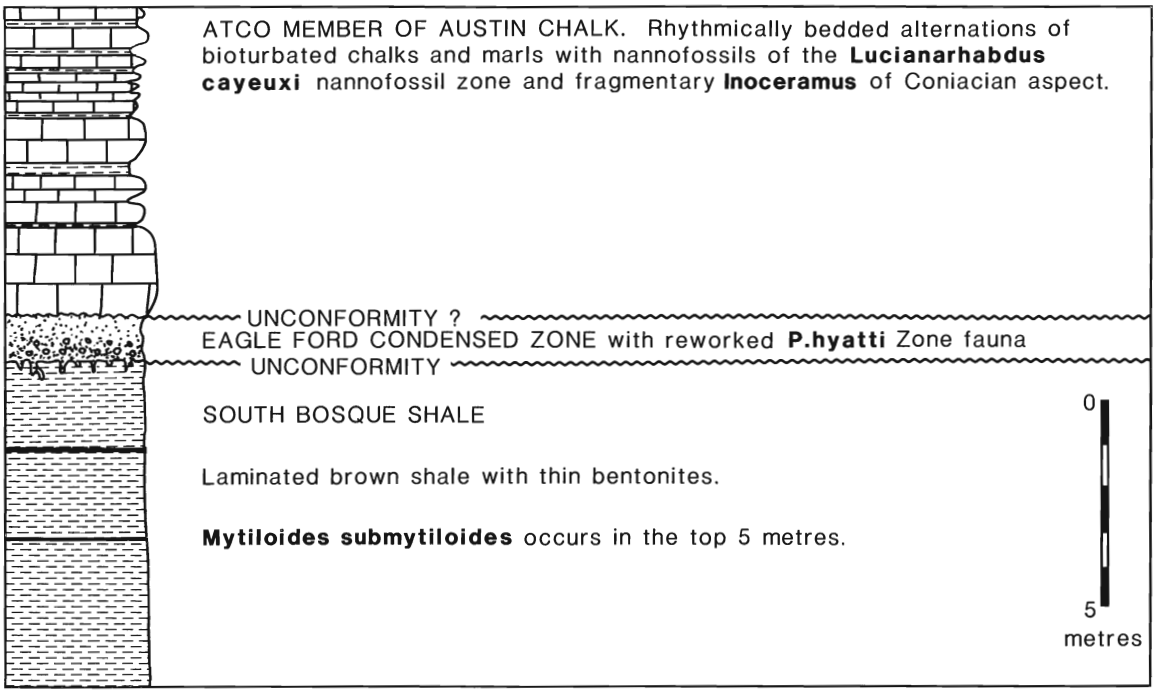
(C) Zone undetermined; laminated shale with thin bentonite seams, a 4–10 inch bentonite seam at base; colour yellow from groundwater; *Inoceramus* spp., pelecypods, fish teeth; about 16·5 feet.

(B) 3, 1. Black limestone flags and shale; *Exogyra columbella*, *Mantelliceras* n. sp. (compressed), *Acanthoceras* sp. (strongly cornute), *Eucalycoceras leonense* Adkins, *Austiniceras* n. sp., *Eucalycoceras bentonianum* Cragin (?); *Metoicoceras* sp. (?); plants, fish; about 12 feet.

unconformity

(A) Pepper Shale (?): Basal lustrous black shale; *Exogyra columbella* (?), gastropods, pelecypods, *Ammobaculites*; about 15 feet.

Adkins and Lozo (1951) provide additional general information, while a series of detailed sections are given by Feray and Young (1949). The section at Oak Haven Waterfall was studied by Smith (1981) and is shown in text-fig. 7. The South Bosque Formation yielded *Mytiloides subhercynicus* (Seitz, 1935) no more than 5 m below the base of the Condensed Zone (OUM KT 5368); this species is restricted to the *Collignoniceras woollgari* Zone. The base of the so-called Eagle Ford Condensed Zone is a marked erosion surface with the Condensed Zone piped down into the underlying South Bosque Formation. It is about 1·1 m (3·5 ft.) thick, a light to dark grey chalky marl with abundant ferrugineous ooliths, glauconite grains, phosphatic pebbles and fossil moulds, both phosphatized and infilled with matrix. Most are fragmentary and worn. Adkins (1949) provided the most complete account of the fauna of this unit. He believed the Condensed Zone to be equivalent to at least 91 m (300 ft.) of strata in north-central Texas, and to include fossil indicative of his five highest, *Neocardioceras* to *Alectryonia lugubris* Zones of the Eagle Ford.



TEXT-FIG. 7. The Eagle Ford/Austin contact at Oak Haven Waterfall, north of Austin, Travis County.

I have examined several hundred ammonites from the Condensed Zone, in the TMM, USNM, and Conlin collections. Contrary to Adkins' view, I have only seen elements of the *Prionocyclus hyatti* Zone, *Coilopoceras springeri* Subzone; *C. springeri* makes up over 90% of individuals seen, followed by *P. hyatti*. The following are represented by from 1 to 10 individuals:

Puzosia (*Puzosia*) *serratocarinata* Kennedy and Cobban, 1988*a*, *Parapuzosia* (*Austiniceras*) cf. *seali* Clark, 1960, *R.* (*Romaniceras*) *mexicanum* Jones, 1938, *incertae sedis*, *B. yokoyamai*, *S. carlilensis*, and *W. minor*. Smith (1981) has shown the overlying Atco Formation of the Austin Chalk to be Coniacian *L. cayeuxii* nannofossil Zone.

CONVENTIONS

Location of specimens. The following abbreviations are used to indicate the location of specimens mentioned in the text:

BMNH: British Museum (Natural History), London.
MNHP: Muséum National d'Histoire Naturelle, Paris.
OUM: University Museum, Oxford.
USNM: National Museum of Natural History, Washington DC.
TMM: University of Texas Memorial Museum, Austin, Texas.

Suture terminology. The system of Wedekind (1916) as propounded by Kullmann and Wiedmann (1970) is used here. E = external lobe, L = lateral lobe, U = umbilical lobe, I = internal lobe.

Dimensions. All dimensions are given in millimeters; D = diameter, Wb = whorl breadth, Wh = whorl height, U = umbilicus; c = costal, ic = intercostal. Figures in parentheses refer to dimensions as a percentage of diameter. The term rib index as applied to heteromorphs is the number of ribs in a distance equal to the whorl height at the mid-point of the interval counted.

Synonymies. Only citations which include illustrations of material or important systematic, stratigraphic, or geographic information are included.

SYSTEMATIC PALAEONTOLOGY

Order AMMONOIDEA Zittel, 1884, pp. 355, 392
Suborder AMMONITINA Hyatt, 1889, p. 7
Superfamily HAPLOCERATACEAE Zittel, 1884, p. 463
Family BINNEYITIDAE Reeside, 1928, p. 4
Genus BORISSIAKOCERAS Arkhanguelsky, 1916, p. 55

Type species. By original designation; *Borissiakoceras mirabile* Arkhanguelsky, 1916, p. 55, pl. 8, figs. 2 and 3.

Discussion. Cobban (1961), Cobban and Gryc (1961), and Cobban and Scott (1973) review North American records of this genus, also known from the USSR (Arkhanguelsky 1916; Bodylevskya and Shulinga 1958), northern France (Kennedy and Juignet 1973, 1984), Zululand (Kennedy and Klinger 1975), northern Australia (Wright 1963), and, possibly, New Zealand (the Engonoceratidae gen. et sp. nov. of Henderson 1973, p. 106, figs. 14, 8 and 15). There is a good sequence in the US Western Interior, with *B. compressum* Cobban, 1961 in the *Conlinoceras tarrantense* Zone and correlatives in Wyoming, Colorado, and New Mexico, *B. reesidei* Morrow, 1935, in the *Acanthoceras amphibolum* Zone in Kansas, Wyoming, and Colorado, and *B. orbiculatum* Stephenson, 1955, originally described from the *amphibolum* Zone of north-central Texas in the *Plesiacanthoceras wyomingense* Zone of Wyoming, Montana, and possibly Colorado, and in the *Calycoceras canitaurinum*/*Dunveganoceras pondi* Zone in the Black Hills. The genus is common (but poorly preserved) in the *gracile* Zone in west Texas (Chispa Summit) (OUM collections) and a few specimens from north-east Texas are described below. Nearly contemporaneous is the older of the two Alaskan occurrences (Cobban and Gryc 1961) with *B. inconstans* Cobban and Gryc, 1961; the association with *B. ashurkoffae* Cobban and Gryc, 1961 is early Turonian. The present species thus go some way to filling in the late Cenomanian record of the Binneyitidae, although the material is sparse. In particular, dimorphism, documented by Kennedy and Cobban (1976), cannot be recognized in the present material.

Borissiakoceras orbiculatum Stephenson, 1955

Plate 1, figs. 23–26

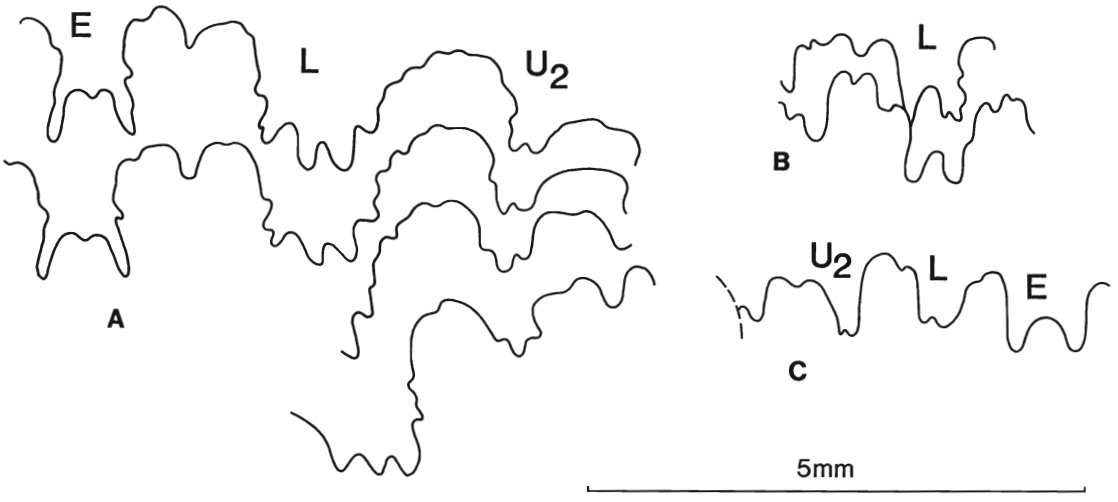
1955 *Borissiakoceras orbiculatum* Stephenson, p. 64, pl. 6, figs. 1–4.
1955 *Borissiakoceras* sp., Stephenson, p. 64, pl. 6, fig. 5.
1961 *Borissiakoceras orbiculatum* Stephenson; Cobban, p. 750, pl. 88, figs. 15–44; text-fig. 5*a–f*.
? 1973 *Borissiakoceras* cf. *orbiculatum* Stephenson; Cobban and Scott, p. 83, pl. 2, fig. 12.
1975 *Borissiakoceras* cf. *orbiculatum* Stephenson; Hattin, pl. 2, N.
1984*b* *Borissiakoceras* cf. *orbiculatum* Stephenson; Cobban, p. 18, pl. 4, fig. 4.

Holotype. USNM 108832 from the basal Eagle Ford concretions on Walnut Creek, 4·75 miles north-east of Mansfield, Texas; *A. amphibolum* Zone.

Material. USNM 41427–41429 from Texcrete Quarries, 0·3 miles south-east of Loop 12 interchange on Fort Worth–Dallas Turnpike, Dallas County.

Discussion. These specimens closely resemble the abundant material from the somewhat older *D. pondi*/*C. canitaurinum* Zone of the Black Hills figured by Cobban (1961). The illustrated specimens appear to be macroconchs and confirm previous records of *B.* cf. *orbiculatum* in the *gracile* Zone of the north-eastern flank of the Black Hills in south-eastern Dakota.

Occurrence. The species ranges from *amphibolum* to *gracile* Zones. There are records from Wyoming, Montana, Colorado, Kansas, and Texas.



TEXT-FIG. 8. External sutures. A, *Nannometoicoceras acceleratum* (Hyatt, 1903), USNM 411523. B, *Borissiakoceras desmoceratoides* sp. nov., USNM 411430. C, *B. auriculatum* sp. nov., USNM 411431.

Borissiakoceras auriculatum sp. nov.

Plate 1, figs. 14–20; text-fig. 8C

Types. Holotype USNM 411430, paratypes USNM 411431–411432, all from the Britton Formation, Texcrete Quarries, Dallas County; Upper Cenomanian, *Sciponoceras gracile* Zone.

Diagnosis. A small species of *Borissiakoceras* with five broad ribs and strong clavate tubercles per half whorl on the phragmocone, and a relatively smooth body-chamber. Suture typical for genus.

Discussion. Strong ribbing and clavate, ear-like ventral tubercles on the phragmocone are the distinctive features of this diminutive species. *B. mirabile* Arkanguelsky, 1916 (p. 55, pl. 8, figs. 2 and 3), the type species, is more evolute and lacks the strong, distant tubercles of the present form. *B. compressum* Cobban, 1961 (p. 747, pl. 87, figs. 19–33; pl. 89, figs. 1–9; text-fig. 4*a–k*) is a larger species; an undescribed collection from the Frontier Formation at USGS Mesozoic Locality D9805 in Wyoming includes individuals up to 60 mm in diameter. It is more compressed and high-whorled, and usually smooth. The nodate form (Cobban 1961, p. 749, pl. 8, figs. 1–7) is more involute and commonly has more nodes per whorl, the nodes bullate rather than clavate. *B. reesidei* Morrow, 1935 (p. 463, pl. 49, fig. 7; pl. 50, fig. 5; text-fig. 8; see Cobban 1961, p. 749, pl. 88, figs. 1–14; text-fig. 3*h–k*) is a stouter, larger species, nodate variants having weaker, conical, rather than clavate tubercles of the present species, and lacks strong flank ribs.

B. orbiculatum Stephenson, 1955 (see above) has rather similar proportions but a much sharper umbilical shoulder and vertical umbilical wall; nodate variants do not develop as large tubercles as the present species, nor strong flank ribs. *B. inconstans* Cobban and Gryc, 1961 (p. 187, pl. 38, figs. 30–37; text-fig. 2*i*, *l*), a near contemporary, is much smaller; nodate variants resemble the present species, but flank ribs are weaker with nodes conical rather than clavate. *B. ashurkoffae* Cobban and Gryc, 1961 (p. 188, pl. 38, figs. 38–43; text-fig. 2*j*, *k*, *m*) and *B. desmoceratoides* sp. nov., described below, are both utterly distinctive.

Occurrence. As for types.

Borissiakoceras desmoceratoides sp. nov.

Plate 1, figs. 21, 22, 27, 28; text-fig. 8B

Types. Holotype USNM 411435, paratype USNM 411436, both from the Britton Formation, Texcrete Quarries, Dallas County.

Diagnosis. Body-chamber evolute and only slightly compressed, with broadly rounded venter ornamented by bunches of falcoid growth striae and lirae that may strengthen into ventrolateral bullae. Feeble falcoid constrictions variably developed. Sutures typical for genus.

Discussion. The two body-chambers referred to this species have similar proportions and growth lines, differing only in the variable development of tubercles, a phenomenon seen in many other *Borissiakoceras* species. Whorl section and coiling alone distinguish *B. desmoceratoides* sp. nov. from *B. mirabile*, *B. compressum*, *B. orbiculatum B. inconstans*, and *B. auriculatum*. There is some similarity to *B. reesidei* Morrow, 1935 (p. 463, pl. 49, fig. 7; pl. 50, fig. 5; text-fig. 8; see also Cobban 1961, p. 749, pl. 88, figs. 1–4; text-fig. 3*h–k*) which may also have rounded flanks and venter, but the lower whorls, falcoid growth lines, constrictions, and persistence of nodes of *B. desmoceratoides* are distinctive. There is a closer similarity to *B. ashurkoffae* Cobban and Gryc, 1961 (p. 188, pl. 38, figs. 38–43; text-fig. 2*j*, *k*, *m*) but the umbilicus is shallower in that species, whorls higher, with no development of nodes and constrictions on the body-chamber.

Occurrence. As for types.

Superfamily DESMOCERATACEAE Zittel, 1895, p. 426

[*nom. transl.* Wright and Wright 1951, p. 18; *ex* Desmoceratidae Zittel, 1895, p. 426]

Family DESMOCERATIDAE Zittel, 1895, p. 426
Subfamily DESMOCERATINAE Zittel, 1895, p. 426
Genus DESMOCERAS Zittel, 1884, p. 465

[= *Latidorsella* Jacob, 1907, p. 295 (objective synonym); *Phyllodesmoceras* Spath, 1925*a*, p. 100; *Lunatodorsella* Breistroffer 1947, p. 60]

Type species. Ammonites latidorsatus Michelin, 1838, p. 101, pl. 12, fig. 9; by the subsequent designation of Böhm 1895, p. 364.

EXPLANATION OF PLATE 1

Figs. 1–13. *Desmoceras* (*Moremanoceras*) *scotti* (Moreman, 1942). 1–11, USNM 411437–411442, ontogenetic series from USGS Mesozoic Locality 19716, 2 miles north-east of Bells, Grayson County; 12 and 13, holotype, TMM 19807, from Hackberry Creek, 0·5 miles north of Sowers–Coppel road, north of Sowers (Locality 12 of Moreman 1942, p. 197).

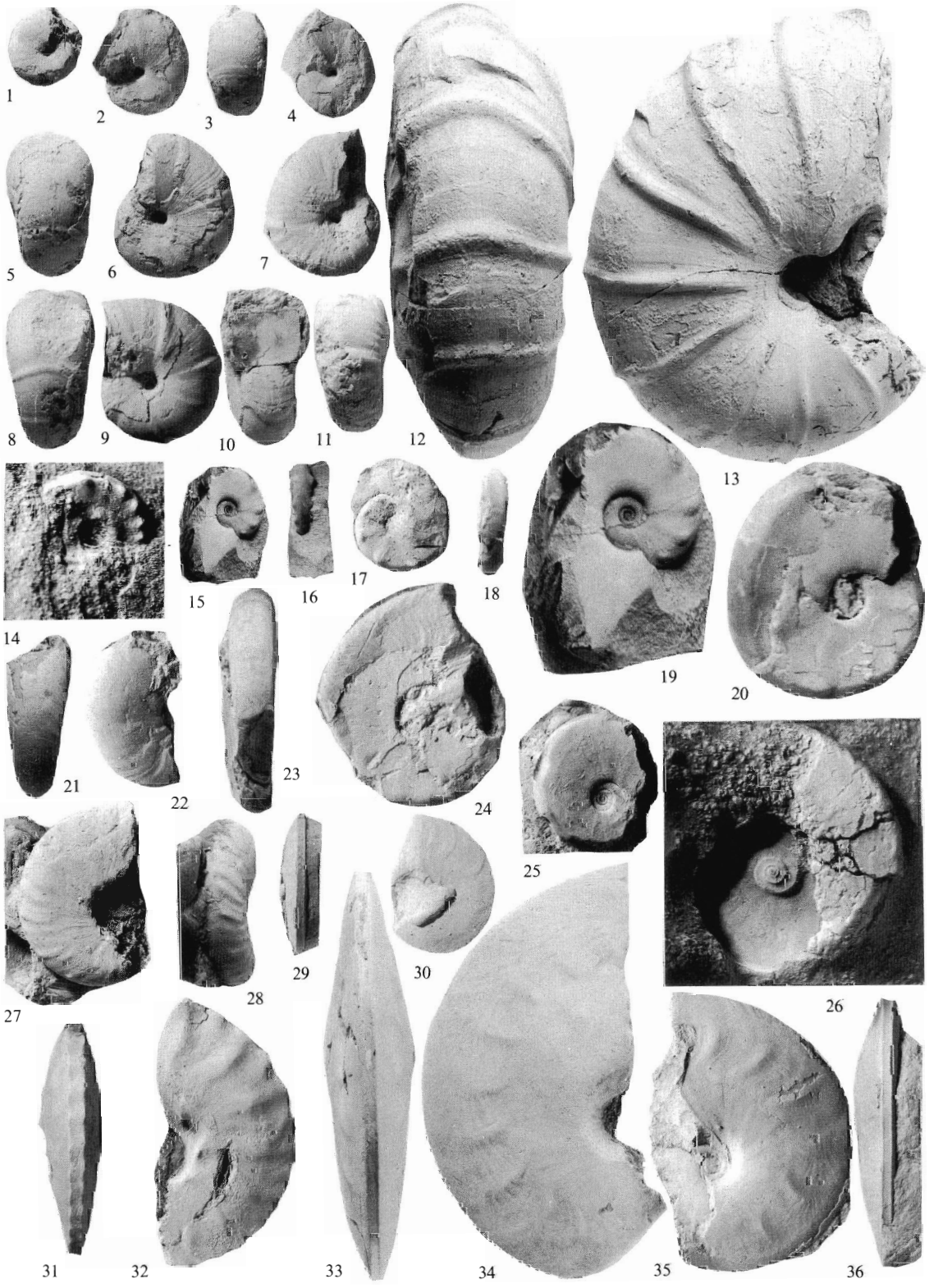
Figs. 14–20. *Borissiakoceras auriculatum* sp. nov. 14, paratype, USNM 411432; 15, 16, 19, holotype, USNM 41430; 17, 18, 20, paratype, USNM 411431; all from the Texcrete Quarries, Dallas County.

Figs. 21, 22, 27, 28. *B. desmoceratoides* sp. nov. 21 and 22, holotype, USNM 411435; 27 and 28, paratype, USNM 411436; both from the Texcrete Quarries, Dallas County.

Figs. 23–26. *B. orbiculatum* Stephenson, 1955. 23 and 24, USNM 411427; 25 and 26 USNM 411428; both specimens from the Texcrete Quarries, Dallas County.

Figs. 29–36. *Placenticeras cumminsi* Cragin, 1893. 29 and 30, USNM Collections from USGS Mesozoic Locality 22604, first creek north of Britton, 2·5 miles on farm road, Ellis County; 31 and 32, USNM 411443; 33 and 34, TMM 19575, from Eagle Ford on the Trinity River, Dallas County; 35 and 36, USNM 411444, from Texcrete Quarries, Dallas County.

All specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation of north-east Texas. Figs. 1–13, 29–36, ×1; 14–18, 21–28, ×2; 19 and 20, ×4.



KENNEDY, *Desmoceras*, *Borissiakoceras*, *Placenticeras*

Subgenus MOREMANOCERAS Cobban, 1972, p. 5

Type species. Tragodesmoceras scotti Moreman, 1942, p. 208, pl. 33, fig. 8; text-fig. 2*d*; by original designation.

Desmoceras (*Moremanoceras*) *scotti* (Moreman, 1942)

Plate 1, figs. 1–13

1927 *Pachydiscus* sp. A Moreman, p. 208, pl. 15, fig. 4.
1942 *Tragodesmoceras scotti* Moreman, p. 208, pl. 33, fig. 8; text-fig. 2*d*.
1960 *Onitschoceras*? *scotti* (Moreman); Matsumoto, p. 46, text-fig. 10*a–c*.
1972 *Desmoceras* (*Moremanoceras*) *scotti* (Moreman); Cobban, p. 6, pl. 2, figs. 1–23; text-figs. 3–5.
1977 *Desmoceras* (*Moremanoceras*) *scotti* (Moreman); Kauffman, pl. 16, figs. 1 and 2.
1986 *Moremanoceras scotti* (Moreman); Cobban, fig. 3*a*, *b*.

Holotype. By monotypy, TMM 19807 from the Britton Formation on Hackberry Creek, 0·5 miles north of Sowers–Coppel road, north of Sowers (locality 12 of Moreman 1942, p. 197); Upper Cenomanian, *S. gracile* Zone.

Material. Fifty-four specimens from the same horizon as the holotype at USGS Mesozoic Locality 19716, 2 miles north-east of Bells, Grayson County, including USNM 166340–166348, 411437–411442. Seventeen specimens from the same horizon at USGS Mesozoic Locality D9489, slopes and gullies alongside US Highway 69, 2·1 miles north-west of Bells, Grayson County.

Discussion. This species is described and discussed at length by Cobban (1972), to whose work the reader is referred. The holotype is shown as Plate 1, figs. 12 and 13 and a suite of juveniles as Plate 1, figs. 1–11. *Desmoceras* (*Moremanoceras*) *scotti* is the only described species of the subgenus. A number of other poorly preserved forms occur in the older Cenomanian of the US Western Interior in Montana, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Arizona (see Cobban 1984*b*, p. 18 for details).

Occurrence. Upper Cenomanian, *S. gracile* Zone of west and north-central Texas, New Mexico, Arizona, and Colorado. See Cobban (1972) for details.

Subfamily PUZOSIINAE Spath, 1922*a*, p. 126

[= Silesitoidinae Breistroffer, 1953, p. 74; Melchioritinae Beskovski, 1977, p. 892 (*nom. correct.* Wright and Kennedy 1984, p. 54, *ex* Melcioritinae Beskovski); Abrytusitinae Beskovski, 1977, p. 893 (*nom. correct.* Wright and Kennedy 1984, p. 54, *ex* Abritusitinae Beskovski]

Genus and Subgenus PUZOSIA Bayle, 1878, explanation of plates 45 and 46

Type species. Ammonites planulatus J. de C. Sowerby, 1827, p. 134, pl. 570, fig. 5 *non* Schlotheim, 1820, p. 59; = *Ammonites mayorianus* d'Orbigny, 1841, p. 267; by subsequent designation of H. Douvillé, 1879, p. 91 (see Wright and Kennedy 1984, p. 54, for clarification of type species).

Puzosia (*Puzosia*) *serratocarinata* Kennedy and Cobban, 1988*a*

Plate 2, figs. 8–10, 12–14, 16–18; text-fig. 26A

1988*a* *Puzosia* (*Puzosia*) *serratocarinata* Kennedy and Cobban, fig. 2; fig. 4: 1–3.

Types. Holotype TMM 1576TX/15, paratype TMM 1576TX/13; TMM locality 17255, Lower Conchos Valley, west of El Alamo, Chihuahua, Mexico; *Prionocyclus hyatti* Zone.

Material. Five specimens. USNM 420075 is from 22·8 m (75 ft.) below the top of the Arcadia Park Formation, approximately 2 miles west of Cedar Hill, Dallas County. USNM 420076, 420078, 420079 are from the Eagle

Ford Condensed Zone at Oak Haven Waterfall, second north-flowing branch of Walnut Creek, 8·25 miles (airline) 9° N. 30′ E. from the University Campus, Austin, Travis County. USNM 420077 is also from the Eagle Ford Condensed Zone at Austin.

Description. USNM 420075 shows the earliest stages (Pl. 2, figs. 12–14), the remaining specimens are all wholly septate up to a whorl height of 60 mm. The most complete specimen is USNM 420078. It is a slightly distorted phosphatic internal mould with a trace of phosphatized shell; maximum diameter is 76·8 mm (Pl. 2, figs. 8–10). Coiling evolute, with U = 33% of diameter approximately, shallow, with low subvertical wall. Whorl section compressed with whorl breadth to height ratio of 0·57 approximately, flanks subparallel, with narrow, arched venter. Surface of internal mould lacks visible ornament except on ventral region, where there is a trace of fine even ribbing. Ornament of similar style, but stronger, is present on a small patch of phosphatized shell. There are traces of a single constriction, apparently falcoid and prorsiradiate. It is concave on the outer flank/ventrolateral shoulder and crosses the venter with an acute chevron. An artificial mould from the dorsum of USNM 420076 (Pl. 2, fig. 17) shows that the ventrolateral shoulders and venter of the shell exterior bore low, narrow concave prorsiradiate ribs, as wide as the interspaces, and a sharp keel, with crenulations corresponding to the ribs. Presence of this keel on the shell exterior but not interior (Pl. 2, figs. 8 and 16) shows it was solid, although ribs occur on both internal mould and shell surface. USNM 420075 confirms this, and shows a single strong, flexuous constriction.

Discussion. The solid, serrated keel and ventrolateral ribs are identical to those of the type material of *Puzosia* (*Puzosia*) *serratocarinata* (Kennedy and Cobban, 1988*a*, fig. 2; fig. 4: 1–3), and differentiate the material from all other *Puzosia* species.

Occurrence. Prionocyclus hyatti Zone of central Texas and Chihuahua, Mexico.

Genus PARAPUZOSIA Nowak, 1913, p. 350

Type species. Sonneratia daubréei de Grossouvre, 1894, p. 154, pl. 28; by original designation.

Subgenus AUSTINICERAS Spath, 1922*a*, p. 127

Type species. Ammonites austeni Sharpe, 1855, p. 28, pl. 12, fig. 1; by original designation.

Parapuzosia (*Austiniceras*) *seali* Clark, 1960

Plate 13, figs. 1 and 2

1960 *Parapuzosia* (*Austiniceras*) *seali* Clark, p. 235, pl. 34, figs. 1–3.

Holotype. By monotypy; Southern Methodist University Collections no. 35024, from the upper Britton Formation by the Britton–Cedar Hill road, 1·5 miles south-east of Britton, Dallas County, Texas; *P. hyatti* Zone inferred.

Material. A fragment from the Eagle Ford Condensed Zone at USGS Locality 14604, Bouldin Creek, 1·75 miles south-south-west of the Capitol Building, Austin, Travis County.

Description. 'Large phragmocone, no body chamber, greatest diameter of 600 mm. Umbilicus large and 180 mm diameter at greatest diameter of specimen. Height of last whorl is 250 mm, width 180 mm. Umbilical wall is 40 mm at maximum diameter. There are four whorls shown by the wide umbilicus. Some of ribbing removed exposing excellent sutures of the general Puzosiinae type *A. seali*, n. sp. is distinguished by its extremely narrow converging whorl section and sinuous forward projecting ribs which are closely spaced and of equal size. These features distinguish it from *A. austeni* (Sharpe) whose whorl section has a dorsal bulge and from other species of *Austiniceras*' (Clark 1960, p. 235).

Occurrence. P. hyatti Zone of central Texas.

Family MUNIERICERATIDAE Wright, 1952, p. 222
[= Pseudoschloenbachiidae Van Hoepen, 1968, p. 186]

Genus TRAGODESMOCERAS Spath, 1922*a*, p. 127

Type species. Desmoceras clypealoides Leonhard, 1897, p. 57, pl. 6, fig. 2; by original designation.

Tragodesmoceras sp.

Plate 12, fig. 9

Material. USNM 420080, from the top of the Bouldin Member of the Lake Waco Formation on Cloice Branch, McLennan County; ?*P. hyatti* Zone.

Description. The specimen is crushed, the maximum diameter being 85·5 mm. Coiling fairly evolute, with 50% of previous whorl covered. Strong primary ribs arise at the umbilical seam, strengthening across umbilical shoulder, straight and rectiradiate to feebly prorsiradiate to mid-flank, where they flex back and are concave over the outer flank, sweeping forwards to form a marked ventral chevron. Long secondaries arise below mid-flank, while short secondaries, inserted on the outer flank are also developed so that there are three times as many ribs on the venter as on the umbilical shoulder. All the ribs are strong on the venter which is markedly crenulate in profile as a result.

Discussion. The specimen is specifically indeterminate. *Tragodesmoceras bassi* Morrow, 1935 (p. 468, pl. 52, fig. 1*a–c*; pl. 53, figs. 3–5; text-figs. 1, 3; Cobban and Scott 1973, p. 58, pl. 38, figs. 2, 3, 5–13; pl. 39) is a *Mammites nodosoides* Zone species known from Kansas and south-eastern Colorado. *T. carlilense* Cobban, 1972 (p. 8, pl. 3, figs. 1 and 2; pl. 4, figs. 1–16; pl. 5; text-figs. 6–8) is a *Collignoniceras woollgari* Zone species known from north-eastern Wyoming and south-western South Dakota and, perhaps, Kansas and south-eastern Colorado (Cobban 1972, p. 10). *T. socorroense* Cobban and Hook, 1980*b* (p. 13, pl. 5, figs. 9 and 10; pls. 6 and 7; pl. 11, fig. 10; text-fig. 4) is also a *C. woollgari* Zone species, known only from New Mexico and Trans-Pecos Texas. If correctly dated, the present specimen is the youngest North American occurrence of the genus.

Occurrence. As for material.

Superfamily HOPLITACEAE H. Douvillé, 1890, p. 290
[*nom. correct.* Wright and Wright, 1951, p. 21 (*pro* Hoplitida Spath, 1922*b*, p. 95, *nom. transl. ex.* Hoplitidés Douvillé, 1890)]
[= Placenticerataceae Hyatt, 1900, p. 584, *nom. correct.* Casey, 1960, p. 208, *pro* Placenticeratida Hyatt, 1900; Engonocerataceae Hyatt, 1900, p. 585, *nom. transl.* Basse, 1952, p. 658, *ex* Engonoceratidae Hyatt, 1900]

EXPLANATION OF PLATE 2

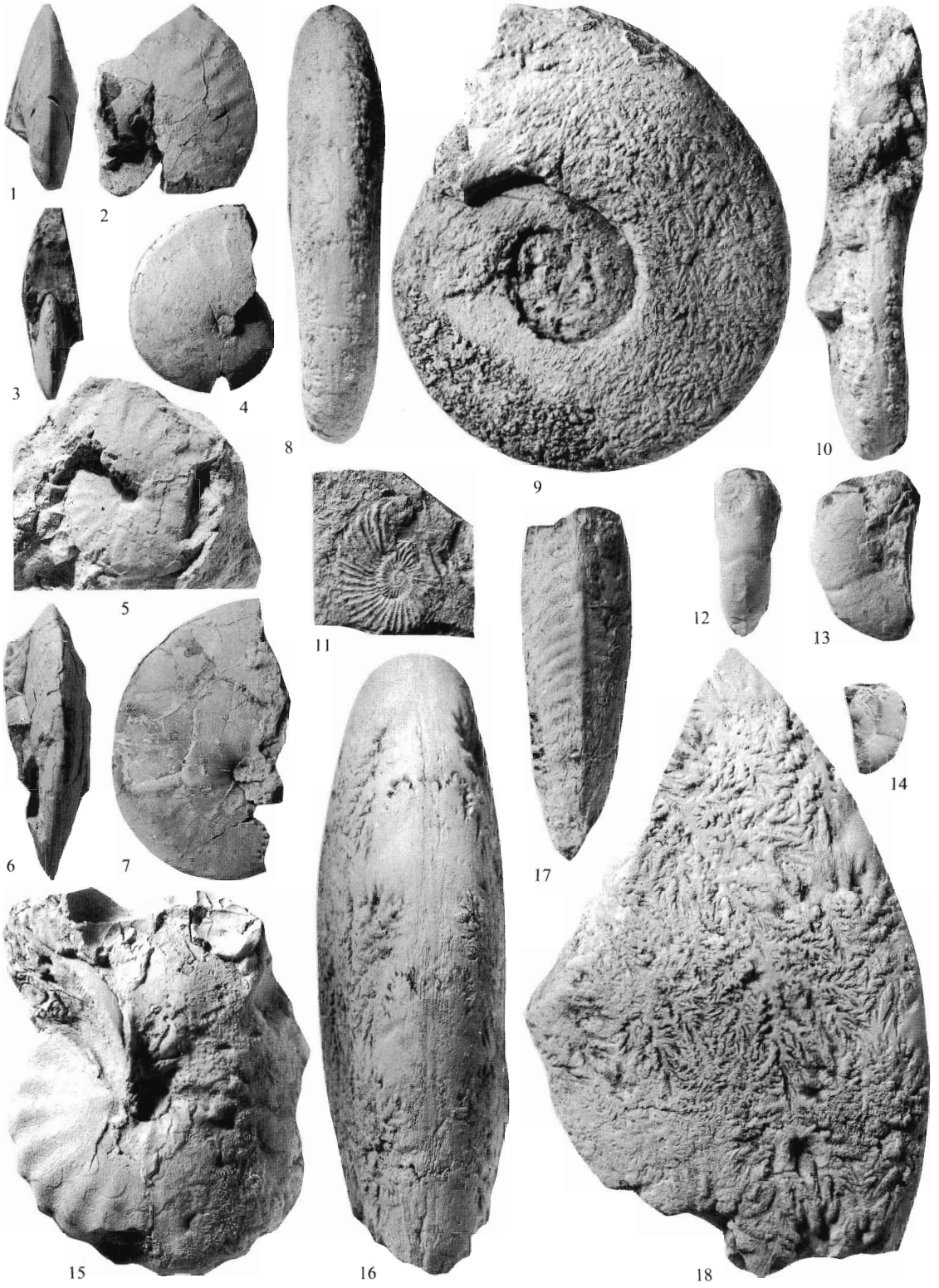
Figs. 1–7. *Hoplitoides sandovalensis* Cobban and Hook, 1980. 1 and 2, USNM 420148; 3 and 4, USNM 420145; 5, USNM 420150; 6 and 7, USNM 420147. 1, 2, 6, 7, from USGS Locality 22608, east of Power Plant on Mountain Creek Lake, Dallas County; 3 and 4, from 5 ft. below the base of the Austin Chalk, White Rock scarp, 2 miles approximately west of Cedar Hill, Dallas County; 5, imprecisely localized, but from the Dallas area. All Arcadia Park Formation, *Prionocyclus hyatti* Zone.

Figs. 8–10, 12–14, 16–18. *Puzosia* (*Puzosia*) *serratocarinata* Kennedy and Cobban, 1988. 8–10, USNM 420078; 16–18, USNM 420076, both from Oak Haven Waterfall on Walnut Creek, north of Austin, Travis County, Eagle Ford Condensed Zone. 17 is silicone squeeze of the dorsal impressed zone of USNM 420076. 12–14, USNM 420075, Arcadia Park Formation, 75 ft. below the base of the Austin Chalk, 2 miles west of Cedar Hill, Dallas County, Arcadia Park Formation. All specimens are from the *Prionocyclus hyatti* Zone.

Fig. 11. *P. macombi* Meek, 1876*b*. OUM KT 3903, from the South Bosque Shale, Gravel and Aggregate Pit near South Bosque, McLennan County, *P. macombi* Zone.

Fig. 15. *Spathites* (*Spathites*) *puercoensis* (Herrick and Johnson, 1900*a*). USNM 420086, from 1·8 miles west of junction of US Highways 89 and 82 in Bells, Grayson County. Arcadia Park Formation, *P. hyatti* Zone.

Figs. 11–13, 17 are ×2; the remainder are ×1.



KENNEDY, *Hoplitoides*, *Puzosia*, *Prionocyclus*, *Spathites*

Family PLACENTICERATIDAE Hyatt, 1900, p. 585

[= Hypengonoceratinae Chiplonkar and Ghare, 1976, p. 2; Baghiceratinae Chiplonkar and Ghare, 1976, p. 3]

Genus PLACENTICERAS Meek, 1876*a*, p. 462

[for synonymy see Kennedy and Wright 1983, p. 869]

Type species. Ammonites placenta DeKay, 1828, p. 278; by original designation by Meek, 1876*a*, p. 462.

Placenticeras cumminsi Cragin, 1893

Plate 1, figs. 29–36; Plate 3, figs. 10–15; text-figs. 9, 10A, C, G, 11C, 12–19

1893 *Placenticeras syrtalis* Morton var. *cumminsi* Cragin, p. 237.
1894 *Placenticeras placenta* DeKay?, Stanton, p. 169 (*pars*), pl. 39, figs. 2 and 3 only.
1903 *Placenticeras stantoni* Hyatt, p. 214.
1903 *Placenticeras stantoni* var. *Bolli* Hyatt, p. 214, pl. 40, figs. 3–7; pl. 41; pl. 42; pl. 43, figs. 1 and 2.
1903 *Placenticeras pseudoplacenta* Hyatt, p. 216 (*pars*), pl. 43, figs. 3–11, *non* pl. 44.
1903 *Placenticeras pseudoplacenta* var. *occidentale* Hyatt, p. 217 (*pars*), pl. 45, fig. 2, *non* fig. 1.
1910 *Placenticeras stantoni* Hyatt; Grabau and Shimer, p. 219, fig. 1496*c*, *d*.
?*non* 1928 *Placenticeras pseudoplacenta* Hyatt; Reeside, p. 8, pl. 2, figs. 20 and 21.
1928 *Placenticeras cumminsi* Cragin; Adkins, p. 253.
1942 *Proplacenticeras cumminsi* (Cragin); Moreman, p. 219.
1942 *Proplacenticeras stantoni* var. *bolli* (Hyatt); Moreman, p. 219.
1942 *Proplacenticeras pseudoplacenta* var. *occidentale* (Hyatt); Moreman, p. 219.
1978 *Proplacenticeras pseudoplacenta* (Hyatt); Hattin and Siemers, fig. 10.12.
1980 *Proplacenticeras pseudoplacenta* (Hyatt); Cobban and Hook, p. 14, pl. 8, figs. 1–5.
1983 *Placenticeras cumminsi* Cragin; Cobban and Hook, p. 8, pl. 3, figs. 12–18; pl. 5, figs. 4 and 5.
1983 *Proplacenticeras stantoni* (Hyatt); Cobban, p. 12, pl. 7, figs. 1 and 2.
1983 *Proplacenticeras pseudoplacenta* (Hyatt); Cobban, p. 11, pl. 7, figs. 3–5.

Holotype. By monotypy, TMM 21679 from the Britton Formation on Hackberry Creek, Dallas County; Upper Cenomanian, *S. gracile* Zone (text-fig. 13).

Material. More than 100 specimens in the USGS, USNM, TMM, and OUM collections from the Britton Formation in the Dallas/Fort Worth area; Upper Cenomanian, *S. gracile* Zone.

EXPLANATION OF PLATE 3

Figs. 1 and 2. *Tarrantoceras sellardsi* (Adkins, 1928). 1, USNM 411464; 2, USNM 411465; from bentonitic shales in the lower part of the Eagle Ford at USGS Mesozoic Locality D9423, drainage ditch between north and southbound lanes of State Highway 36, north part of Arlington, between Randol Mill Road and Dallas–Fort Worth Turnpike, Tarrant County.

Fig. 3. *Acanthoceras* cf. *amphibolum* Morrow, 1935. USNM 41466; from the same horizon and locality as the originals of figs. 1 and 2.

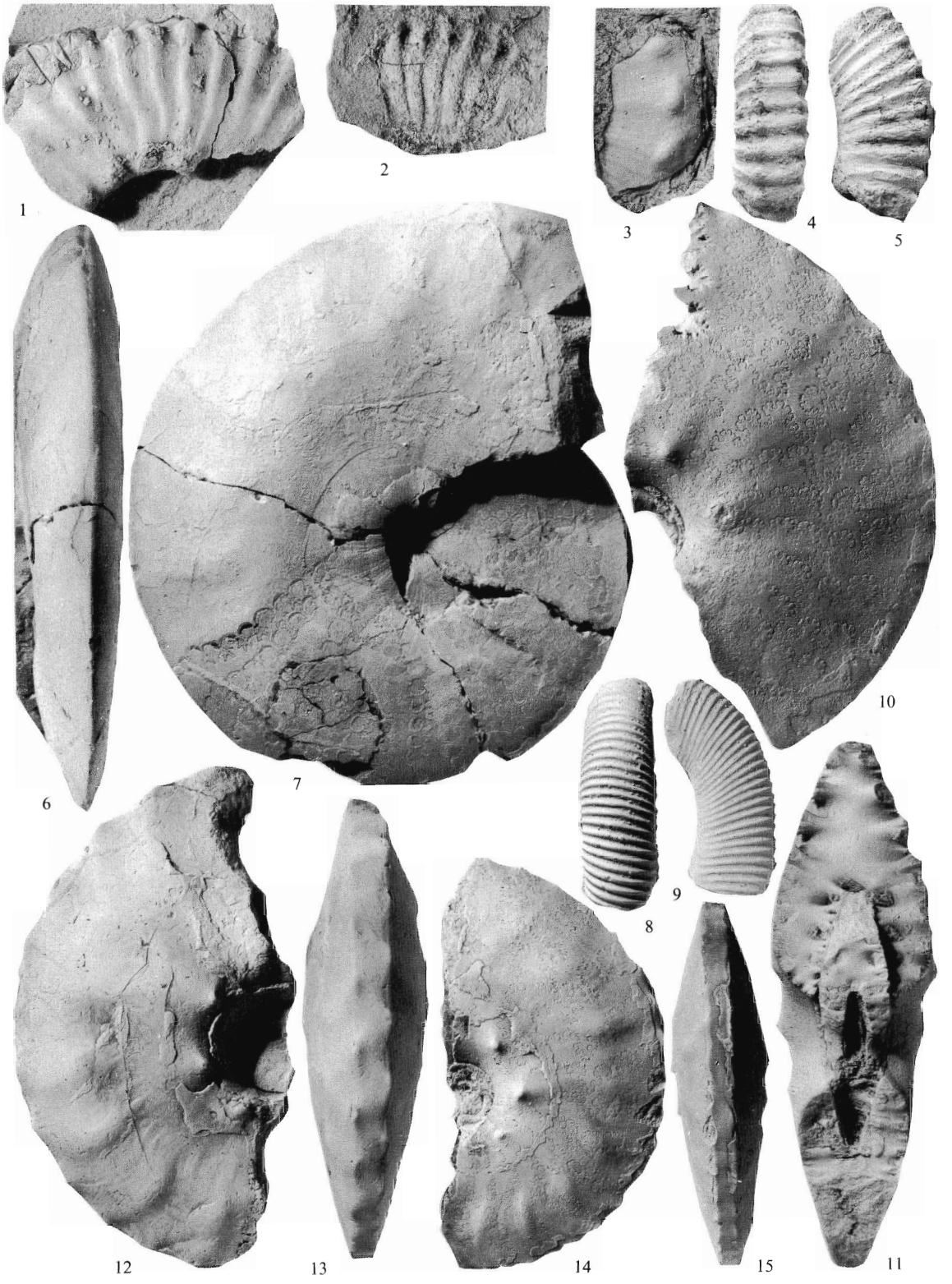
Figs. 4 and 5. *Allocrioceras dentonense* Moreman, 1942. Holotype, TMM 19808; from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation, gully south of Lewisville–Hebron road, 3·5 miles east of Lewisville Station, Ellis County.

Figs. 6 and 7. *Metengonoceras acutum* Hyatt, 1903. TMM 19830; from the same horizon as the original of figs. 4 and 5, on Hackberry Creek, 0·25 miles west of Hackberry–Irving road, Dallas County.

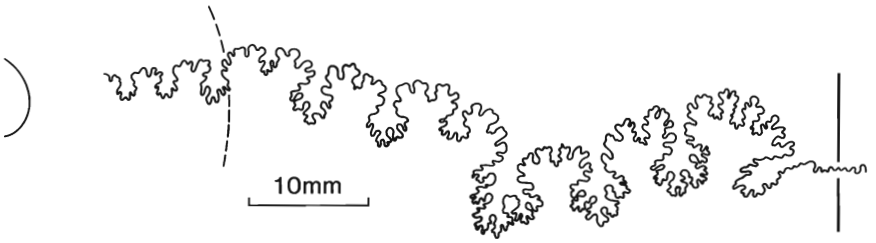
Figs. 8 and 9. *Puebloites corrugatus* (Stanton, 1894). USNM 411467; cast in the Conlin Collection, from Texcrete Quarries, Dallas County; horizon as for the original of figs. 4 and 5.

Figs. 10–15. *Placenticeras cumminsi* Cragin, 1893. 10 and 11, USNM 411450, from the same horizon as the original of figs. 4 and 5, 1·5–1·8 miles east-south-east of Britton on Rogers Farm, Ellis County; 12 and 13, USNM 411447, same horizon and locality as for original of figs. 8 and 9; 14 and 15, USNM 411445, horizon and locality as for figs. 10 and 11.

All specimens are from the Britton Formation of north-east Texas; × 1.



KENNEDY, *Tarrantoceras*, *Acanthoceras*, *Allocrioceras*, *Metengonoceras*, *Puebloites*, *Placenticeras*



TEXT-FIG. 9. External suture of *Placenticeras cumminsi* Cragin, 1893, USNM 411451. From an unpublished manuscript by W. A. Cobban.

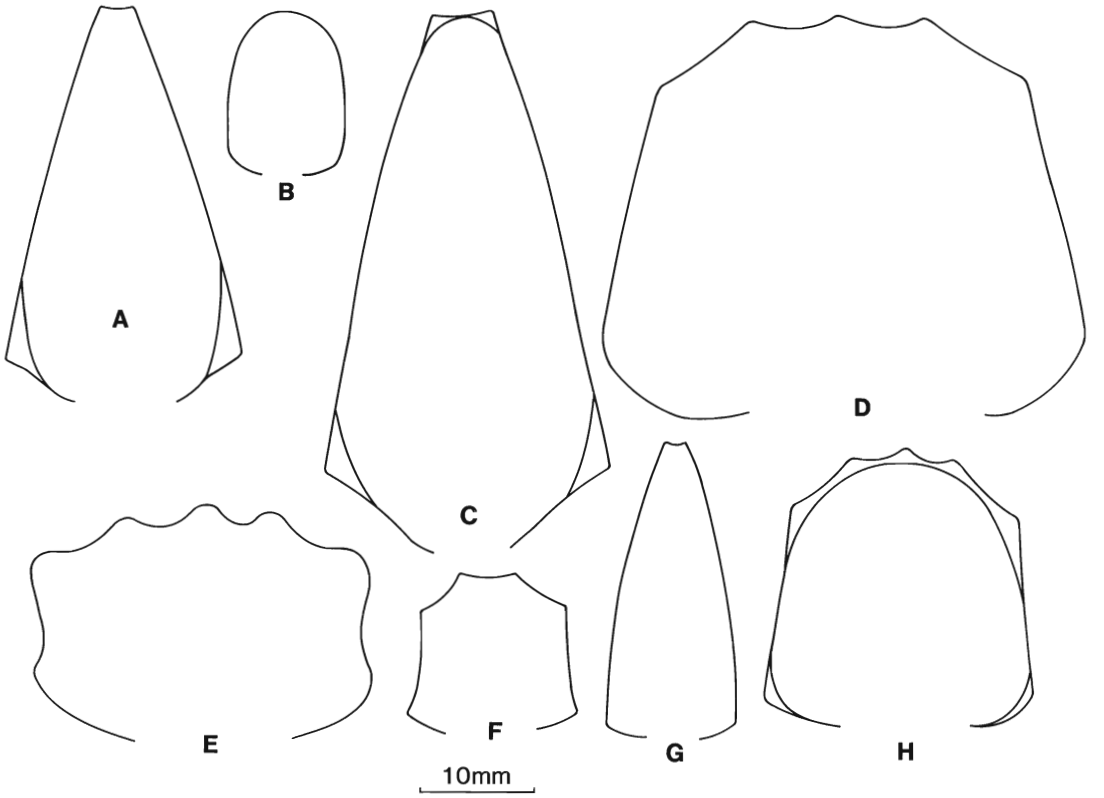
Dimensions.	*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
Juveniles					
USNM 411443	41·7(100)	11·8(28·3)	20·2(48·4)	0·58	6·0(14·4)
USNM 411444	45·5(100)	—(—)	25·0(54·9)	—	4·2(9·2)
USNM 411445	63·9(100)	16·4(25·7)	31·9(49·9)	0·51	9·0(14·1)
USNM 411446	75·3(100)	16·6(22·1)	40·5(53·8)	0·41	9·1(12·1)
USNM 411447	78·0(100)	20·0(25·6)	38·2(49·0)	0·52	14·6(18·7)
USNM 411449	81·0(100)	17·0(20·1)	43·5(53·7)	0·39	—(—)
OUM KT 1645	108·5(100)	29·3(27·0)	47·5(43·9)	0·61	18·2(16·9)
Microconchs					
USNM 411453	158(100)	47·5(30·1)	86·0(54·5)	0·55	20·5(13·0)
USNM 411454	168(100)	48·5(28·9)	85·0(50·6)	0·57	25·0(14·9)
USNM 411455	185(100)	51·0(27·6)	93·0(50·3)	0·55	27·5(14·9)
Macroconchs					
USNM 411456	195(100)	54·0(27·7)	104·0(53·3)	0·52	27·0(13·8)
USNM 411457	235(100)	67·0(28·5)	116·0(49·4)	0·58	37·8(16·1)
USNM 411458	290(100)	—(—)	140·0(48·3)	—	45·5(15·7)
USNM 411459	295(100)	—(—)	148·0(50·2)	—	45·5(15·4)

Description. Juveniles highly variable. At one extreme are compressed oxycones with whorl breadth to height ratios down to 0·38, ornamented by falcoid to falcate growth lines and striae only (Pl. 1, figs. 29 and 30). As ornament strengthens, the 'blades' of the 'sickles' strengthen into crescentic ribs on the outer flank (Pl. 1, figs. 33–36). In other specimens the 'hafts' of the sickles also strengthen into low ribs that connect to minute umbilical bullae, of which there may be up to eight per half whorl (text-fig. 12C, F) and minute ventral clavi. With increasing inflation (whorl breadth to height ratio 0·6) the ribs and bullae become yet stronger (Pl. 1, figs. 31 and 32; Pl. 3, figs. 10–15). The latter decrease in number as they strengthen (Pl. 3, figs. 10, 12, 14) and may give rise to one or two sickle-shaped ribs with, occasionally, two 'blades' corresponding to a single 'haft'. These stronger-ornamented specimens generally have four to five bullae per half whorl and twelve to fifteen ventral clavi, alternate across the venter (Pl. 1, fig. 31; Pl. 3, figs. 13 and 15). As size increases, this range of variation persists into middle growth, some specimens bearing growth striae only, with entire keels on either ventrolateral shoulder, the venter concave between until the final whorl, where the venter rounds on the mature body-chamber.

Individuals with feeble ribs may bear up to twenty tiny umbilical bullae per whorl that persist on to the adult body-chamber (text-fig. 19). Others have as few as seven bullae or conical umbilical tubercles, which extend on to the body-chamber in some (text-fig. 17) but decline in others (text-fig. 16). Ventral clavi may persist to the outer whorl in such individuals (text-fig. 15).

The species is strongly dimorphic at maturity, with adult phragmocones falling into two size classes: 200–240 mm in macroconchs (six specimens gave 200, 210, 215, 215, 225, 240 mm) (text-figs. 16, 18, 19) and 120–165 mm in microconchs (six specimens gave 120, 130, 153, 155, 160, 165 mm) (text-figs. 14 and 15). Most specimens lack part of the body-chamber; the largest incomplete macroconch seen measured 290 mm, the largest complete microconch 240 mm in diameter.

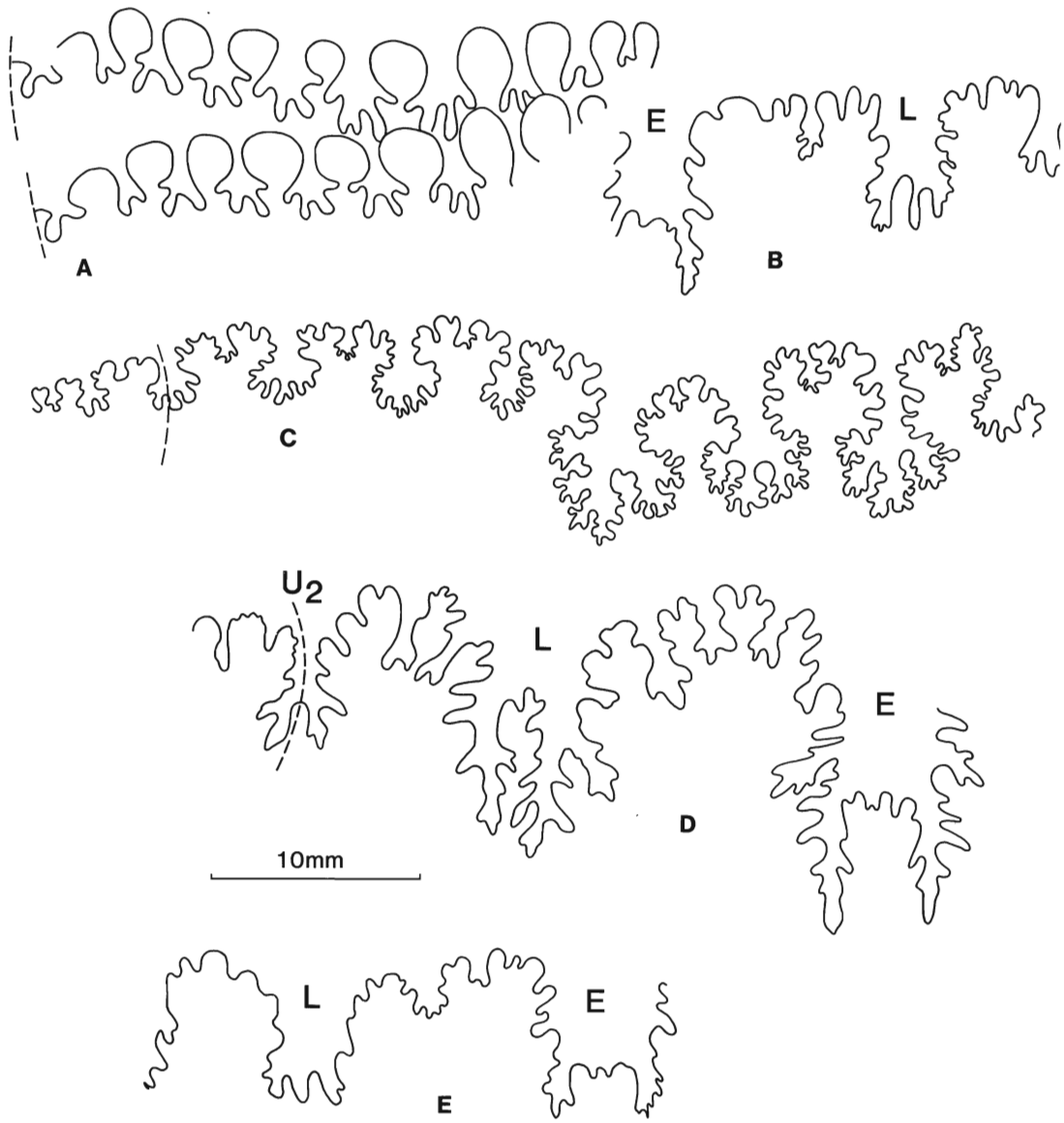
Discussion. The abundant material of this species confirms a range of variation comparable to that seen in other *Placenticeras* species (e.g. Wolleben 1967; Kennedy and Wright 1983; Klinger and



TEXT-FIG. 10. Whorl sections. A, C, G, *Placenticeras cumminsi* Cragin, 1893. A, C, USNM 411450; G, USNM 411448. B, *Tarrantoceras* (*Sumitomoceras*) *conlini* Wright and Kennedy, 1981, USNM 411481. D, H, *Pseudocalycoceras angolaense* (Spath, 1931); D, USNM 411480; H, USNM 411457. E, *Euomphaloceras septemseriatum* (Cragin, 1893), USNM 411493. F, *T.* (*S.*) *crassum* sp. nov., USNM 411487.

Kennedy, in press), but the dimorphism recognized concerns merely size and does not show the development of relatively evolute coarse-ribbed and robust microconchs of '*Stantonoceras*' Johnson, 1903 and '*Parastantonoceras*' Collignon, 1965*a*, type. *Placenticeras cumminsi* is the earliest name applied to late Cenomanian *Placenticeras* from North America. Hyatt described a series of forms from the *gracile* Zone of the Upper Kanab Valley in Utah that are no more than variants of this species. Thus *P. stantoni* Hyatt, 1903 (p. 214; holotype, by monotypy, USNM 22939, the original of Stanton 1894, pl. 39, figs. 2 and 3) is a variant with feeble umbilical bullae and ventral clavi. *P. stantoni* var. *bolli* Hyatt, 1903 (p. 214, pl. 40, figs. 3–7; pl. 41; pl. 42; pl. 43, figs. 1 and 2) encompasses strongly ribbed forms. *P. pseudoplacenta* Hyatt, 1903 (p. 216 (*pars*), pl. 43, figs. 3–11; *non* pl. 44) is an Upper Turonian *Prionocyclus hyatti* Zone species (W. A. Cobban, pers. comm.), the original of pl. 43, figs. 3–6 being the lectotype by the subsequent designation of Cobban 1983, p. 12. It is probably no more than merely a near-smooth variant. *Placenticeras pseudoplacenta* var. *occidentale* Hyatt, 1903 (p. 217 (*pars*), pl. 45, fig. 2, *non* fig. 1) is in part based on material from the Texas *gracile* Zone, the illustration being of a suture only.

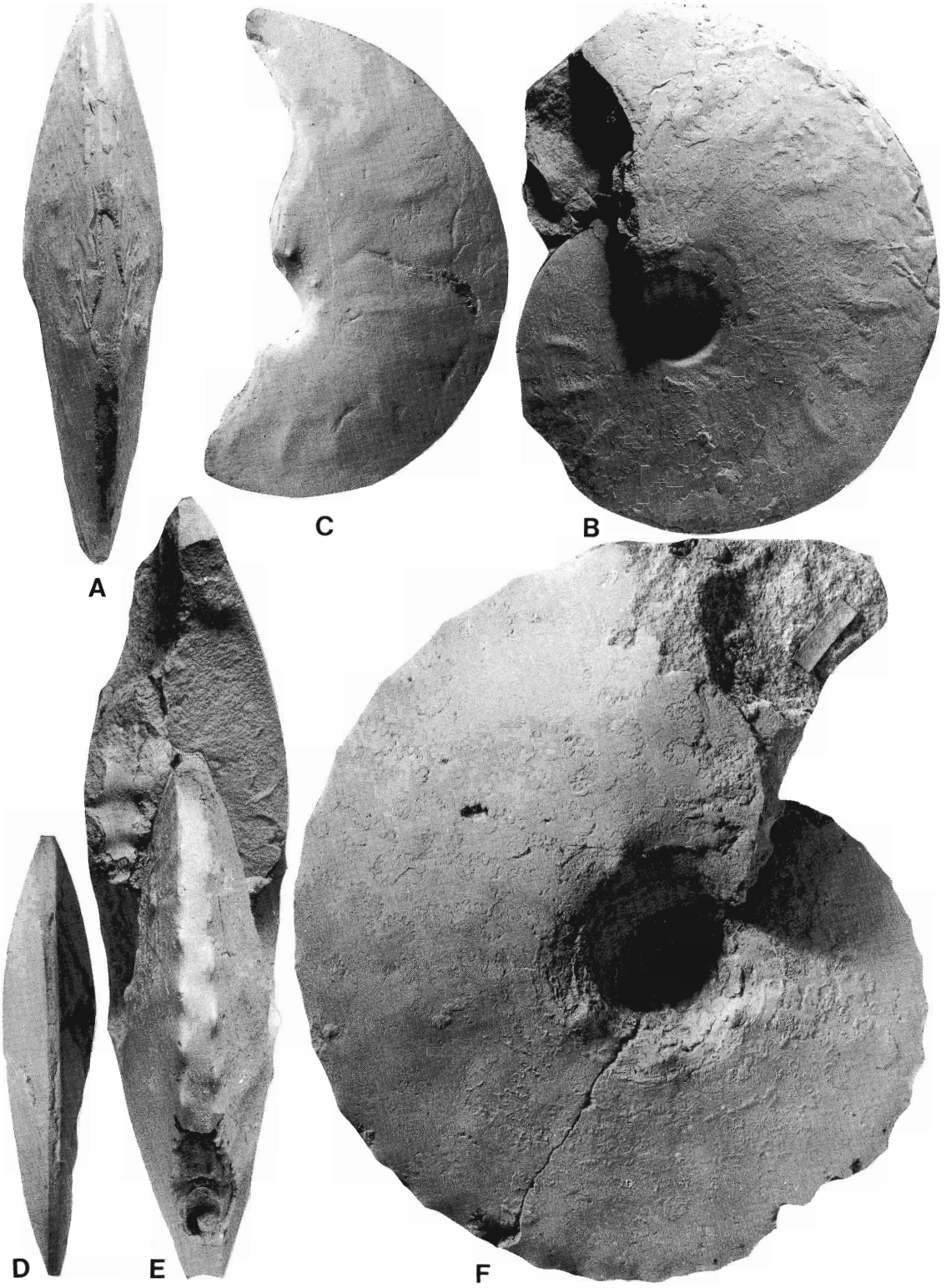
The earliest names applied to approximately contemporary European species of *Placenticeras* are *memoriaeschloenbachi* Laube and Bruder, 1887 (p. 221, pl. 23, fig. 1), *kharesmenense* Lahusen, 1884 (p. 134, pl. 2; pl. 3, fig. 1), and *kysylcumense* Arkhanguelsky, 1916 (p. 45, pl. 7, figs. 4–7; text-fig. 16). I suspect these to be conspecific with the American forms, but having no well-preserved material for comparison and only the schematic illustrations of the first two named taxa I apply the American



TEXT-FIG. 11. External sutures. A, *Metengonoceras acutum* Hyatt, 1903, TMM 19830. B, E, *Pseudocalycoceras angolaense* (Spath, 1931). B, USNM 411473; E, USNM 411479. C, *Placenticeras cumminsi* Cragin, 1893, USNM 411450. D, *Euomphaloceras septemseriatum* (Cragin, 1893), J. P. Conlin Collection, no. 4802.

terminology at this time. Dr Cobban points out that the suture of this species is like that of *Karamaites* Sokolov *in* Casey, 1965 (p. 461) of the older Cenomanian rather than Turonian material he has studied, which has a typical *Placenticeras* configuration.

Occurrence. Upper Cenomanian, *Sciponoceras gracile* Zone in north-east Texas, Colorado, and Utah; Lower Turonian, *Mammites nodosoides* Zone; and Middle Turonian, *C. woollgari* Zone in New Mexico, *woollgari* Zone of Minnesota. *P. pseudoplacenta* of Hyatt 1903 (*pars*) are from the Upper Turonian *Prionocyclus hyatti* Zone of Colorado.



TEXT-FIG. 12. *Placenticeras cumminsi* Cragin, 1893, × 1. A, B, USNM 411452; C, D, USNM 411446; E, F, USNM 411451. All from the Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation, first creek north-east of Britton, 2·5 miles on farm road, Ellis County.

TEXT-FIG. 13. Holotype of *Placenticeras cumminsi* Cragin, 1893, UTA 21679, from the Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation, Hackberry Creek, Dallas County. ×0·95.

Placenticeras sp.

Plate 14, figs. 3 and 9

Material. USNM 420081–420084 from USGS Mesozoic Locality D9446, Britton Formation, *C. woollgari* Zone, road cuts on Kiest Boulevard, 0·5 miles west of Ledbetter Drive, just east of Mountain Creek Lake, at Dallas Baptist College, Dallas County.

Discussion. All specimens are crushed and specifically indeterminate. Involute coiling with a tiny umbilicus plus the sinuous growth lines indicate them to be a *Placenticeras*, probably *P. cumminsi* Cragin, 1893.

TEXT-FIG. 14. *Placenticeras cumminsi* Cragin, 1893. USNM 411461, a complete adult microconch, 235 mm in diameter, from USGS Mesozoic Locality 22604, first creek north-east of Britton, 2·5 miles on farm road, Ellis County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation. ×0·6.

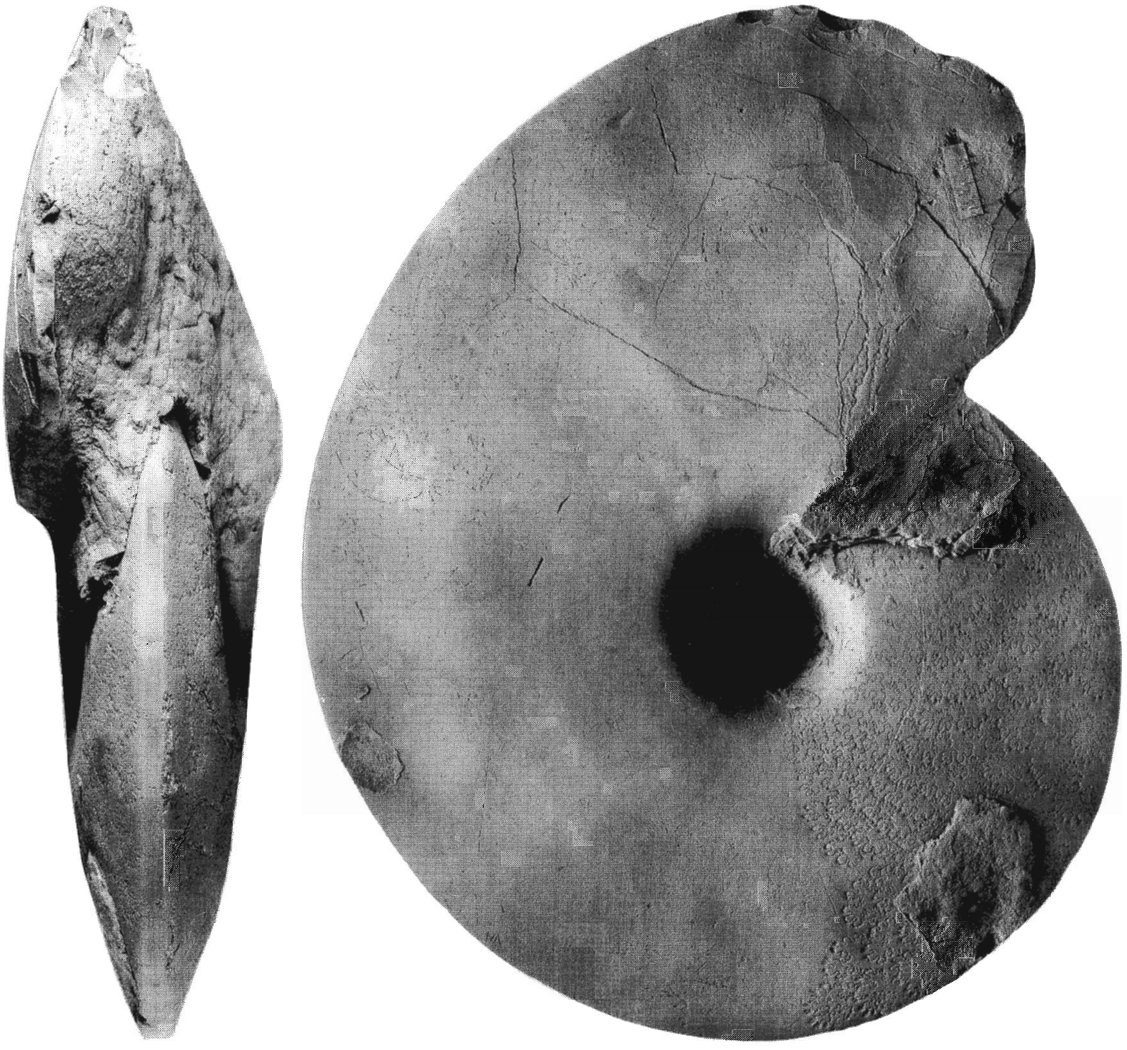
Family ENGONOCERATIDAE Hyatt, 1900, p. 585

[= Knemiceratidae Hyatt, 1900, p. 144; Neolobitinae Luppov *in* Orlov 1958, p. 125]

Genus METENGONOCERAS Hyatt, 1903, p. 179

[= *Epengonoceras* Spath, 1924, p. 508]

Type species. Metengonoceras inscriptum Hyatt, 1903, p. 180, pl. 25, figs. 5–9; pl. 26, figs. 1–4; by subsequent designation by Roman, 1938 (p. 491).



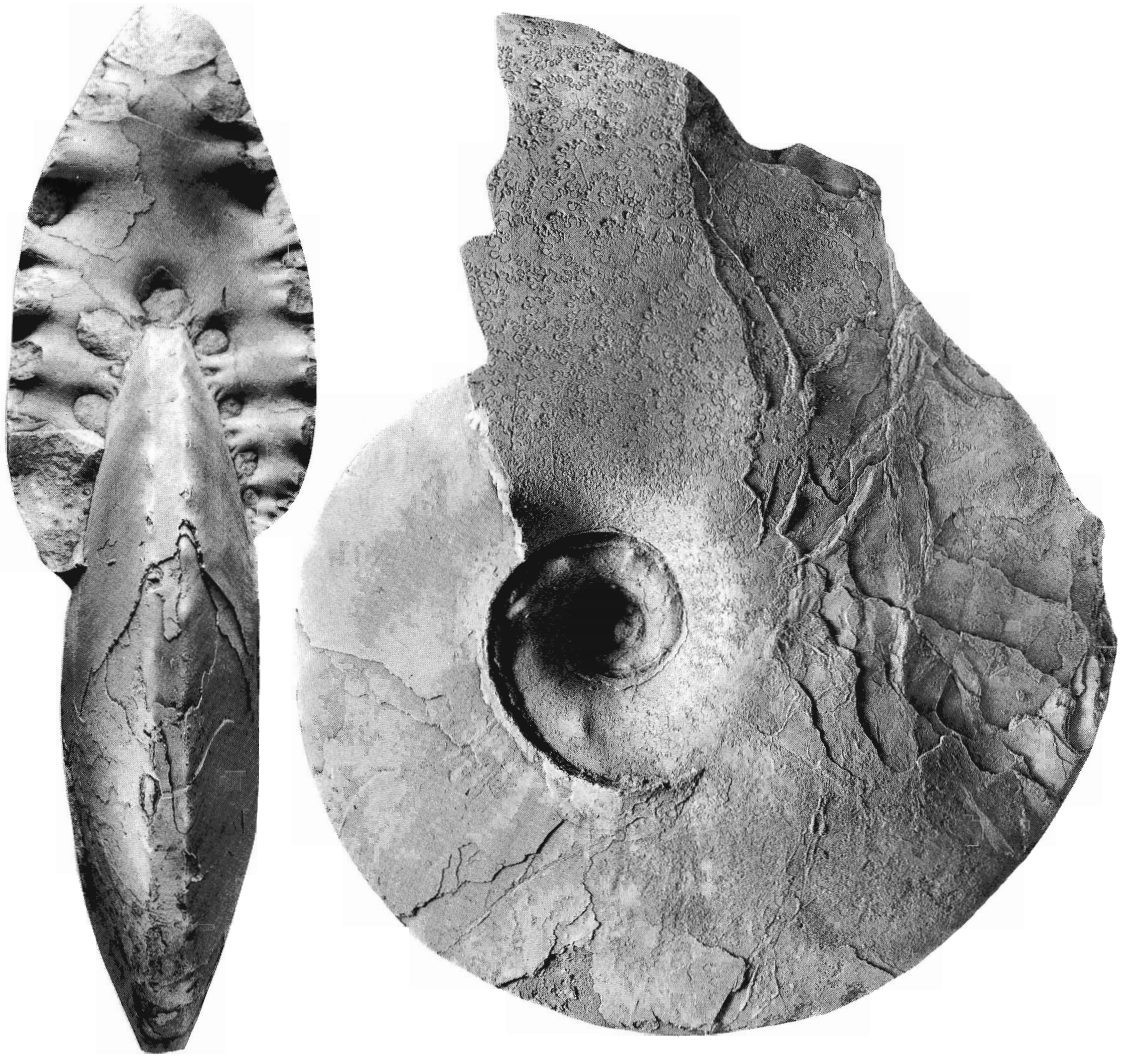
TEXT-FIG. 15. *Placenticeras cumminsi* Cragin, 1893. USNM 411460, an adult microconch, 180 mm in diameter, from USGS Mesozoic Locality 22609, 1 mile south of intersection of highways 661 and 287, Dallas County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation. ×0·75.

Metengonoceras acutum Hyatt, 1903

Plate 3, figs. 6 and 7; text-fig. 11A

1903 *Metengonoceras acutum* Hyatt, p. 184, pl. 26, fig. 8; pl. 27, figs. 1 and 2.
1928 *Epengonoceras(?) acutum* Hyatt; Adkins, p. 264 (*pars*).
1942 *Epengonoceras acutum* (Hyatt); Moreman, p. 218.
1981 *Metengonoceras acutum* Hyatt; Kennedy, Juignet, and Hancock, p. 36, text-fig. 5A.
1987 *Metengonoceras acutum* Hyatt; Cobban, p. C3, pl. 1, figs. 1, 2, 7; pl. 2, figs. 4–8; pl. 3.

Holotype. By original designation; the original of Hyatt 1903, p. 184, pl. 26, fig. 8; pl. 27, figs. 1 and 2, in the Boll Collection, Museum of Comparative Zoology, Harvard; from the Britton Member, Upper Cenomanian, *S. gracile* Zone, Elm Fork, Dallas County.

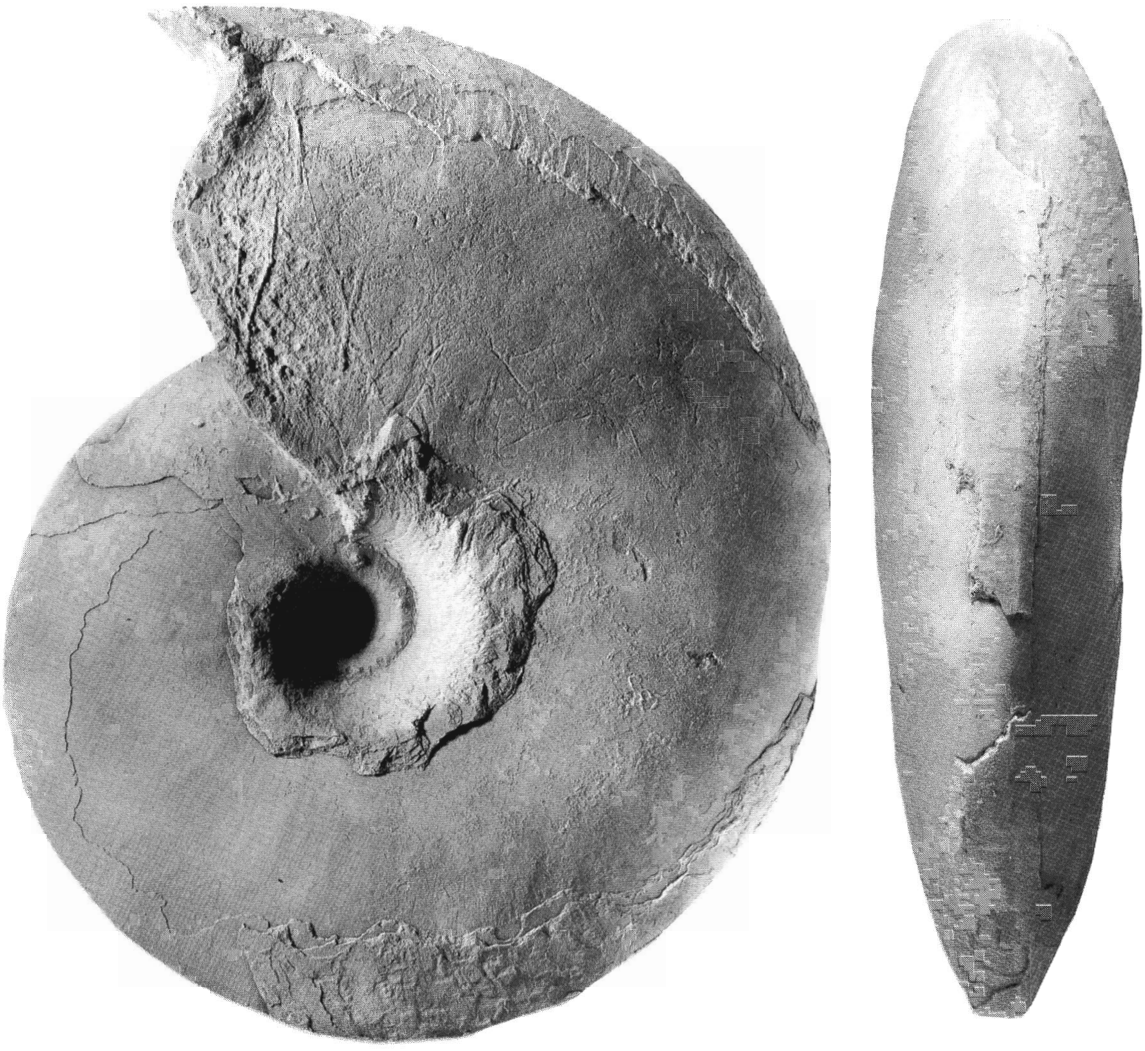


TEXT-FIG. 16. *Placenticeras cumminsi* Cragin, 1893. USNM 411463, a macroconch phragmocone, 185 mm in diameter, from stream banks 1·5 to 1·8 miles south-east of Britton, Ellis County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation. ×0·75.

Material. TMM 19830, from the Britton Formation on Hackberry Creek, 0·25 miles west of the Hackberry–Irving road, Dallas County.

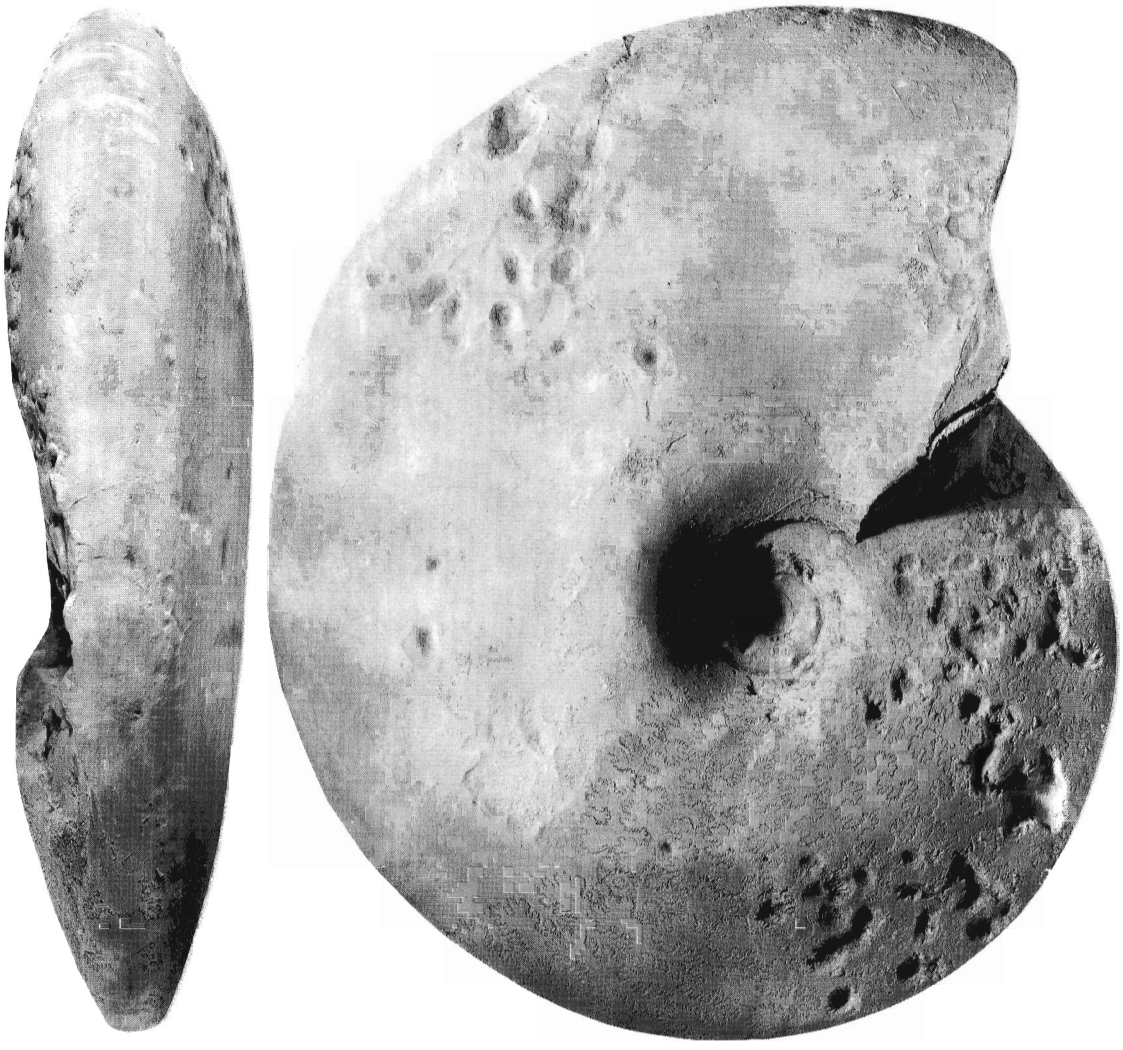
Dimensions.	*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
TMM 19830	100·5(100)	—(—)	51·5(51·2)	—	7·0(7·0)

Description. Oxycone, venter acute for all of phragmocone, broadening and rounding slightly towards the end of the body-chamber. Inner flanks of mould smooth, but pronounced crescentic, concave ribs present on last part of phragmocone, broadening and strengthening on the body-chamber, where they are broad and distant, declining before the venter is reached. Falcoid growth lines and ridges strengthen on body-chamber, notably on interspaces between crescentic ribs. Suture with entire phylloid terminations to saddles (text-fig. 11A).



TEXT-FIG. 17. *Placenticeras cumminsi* Cragin, 1893. USNM 411455, an adult microconch, 195 mm in diameter from 1·5 to 1·8 miles south-east of Britton, Ellis County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Member. ×0·7.

Discussion. This is a rare species, the illustrated specimen being that cited by Moreman (1942, p. 218, from his locality no. 15); I have not seen the types, but presume the paratypes from the Grayson Marl cited by Hyatt (1903, p. 185) belong to some other species. This species most closely recalls *Metengonoceras dumbli* Cragin, 1893 (p. 243, pl. 44, fig. 6; see revisions by Cobban and Scott 1973, p. 59; Kennedy *et al.* 1981, p. 32, pl. 3, figs. 1–5; pl. 7, figs. 4–6; text-figs. 4A–G and 5B–F; Cobban 1983, p. 11, pl. 6; pl. 7, fig. 8; pl. 8, figs. 5 and 6; Kennedy and Juignet 1984, p. 100, figs. 1*a–c*, 3*q*, *r*, 5*a–h*, 6*a–g*). The lectotype is from the Middle Cenomanian Templeton Member of the Woodbine Formation near Whitesboro, Grayson County, Texas, and it is common there and in the Tarrant Member. Comparison of the present specimen with abundant material in the USNM and OUM collections shows *acutum* to have a subvertical umbilical wall and abruptly rounded umbilical shoulder; in *dumbli* the wall inclines out and the shoulder is blunter. *M. dumbli* never develops the



TEXT-FIG. 18. *Placenticeras cumminsi* Cragin, 1893. USNM 411459, an adult macroconch, 290 mm in diameter from 1·5 to 1·8 miles south-east of Britton, Ellis County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Member. ×0·7.

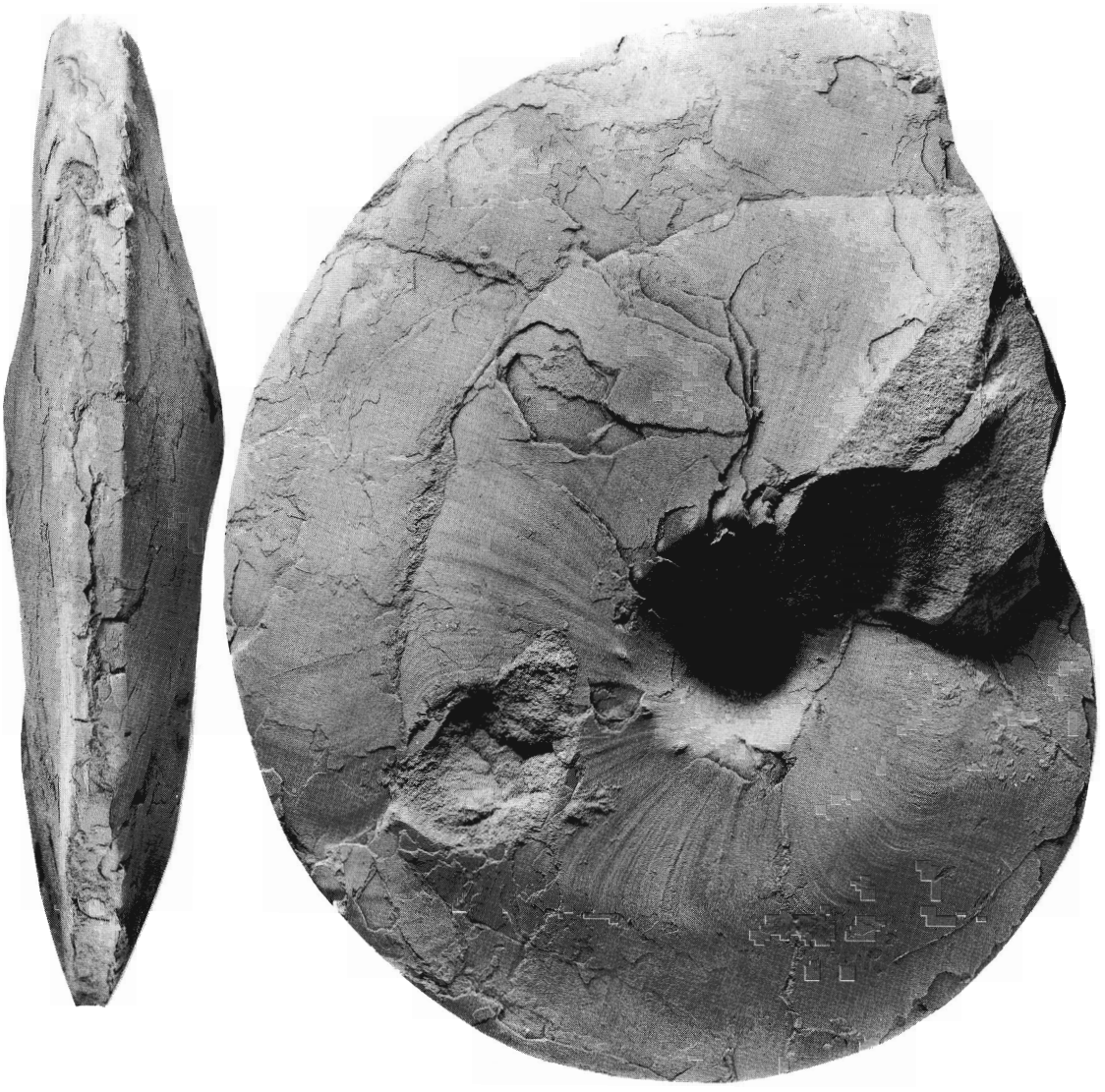
distinctive flank ornament of *acutum* and has a markedly broader and stouter whorl section to the mature body-chamber. The sutures also differ markedly, as noted at length by Hyatt.

Occurrence. Britton Formation, Upper Cenomanian, *Sciponoceras gracile* Zone of north-central Texas only.

Metengonoceras dumbli (Cragin, 1893)

not figured

1893 *Sphenodiscus dumbli* Cragin, p. 243, pl. 44, fig. 6.
1981 *Metengonoceras dumbli* (Cragin); Kennedy, Juignet, and Hancock, p. 32, pl. 3, figs. 1–5; pl. 7, figs. 4–6; text-figs. 4A–G and 5B–F.



TEXT-FIG. 19. *Placenticeras cumminsi* Cragin, 1893. USNM 411462, a juvenile macroconch with shell preserved, 195 mm in diameter from 1·5 to 1·8 miles south-east of Britton, Ellis County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Member. ×0·75.

1983 *Metengonoceras dumbli* (Cragin); Cobban, p. 11, pl. 6; pl. 7, fig. 8; pl. 8, figs. 5 and 6.
1984 *Metengonoceras dumbli* (Cragin); Kennedy and Juignet, p. 100, figs. 1*a–c*, 3*q*, *r*, 5*a–h*, 6*a–g*.
1987 *Metengonoceras dumbli* (Cragin); Cobban, p. C2, pl. 1, figs. 3–6, 8; pl. 2, figs. 1–3, 9–10; text-fig. 1.

Discussion. Cragin (1893, p. 244) referred specimens from what is now known as the Britton Formation of Hackberry Creek and at Keenan's Crossing on the Trinity River to this species. Moreman (1942, p. 218) doubted the species occurred at this level, and I have seen none that can be attributed to it. In France, however, the species certainly occurs in the correlatives of the *S. gracile* Zone of both Sarthe (Kennedy and Juignet 1984) and Loire-Atlantique (Kennedy *et al.* 1981).

Genus PROTENGONOCERAS Hyatt, 1903

Type species. By original designation; *Engonoceras gabbi* Böhm, 1898, p. 197.

Protengonoceras planum Hyatt, 1903

not figured

1903 *Protengonoceras planum* Hyatt, p. 156, pl. 18, figs. 6–9.
1928 *Protengonoceras planum* Hyatt; Adkins, p. 261.
1942 *Protengonoceras planum* Hyatt; Moreman, p. 217.

Holotype. By monotypy; the original of Hyatt 1903, pl. 18, figs. 6–9, from Texas.

Discussion. Hyatt thought this to be from what is now known as the Britton Member because T. W. Stanton thought the preservation to be like that of material from this unit at Horton's Mill, Dallas County. *Protengonoceras* is otherwise exclusively Albian and I believe the attribution to the Upper Cenomanian to be incorrect.

Superfamily ACANTHOCERATACEAE de Grossouvre, 1894, p. 22

[*nom. correct*. Wright and Wright, 1951, p. 24, *pro* Acanthoceratida Hyatt, 1900, p. 585; *nom. transl. ex* Acanthoceratidae Hyatt, 1900, p. 585; *nom. correct. ex* Acanthoceratidés de Grossouvre, 1894]

Family ACANTHOCERATIDAE de Grossouvre, 1894, p. 22

[*nom. correct*. Hyatt, 1900, p. 585; *ex* Acanthoceratidés de Grossouvre 1894, p. 22]

Subfamily ACANTHOCERATINAE de Grossouvre, 1894, p. 22

[*nom. correct*. Hyatt, 1900, p. 585; *ex* Acanthoceratidés de Grossouvre, 1894; *nom. transl*. Wright and Wright, 1951, p. 28; *ex* Acanthoceratidés de Grossouvre]

Genus CALYCOCERAS Hyatt, 1900, p. 589

(ICZN Generic Name no. 1352)
[Synonym: *Metacalycoceras* Spath, 1926, p. 83; obj.; ICZN Rejected Name no. 1265]

Type species. By designation under the Plenary Powers (ICZN Opinion no. 557); *Ammonites navicularis* Mantell, 1822, p. 198, pl. 22, fig. 5 (ICZN Specific Name no. 1633).

Subgenus CALYCOCERAS (CALYCOCERAS) Hyatt, 1900, p. 589

Calycoceras (*Calycoceras*) *naviculare* (Mantell, 1822)

Plate 4, fig. 10

1822 *Ammonites navicularis* Mantell, p. 198, pl. 22, fig. 5 (in error in explanation of plate: *Ammonites catinus*).
non 1957 *Calycoceras obrieni* Young, p. 1171, pl. 150, figs. 1–4; text-fig. 1*f*, *h*.
1968 *Calycoceras naviculare*; Sastry, Rao, and Mamgain, pl. 1, figs. 5 and 6.
? 1917 *Calycoceras* (*Lotzeites*) aff. *barruei* (Pervinquière); Kennedy, pl. 59, fig. 7.
? 1978 *Calycoceras stoliczkai* Collignon; Phansalkar, p. 222.
?*non* 1980 *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822); Marcinowski, p. 301, pl. 14, figs. 1 and 2 (indeterminable).
1981 *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822); Wright and Kennedy, p. 34, pl. 4; pl. 5, figs. 1–3; text-figs. 13 and 14*c–e* (with full synonymy).
1981 *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822); Kennedy and Juignet, p. 29, fig. 6*b*, *c*.
1983 *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822); Moreau, Francis, and Kennedy, p. 320, figs. 3, 4, 5*a–c*.
1983 *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822), Förster, Meyer, and Risch, p. 131, pl. 2, figs. 8–12.
? 1983 *Calycoceras* (*Calycoceras*) cf. *naviculare* (Mantell, 1822); Förster, Meyer, and Risch, pl. 2, fig. 5.
1985 *Calycoceras* (*Calycoceras*) *naviculare* (Mantell); Howarth, p. 91, fig. 21.
? 1985 *Calycoceras* (*Calycoceras*) *naviculare* (Mantell); Immel and Seyed-Emami, p. 104, pl. 6, fig. 1.

Holotype. By monotypy; BMNH 5681, the original of Mantell 1822, pl. 22, fig. 5, from the Upper Cenomanian, *Metoicoceras geslinianum* Zone Plenus Marl of 'Offham', Sussex (see Wright and Kennedy 1981, p. 35).

Material. A single fragment, USNM 411469, from the Britton Member, Upper Cenomanian, *S. gracile* Zone at USGS Mesozoic Locality 14555, an old brickpit 0·2 miles west-south-west of Elsworth School, 4 miles south-south-west of Denison, Grayson County (L. W. Stephenson, T. W. Stanton, and J. B. Reeside Collection, 1929).

Discussion. This is a beautifully preserved fragment of the body-chamber of an individual with an original whorl height of 71 mm. It closely matches sparsely ribbed examples that lack ventral tubercles and are well known at this horizon in the US Western Interior and elsewhere. This species has not been previously recorded from Texas.

Occurrence. Calycoceras (*Calycoceras*) *naviculare* first appears in the Upper Cenomanian, *C. guerangeri* Zone and its correlatives in England and France, but is much more widespread in the succeeding *M. geslinianum* (in Europe)/*S. gracile* Zone (US and elsewhere) and their correlatives in England, France, Germany, Spain, and Portugal, Texas, New Mexico, Colorado, Kansas, and California in the USA, North Africa, Angola, Madagascar, the Near East, Iran, south India, and Japan.

Genus EUCALYCOCERAS Spath, 1923, p. 144

(ICZN Generic Name no. 1354)

[= *Pseudomantelliceras* Thomel, 1972, p. 35]

Type species. By original designation; *Ammonites pentagonus* Jukes-Browne, 1896, p. 156, pl. 5, fig. 1 (ICZN Specific Name no. 1635).

Eucalycoceras sp.

Plate 4, figs. 4 and 5

Material. One specimen only, USNM 411470, from USGS Mesozoic Locality D9465, Britton Member, Upper Cenomanian, *S. gracile* Zone, exposures along Valley View Lane, 400 m south of Royal Lane and State Highway 114, Dallas County.

Description. The specimen is an internal mould of part of the body-chamber with a maximum whorl height of 29 mm. Coiling appears to have been moderately evolute, with a deep umbilicus, the umbilical wall inclined outwards and rounded. Whorl section compressed polygonal, with greatest breadth at umbilical bulla : whorl breadth to height ratio 0·91, flanks flattened, subparallel, venter broadly rounded intercostally, flattened

---

EXPLANATION OF PLATE 4

Figs. 1, 2, 6–9, 11–12. *Pseudocalycoceras angolaense* (Spath, 1931). 1 and 2, inner whorls of USNM 411473, from Texcrete Quarries, Dallas County; 6 and 7, USNM 411474, a microconch, from USGS Mesozoic Locality 22613, California Crossing on the Elm Fork of Trinity River, Dallas County; 8 and 9, holotype of *Eucalycoceras dentonense* Moreman, 1942, TMM 19804; 11 and 12, holotype of *E. lewisvillense* Moreman, 1942, TMM 19806, both from Indian Creek, 5·5 miles east of Lewisville railway station on the Hebron Road, Denison County.

Fig. 3. *Anaptychus*, USNM 411563, from tributary to Newton Branch, 3·75 miles south of old Britton–Midlothian road, Ellis County.

Figs. 4 and 5. *Eucalycoceras* sp., USNM 411470, from USGS Mesozoic Locality D9465, exposures along Valley View Lane, 400 m south of Royal Lane and State Highway 114, Dallas County.

Fig. 10. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822). USNM 41469, from USGS Mesozoic Locality 14555, an old brickpit 0·2 miles west-south-west of Elsworth School, 4 miles south-south-west of Denison, Grayson County.

All specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation of north-east Texas; ×1.

KENNEDY, *Pseudocalycoceras*, *Eucalycoceras*, *Calycoceras*, anaptychus

costally. Dorsal impressed zone shows inner whorls bore conical inner, clavate outer ventrolateral and clavate siphonal tubercles on a markedly angular, polygonal ventral region. The body-chamber fragment bears six primary ribs that arise at the umbilical seam and strengthen into small, sharp, and distant umbilical bullae. These give rise to pairs of low, broad, flexuous, recti- to prorsiradiate ribs, all of which bear a feebly clavate inner ventrolateral tubercle, as do occasional long intercalated ribs. A stronger, rounded rib connects each to a slightly stronger outer ventrolateral clavus, while a strong rounded rib passes straight across the venter. There are feeble siphonal clavi at the apical end of the fragment but these decline rapidly. Sutures not seen.

Discussion. This specimen resembles angular-whorled variants of *Pseudocalycoceras angolaense* (Spath, 1931), described below, but there are important differences: the ribs are feebler and less-markedly rursiradiate in the present fragment, siphonal tubercles are lost while ventrolaterals are strong and the venter still flattened. In all *P. angolaense* studied the inner ventrolateral tubercles are the first to disappear, the outer ventrolateral and siphonal persisting until the venter rounds, whereupon they eventually decline too.

Most *Eucalycoceras* species are upper Middle of low Upper Cenomanian, and older than the present form. I have, however, found *E. pentagonum*, the type species, in the *M. geslinianum* Zone in Provence and there is a specimen from the same horizon in the Sables à *Catopygus obtusus* of Sarthe, also in France (P. Juignet Collection). Dr W. A. Cobban has shown me specimens of the species from the *gracile* Zone of Colorado and a slightly lower horizon in New Mexico. The only other North American representative of the genus is an undescribed species in the Conlin Collection, from the Templeton Member of the Woodbine Formation in north-east Texas.

Occurrence. As for material.

Genus PSEUDOCALYCOCERAS Thomel, 1969, p. 650

Type species. By original designation; *Ammonites harpax* Stoliczka, 1864, p. 72 (*pars*), pl. 39, fig. 1 only.

Pseudocalycoceras angolaense (Spath, 1931)

Plate 4, figs. 1, 2, 6–9, 11, 12; Plate 5, figs. 1–12; Plate 8, figs. 7 and 8; Plate 22, figs. 8 and 9; text-figs. 10H and 11B, E

1927 *Acanthoceras* sp. A. Moreman, p. 95, pl. 15, fig. 2.
1931 *Protacanthoceras angolaense* Spath, p. 316.
1939 *Acanthoceras* (*Mantilliceras*) *mantelli* (Sowerby); Dacqué, p. 87, pl. 2, figs. 13 and 14.
1942 *Eucalycoceras dentonense* Moreman, p. 205, pl. 33, figs. 4 and 5; text-fig. 2*k*.
1942 *Eucalycoceras indianense* Moreman, p. 206, pl. 33, figs. 9 and 10; text-fig. 2*l*.
1942 *Eucalycoceras lewisvillense* Moreman, p. 206, pl. 33, figs. 6 and 7; text-fig. 2*n*, *u*.
non 1962 *Protacanthoceras angolaense* Spath; Avnimelech and Shoresh, p. 531.
1977 *Pseudocalycoceras dentonense* (Moreman); Kauffman, pl. 18, figs. 5 and 6.
1978 *Pseudocalycoceras angolaense* (Spath); Cooper, p. 96, text-figs. 4A–C, H–K, 6I, J, 10F, G, 14A, 18E, F, 19A, B, 23–25, 26F–K (with additional synonymy).
1978 *Pseudocalycoceras dentonense* (Moreman); Hattin, text-fig. 5.13.
1978 *Pseudocalycoceras dentonense* (Moreman); Hattin and Siemers, text-fig. 6.13.
1981 *Pseudocalycoceras dentonense* (Moreman); Wright and Kennedy, p. 37, pl. 5, fig. 4; pl. 6, figs. 3, 6, 7; text-figs. 15A, B, E–H, 19S, T (with full synonymy).
1983 *Pseudocalycoceras dentonense* (Moreman, 1942): Moreau, Francis, and Kennedy, text-fig. 7*a*, *b*.
1983 *Pseudocalycoceras* cf. *dentonense* (Moreman, 1942); Moreau, Kennedy, and Francis, p. 326, text-fig. 7*c*, *d*.
1983 *Pseudocalycoceras dentonense* (Moreman); Förster, Meyer, and Risch, p. 131, pl. 2, figs. 1–4.

Lectotype. Here designated; the original of Douvillé 1931, p. 17, pl. 1, fig. 1, from the Upper Cenomanian of Salinas, Angola. This is not the holotype as indicated by Cooper (1978), because Spath specifically refers to a second specimen, which is a paralectotype of the species.

Material. More than fifty specimens, mostly from Texcrete Quarries (Conlin and Powell collections; OUM KT 1697) with additional specimens from USGS Mesozoic Locality 22613, California Crossing on Elm Fork of

Trinity River, Dallas County (*ex* Renfo Collection); USGS Mesozoic Locality D9430, outcrops on north-west side of intersection of State Highway 114 and Royal Lane, Dallas County (*ex* Powell Collection); USGS Mesozoic Locality D9439, walls of emergency spillway at Garza–Little Elm Reservoir, Denton County (*ex* Powell Collection); outcrops 1·5 to 1·8 miles south-east of Britton, Ellis County (*ex* Conlin Collection); stream bank 2·5 miles south of Britton on old Britton–Midlothian road, Ellis County (*ex* Conlin Collection); TMM 869TXI from 4 miles west of Cedar Hill, Dallas County. In addition, the holotypes of *E. dentonense* Moreman, 1942, TMM 18904, *E. indianense* Moreman, 1942, TMM 19805, and *E. lewisvillense* Moreman, 1942, TMM 19806, all from outcrops on Indian Creek, 5·5 miles east of Lewisville Station on the Hebron Road, Denison County.

Dimensions.		*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
USNM 411471	c	58·5(100)	20·3(34·7)	22·4(38·3)	0·91	20·0(32·2)
	ic	56·0(100)	18·4(32·9)	19·5(34·8)	0·94	20·0(35·7)
USNM 411472	c	61·3(100)	22·0(35·9)	25·3(48·9)	0·87	19·5(31·8)
	ic	58·2(100)	19·5(33·5)	23·5(40·3)	0·83	19·5(33·5)

Description and Discussion. Cobban and Scott (1973) fully described US Western Interior material (as *P. dentonense* (Moreman, 1942)), Cooper (1978) described Angolan topotypes, and Wright and Kennedy (1981) described the rather poor English material (as *P. dentonense*); detailed description of the present collection is thus pointless. The specimens show, however, a range of previously unreported aspects of morphology and variation. Juveniles vary from evolute, depressed, strongly and distantly ribbed and tuberculate to compressed involute, and finely ornamented. This variation extends through middle growth (Pl. 5, figs. 3–6, 9–10; Pl. 8, figs. 7 and 8); some specimens have as few as twelve ribs per half whorl and a whorl breadth to height ratio of 1·3; others up to twenty-two ribs per half whorl and whorl breadth to height ratio of 0·83. The relative strength of ribs and tubercles is also highly variable (Pl. 5, figs. 1–12), the former dominate in some individuals, the latter in others. Rib direction varies from feebly (Pl. 5, fig. 1) to distinctly flexuous (Pl. 5, fig. 6) and is variably rursiradiate (Pl. 5, figs. 4 and 7). Although fragmentary, individuals show a decline and loss of tuberculation, rounding of venter, and weakening and crowding of ribs indicative of maturity at disparate diameters. Microconchs are thus adult at as little as 60 mm (Pl. 5, figs. 1–2, 7–8), while the largest complete macroconch is 105 mm in diameter (Pl. 5, figs. 11 and 12). This dimorphism is confirmed in specimens from the US Western Interior, illustrated by Cobban and Scott (1973); their plate 15, figs. 10 and 11 is a microconch 64 mm approximately in diameter, plate 15, figs. 12 and 13 a macroconch 100 mm in maximum diameter. Cobban (pers. comm.) has a macroconch from New Mexico 113 mm in diameter.

Wright and Kennedy (1981) believed *P. dentonense* (with *indianense* and *lewisvillense* of Moreman and *underwoodi* of Powell 1963*a* as synonyms) to be specifically distinct from *P. angolaense*. The present new material includes specimens with distant ribbing, as in the lectotype of *angolaense*, and there is a degree of overlap of characters between material from Texas and Angola suggesting that although individuals have different combinations of ribbing, tuberculation, and whorl proportions these differences are intraspecific rather than interspecific.

Occurrence. Upper Cenomanian, *S. gracile* Zone and correlatives in north-central and west Texas, New Mexico, Arizona, Colorado, Kansas, and Utah in the USA, southern England, northern France, Angola, and Japan. Records from Lebanon (Basse 1940, p. 448, pl. 6, fig. 3) and Israel (Avnimelech and Shoresh 1962, p. 531) are of a significantly older species of *Pseudocalycoceras*.

Genus TARRANTOCERAS Stephenson, 1955, p. 59

Type species. By original designation; *Tarrantoceras rotatile* Stephenson, 1955, p. 59, pl. 5, figs. 1–10 = *Mantelliceras sellardsi* Adkins, 1928, p. 239, pl. 25, fig. 1; pl. 26, fig. 4.

Discussion. See Wright and Kennedy 1981, p. 38, for a recent diagnosis. Study of a large collection of topotypes (OUM, JPC, USGS collections) and other specimens suggest that the co-occurring species described by Stephenson in 1955 (*rotatile*, *stantoni*, and *lilianense*) are synonyms (Cobban 1977,

p. 23) of one variable, dimorphic species as is *M. sellardsi* Adkins, 1928 (p. 239, pl. 25, fig. 1; pl. 26, fig. 4).

Subgenus SUMITOMOCERAS Matsumoto, 1969, p. 280

Type species. By original designation; *Sumitomoceras faustum* Matsumoto and Muramoto, 1969, p. 283, pl. 38, figs. 1–4; text-fig. 8.

Discussion. Sumitomoceras and *Tarrantoceras* were treated as synonyms by Cooper (1978, p. 93). They differ in the earlier loss of siphonal tubercles in *Sumitomoceras* (they are present at the earliest growth stages only), development of constriction-like deepened interspaces in some species and rounded venter in middle and later growth (see also Wright and Kennedy 1981, p. 38). The present material consists of only ten specimens. These vary widely in morphology, and fall into four quite distinct groups, described below as separate species. Given the very wide variation within *T.* (*Tarrantoceras*) *sellardsi* it may be that larger collections will show this division to be excessive.

Occurrence. Late Cenomanian, *Sciponoceras gracile* Zone and correlatives in north-east and west Texas, New Mexico, and Colorado in the USA, southern England, northern France, and Japan.

Tarrantoceras (*Sumitomoceras*) *conlini* Wright and Kennedy, 1981

Plate 6, figs. 1–5, 8–13, 16, 17; text-fig. 10B

1981 *Tarrantoceras* (*Sumitomoceras*) *conlini* Wright and Kennedy, p. 39, text-fig. 16A.

Holotype. By monotypy; USNM 400803, from the Britton Formation, Upper Cenomanian, *S. gracile* Zone, east bank of creek 0·5 miles west of the old Britton–Midlothian road, 2·5 miles south of Britton, Ellis County.

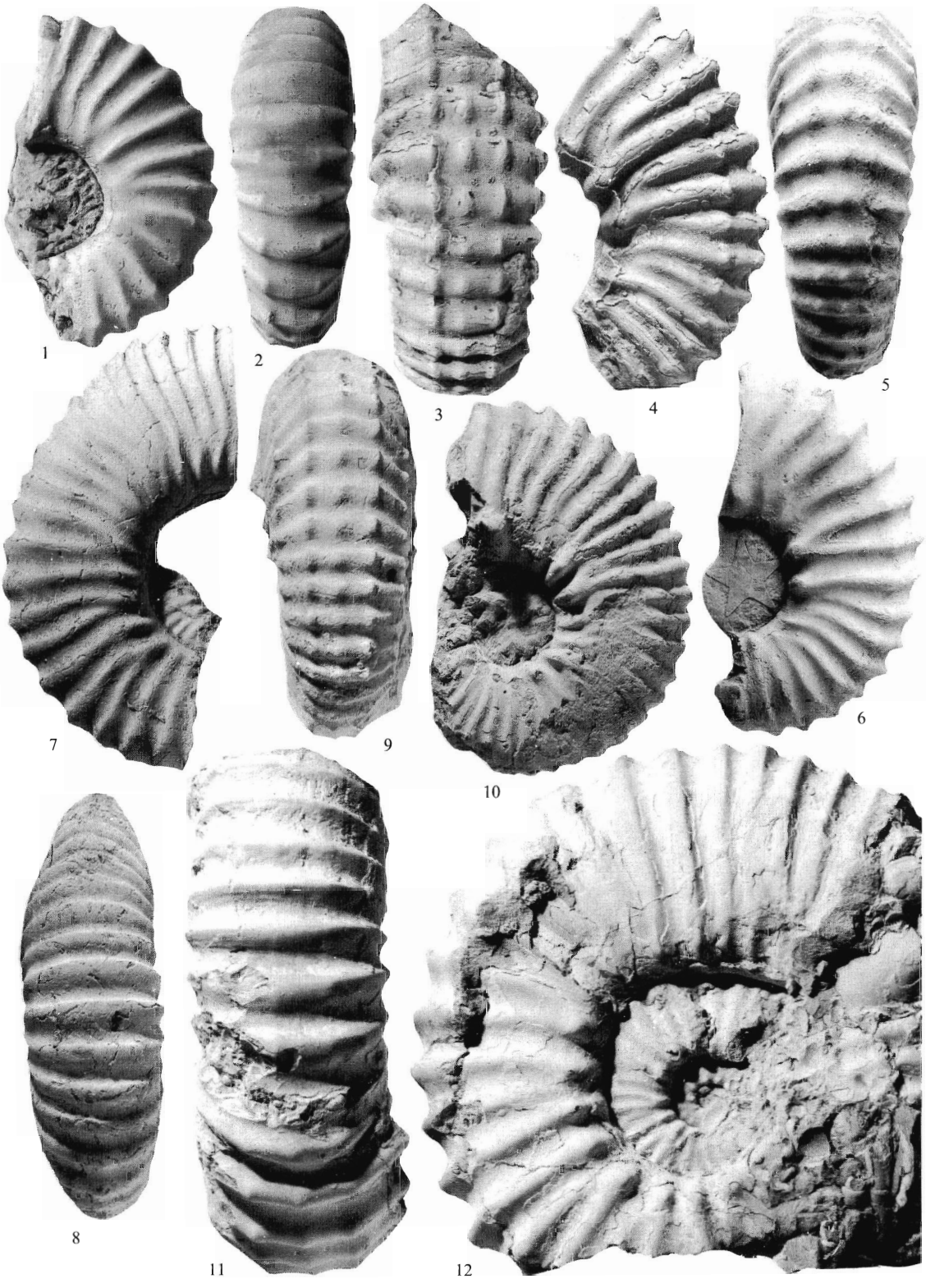
Material. USNM 411481–411483 and a specimen in the J. M. Hancock Collection, from the same horizon as the holotype on California Crossing on Elm Fork of Trinity River, Dallas County.

Description. Macroconch, as represented by the holotype, had an estimated original diameter of 68 mm. Coiling evolute, with shallow dorsal impressed zone. Umbilicus broad (estimated 34 % of diameter), of moderate depth with flattened, vertical wall. On inner whorls, preserved to a diameter of 31 mm, whorl section is compressed with estimated whorl breadth to height ratio of 0·78. Sides flattened and parallel, ventrolateral shoulders flattened, convergent, venter flat. Twelve primary ribs arise at umbilical seam, pass straight up umbilical wall and develop into strong umbilical bullae, projected into umbilicus, and separated by deep interspaces. One to three ribs arise from bullae and are straight to feebly convex and prorsiradiate. Shorter single intercalated ribs are inserted low on flank between groups of primaries, and all ribs develop a small conical inner ventrolateral tubercle. Ribs broaden and strengthen from this, flatten somewhat and pass straight across the ventrolateral facet to stronger, feebly clavate outer ventrolaterals. These are linked across the flattened venter by a strong rib, slightly elevated on the siphonal line, but not developed into a clearly differentiated tubercle, although the elevation suggests the presence of such a tubercle at smaller diameters. Suture poorly exposed with little-incised narrow and bifid L/U_2, U_2, and U_2/U_3.

EXPLANATION OF PLATE 5

Figs. 1–12. *Pseudocalycoceras angolaense* (Spath, 1931). 1 and 2, USNM 411471, a microconch from 1·5 to 1·8 miles south-east of Britton on Rogers Farm, Ellis County; 3 and 4, USNM 411475, from USGS Mesozoic Locality D9439, walls of emergency spillway at Garza–Little Elm reservoir, Denton County, 5 and 6, holotype of *Eucalycoceras indianense* Moreman, 1942, TMM 19805, from Indian Creek, 5·5 miles east of Lewisville railway station on the Hebron Road, Denison County; 7 and 8, USNM 411476, a microconch from USGS Mesozoic Locality 22604, first creek north-east of Britton, 2·5 miles on farm road, Ellis County, 9 and 10, USNM 411477, from the tributary to Newton Branch, 3·75 miles south of Britton, Ellis County, 11, 12, USNM 411478, a macroconch from USGS Mesozoic Locality D9433, Texcrete Quarries, Dallas County.

All specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation of north-east Texas; × 1.



KENNEDY, *Pseudocalycoceras*

Body-chamber has whorl breadth to height ratio of 0·80 with greatest breadth at umbilical bulla on inner flank. Sides convergent, flattened, ventrolateral shoulders broadly rounded, with flattened venter. There are twelve sharp umbilical bullae, projected into umbilicus; these decline in strength towards the aperture. They give rise to one or two narrow, rounded ribs that are feebly flexuous and prorsiradiate, straight and feebly convex across the inner flank, and feebly convex over the ventrolateral shoulder. Occasional primaries bifurcate at mid-flank, while both long and short intercalatories are inserted between the groups of primaries, arising high or low on the flank to give thirty-two to thirty-three ribs corresponding to twelve bullae. A very weak outer ventrolateral tubercle is present at the beginning of the body-chamber, but is rapidly lost. Two interspaces are broader and deeper than the others and might be termed constrictions. A second macroconch body chamber (Pl. 6, figs. 12 and 13) has rather stronger bullae but is otherwise similar.

What seem to be microconchs are two fragments (Pl. 6, figs. 4, 5, 8, 9) that show the same style of ornament as the macroconchs, but loose their ventral tubercles on the early body-chamber at whorl heights of 11·5 and 13·5 mm respectively, a size at which the macroconch is still septate and tuberculate (Pl. 6, figs. 16 and 17).

Discussion. The detailed description above amplifies the brief diagnosis given by Wright and Kennedy in 1981. *T.* (*Sumitomoceras*) *conlini* differs from *T.* (*S.*) *faustum* Matsumoto and Muramoto, 1969 (p. 283, pl. 38, figs. 1–4; text-fig. 8) from the Upper Cenomanian of Japan and *T.* (*S.*) *cautisalbae* Wright and Kennedy, 1981 (p. 39, pl. 6, figs. 1 and 2) from southern England (and, possibly, northern France) in being more compressed with higher, flat-sided much more densely ribbed whorls. *T.* (*S.*) *bentonianum* (Cragin, 1893), described below, is more evolute, with slower-expanding whorls bearing distant, stronger, and sharper ribs, with single, more flexuous primaries separated a single secondary and a rounded venter. *T.* (*S.*) *proteus* sp. nov., described below, is a slender-whorled species, coarsely ribbed, and tuberculate on the early whorls and first part of the body-chamber, the last part of which is irregularly ribbed and bears dense irregular growth striae and lirae. *T.* (*S.*) *crassum* sp. nov., also described below, has coarsely and irregularly ribbed and tuberculate inner whorls that are immediately distinctive. The body chamber is more distantly and sharply ribbed.

Occurrence. As for material. USNM 411485, a specimen from the Boquillas Formation at the crossing of US Highway 90 and Lozier Canyon, Terrell County, Texas (Pl. 6, figs. 10 and 11), may also belong here, while Dr W. A. Cobban has shown me specimens from the Upper Cenomanian, *S. gracile* Zone of New Mexico and south-east Colorado.

EXPLANATION OF PLATE 6

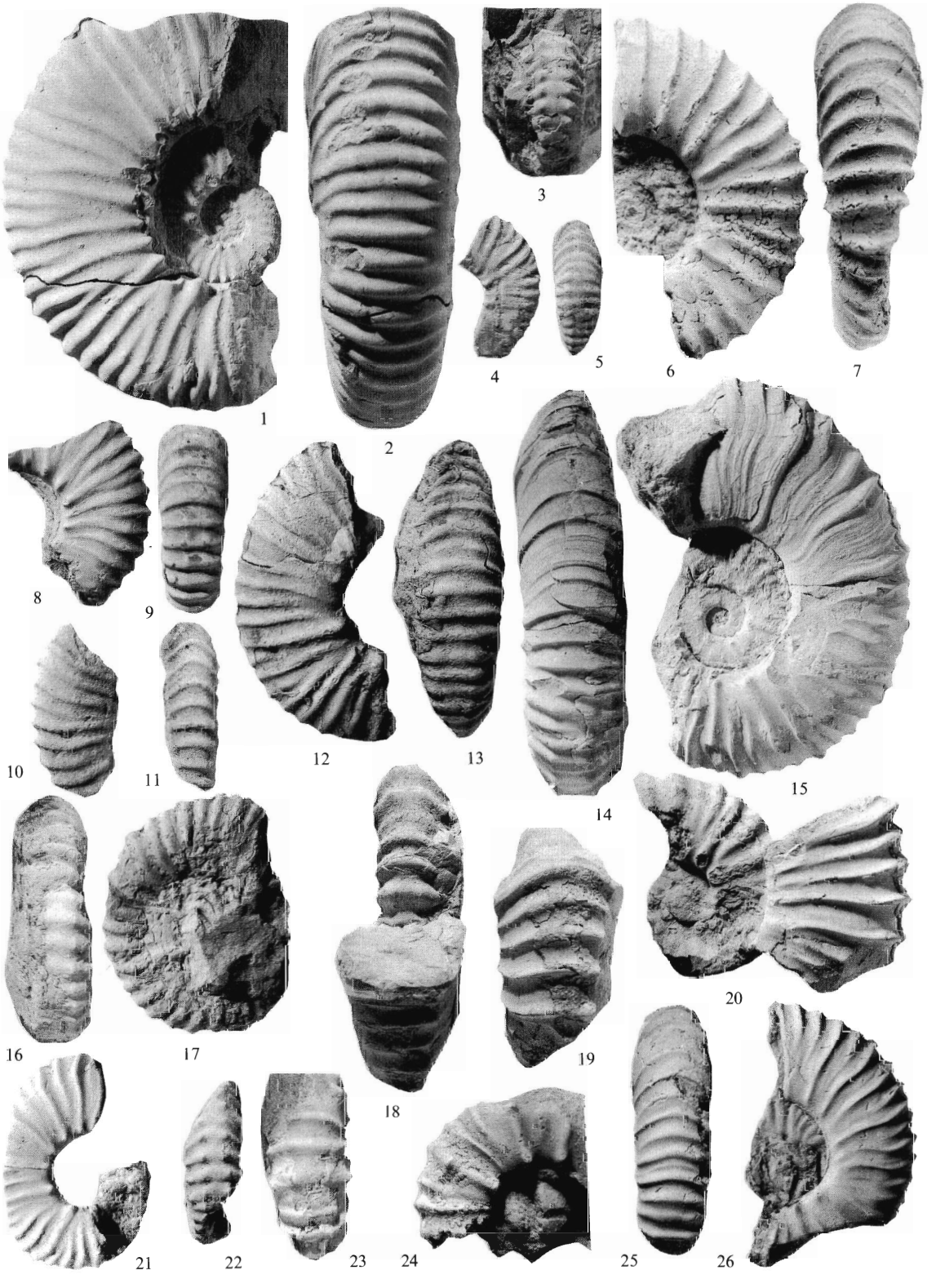
Figs. 1–5, 8–13, 16, 17. *Tarrantoceras* (*Sumitomoceras*) *conlini* Wright and Kennedy, 1981. 1–3, holotype, USNM 400803, from east bank of creek 0·5 miles west of the old Britton–Midlothian road, 2·5 miles south of Britton, Ellis County. 4 and 5, USNM 411481; 8 and 9, USNM 411482; 12 and 13, J. M. Hancock Collection; 16 and 17, USNM 411483, all from California Crossing on Elm Fork of Trinity River, Dallas County. 10 and 11, USNM 411485, from the Boquillas Formation at the crossing of US Highway 90 and Lozier Canyon, Terrel County, Texas.

Figs. 6, 7, 25, 26. *T.* (*S.*) *bentonianum* (Cragin, 1893). 6 and 7, holotype, TMM 6180, from Hackberry Creek, Dallas County, 25 and 26, USNM 411489, from California Crossing on Elm Fork of Trinity River, Dallas County.

Figs. 14, 15, 21, 22. *T.* (*S.*) *proteus* sp. nov. 14 and 15, holotype, USNM 400816, from tributary to Newton Branch, 3·75 miles south of Britton, Ellis County. 21 and 22, paratype, USNM 411488, from Texcrete Quarries, Dallas County.

Figs. 18–20, 23, 24. *T.* (*S.*) *crassum* sp. nov. 18–20, holotype, USNM 411486, from USGS Mesozoic Locality 19523, subsurface equivalent of Tarrant Member, Upper Cenomanian *Sciponoceras gracile* Zone, Jasper County, Mississippi (see text for details), 23 and 24, paratype, USNM 411487, from Texcrete Quarries, Dallas County.

All specimens except the originals of figs. 10, 11, 18, 19, 20 are from the Upper Cenomanian *S. gracile* Zone fauna of the Britton Formation of north-east Texas. All specimens are figured × 1.



KENNEDY, *Tarrantoceras*

Tarrantoceras (*Sumitomoceras*) *crassum* sp. nov.

Plate 6, figs. 18–20, 23, 24; text-fig. 10F

Types. Holotype USNM 411486 (Pl. 6, figs. 18–20) is from USGS Mesozoic Locality 19523, the subsurface equivalent of the Britton Formation, Upper Cenomanian, *S. gracile* Zone, Gulf Refining Company Helen Morrison no. 1 Well, Heidelberg Field in Section 30, Township I N., Range 13 E., Jasper County, Mississippi. Paratype USNM 411487 (Pl. 6, figs. 23 and 24) is from the Britton Formation at California Crossing on Elm Fork of Trinity River, Dallas County.

Diagnosis. T. (*Sumitomoceras*) with coarsely, irregularly and distantly ribbed, and tuberculate inner whorls and sharply and distantly ribbed body-chamber.

Description. The holotype is a phragmocone 37 mm in diameter and part of the adult body-chamber. Coiling evolute with shallow dorsal impressed zone. Umbilicus broad, with moderately high, flattened umbilical wall. The whorls expand rather slowly. Whorl section of phragmocone compressed (Wb : Wh is 0·87), polygonal in costal section with greatest breadth at umbilical bullae. Ribs strong, distant, and coarse. Primary ribs bear strong pointed umbilical bullae and are strong, straight, and prorsiradiate on inner flank, bearing strong clavate inner and outer ventrolateral tubercles, connected across venter by a strong rib without a siphonal tubercle (Pl. 6, fig. 18). Single secondaries alternate regularly with primaries arising low on flank, sometimes extending to umbilical shoulder although lacking an umbilical bulla. They lack an inner ventrolateral tubercle and have weaker outer ventrolateral tubercles than the primaries, although connected over the venter by a rib of similar strength. Shorter intercalated ribs are irregularly developed. They arise high or low on the flank and have only outer ventrolateral tubercles. Periodic interspaces are strengthened into constrictions. The paratype shows this strong ornament extending on to the early part of the adult body-chamber (Pl. 6, figs. 23 and 24). The end of the adult body-chamber is present on the holotype. It has a compressed oval whorl section (Wb : Wh = 0·85) with distant, narrow, sharp, flexuous prorsiradiate ribs with neither umbilical bullae nor ventral tubercles. Sutures imperfectly exposed.

Discussion. The coarsely and irregularly ribbed and tuberculate phragmocone distinguishes this species from all other described forms. The mature body-chamber ornament is more distant, stronger, sharper, and narrower than that of *T.* (*S.*) *conlini*, *faustum*, and *cautisalbae*, the species thus standing clearly apart from all other known material of the subgenus.

Occurrence. As for types.

Tarrantoceras (*Sumitomoceras*) *proteus* sp. nov.

Plate 6, figs. 14, 15, 21, 22

1981 *Tarrantoceras* (*Tarrantoceras*) aff. *liliänense* Stephenson, 1951; Wright and Kennedy, p. 41, text-fig. 41C, D.

Types. Holotype is USNM 400816, from the top of the Britton Formation, Upper Cenomanian, *S. gracile* Zone, tributary to Newton Branch, 3·75 miles south of Britton, Ellis County. Paratype is USNM 411488, from Texcrete Quarries, Dallas County.

Dimensions.

	D	*Wb*	*Wh*	*Wb : Wh*	*U*
Holotype c	61·9(100)	—(—)	22·9(37·0)	—	22·6(36·5)
ic	59·1(100)	—(—)	22·0(37·2)	—	22·6(38·2)
Paratype c	38·7(100)	—(—)	14·1(36·4)	—	12·7(32·8)

Diagnosis. Evolute, slowly expanding *Sumitomoceras* in which middle growth stages bear sharp, distant, irregularly long and short slender ribs with umbilical, inner and outer ventrolateral tubercles that survive onto the early parts of the body-chamber, the last part of which bears irregular distant non-tuberculate ribs and densely crowded growth striae and riblets.

Description. Coiling very evolute with shallow dorsal impressed zone. Umbilicus broad (33–38 % of diameter) shallow, with rounded, outwards-inclined umbilical wall. Inner whorls of holotype damaged but smaller paratype (Pl. 6, figs. 21 and 22) show whorl section to be compressed (Wb : Wh = 0·79), greatest breadth at

umbilical bulla, sides flattened, parallel, ventrolateral shoulder flattened in costal section with venter feebly concave between clavi and broadly rounded intercostally. Eight small sharp umbilical bullae per half whorl are borne on the umbilical shoulder. They give rise to single, narrow, rather low, rounded, prorsiradiate ribs (rarely pairs) that are straight or feebly convex across inner to middle flank, flexed forwards across the ventrolateral shoulder with, at the smallest diameter visible in the paratype, small conical inner and feebly clavate outer ventrolateral tubercles. As size increases the inner ventrolaterals weaken. There are up to four secondaries inserted between the primaries. Some arise low on the flank, and may connect to the umbilical bullae via tenuous striae; others arise inside the ventrolateral shoulder. Long secondaries may bear a weak inner ventrolateral tubercle; the shorter ones do not, but all ribs bear well-developed outer ventrolaterals. Whorl section remains polygonal to the beginning of the adult body-chamber in the holotype, with bullate primaries and two to three shorter intercalatories, the shortest of which are confined to the venter only. Inner ventrolateral tubercles are present but weak on the primary ribs and long secondaries but absent on short ones. All but the shortest ribs bear well-developed sharp outer ventrolateral tubercles.

This pattern is abruptly interrupted over the last half whorl. Irregular distant ribs lack tubercles and are separated by wide interspaces covered in irregularly developed growth lines, lirae, and riblets. A strong constriction marks the beginning of the adult body-chamber and a second one separates the ribbed from striate portion.

Discussion. The remarkable change in ornament seen on the adult body-chamber distinguishes this species from all other *T.* (*Sumitomoceras*). Early ornament, with distant, wiry ribs of variable length and strength but persistent ventrolateral tubercles (Pl. 6, figs. 21 and 22), is also distinctive and very different from the broader, crowded ribs of the high-whorled *T.* (*S.*) *conlini*, where tubercles are also very feeble (Pl. 6, figs. 1–3). The inner whorls are stronger ribbed than in *T.* (*S.*) *conlini* and although irregular as in *T.* (*S.*) *crassum* sp. nov. are very much weaker with tubercles subordinate to ribs, rather than the reverse. There is a closer similarity to the inner whorls of *T.* (*S.*) *faustum* and *cautisalbae*, but the adult ornament is distinctive.

Occurrence. As for types.

Tarrantoceras (*Sumitomoceras*) *bentonianum* (Cragin, 1893)

Plate 6, figs. 6, 7, 25, 26

1893 *Pulchellia bentoniana* Cragin, p. 239.
1931 *Eucalycoceras bentonianum* (Cragin); Adkins, p. 63.
1942 *Eucalycoceras bentonianum* (Cragin); Moreman, p. 207, text-fig. 2E.
1951 *Eucalycoceras bentonianum* (Cragin); Adkins and Lozo, pl. 6, figs. 9 and 10.
1971 '*Eucalycoceras*' *bentonianum* (Cragin); Kennedy, p. 121.
1978 *Eucalycoceras bentonianum* (Cragin); Young and Powell, p. XXV.15.
1978 *Tarrantoceras bentonianum* (Cragin); Cooper, p. 96.
1981 *Tarrantoceras* (*Sumitomoceras*) *bentonianum* (Cragin); Wright and Kennedy, p. 39.

Type. Holotype, by monotypy, TMM 21680, from the Britton Formation, Upper Cenomanian, *Sciponoceras gracile* Zone, Hackberry Creek, Dallas County.

Material. USNM 411489, from the same horizon as the holotype at California Crossing on the Elm Fork of the Trinity River, Dallas County.

Diagnosis. Evolute, slowly expanding *T.* (*Sumitomoceras*) with weakly ribbed and tuberculate inner whorls; body-chamber with strong, sharp, narrow, distant, alternately long and short straight or flexuous ribs, initially with weak outer ventrolateral tubercles that are rapidly lost.

Description. Both specimens are internal moulds of body-chamber with only traces of the inner whorl. Coiling is fairly evolute, with moderately impressed dorsal zone. Umbilicus comprises an estimated 40% of diameter, is of moderate depth with a rounded umbilical shoulder. Inner whorls (Pl. 6, fig. 26) appear to have been rather weakly ribbed and tuberculate, as in *T.* (*S.*) *conlini*. Body-chamber compressed (Wb : Wh = 0·94) with compressed oval intercostal section. Flanks flattened at beginning of body-chamber with rounded ventrolateral shoulders and flattened venter, becoming rounded towards aperture. Sharp narrow primary ribs bear small bullae at beginning of body-chamber. They are widely separated, prorsiradiate, straight in the holotype but

gently flexuous in the second specimen (Pl. 6, fig. 26). They are separated by one or two shorter intercalated ribs that arise low or high on the flank. Both specimens retain a trace of an outer ventrolateral tubercle at the smallest diameter visible, but it is soon lost. The suture is only partially visible.

Discussion. The second specimen referred to the species differs mainly in the degree of flexure of the ribs, the style, strength, and narrowness of which suggests them to be conspecific. Coiling, whorl section, distant and sharp body-chamber ribbing immediately distinguish *T.* (*S.*) *bentonianum* from *T.* (*S.*) *conlini*; *T.* (*S.*) *crassum* has much coarser ornament on the inner whorls. *T.* (*S.*) *proteus* is distinguished by its remarkable body-chamber ornament. Both *T.* (*S.*) *faustum* and *T.* (*S.*) *cautisalbae* are more rapidly expanding species with more and broader, blunter ribs than the present species.

Occurrence. Upper Cenomanian, *S. gracile* Zone, Britton Formation in north-central Texas; Dr W. A. Cobban has shown me specimens from the same horizon in south-west New Mexico and south-east Colorado.

Genus WATINOCERAS Warren, 1930, p. 66

[= *Arkhangelskiceras* Ilyin, 1957, p. 425]

Type Species. Watinoceras reesidei Warren, 1930, p. 67, pl. 3, fig. 2; pl. 4, figs. 9–12; by original designation.

Watinoceras reesidei Warren, 1930

Plate 7, figs. 3, 4, 6

1927 *Gauthiericeras* aff. *bravaisi* d'Orbigny; Moreman, p. 96, pl. 14, fig. 2.
1930 *Watinoceras reesidei* Warren, p. 67, pl. 3, fig. 2; pl. 4, figs. 9–12.
1947 *Watinoceras reesidei* Warren, p. 122, pl. 30, fig. 6.
1959 *Watinoceras reesidei* Warren; Ilyin, fig. 4*r*.
1961 *Watinoceras reesidei* Cobban and Gryc, p. 186, pl. 38, figs. 46–49; text-fig. 2*g*, *h*.
1969 *Watinoceras reesidei* Warren; Matsumoto, Muramoto, and Takahashi, pp. 281 and 282.
1973 *Watinoceras reesidei* Warren?; Cobban and Scott, p. 75, pl. 28, fig. 4.
1977 *Watinoceras reesidei* Warren; Kauffman, pl. 19, fig. 10.
1981 *Neocardioceras juddii* (Barrois and Guerne, 1878); Wright and Kennedy, pl. 9, fig. 11 only.
1981 *Watinoceras amudariense* (Arkhanguelsky); Wright and Kennedy, p. 51 (*pars*), *non* pl. 10, figs. 6 and 14; text-fig. 19N, Q.
? 1982 *Watinoceras reesidei* Warren; Renz, p. 94, pl. 29, figs. 7–9.

Types. The holotype is the original of Warren 1930, pl. 4, fig. 9, University of Alberta Collections no. 478, from the base of the Smoky River Shale near Watino, Alberta, Canada. Paratypes are nos. 479–481 in the same collections.

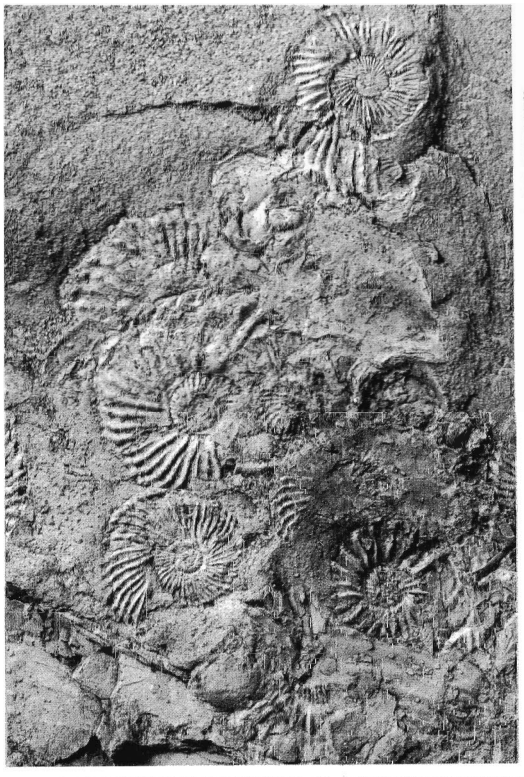
Material. OUM KT 4168–4172 from the basal 50 cm of the Britton Formation above the intraformational unconformity, road cuts on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, Dallas County. *Pseudaspidoceras flexuosum* Zone.

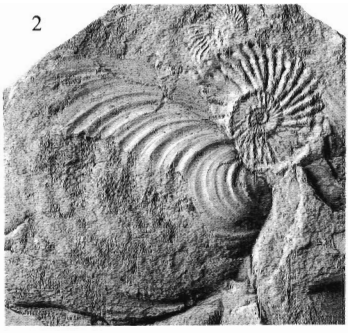
EXPLANATION OF PLATE 7

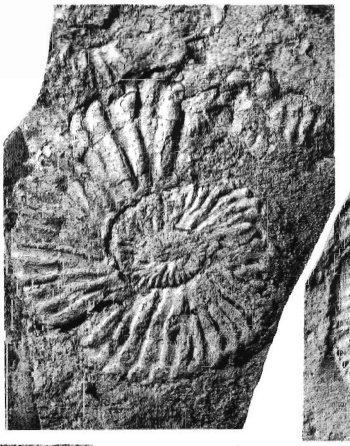
Figs. 1, 2, 5, 7–11. *Watinoceras coloradoense* (Henderson, 1908). 1, OUM KT 4140; 2 and 7, OUM KT 4123; 5, OUM KT 4130; 8, OUM KT 4109; 9, OUM KT 4101; 10, OUM KT 4136; 11, OUM KT 4125, all from the Britton Formation, 0·5–2·5 m above the intraformational unconformity, road cuts on Loop 12, east of Furlong Road, just south of Route 80, Dallas County; *Vascoceras* (*Greenhornoceras*) *birchbyi* Zone.

Figs. 3, 4, 6. *W. reesidei* Warren, 1930. 3, OUM KT 4168; 4, OUM KT 4169; both from up to 0·5 m above intraformational unconformity within the Britton Formation. Locality details as above, *Pseudaspidoceras flexuosum* Zone. 6, cast of Moreman's figured specimen (1927, pl. 14, fig. 2) of *Gauthiericeras* aff. *bravaisi* (d'Orbigny), from the Britton Formation, 7 miles east of Lewisville.

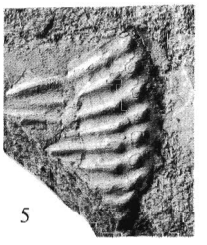
Figs. 2 and 4 are × 1; the ramainder are × 2.

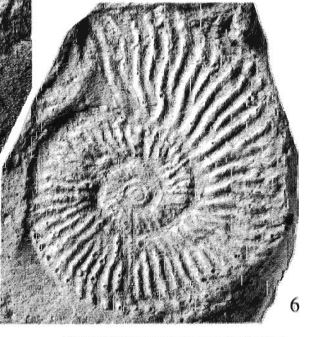

1

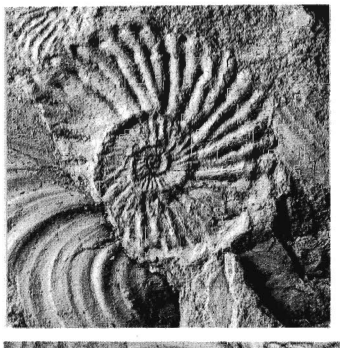

2


3

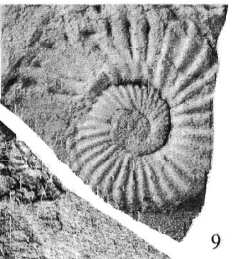

4


5


6


7


8


9


10

11

KENNEDY, *Watinoceras*

Description. All specimens are crushed, but retain traces of aragonitic shell; the smallest is 15·5 mm in diameter, the largest has a whorl height of 15 mm. Coiling is evolute, with U = 30% approximately. Primary ribs arise singly or in pairs at the umbilical shoulder, and alternate with secondaries inserted low on the flank, are straight and prorsiradiate on the inner flank, then flexing forwards and concave on the outer flank. There are bullate inner, and clavate outer ventrolateral tubercles.

Discussion. Although crushed, these specimens match well-preserved individuals of *W. reesidei* from Alaska and the US Western Interior. They are inseparable from some very small *W. coloradoense* (Henderson, 1908) occurring in the overlying shales in the Dallas area (Pl. 7, figs. 1, 2, 7, 11), but as size increases, *coloradoense* are seen to be coarser ribbed, with much stronger umbilical bullae, inner and outer ventral tubercles (Pl. 7, figs. 8 and 10). Wright and Kennedy (1981, p. 51) treated *W. reesidei* as a synonym of *W. amudariense* (Arkhanguelsky, 1916) (p. 48, pl. 7, figs. 8–13; pl. 8, figs. 8–10). Inner whorls of the two are identical, but Dr W. A. Cobban (in litt.) points out that adult *W. amudariense* develop a rounded venter crossed by chevron ribs whereas the venters of adult *W. reesidei* are smooth and flat. The North American name is used here, though I doubt them to be fully specifically separate.

The *Gauthiericeras* aff. *bravaisi* of Moreman (1927, p. 96, pl. 14, fig. 2; see Pl. 7, fig. 6), referred to *Neocardioceras juddii* (Barrois and Guerne, 1878) by Wright and Kennedy (1981, pl. 9, fig. 11) belongs here.

Occurrence. Lower Turonian, *P. flexuosum* and *Vascoceras* (*Greenhornoceras*) *birchbyi* Zones. Widespread in the US Western Interior: south-west Colorado, Kansas, Montana, and Alberta; British Columbia and Alaska; not previously recognized in north-east Texas.

Watinoceras coloradoense (Henderson, 1908)

Plate 7, figs. 1, 2, 5, 7–11; Plate 14, fig. 6

1902 *Schlönbachia gracillima* Kossmat; Petrascheck, p. 153, pl. 9, fig. 3.
1908 *Acanthoceras coloradoensis* Henderson, p. 259, pl. 13, figs. 10 and 11.
1916 *Acanthoceras amudariense* Arkhanguelsky var. *horridum* Arkhanguelsky, p. 49, pl. 8, figs. 8–10, 14, 15.
1928 *Acanthoceras coloradoense* Henderson; Adkins, p. 245.
1931 '*Acanthoceras*' *coloradoense* Henderson; Adkins, p. 62.
1937 *Watinoceras coloradoense* (Henderson); McLearn, p. 115.
1959 *Arkhangelskiceras costatum* Ilyin, p. 212, pl. 4, fig. 2; pl. 5, fig. 1; text-fig. 6.
1959 *Acanthoceras horridum* (Arkhanguelsky); Ilyin, p. 213.
1973 *Watinoceras coloradoense* (Henderson); Cobban and Scott, p. 76, pl. 27, figs. 11–19; pl. 28, figs. 1–3, 5–9; figs. 36, 37.
1977 *Watinoceras coloradoense* (Henderson); Kauffman, pl. 19, figs. 8 and 9; pl. 22, figs. 7 and 8.
1978 *Watinoceras coloradoense* (Henderson); Kauffman, Cobban, and Eicher, pl. 5, figs. 7 and 8.
1978 *Watinoceras* (*Watinoceras*) *coloradoense* (Henderson); Cooper, p. 123 (*pars*), text-fig. 31 only.
1981 *Watinoceras coloradoense coloradoense* (Henderson); Wright and Kennedy, p. 53, text-fig. 8C–F.
1983 *Watinoceras coloradoense* (Henderson); Cobban, p. 15, pl. 15, fig. 2.

Holotype. USNM 30877; the original of Henderson 1908, pl. 13, figs. 10 and 11; by original designation.

Material. OUM KT 4098–4146, from the Britton Formation 0·5 to 2·5 m above the intraformational unconformity, road cuts on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, Dallas County.

Description. All specimens are crushed and retain trace of the original aragonitic shell; the largest complete individual is 28 mm in diameter. Coiling is evolute, with U = 35% approximately. During early growth stages ribbing is dense with up to fifty ribs per whorl. Primary ribs arise singly or in pairs from umbilical bullae with one or two intercalated ribs arising on the inner flank. All ribs are feebly flexuous and prorsiradiate and bear small bullate inner and clavate outer ventrolateral tubercles. A few ventral impressions show the outer ventrolaterals to be oblique to the line of the venter, defining a feeble chevron. This closely ribbed stage is succeeded by one in which the ribbing coarsens markedly, becomes widely spaced, with much stronger umbilical bullae, and clavate inner and outer ventrolateral tubercles.

Discussion. Specimens of *W. coloradoense* reach a much larger size than other species of the genus. One fragment in the present collection must have approached 100 mm diameter. The species is easily distinguished from others by the abrupt change in strength and density of ornament, although some crushed juveniles in the present collection are inseparable from *W. reesidei.*

Occurrence. Lower Turonian, *V.* (*G.*) *birchbyi* Zone of south-eastern Colorado, south-western Kansas, north-western New Mexico, north-east Texas, western Alberta, north-eastern British Columbia, Brazil, and Turkestan.

Subfamily EUOMPHALOCERATINAE Cooper, 1978, p. 102
Genus EUOMPHALOCERAS Spath, 1923, p. 143
[= *Kanabiceras* Reeside and Weymouth, 1931, p. 11]

Type species. By monotypy, *Ammonites euomphalus* Sharpe, 1855, p. 31, pl. 13, fig. 4.

Discussion. Cooper (1978) derived Euomphaloceratinae from Acanthoceratinae *via Acanthoceras* and followed recent authors in regarding *Cunningtoniceras* Collignon, 1937 (p. 64 (40)) with *A. cunningtoni* Sharpe, 1855 (p. 35, pl. 15, fig. 2) as type species as a synonym. Subsequent work shows that *Cunningtoniceras* are derivatives of *Acanthoceras* but *Euomphaloceras* originate in *Lotzeites* Wiedmann, 1960, resemblance between the two being superficial only (Wright and Kennedy, in press).

In the United States, the type species, *E. euomphalum* precedes the type species of *Kanabiceras*, *K. septemseriatum* (Cragin, 1893) in New Mexico, occurring in the *Metoicoceras mosbyense* Zone 3 m below the base of the *S. gracile* Zone at USGS Mesozoic Locality D11483 in the Cooke Range, Luna County (I thank Dr W. A. Cobban for this information). *Kanabiceras* is treated as a synonym of *Euomphaloceras* for reasons outlined by Wright and Kennedy (1981, p. 55).

Euomphaloceras septemseriatum (Cragin, 1893)

Plate 8, figs. 1–6, 9; Plate 9, figs. 1–3, 5–7, 9–12; Plate 22, fig. 3; text-figs. 10E and 11D

1893 *Scaphites septem-seriatus* Cragin, p. 240.
1981 *Euomphaloceras septemseriatum* (Cragin, 1893); Wright and Kennedy, p. 55, pl. 12, figs. 1–8; pl. 13, figs. 1–6; pl. 14, figs. 5–9 (with full synonymy).
1981 *Euomphaloceras septemseriatum* (Cragin, 1983); Kennedy and Juignet, p. 38, fig. 9*b–d* (with synonymy).
1983 *Euomphaloceras septemseriatum* (Cragin); Förster, Meyer, and Risch, p. 132, pl. 3, figs. 6–8.
1984 *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy, Amédro, Badillet, Hancock, and Wright, p. 36, fig. 3*k*, *l.*
1985 *Euomphaloceras* (*Kanabiceras*) *septemseriatum* (Cragin); Howarth, p. 95, figs. 26–29.
1986 *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy, Amédro, and Colleté, p. 206, fig. 3*c*, *d.*

Holotype. By monotypy; TMM 21058, from the Britton Formation, Upper Cenomanian, *S. gracile* Zone, Keenan's Crossing on the Trinity River, Dallas County.

Material. More than fifty specimens from north-east Texas in the TMM, JPC, JDP, USGS, USNM (notably Renfro), BMNH, and OUM collections, not listed separately.

Dimensions.		*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
USNM 411490	c	75·0(100)	39·8(53·1)	29·0(38·7)	1·31	28·3(37·7)
	ic	73·5(100)	37·3(50·7)	25·0(34·0)	1·49	28·3(38·5)
USNM 411491	c	79·0(100)	38·5(48·7)	29·1(36·8)	1·32	29·0(36·7)
	ic	76·5(100)	36·3(47·5)	29·0(37·9)	1·25	29·0(37·9)

Discussion. Cobban and Scott (1973) and Wright and Kennedy (1981) describe this species in detail on the basis of indifferently preserved material from limestone and chalk facies. The present material, which commonly retains original aragonitic shell, shows a number of interesting and remarkable features as well as being markedly dimorphic, the latter not previously recognized in the genus. At the smallest diameter seen (5 mm) (Pl. 7, fig. 5) a full complement of ribs and tubercles is present, and the

species is immediately recognizable from this size onwards (Pl. 9, figs. 1–3, 6). Rib strength varies, and some interspaces may be slightly deepened on ventrolateral shoulders and venter. In middle and later growth (Pl. 8, figs. 1–6, 9; Pl. 9, figs. 7, 9–12; Pl. 10, fig. 3) there is wide variation in the relative strength and development of ribs and tubercles and the variable occurrence of ventral constrictions (e.g. Pl. 22, fig. 3). A number of specimens show that the inner ventrolateral tubercles of the species are actually the septate bases of enormous spines (Pl. 8, figs. 4, 6, 9). These define the form of the succeeding whorl, which is distorted to accommodate the spines of the preceding whorl in grooves. In some cases these grooves extend for almost the full height of the whorl (Pl. 9, fig. 11), indicating the former presence of spines with hair-like terminations, which generally broke off prior to burial or during extraction (but see Pl. 8, figs. 4, 6, 9). The spines interfere with both ribs and tubercles, and may be almost entirely concealed in the shell wall (Pl. 8, fig. 4); they are the reason for the highly variable and irregular ornament of the species, remarked on by previous authors. It is not clear whether or not the umbilical bullae are also the bases of long spines, but the outer ventrolateral and siphonal tubercles appear to have borne no such spines, or lost them prior to enclosure in the dorsum of the succeeding whorl (Pl. 8, fig. 9).

Maturity in the species is marked by a decline in strength of ribs and an outwards migration of the umbilical tubercles. Small adults, taken to be microconchs, are 50 mm in diameter (Pl. 8, figs. 1 and 2; Pl. 9, figs. 9 and 10) and may show a short terminal section with growth lines only, just before the terminal aperture (Pl. 8, fig. 1); while large adults, taken to be macroconchs (Pl. 8, fig. 6; Pl. 9, figs. 11 and 12) are up to 110 mm diameter, judging from large fragments in the Conlin Collection. The holotype (Pl. 9, fig. 7) is an incomplete macroconch.

Occurrence. Upper Cenomanian, *S. gracile* Zone and correlatives; in the United States, the species occurs in north-east and west Texas, New Mexico, Arizona, Colorado, Kansas, Montana, Utah, and California, in northern Mexico, Brazil, southern England, northern France and the German Federal Republic, Angola, Nigeria, and Japan.

Genus ROMANICERAS Spath, 1923, p. 144

Subgenus ROMANICERAS Spath, 1923, p. 144

[= *Kossmatia* Yabe, 1927, p. 42, *non* Uhlig, 1910, p. 470; *Proromaniceras* Wiedmann, 1960, p. 134]

Type species. By original designation; *Ammonites deverianus* d'Orbigny, 1841, p. 356, pl. 110, figs. 1 and 2.

Romaniceras (*Romaniceras*) *mexicanum* Jones, 1938

Plate 10, figs. 1–4, 14–17; text-fig. 24G

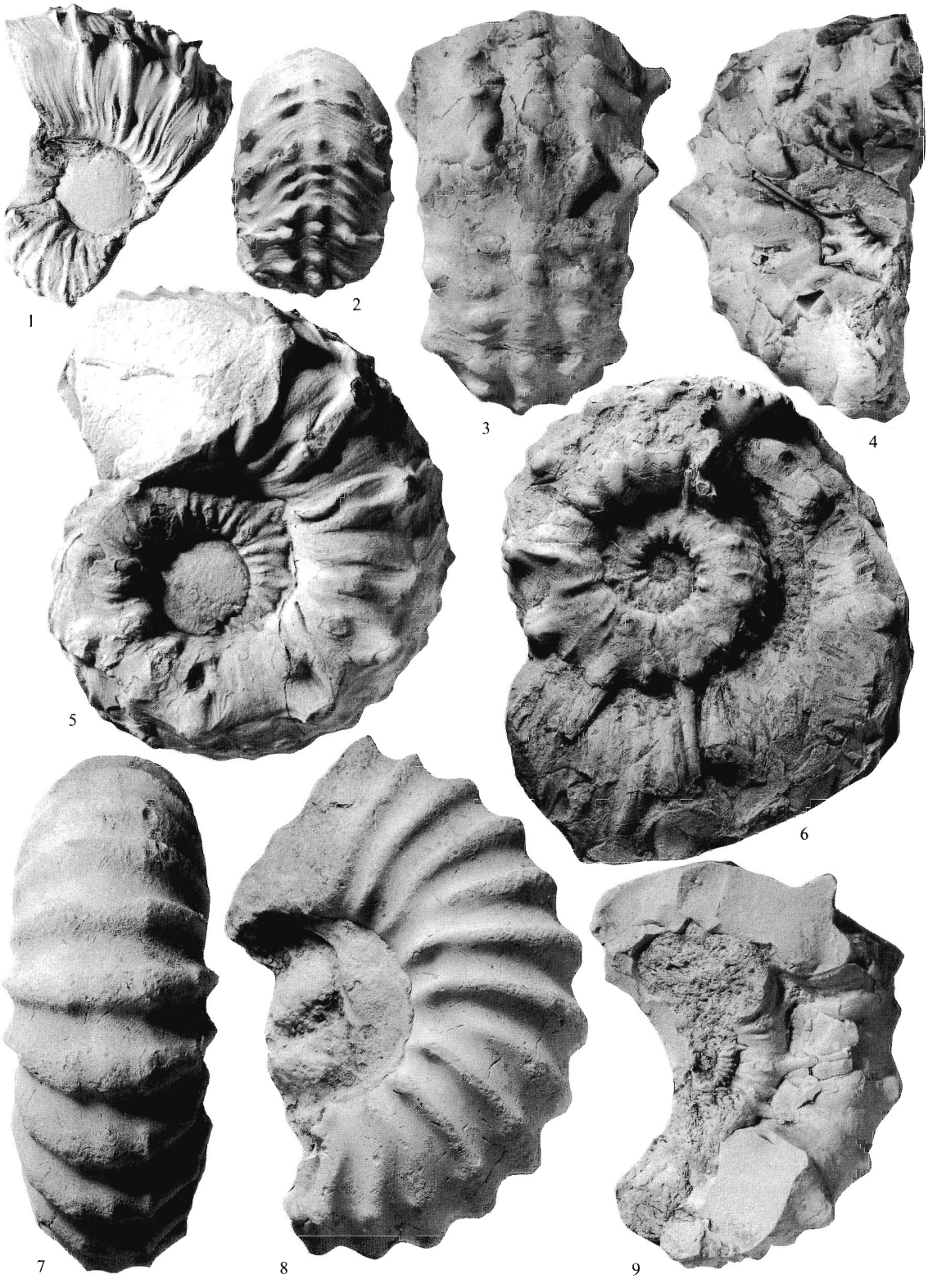
1938 *Romaniceras mexicanum* Jones, p. 121, pl. 7, figs. 1 and 6.
1938 *Romaniceras adkinsi* Jones, p. 120, pl. 8, figs. 4 and 5.
1938 *Romaniceras santaanaense* Jones, p. 121, pl. 8, figs. 1 and 6.

EXPLANATION OF PLATE 8

Figs. 1–6, 9. *Euomphaloceras septemseriatum* (Cragin, 1893). 1 and 2, microconch, USNM 411492; 3, 4, 9, USNM 411493, individual with spines preserved, from Texcrete Quarries, Dallas County. 5, USNM 411490, incomplete macroconch retaining shell and showing well-developed grooves to house inner ventrolateral spines, from 1·5 to 1·8 miles south-east of Britton on Rogers Farm, Ellis County. 6, TMM, W. S. Adkins Collection no. 2019, 4 miles south of Britton, near Britton–Midlothian Highway, Ellis County. Figured by Moreman (1927, pl. 13, fig. 5), a macroconch with well-preserved spines.

Figs. 7 and 8. *Pseudocalycoceras angolaense* (Spath, 1931). TMM, Adkins Collection 869 TXI, a macroconch from 4 miles west of Cedar Hill, Dallas County.

All specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation of north-east Texas; ×1.



KENNEDY, *Euomphaloceras*, *Pseudocalycoceras*

1938 *Romaniceras toribioense* Jones, p. 122, pl. 7, figs. 7 and 8.
? 1942 *Romaniceras* sp. Moreman, p. 207.
1959*a* *Romaniceras pseudodeverianum* (Jimbo); Matsumoto, p. 93 (*pars.*).
1980*a* *Shuparoceras* sp. nov. Kennedy, Wright, and Hancock, p. 329; text-fig. 2.
1980*a* *Romaniceras* (*Romaniceras*) *kallesi* (Zázvorka, 1958); Kennedy, Wright, and Hancock, p. 342 (*pars*), text-fig. 6.
1988*b* *Romaniceras* (*Romaniceras*) *mexicanum* Jones, 1938; Kennedy and Cobban, p. 25, figs. 2, 3, 5, 6A–D, G, 7–10.

Material. TMM 190, 205 are from the Eagle Ford Condensed Zone at Watters Park, Austin, Travis County; TMM, W. S. Adkins Collection 871 TX1 and 871 TX2 are from the same unit in Travis County; USNM 420085 is from Oak Haven Waterfall on Walnut Creek, Austin, Travis County. All *Prionocyclus hyatti* Zone.

Discussion. This species is described in detail by Kennedy and Cobban (1988*b*), to whom reference should be made. All the present specimens are robustly ornamented with weak to strong lateral tubercles. The largest is still septate at a whorl height of 90 mm.

Occurrence. P. hyatti Zone, *Coilopoceras springeri* Subzone of northern Chihuahua, Chispa Summit in Trans-Pecos Texas, Eagle Ford Condensed Zone in central Texas, Mancos and Carlile Shales of north-central New Mexico.

incertae sedis

Plate 10, figs. 5 and 6

Material. TMM 42840, Eagle Ford Condensed Zone, Oak Haven Waterfall, Walnut Creek, Austin, Travis County. *P. hyatti* Zone.

Description. Specimen is a wholly septate fragment with a maximum preserved whorl height of 19·5 mm. Whorl section very depressed, reniform in intercostal section with greatest breadth around mid-flank. Costal section depressed polygonal with greatest breadth at lateral tubercle; whorl breadth to height ratio 1·52. Strong, straight, distant prorsiradiate primary ribs arise from umbilical bullae and bear strong conical mid-lateral and inner ventrolateral tubercles. In one case a primary rib divides into two at the lateral tubercle. Ribs on the venter are narrower, finer, and more numerous than on the flank. They arise in pairs from the inner ventrolateral tubercles or intercalate, and all bear a small outer ventrolateral tubercle. Preservation of the mid-venter is poor, but a feeble siphonal tubercle is also present at the smallest diameter visible.

Discussion. Tuberculation and multiple ventral ribbing all indicate Euomphaloceratinae but the specimen bears little resemblance to any described taxon and is probably a new genus and species.

Occurrence. As under material.

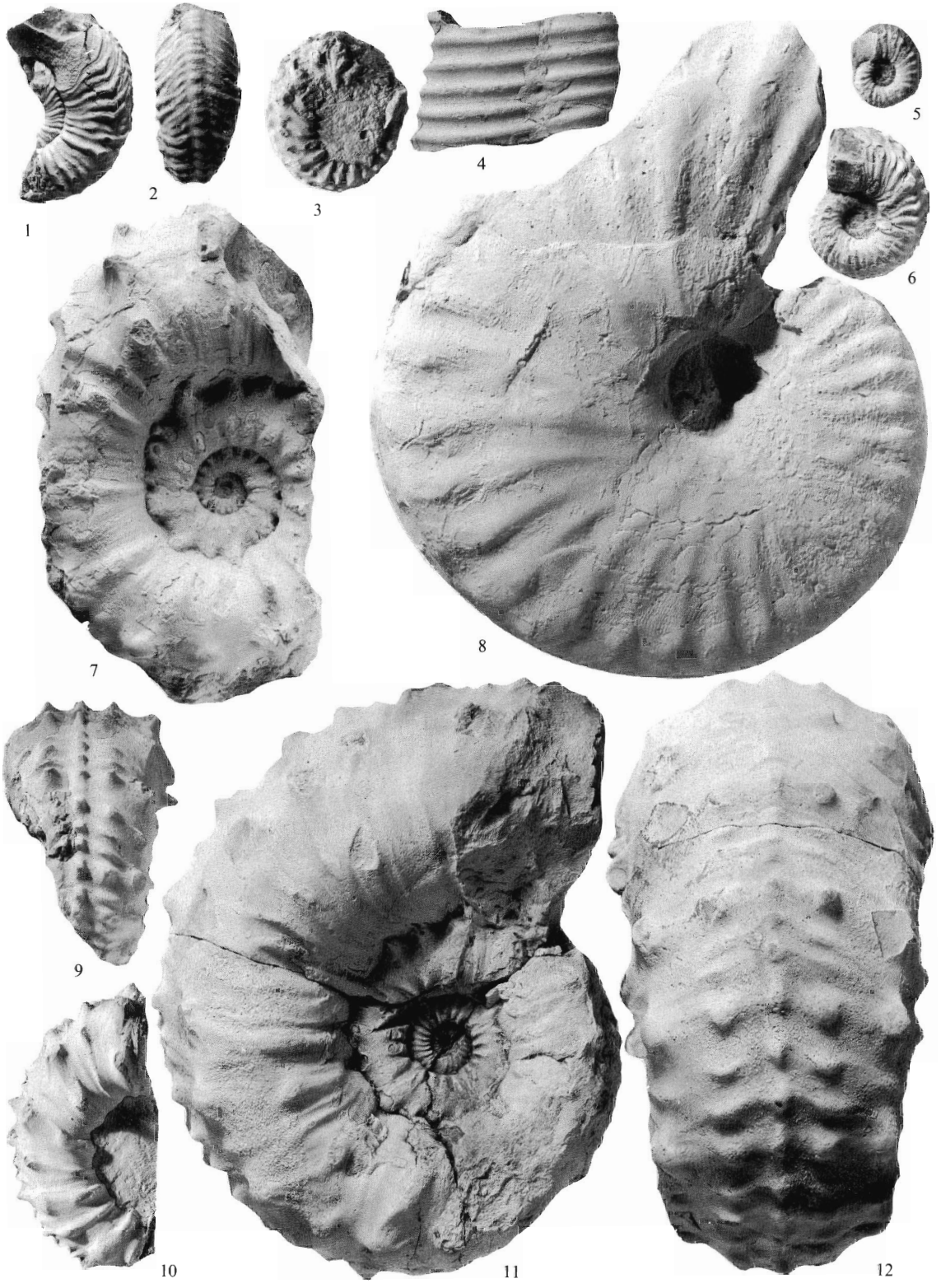
EXPLANATION OF PLATE 9

Figs. 1–3, 5–7, 9–12. *Euomphaloceras septemseriatum* (Cragin, 1893). 1 and 2, USNM 411494; 3, USNM 411495; 5 and 6, USNM 411496–7; 9, 10 USNM 411498; the last a microconch, all from Texcrete Quarries, Dallas County. 7, holotype, TMM 21058; from Keenan's Crossing on the Trinity River, Dallas County. 11 and 12, macroconch, TMM, W. S. Adkins Collection no. 1936, from 4 miles south of Britton, Ellis County.

Fig. 4. *Puebloites corrugatus* (Stanton, 1894). USNM 411468, from USGS Mesozoic Locality 22604, bed of first creek north-east of Britton, 2·5 miles on farm road, Ellis County.

Fig. 8. *Metoicoceras geslinianum* (d'Orbigny, 1850). Cast of the holotype of *M. irwini* Moreman, 1927; the original was from 3·2 miles north of Sowers, where a tributary of Hackberry Creek forms a low bluff on east side of road, Dallas County.

All Specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation of north-east Texas. Figs. 1–3, 5, 6 are ×2; the remainder are ×1.



KENNEDY, *Euomphaloceras*, *Puebloites*, *Metoicoceras*

Subfamily MAMMITINAE Hyatt, 1900, p. 588

[= Buchiceratinae Hyatt, 1903, p. 26; Metoicoceratidae Hyatt, 1903, p. 115; Fallotitinae Wiedmann, 1960, p. 741]

Genus METOICOCERAS Hyatt, 1903, p. 115

Type species. By subsequent designation by Shimer and Shrock, 1944 (p. 591); *Ammonites swallovi* Shumard, 1860, p. 591.

Metoicoceras geslinianum (d'Orbigny, 1850)

Plate 9, fig. 8; Plate 10, figs. 25–27; Plate 22, figs. 16 and 17; text-figs. 20–23

1841 *Ammonites catillus* d'Orbigny, p. 325, pl. 97, figs. 1 and 2.
1850 *Ammonites geslinianus* d'Orbigny, p. 146.
1927 *Metoicoceras irwini* Moreman, p. 92, pl. 13, figs. 3 and 4.
1942 *Metoicoceras ornatum* Moreman, p. 211, pl. 32, fig. 4; text-fig. 2*c*.
1942 *Barroisiceras trinodosum* Moreman, p. 212, pl. 33, figs. 1 and 2; text-fig. 2*a*.
1942 *Barroisiceras brittonense* Moreman, p. 212, pl. 33, fig. 3; text-fig. 2*b*.
1981 *Metoicoceras geslinianum* (d'Orbigny, 1850); Wright and Kennedy, p. 62, pl. 17, fig. 2; pl. 18, figs. 1 and 2; pl. 19, figs. 1 and 2; pl. 20, figs. 1–3; pl. 21, figs. 1 and 2; text-figs. 19C–E, 20, 21A–D (with full synonymy).
1981 *Metoicoceras geslinianum* (d'Orbigny); Kennedy and Juignet, p. 39, text-figs. 7*d*, *e*, 8*a*–*c*, 9*a*, *e*, 10*a*.
1983 *Metoicoceras geslinianum* (d'Orbigny, 1850); Förster, Meyer, and Risch, p. 132, pl. 3, figs. 12–16.
1983 *Metoicoceras geslinianum* (d'Orbigny, 1850); Moreau, Francis, and Kennedy, p. 335, text-figs. 10*c*, *d*.
1984 *Metoicoceras geslinianum* (d'Orbigny, 1850); Kennedy, Amédro, Badillet, Hancock, and Wright, p. 37.
1986 *Metoicoceras geslinianum* (d'Orbigny); Cobban, figs. J, K.

Lectotype. MNHP 6110, said to be from Lamennais near Vibraye, Sarthe, France, refigured by Wright and Kennedy (1981, text-fig. 21A, B).

Material. Several hundred specimens in the TMM, USGS, JPC, JDP, USNM, BMNH, and OUM collections from Upper Cenomanian, *S. gracile* Zone, Britton Formation of north-east Texas, the majority from Texcrete Quarries. Not listed separately.

EXPLANATION OF PLATE 10

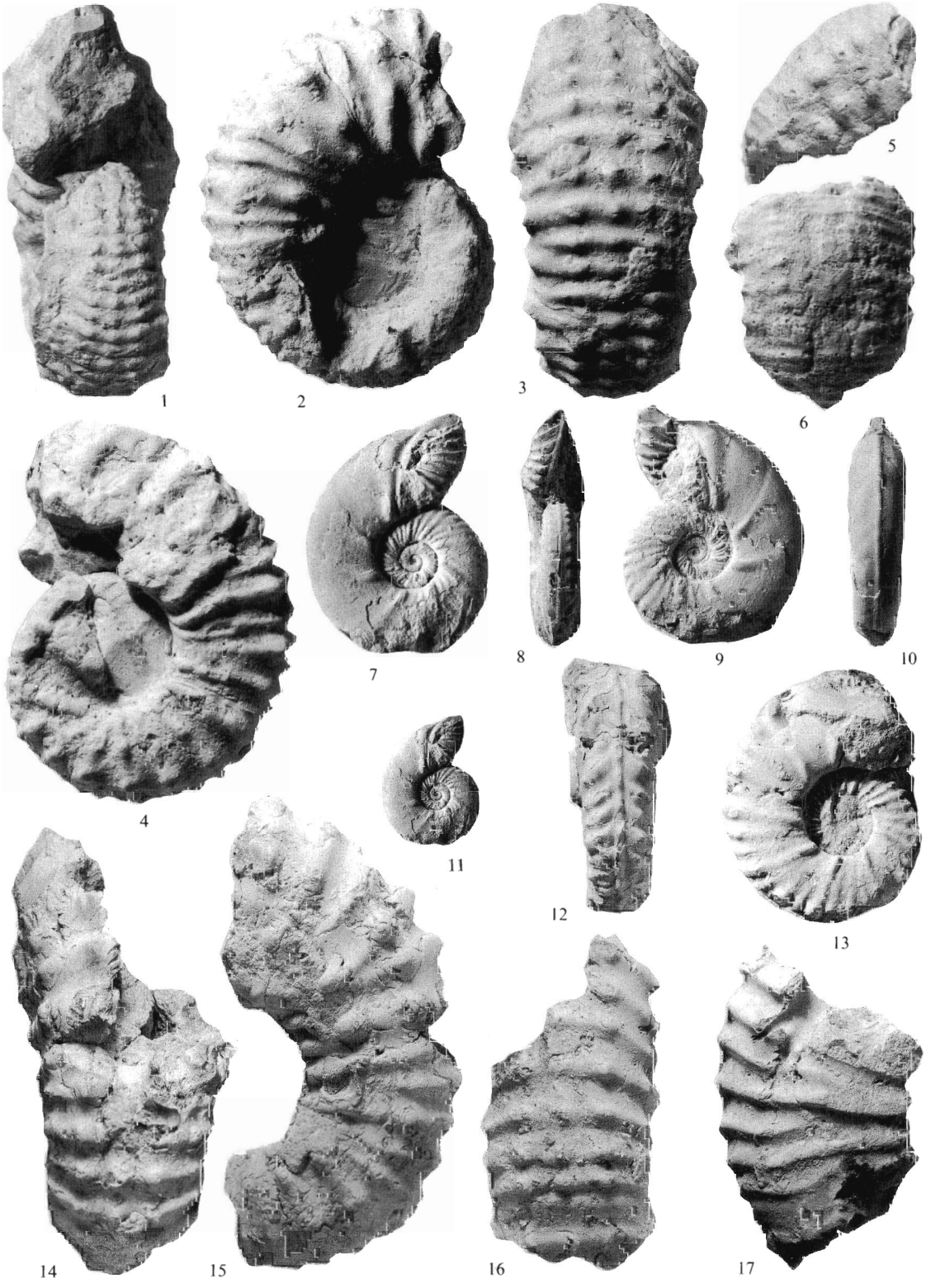
Figs. 1–4, 14–17. *Romaniceras* (*Romaniceras*) *mexicanum* Jones, 1938. 1–4, TMM 190; 14 and 15, TMM 205; from Watters Park, Travis County. 16 and 17, TMM, W. S. Adkins Collection 871 TX1, from Travis County. All Eagle Ford Condensed Zone, *Prionocyclus hyatti* Zone.

Figs. 5 and 6. Euomphaloceratinae *incertae sedis*. TMM 4280, Eagle Ford Condensed Zone, Oak Haven Waterfall, Walnut Creek, north of Austin, Travis County.

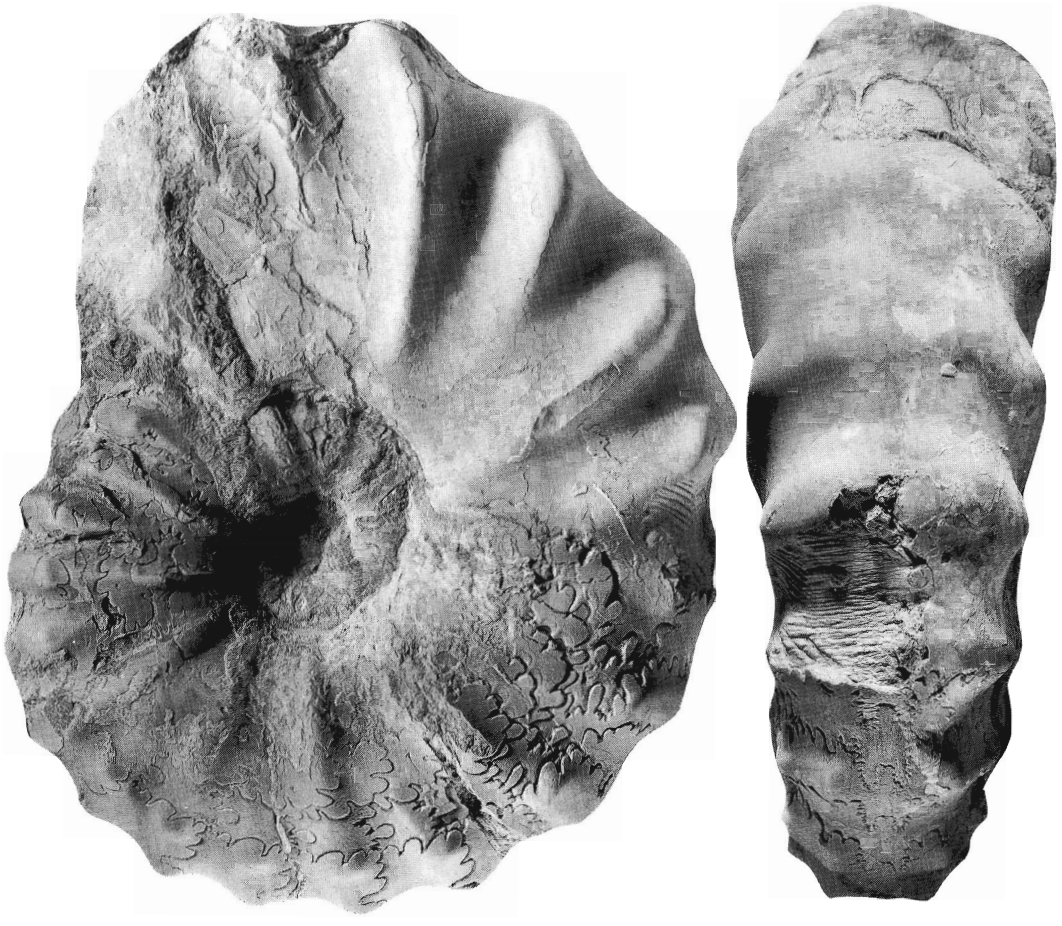
Figs. 7–11. *Prionocyclites mite* gen. et sp. nov. The holotype, USNM 420144, from the Arcadia Park Formation at USGS Locality 22608, east of Power Plant on Mountain Creek, Dallas County.

Figs. 12 and 13. *Prionocyclus hyatti* (Stanton, 1894). USNM 420118, Arcadia Park Formation, concretions on valley slopes south-east of Cedar Hill–Duncanville road, midway between the two towns, Dallas County.

All specimens are from the *P. hyatti* Zone. Figs. 7, 8, 9, 10 are ×2; the remainder are ×1.

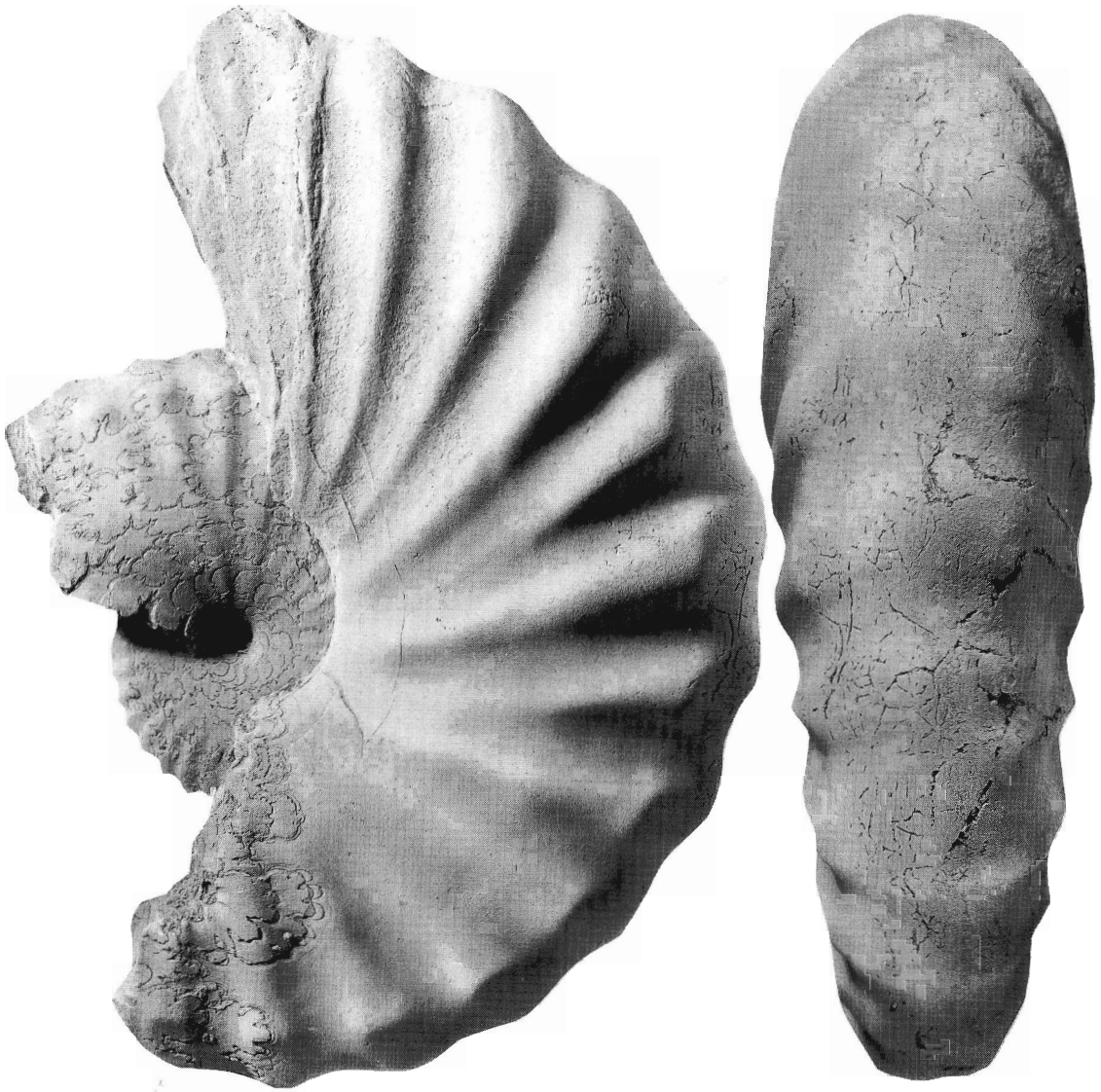


KENNEDY, *Romaniceras*, *Prionocyclites*, *Prionocyclus*, Euomphaloceratinae *incertae sedis*



TEXT-FIG. 20. *Metoicoceras geslinianum* (d'Orbigny, 1850). USNM 411502, an adult microconch, 200 mm in diameter from Texcrete Quarries, Dallas County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation. Reduced ×0·6.

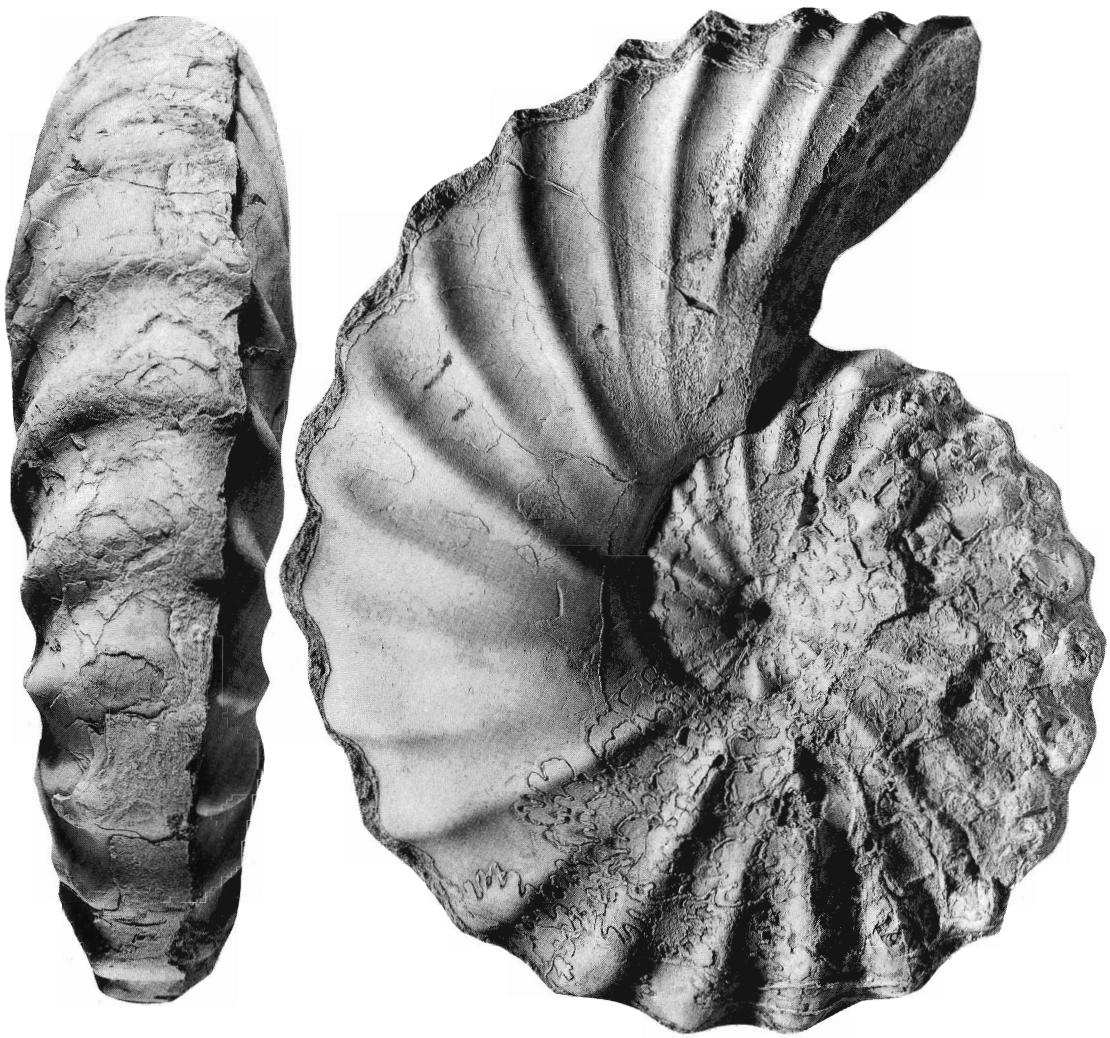
Dimensions.		*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
Adult microconchs						
USNM 411500	c	127(100)	46·3(36·5)	52·0(40·9)	0·89	35·6(28·0)
	ic	123(100)	39·8(32·4)	48·6(39·5)	0·82	35·6(28·9)
USNM 411501	c	178(100)	62·5(35·1)	84·5(47·5)	0·74	39·1(22·0)
	ic	170(100)	56·0(32·9)	82·0(48·2)	0·68	39·1(23·0)
USNM 411502		188(100)	—(—)	85·0(45·2)	—	54·0(28·7)
		185(100)	—(—)	78·5(42·4)	—	54·0(29·2)
Adult macroconchs						
USNM 411504	c	159(100)	47·5(29·9)	75·0(47·2)	0·63	22·5(14·2)
	ic	159(100)	45·0(28·3)	75·0(47·2)	0·60	22·5(14·2)
USNM 411505	c	185(100)	56·0(30·3)	80·5(43·5)	0·69	34·0(18·4)
	ic	185(100)	50·5(27·3)	78·0(42·2)	0·65	34·0(18·4)
USNM 411506	c	205(100)	58·3(28·4)	94·5(46·1)	0·62	37·0(18·0)
	ic	203(100)	55·0(27·1)	93·0(45·8)	0·59	37·0(18·2)
USNM 411507	c	248(100)	67·2(27·1)	101·0(40·7)	0·67	61·0(24·6)
	ic	240(100)	62·5(26·4)	—(—)	—	61·0(25·4)



TEXT-FIG. 21. *Metoicoceras geslinianum* (d'Orbigny, 1850). USNM 411503, an adult microconch 215 mm in diameter from east bank of stream, 2·5 miles south of Britton on the old Britton–Midlothian road, Ellis County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation. Reduced ×0·7.

Description. The early and middle growth stages are amply documented and illustrated by previous authors (see synonymy in Wright and Kennedy 1981). Among the hundreds of specimens from the Britton there are numerous complete adults that show the species to be strongly dimorphic.

Microconchs (text-figs. 20 and 21) are evolute, stout-whorled, coarsely ribbed and tuberculate forms that retain tubercles on most of the adult body-chamber and reach 135–210 mm diameter, most being adult at 135–180 mm. Included here is the holotype of *Metoicoceras ornatum* Moreman, 1942 (p. 211, pl. 32, fig. 4; text-fig. 2*c* = *M. swallovi* Shumard of Moreman 1927, p. 95, pl. 15, fig. 3) (Pl. 11, figs. 25–27). These coarsely ornamented specimens commonly have eight to ten strong umbilical bullae per whorl in middle growth stages. These give rise to strong, straight, prorsiradiate ribs of pairs of ribs while there are additional short



TEXT-FIG. 22. *Metoicoceras geslinianum* (d'Orbigny, 1850). USNM 411507, an adult macroconch, 250 mm in diameter from 1·5 to 1·8 miles south-east of Britton, Ellis County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation. Reduced ×0·56.

intercalatories giving a total of around twenty ribs per whorl. All bear strong, slightly clavate inner, and stronger, very clavate outer ventrolateral tubercles on either side of a broad sulcate venter across which they are linked by a low, broad rib. This style of ornament continues on to the early part of the body-chamber, where the umbilical seam egresses slightly (text-figs. 20 and 21). Umbilical tubercles decline and may disappear, the umbilical wall flattens, and the last few ribs become narrower and crowd. The ventrolateral tubercles change from clavate to bullate and are no wider than the rib. The ventral rib becomes thinner and sharper than on the first half of the body-chamber (text-fig. 21) to give a compressed octagonal whorl section.

Macroconchs (text-figs. 22 and 23) are adult between 195 and 245 mm diameter. Coiling is more involute than in microconchs, the whorl section higher, more compressed, with tubercles lost on the body-chamber. Included here are the Kanab specimens of *M. whitei* Hyatt, 1903 (p. 122, pl. 13, figs. 3 and 4) and *M. gibbosum* Hyatt, 1903 (pl. 15, figs. 5 and 6), the holotype of *M. irwini* Moreman, 1927 (pl. 13, fig. 3; Pl. 9, fig. 8), *M. gibbosum* of Moreman (1927, pl. 14, fig. 4), *M. whitei* of Moreman (1927, pl. 14, fig. 1) and Cobban and Scott (1973, pl. 14,

figs. 4–11), and the *Hemitissotia* sp. A of Moreman (1927 pl. 14, fig. 1). These macroconchs have a smaller umbilicus than microconchs and many more ribs—twenty-eight to thirty-two in most cases—lacking umbilical bullae and arising singly or in pairs from the umbilical shoulder with additional intercalatories of various lengths. Conical inner ventrolateral tubercles are present and may be lost in middle growth or persist. Clavate outer ventrolaterals persist onto the body-chamber. This generally extends for just over half a whorl, as in microconchs, while the umbilical seam is equally excentric (text-figs. 22 and 23). The venter broadens and flattens, tubercles decline, and ribs crowd as the adult aperture is approached.

Discussion. The synonymy includes only those species based on Texas specimens. So far as I can see all but one of the *S. gracile* Zone *Metoicoceras* species described to date belong to a single variable species for which *geslinianum* is the earliest name; the exception is the diminutive *M. acceleratum* Hyatt, 1903, type species of *Nannometoicoceras* gen. nov., described below. I illustrate here the types of *M. ornatum* Moreman, 1942, a juvenile microconch (Pl. 11, figs. 25–27) and *M. irwini* Moreman, 1927 (Pl. 9, fig. 8), a juvenile macroconch. *Barroisiceras trinodosum* Moreman, 1942 (p. 212, pl. 33, figs. 1 and 2; text-fig. 2*a*) is a pathological *M. geslinianum* (Pl. 22, figs. 16 and 17); *B. brittonense* Moreman, 1942 (p. 212, pl. 33, fig. 3; text-fig. 2*b*) is a similarly deformed individual; the holotype, UTA 19811, appears to be part of a macroconch body-chamber. The *Hemitissotia* sp. A of Moreman (1927, p. 94, pl. 14, fig. 1) is also a fragment of the present species.

It is interesting to note that Wright and Kennedy (1981, p. 64) described (as form α) what are here regarded as microconchs only 62 to 114 mm in diameter and (as form β) what are here regarded as macroconchs only 94 to 160 mm in diameter, suggesting a markedly smaller adult size in at least some English populations, notably those from condensed chalk basement bed facies in south-west England, although specimens from more offshore pelagic chalks may reach a size comparable to US material described here (e.g. Wright and Kennedy 1981, text-fig. 20). The better-preserved material from Anjou and Vendée in France, described as seven different species by de Grossouvre in 1912 shows the same range of intraspecific variation and dimorphism as the Texas material figured here (see illustrations in Kennedy *et al.* 1981). It must be admitted, however, that individuals from Europe and Texas differ in details of combination of elements of ornament as, for example, the Texas and Angolan examples of *Pseudocalycoceras angolaense* described above. As with that species, I regard these differences as of less than specific significance although the populations are subtly different.

Examination of large collections of *Metoicoceras* from the *S. gracile* Zone fauna of the Tropic Shale in Utah (USGS Mesozoic Localities 22339, 11723, 23936) reveals numerous compressed involute specimens I take to be macroconchs, although I have seen none of the evolute form I take to be the microconch. They do, however, occur together in the Mancos Shale of equivalent age in New Mexico at USGS Mesozoic Locality D6793 on the north side of Paradise Canyon, $NE\frac{1}{4}NW\frac{1}{4}$ Section 23, Township 7 N., Range 8 W., Valencia County, New Mexico.

Similar co-occurrence of larger involute and smaller evolute forms that I take to be dimorphs is found in some older *Metoicoceras*. Thus the evolute *M. mosbyense* Cobban, 1953*a* (p. 48, pl. 6, figs. 1–14; pl. 7, figs. 1–3) seems to be the microconch of *M. mulleri* Cobban, 1953*a* (p. 49, pl. 6, figs. 15 and 16; pl. 8, figs. 1–7; pl. 9) (see also Cobban 1984*a*, p. 80) and the immediate predecessor and likely ancestor of *M. geslinianum*.

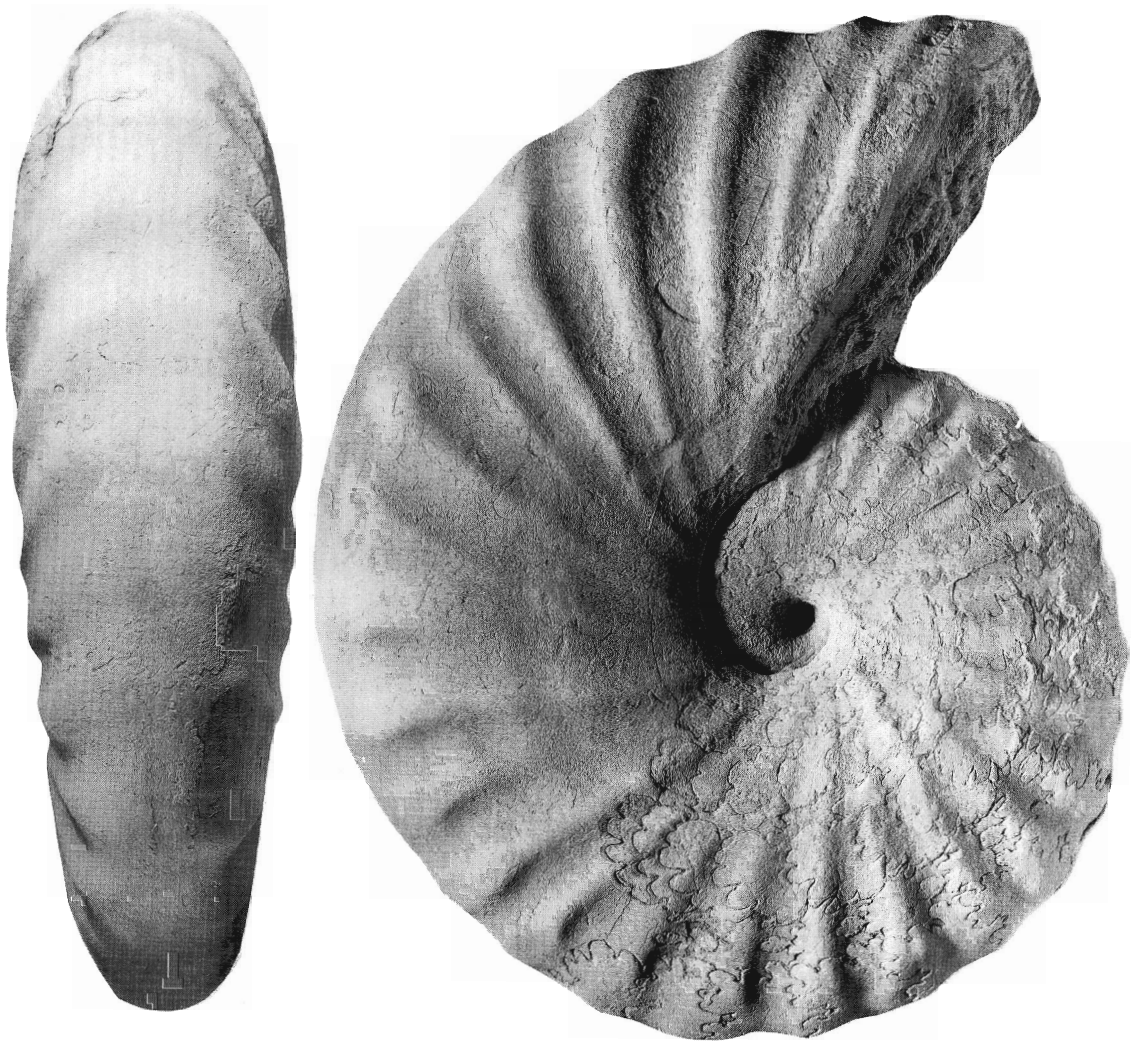
It may well be that the anomalous occurrence of predominantly macroconch *M. geslinianum* in the Tropic Shale of the Upper Kanab Valley, Utah, records sexual segregation within the species.

Occurrence. Upper Cenomanian, *S. gracile* Zone and correlatives in Texas, New Mexico, Colorado, Kansas, Utah, and elsewhere in the US Western Interior, northern Mexico, southern England, France, Spain, Germany, Czechoslovakia, Iran(?), Israel (Lewy *et al.* 1984), Angola, Nigeria, and, possibly Morocco.

Genus NANNOMETOICOCERAS nov.

Type species. Metoicoceras acceleratum Hyatt, 1903, p. 127, pl. 14, figs. 1–11. Upper Cenomanian, *S. gracile* Zone, Horton's Mill, Elm Fork, Dallas County, Texas.

Diagnosis. Very involute rectangular-whorled dwarf derivatives of *Metoicoceras*; strongly dimorphic with macroconchs 40 mm or less and microconchs 25 mm or less in diameter. Phragmocone



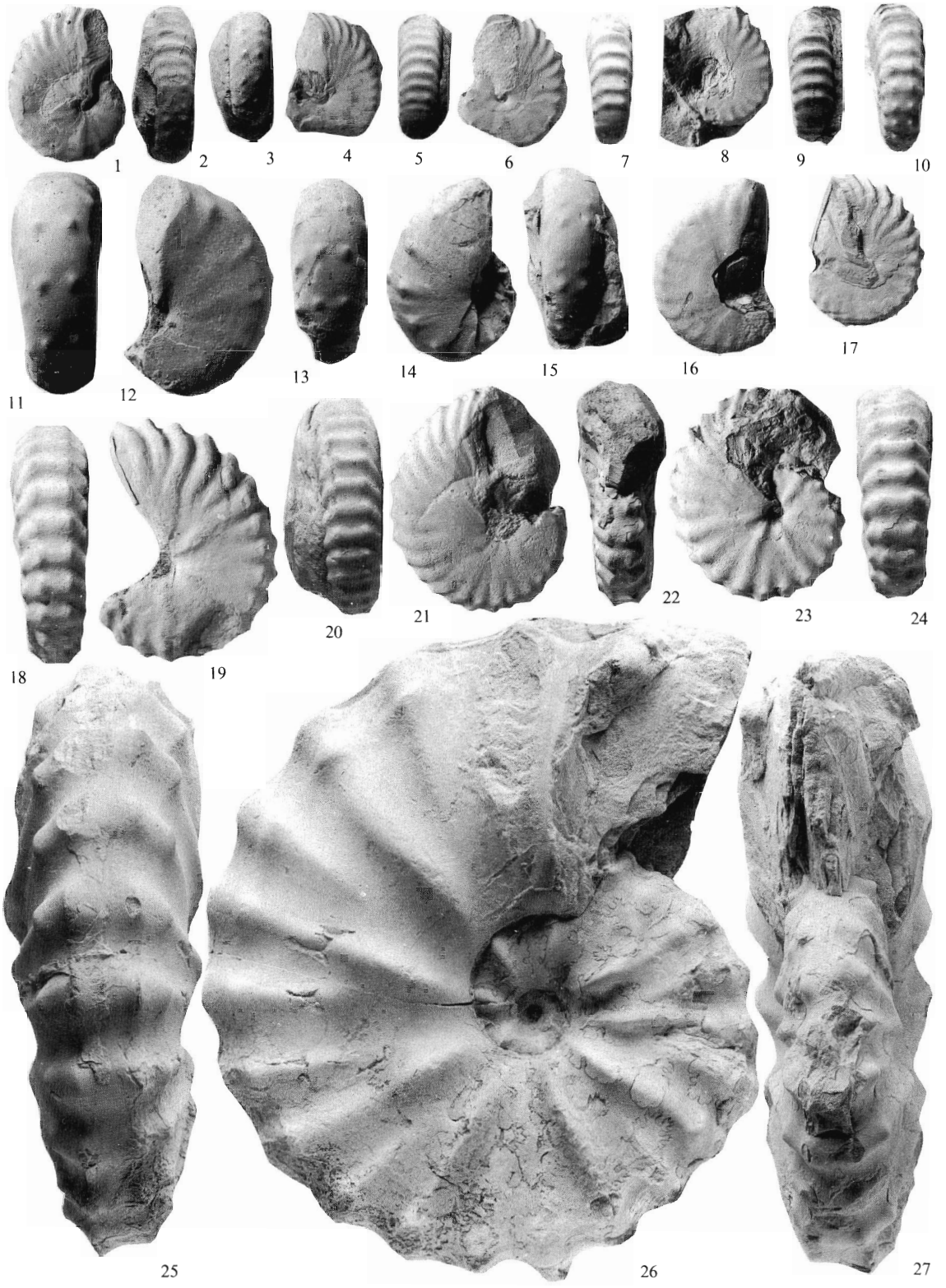
TEXT-FIG. 23. *Metoicoceras geslinianum* (d'Orbigny, 1850). USNM 411505, an adult macroconch, 185 mm in diameter from the first creek north-east of Britton, Ellis County, 2·5 miles on farm road. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation. Reduced ×0·75.

EXPLANATION OF PLATE 11

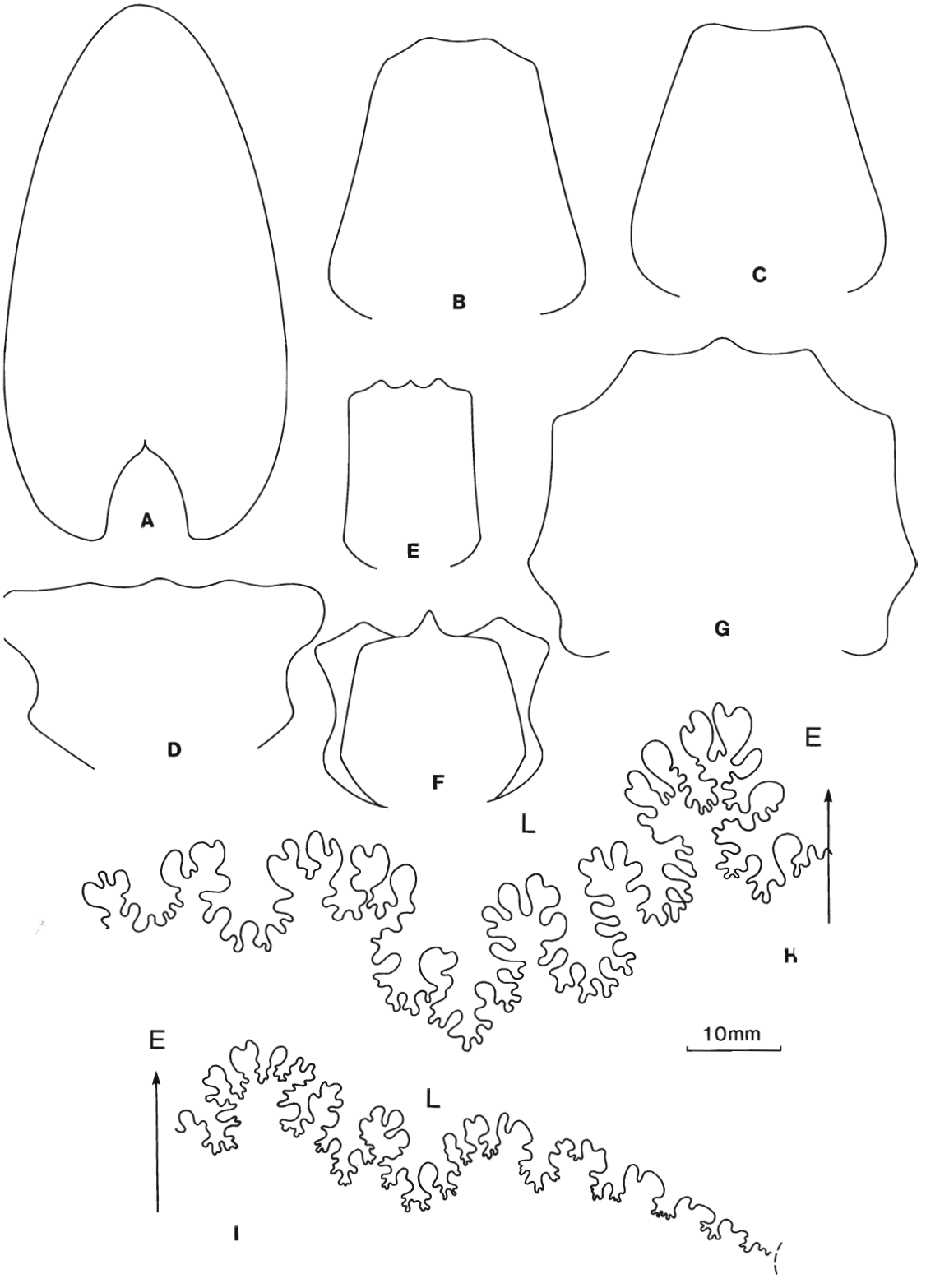
Figs. 1–24. *Nannometoicoceras acceleratum* (Hyatt, 1903). 1–3, USNM 411513; 4 and 5, USNM 411514; 6 and 7, USNM 411515; 8 and 9, USNM 411516; 10 and 17, USNM 411517; 11 and 12, USNM 411518; 13 and 14, USNM 411519; 15, USNM 411520; 16, USNM 411521; 18 and 19, USNM 411510; 20 and 21, USNM 411522; 22–24, USNM 411512. 1–10, 17, are adult microconchs; 18–24 adult macroconchs; 11, 12, 16, juvenile macroconchs. All from Texcrete Quarries, Dallas County.

Figs. 25–27. *Metoicoceras geslinianum* (d'Orbigny, 1850). TMM 19809, holotype of *M. ornatum* Moreman, 1942, from 4 miles south of Britton on east side of Midlothian highway, Ellis County.

All specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation of north-east Texas. Figs. 11–15 are ×2; the remainder ×1.



KENNEDY, *Nannometoicoceras*, *Metoicoceras*


A
B
C
D
E
F
G
E
L
H
10mm
E
L
I

ornamented by weak to strong flexuous prorsiradiate primary ribs with up to three intercalatories and conical inner and outer ventrolateral tubercles, the latter projected adaperturally of the former, or with tubercles only. Body-chambers develop weak to strong primary flank ribs, the latter with or without bullae, with two to three intercalatories. Inner ventrolateral tubercles conical to clavate, outer ventrolaterals clavate, absorbed into bar-like ribs on tabulate venter at maturity. Suture with little-incised bifid E/L, broad L, and little incised L/U_2.

Discussion. This diminutive genus stands in the same relationship to *Metoicoceras* as does *Protacanthoceras* Spath, 1923 to *Acanthoceras* Neumayr, 1875 (Wright and Kennedy 1980, 1986; Kennedy and Wright 1985). That co-occurring *Metoicoceras* and *Nannometoicoceras* are themselves dimorphic shows beyond doubt that the latter cannot be the microconch of the former. Adult *Nannometoicoceras* are readily distinguished from juvenile *Metoicoceras* of comparable size by their rectangular compressed whorl section, minute conical umbilicus, tabulate venter in costal section, early loss of ventrolateral tubercles, and quite different suture. Juveniles of the two genera are equally easy to differentiate. The ribbing of *Metoicoceras* nuclei is stronger, tubercles clavate rather than conical, and the suture more complex at a comparable size.

Occurrence. Known with certainty only from the Upper Cenomanian, *M. geslinianum* Zone in Texas. A possibly analogous form occurs in the older *Dunveganoceras pondi* Zone of the Black Hills and may represent a comparable offshoot from some older *Metoicoceras* species or be the ancestor of *N. acceleratum*.

Nannometoicoceras acceleratum (Hyatt, 1903)

Plate 11, figs. 1–24; text-fig. 8A

1903 *Metoicoceras acceleratum* Hyatt, p. 127, pl. 14, figs. 11–14.
1928 *Metoicoceras acceleratum* Hyatt; Adkins, p. 249.
1942 *Metoicoceras acceleratum* Hyatt; Moreman, p. 211.

Holotype. By monotypy, the original of Hyatt 1903, p. 127, pl. 14, figs. 11–14, from Horton's Mill, Elm Fork, Dallas County; Britton Member, Upper Cenomanian, *S. gracile* Zone.

Material. Thirty-seven specimens, of which ten are macroconchs (JPC and JDP collections, from Texcrete Quarries; Renfro Collection, from USGS Mesozoic Locality 22613, California Crossing on Elm Fork of Trinity River, Dallas County), twelve microconchs (JPC and JDP collections, localities as above), and fifteen juveniles (JPC and JDP collections, localities as above).

Dimensions.

	D	*Wb*	*Wh*	*Wb : Wh*	*U*
Microconchs					
USNM 411508	22·8(100)	8·2(36·0)	12·0(52·6)	0·68	0·5(—)
USNM 411509	20·7(100)	8·5(41·6)	11·0(53·1)	0·77	—(—)
Macroconchs					
USNM 411510	35·8(100)	12·0(33·5)	20·3(56·7)	0·59	—(—)
USNM 411511	28·4(100)	9·6(33·8)	15·3(53·9)	0·63	2·3(0·1)
USNM 411512	33·0(100)	—(—)	18·3(55·5)	—	2·1(0·1)

Diagnosis. As for genus.

Description. Macroconchs reach maturity at diameters ranging from 32·8 to 37·5 mm (five specimens gave 32·8, 33·0, 33·5, 37·5 mm). Microconchs reach maturity at 17·0 to 23·5 mm diameter (ten specimens gave 17·0, 17·5,

---

TEXT-FIG. 24. Whorl sections of: A, *Puzosia* (*Puzosia*) *serratocarinata* Kennedy and Cobban, 1988*a*; USNM 420076. B, C, *Spathites* (*Spathites*) *puercoensis* (Herrick and Johnson, 1900*a*); USNM 420088 and USNM 420089. D–F, *Prionocyclus hyatti* (Stanton, 1894); USNM 420113, USNM 420131, USNM 420101. G, *Romaniceras* (*Romaniceras*) *mexicanum* Jones, 1938; TMM 205. External sutures of: G, USNM 420113. H, I, *Coilopoceras springeri* Hyatt, 1903; USNM 420161, USNM 420159.

19·5, 20·5, 20·5, 20·8, 21·5, 22·8, 23·0, 23·5 mm). Coiling is very involute, with a tiny, crater-like umbilicus. Whorl section compressed, sides flattened, subparallel, with broadly rounded ventrolateral shoulders and flattened venter. At the smallest diameter seen, there are fifteen ribs per whorl, alternately long and short, the long ribs arising as mere striae low on the flank, the shorter arising on the outer flank. All ribs bear conical to clavate inner ventrolateral tubercles. These give rise to a relatively strong, rounded, bar-like rib that projects forwards to a conical tubercle that is limited to the thickness of the rib and situated quite close to the siphonal line, so that inner and outer ventrolaterals are separated by a greater distance than the opposed outer ventrolaterals (Pl. 11, figs. 11–15). There may be irregular constrictions on the venter between ribs, and no clear ribs connecting the outer ventrolateral tubercles over the venter (Pl. 11, fig. 15). As size increases a strong rib develops between the tubercles on the phragmocone; in others, both microconchs and macroconchs, ribs do not appear until the middle part of the adult body-chamber (Pl. 11, figs. 1–3). Body-chambers of adult microconchs are flat-sided with tabulate venter. Flank ornament varies from mere striae (Pl. 11, figs. 6 and 8) to coarse primaries with or without bullae towards the adult aperture (Pl. 11, figs. 1 and 17). In feebly ornamented individuals inner and outer ventrolateral tubercles are rapidly assimilated into strong ribs, prorsiradiate on the ventrolateral shoulder but straight and transverse across the venter (Pl. 11, figs. 4–9); tubercles persist a little longer in coarser-ribbed specimens (Pl. 11, figs. 10 and 17). A few specimens show a decline in rib strength towards the adult aperture (Pl. 11, figs. 4 and 6).

Macroconch body-chambers show a similar variation in strength of ornament (Pl. 11, figs. 18–24), with weak to strong ribs, primaries arising at the umbilical shoulder as mere striae or as ribs with or without a bulla and two to three intercalatories between the primaries. There are up to seven bullae in the 270° of body-chamber in the largest specimen seen, and a total of twenty-three ribs. All bear conical inner ventrolateral tubercles at the beginning of the body-chamber that become increasingly clavate as size increases, as well as clavate outer ventrolaterals. At the beginning of the body-chamber ribs are depressed between outer ventrolateral clavi and the costal profile concave in consequence (Pl. 11, figs. 18 and 22) but over the last quarter whorl inner and outer ventrolateral tubercles are assimilated into the rib which strengthens to give a distinctive tabulate venter in costal section (Pl. 11, figs. 20 and 24). Suture (text-fig. 8A) as for genus.

Discussion. Differences between *N. acceleratum* and juvenile and adult *Metoicoceras* are discussed under the account of the genus. I know of no other taxon with which it is likely to be confused.

Occurrence. Upper Cenomanian, *Sciponoceras gracile* Zone, Britton Formation of north-east Texas.

Genus SPATHITES Kummel and Decker, 1954, p. 310
[= *Spathitoides* Wiedmann, 1960, p. 754]
Subgenus SPATHITES Kummel and Decker, 1954, p. 310

Type species. By original designation; *Spathites chispaensis* Kummel and Decker, 1954, p. 311, pl. 30, figs. 1 and 2; pl. 31, figs. 1–15; text-fig. 1; = *Pseudotissotia*(?) *coahuilaensis* Jones, 1938, p. 123, pl. 9, figs. 1, 3, 8.

EXPLANATION OF PLATE 12

Figs. 1–3. *Hoplitoides sandovalensis* Cobban and Hook, 1980*a*. USNM 420146, from the Arcadia Park Formation, 75 ft. below the base of the Austin Chalk, White Rock scarp, 2 miles approximately west of Cedar Hill, Dallas County. *Prionocyclus hyatti* Zone.

Figs. 4–8. *Spathites* (*Spathites*) *pueroensis* (Herrick and Johnson, 1900*a*). 4 and 5, USNM 420087; 6–8, USNM 420088; from the Arcadia Park Formation, 1·8 miles west of junction of US Highways 89 and 82 in Bells, Grayson County

Fig. 9. *Tragodesmoceras* sp. USNM 420080, from the top of the Bouldin Member of the Lake Waco Formation of the Eagle Ford Group on Cloice Branch, McLennan County. ?*P. hyatti* Zone.

Fig. 10. *Mammites* sp. OUM KT 4137, from 0·5 to 2 m above the intraformational unconformity in the Britton Formation, temporary excavations on Loop 12, east of Furlong Road and just south of Route 80, west of Dallas, Dallas County. *Vascoceras* (*Greenhornoceras*) *birchbyi* Zone.

All figures are × 1.

1

2

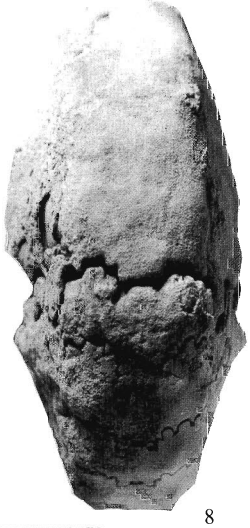
3

4

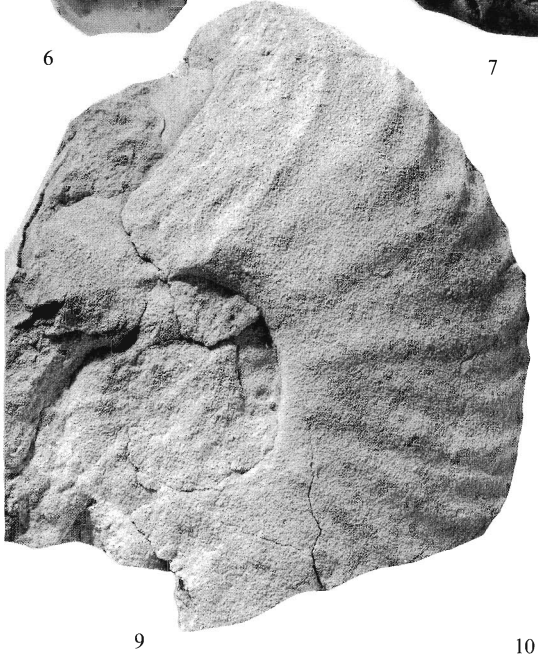
5

6

7



8



9

10

KENNEDY, *Hoplitoides*, *Spathites*, *Tragodesmoceras*, *Mammites*

Spathites (*Spathites*) *puercoensis* (Herrick and Johnson, 1900*a*)

Plate 2, fig. 15; Plate 12, figs. 4–8; text-figs. 24B, C and 31A

1900*a* *Buchiceras swallovi* Shumard; Herrick and Johnson, p. 39, pl. 1, figs. 1 and 2.
1900*a* *Buchiceras swallovi* var. *puercoensis* Herrick and Johnson, p. 39, pl. 1, figs. 3 and 4.
1900*b* *Buchiceras swallovi* Shumard; Herrick and Johnson, p. 213, pl. 27, figs. 1 and 2.
1900*b* *Buchiceras swallovi* var. *puercoensis* Herrick and Johnson, p. 213, pl. 27, figs. 3 and 4.
1980*c* *Spathites* (*Spathites*) *puercoensis* (Herrick and Johnson); Kennedy, Wright, and Hancock, p. 834, pl. 104, figs. 1–5; pl. 106, fig. 3; text-fig. 8*c*.
1982 *Spathites puercoensis* (Herrick and Johnson); Hook and Cobban, p. 37, figs. 2–4.

Types. Formerly in the Hadley Laboratory of New Mexico University and destroyed by fire in 1910. Neotype designation must await revision of the Rio Puerco material.

Material. USNM 420086–420089, from the *Prionocyclus hyatti* Zone fauna of the Arcadia Park Formation, 1·8 miles west of junction of US Highways 89 and 82 in Bells, Grayson County. USNM 420090 (ex J. D. Powell Collection), from exposures in gullies north of Highway 82, 1 mile west of Bells, Grayson County.

Dimensions.		*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
USNM 420087	c	40·2(100)	24·9(61·9)	20·1(50·0)	1·24	6·8(16·9)
USNM 420088	c	54·0(100)	28·7(53·1)	27·8(51·5)	1·03	7·3(13·5)
	ic	54·0(100)	25·7(47·6)	27·8(51·5)	0·92	7·3(13·5)

Description. Very involute, with U = 13–16% of diameter, deep, conical, with outwards inclined wall. Whorl section trapezoidal, compressed to depressed (whorl breadth to height ratio 0·92–1·24 in present material) with greatest breadth at umbilical bulla in costal section and just outside umbilical shoulder intercostally. Ornament strong in depressed specimens, weaker in compressed ones. Six to eight umbilical bullae per whorl vary from weak to massive between individuals. They give rise to pairs of broad, straight prorsiradiate ribs while additional intercalatories arise around mid-flank to give a total of around twenty ribs per whorl. All bear rather weak inner, and much stronger outer ventrolateral clavi, the latter linked over the venter by a low, broad rib. Body-chamber fragments suggests a rapid loss of ornament at maturity with smoothing flanks, a blunt ventrolateral angle, and narrow, flattened venter. Suture (text-fig. 31A) simple, with broad, little-incised elements.

Discussion. *S. coahuilaensis* (Jones, 1938) (p. 123, pl. 9, figs. 1, 3, 8) = *S. chispaensis* Kummel and Decker, 1954 (p. 311, pl. 30, figs. 1 and 2; pl. 31, figs. 1–15; text-fig. 1) is an older, *Collignoniceras woollgari* Zone species of which the poorly known *Pseudotissotia*(?) *kellyi* Jones, 1938 (p. 124, pl. 8, fig. 3; pl. 9, figs. 2 and 7; pl. 10, fig. 9) from Chihuahua, Mexico, may be a synonym and *Neoptychites* (*Spathitoides*) *sulcatus* Wiedmann, 1960 (p. 756, pl. 7, figs. 7 and 8; text-figs. 11 and 12) a junior synonym includes much more inflated individuals with strong ornament that is lost at an earlier ontogenetic stage, adults having sharp ventrolateral shoulders, and a markedly sulcate venter crossed

EXPLANATION OF PLATE 13

Figs. 1 and 2. *Parapuzosia* (*Austiniceras*)*seali* Clark, 1960. Fragment from the Eagle Ford Condensed Zone at USGS Locality 14604, Bouldin Creek, 1·75 miles south-south-west of the Capitol Building, Austin, Travis County.

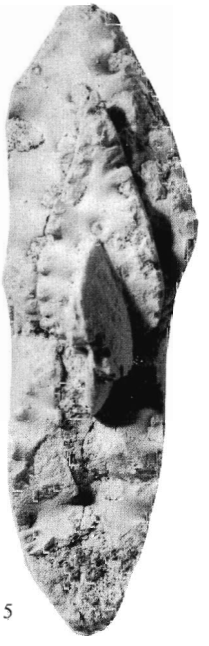
Fig. 3. *Nicaisolopha bellaplicata* (Shumard, 1860). USNM 420177; from exposures along Mansfield Road between Mountain Creek Bridge and White Rock escarpment, just west of Cedar Hill, south-west Dallas County, 30 ft. below top of Arcadia Park Formation, *Prionocyclus hyatti* Zone.

Figs. 4–7. *Coilopoceras springeri* Hyatt, 1903. 4 and 5, USNM 420162. Oak Haven Waterfall, on Walnut Creek, north of Austin, Travis County; 6 and 7, USNM 420160, from Austin, Eagle Ford Condensed Zone, *P. hyatti* Zone.

All figures are × 1.

1

4

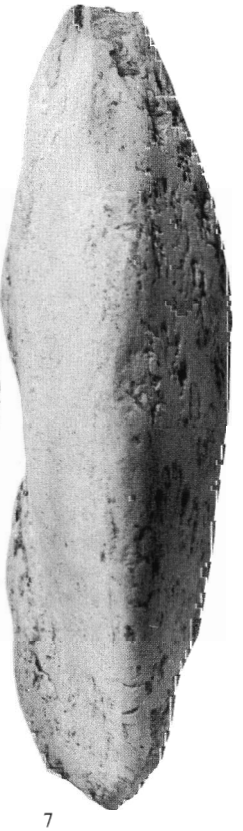


5

3

2

6



7

KENNEDY, *Parapuzosia*, *Nicaisolopha*, *Coilopoceras*

by broad transverse undulations. *S. rioensis* Powell, 1963*b* (p. 1228, pl. 169, fig. 2; pl. 170, figs. 1–3, 6, 7; text-figs. 5 and 6*c–e*) retains ribbing to a large size and has rounded ventrolateral shoulders, a broad flattened to sulcate venter, also crossed by broad transverse undulations.

Occurrence. Upper Turonian, *Prionocyclus hyatti* Zone of New Mexico, west of Gallup in Arizona, north-east and west Texas, Chihuahua, Mexico.

Genus MAMMITES Laube and Bruder, 1887, p. 229
[= *Schluetericeras* Hyatt, 1903, p. 110]

Type species. *Ammonites nodosoides* Schülter, 1871, p. 19, pl. 8, figs. 1–4; by monotypy (*fide* Wright and Kennedy 1981, p. 76).

Mammites sp.

Plate 12, fig. 10

Material. OUM KT 4137, from the Britton Formation, 0·5–2·0 m above the intraformational unconformity in temporary excavations on Loop 12, east of Furlong Road and just south of Route 80, west of Dallas, Dallas County. *Vascoceras* (*Greenhornoceras*) *birchbyi* Zone.

Discussion. The specimen is 53 mm in diameter, crushed, showing prominent umbilical bullae, flank ribs, inner and outer ventrolateral tubercles. It is specifically indeterminate. The genus was previously unknown in Texas east of the Pecos.

Occurrence. See under material.

Family COLLIGNONICERATIDAE Wright and Wright, 1951, p. 30
[*nom. subst.* pro Prionotropidae Zittel, 1895, p. 530 (*ex Prionotropis* Meek, 1876*a*, p. 453, *non* Fieber, 1853, p. 127; = *Collignoniceras* Breistroffer, 1947 (unpaged) (*ex* Prionocyclidae Breistroffer, 1947 (unpaged) (*ex Prionocyclus* Meek, 1876, p. 298, ineligible as family type)].

Subfamily COLLIGNONICERATINAE Wright and Wright, 1951, p. 30
[*nom. transl.* Wright, 1957, p. L426, *ex* Collignoniceratidae]

EXPLANATION OF PLATE 14

Figs. 1, 2, 4, 5, 10, 11. *Collignoniceras woollgari* (Mantell, 1822) *regulare* (Haas, 1946). 1, USNM 420097; 4, USNM 420098, section on Mill Creek at and upstream from bridge on US Highway 82, just west of Bells, Grayson County. 2 and 10, USNM 420100, 420099, from just south of Highway 82 and east of Brushy Creek, 1·7 miles west of Bells, Grayson County. 5, USNM 420096, road cuts on Kiest Boulevard, 0·5 miles west of Ledbetter Drive, just east of Mountain Lake Creek at Dallas Baptist College, Dallas County. Arcadia Park Formation, *C. woollgari* Zone. 11, 0·3–0·5 miles south-east of Loop 12 interchange, Dallas County. Kamp Ranch Limestone, *C. woollgari* Zone, *regulare* Subzone.

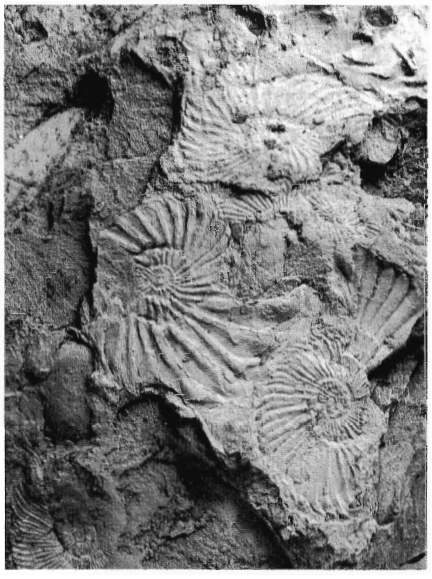
Figs. 3 and 9. *Placenticeras* sp. USNM 420084, 420082, from the same horizon and locality as the original of fig. 5.

Fig. 6. *Watinoceras coloradoense* (Henderson, 1908). OUM KT 4136, Britton Formation, 0·5–2·5 m above intraformational unconformity, road cuts on Loop 12, east of Furlong Road, just south of Loop 12, Dallas County, *Vascoceras* (*Greenhornoceras*) *birchbyi* Zone.

Fig. 7. Undetermined heteromorph. USNM 420182, South Bosque Formation, Atco Cement Quarry, 6 miles south-west of Waco, McLennan County, *Scaphites whitfieldi* Zone.

Fig. 8. *Prionocyclus wyomingensis* Meek, 1876*a*. USNM 420155, Panther Creek, just east of bridge on State Highway 289, 1·5 miles north of intersection with Farm Road 720, 1 mile north of Frisco, Collins County. Arcadia Park Formation, *P. wyomingensis* Zone.

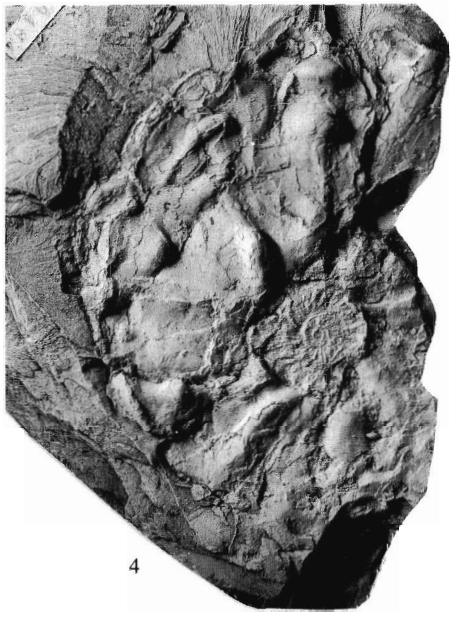
All figures are × 1.



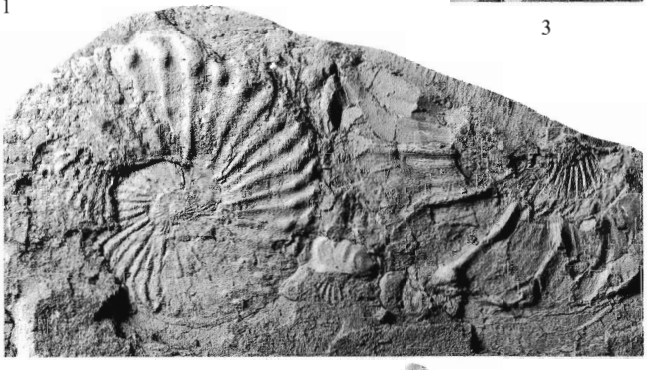
1

2

3



4



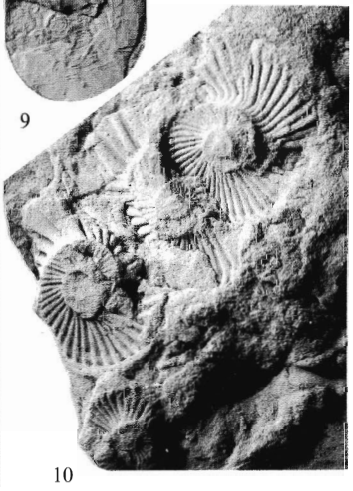
5

6

7

8

9



10

11

KENNEDY, *Collignoniceras*, *Placenticeras*, *Watinoceras*, *Prionocyclus*, indet. heteromorph

Genus COLLIGNONICERAS Breistroffer, 1947, unpaged

[ICZN Opinion 861, 1968; name no. 1798; *pro Prionotropis* Meek, 1876*a*, p. 453, *non* Fieber 1853, p. 127; = *Selwynoceras* Warren and Stelck, 1940, p. 151; *non Collignoniceras* Van Hoepen, 1955, p. 361].

Type species. Ammonites woollgari Mantell, 1822, p. 197, pl. 21, fig. 16; pl. 22, fig. 7, by the original designation of Meek, 1876*a*, p. 453, as type species of *Prionotropis* Meek, 1876*a* (non Fieber, 1853) for which Breistroffer (1947, unpaged) proposed *Collignoniceras* as *nomen novum*.

Collignoniceras woollgari (Mantell, 1822) *regulare* (Haas, 1946)

Plate 14, figs. 1, 2, 4, 5, 10, 11

1876*a* *Prionocyclus* (*Prionotropis*) *woollgari* (Mantell); Meek, p. 455, pl. 6, fig. 2; pl. 7, figs. 1 and 3.
1894 *Prionotropis woolgari* Mantell; Stanton, p. 174, pl. 42, figs. 1–4.
1898 *Prionotropis woolgari* Mantell; Logan, p. 466, pl. 102, figs. 1–4.
1942 *Prionotropis graysonensis* (Shumard); Moreman, p. 213 (*pars*).
1946 *Prionotropis woollgari* (Mantell) and varieties; Haas, p. 150, pls. 11 and 12; pl. 13, figs. 1–3, 5–18 (*non* 4 and 19); pl. 14, figs. 1–10, 12–16 (*non* 7 and 8); pls. 16, 17; pl. 18, figs. 1, 2, 7–9; pl. 24, fig. 1; text-figs. 1–4, 6–44, 46–91.
1951 *Prionotropis* Adkins and Lozo, pl. 5, figs. 4–9.
1956 *Collignoniceras woollgari* (Mantell); Cobban, Rohrer, and Erdmann, p. 1270, fig. 1*b–h*.
1958 *Collignoniceras woollgari* (Mantell); Matsumoto and Miller, p. 353, pl. 44, figs. 1–6; pl. 45, fig. 1.
1965 *Collignoniceras woollgari* (Mantell); Hattin, text-figs. 4-3.
1965 *Collignoniceras woollgari* (Mantell); Matsumoto, p. 11, pl. 1, figs. 1–6; pl. 2, figs. 1–3; pl. 3, figs. 1 and 2; text-fig. 6.
1973 *Collignoniceras woollgari* (Mantell); Cobban and Scott, p. 94, pl. 14, fig. 5; pl. 30, fig. 1; pl. 37, figs. 9 and 10.
1975 *Collignoniceras woollgari* (Mantell); Hattin, p. 10, figs. N, P–R.
1976 *Collignoniceras woollgari* (Mantell); Cobban, p. 120, pl. 1, figs. 6 and 7.
1977 *Collignoniceras woollgari* (Mantell); Kauffman, pl. 22, figs. 4–6.
1978 *Collignoniceras woollgari* (Mantell); Kauffman, Cobban, and Eicher, pl. 5, figs. 5 and 6.
1979 *Collignoniceras woollgari* (Mantell) (late form); Merewether, Cobban, and Cavanaugh, pl. 3, figs. 4 and 5.
1980*b* *Collignoniceras woollgari regulare* (Haas); Cobban and Hook, p. 22, pl. 3, figs. 1–14; pl. 12, fig. 3.
1983 *Collignoniceras woollgari regulare* (Haas); Cobban, p. 16, pl. 15, figs. 2–4, 7–11.
1984*b* *Collignoniceras woollgari regulare* (Haas); Cobban, p. 14, pl. 2, figs. 6 and 7.

Holotype. By original designation; South Dakota State School of Mines Collection no. 1470, the original of Haas 1946, pl. 16, figs. 14 and 16; text-figs. 80 and 81 from an unknown horizon and locality in the Black Hills area (*fide* Haas 1946, p. 198).

Material. More than 100 specimens. The species occurs widely in the Kamp Ranch Limestone Member of the Arcadia Park Formation in the Dallas area: OUM KT 4094, 4096–4097, from temporary excavations on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, Dallas County. USNM 420091–420095, from 0·4 miles south-east of Loop 12 interchange, Dallas/Fort Worth Turnpike, hilltop south-west of Texcrete Quarries. Specimens from USGS Mesozoic Locality D9840, beneath Hampton Road Viaduct over Dallas Floodway of Trinity River, Dallas County. USGS Mesozoic Locality D9446, road cuts on Kiest Boulevard, 0·5 miles west of Ledbetter Drive, just east of Mountain Lake Creek at Dallas Baptist College, Dallas County. USGS Mesozoic Locality D6898, road cut south of Dallas Baptist College, Dallas County. It occurs in shales of the uppermost Britton Formation at USGS Mesozoic Locality D9444, below the Kamp Ranch Limestone in exposures along Mansfield Road in south-west Dallas County between Mountain Creek Bridge and the White Rock Escarpment, just west of Cedar Hill, south-west Dallas County. To the north, there are specimens from the Eagle Ford Group at USGS Mesozoic Locality D9493, Sowell's Bluff on the south side of the Red River below the bridge on State Highway 78, 12 miles north of Bonham in Fannin County and at USGS Mesozoic Locality D9494, small exposures along dirt road leading west from main gravel road about 0·6 miles south-west of the Headquarters Building, Lake Fannin, Fannin County, and from USGS Mesozoic Locality D9495, west-facing bluff overlooking flood plain of the Red River, 1·5 miles airline west of Duplex, Fannin County. USGS

Mesozoic Locality D8837, just south of Highway 82 and east of Brushy Creek, 1·7 miles west of Bells, Grayson County. All *C. woollgari* Zone, *regulare* Subzone.

Discussion. The present material consists entirely of juveniles; the largest (Pl. 14, fig. 11) is some 60 mm in diameter. They correspond to types B, D, and E of Matsumoto (1965). The type material of *C. woollgari* is revised by Kennedy *et al.* (1980*b*) and Wright and Kennedy (1981) who provide a full synonymy for the species. Merewether *et al.* (1979) drew attention to the existence of distinctive early and late forms of the species in the US western interior, while Cobban and Hook (1980*b*) gave further information, pointing out that the early form could be called *C. w. woollgari* and the late form *C. w. regulare*. As they note (and Cobban 1983, p. 16 confirms), the nominate subspecies is characterized by having some adult stage characterized by secondary ribs, more siphonal tubercles than ventral ones and looped ribs connecting opposite ventrolateral horns. Occasional secondary ribs are present on a few individuals of *regulare* but are conspicuous only on the early whorls of what Haas termed var. *praecox* (1946, p. 155, pl. 16, figs. 22 and 23; pl. 17, figs. 1–5; pl. 18, figs. 1, 8, 9; text-figs. 15–18, 79, 84–90). The largest specimen in the present collection has distant primary ribs only on the outer whorl, and for this reason the whole assemblage is referred to subspecies *regulare*.

Occurrence. C. w. regulare occurs in the upper part of the broad *woollgari* Zone in the US Western Interior from the Black Hills, South Dakota, south through Utah, Wyoming, Colorado, New Mexico, Arizona, Kansas, south-central Minnesota, Iowa, and north-east Texas. The nominate subspecies ranges more widely (Wright and Kennedy 1981, p. 106).

Genus PRIONOCYCLUS Meek, 1872, p. 298

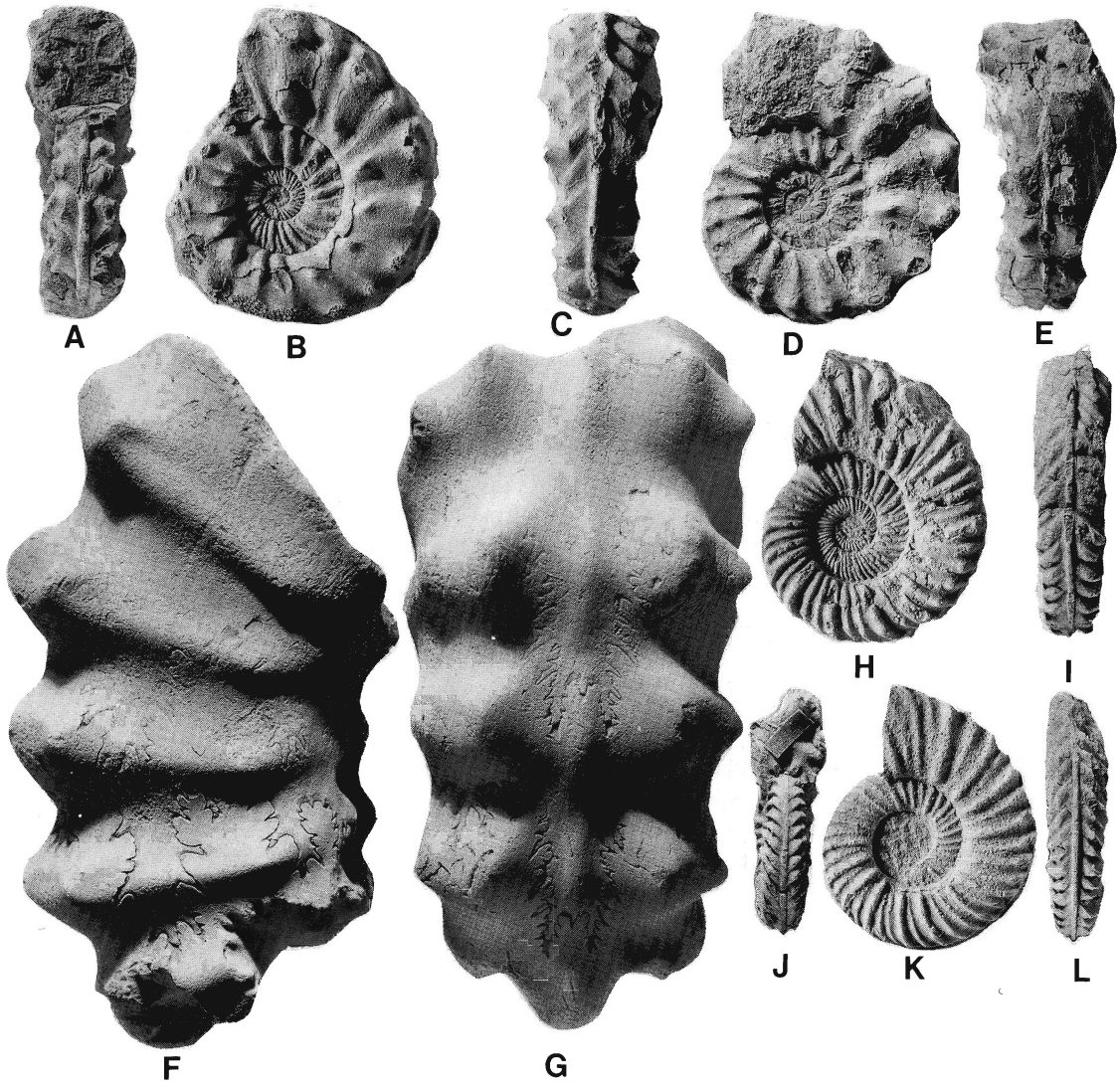
Type species. Prionocyclus serratocarinatus Meek, 1872, p. 298, *non* Stoliczka 1865, p. 57, pl. 32, fig. 3 = *P. wyomingensis* Meek, 1876*a*, p. 452.

Discussion. All of the material available for study consists of juveniles and it has not proved possible to recognize size dimorphism. In ancestral *Collignoniceras*, Kennedy *et al.* (1980*b*) recognized two morphotypes; the same is true in *Prionocyclus* where I recognize a robust form, generally the more-widely umbilicate, less compressed, and stronger ornamented in later growth, and a gracile form, generally with a narrower umbilicus, compressed, and weaker ornamented in later growth, although both forms have similarly variable nuclei. Specimens of *P. hyatti* from Chispa Summit in west Texas have whorl heights of up to 100 mm at the end of the phragmocone, suggesting adult macroconchs of the genus were 250 mm in diameter approximately at this point.

Prionocyclus hyatti (Stanton, 1894)

Plate 15, figs. 1–24; Plate 16, figs. 1–20; Plate 17, figs. 1–7; text-figs. 24D, E, F, 25–27, 31B

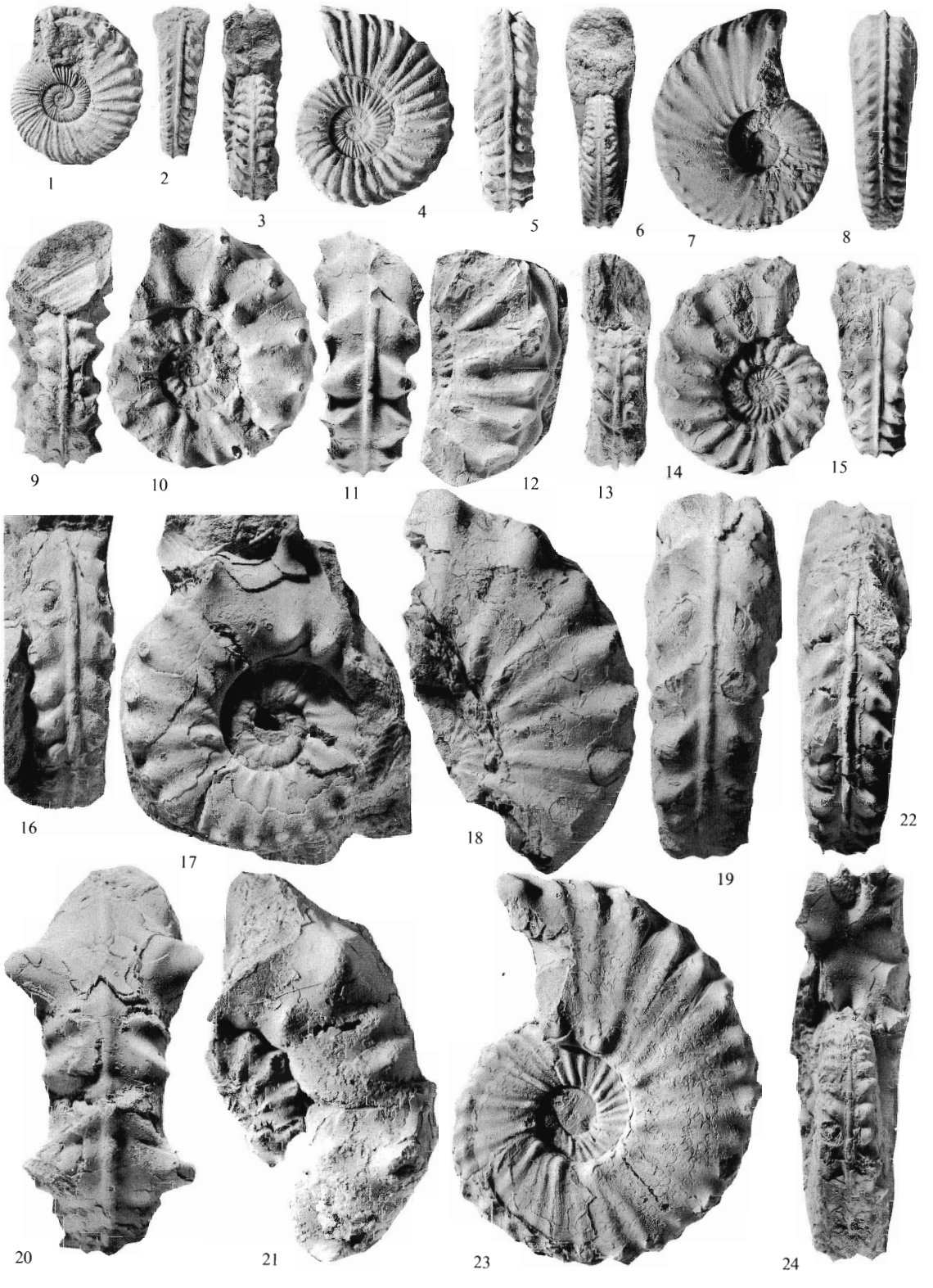
1894 *Prionotropis hyatti* Stanton, p. 176, pl. 42, figs. 5–8.
1898 *Prionocyclus hyatti* Stanton; Logan, p. 468, pl. 102, figs. 5–8.
1910 *Prionocyclus hyatti* Stanton; Grabau and Shimer, p. 228, fig. 1509*e–g*.
1925 *Prionotropis hyatti* Stanton; Diener, p. 156.
1927 *Prionotropis* aff. *woollgari* (Mantell); Moreman, p. 97 (*pars*), pl. 13, fig. 2.
1928 *Prionotropis* aff. *P. hyatti* Stanton, 1893; Adkins, p. 250.
1928 *Prionotropis eaglensis* Adkins, p. 250, pl. 32, figs. 1 and 2.
1931 *Pseudaspidoceras eaglense* (Adkins); Adkins, p. 53.
1942 *Prionotropis graysonensis* (Shumard); Moreman, p. 213.
1942 *Prionotropis hyatti* (Shumard); Moreman, p. 214.
1942 *Prionocyclus* aff. *woollgari* Meek (not Mantell); Moreman, p. 214.
1963*b* *Prionocyclus hyatti* (Stanton), 1893; Powell, p. 1220, pl. 166, figs. 1, 8–12; text-fig. 5*a*, *c*, *d*, *f–h*.
1965 *Collignoniceras hyatti* (Stanton); Hattin, fig. 4.
1965 *Prionocyclus hyatti* (Stanton); Matsumoto, p. 19, pl. 17, fig. 3.
1976 *Prionocyclus hyatti* (Stanton); Cobban, p. 122, pl. 1, fig. 1.



TEXT-FIG. 25. *Prionocyclus hyatti* (Stanton, 1894). A–C, USNM 420127; D, E, USNM 420123; F, G, USNM 420122; H, I, USNM 420124; J, L, USNM 420126. A–C, H, I are from 23 m below the base of the Austin Chalk, White Rock Scarp, 2 miles west of Cedar Hill, Dallas County. D–G are from concretions on valley slopes south-east of Cedar Hill–Duncanville Road, midway between the two towns, Dallas County. H, I are from the east of the Power Plant on Mountain Creek Lake, Dallas County. All are from the Arcadia Park Formation, *P. hyatti* Zone, ×1.

EXPLANATION OF PLATE 15

Figs. 1–24. *Prionocyclus hyatti* (Stanton, 1894). 1 and 2, USNM 420102; 3–5, USNM 420103; 6–8, USNM 420104; 9–11, USNM 420105; 12, USNM 420106; 13–15, USNM 420107; 16 and 17, USNM 420108; 18 and 19, USNM 420125; 20, 21, USNM 420109; 22–24, USNM 420110. The originals of 1, 2, 6–8, 12–24 are from concretions on valley slopes south-east of Cedar Hill–Duncanville road, midway between the two towns, Dallas County. 3–5 is from east of the Power Plant on Mountain Creek Lake, Dallas County. 9–11 is from 75 ft. below the base of the Austin Chalk, White Rock Scarp, 2 miles west of Cedar Hills, Dallas County. All Arcadia Park Formation, *P. hyatti* Zone, ×1.

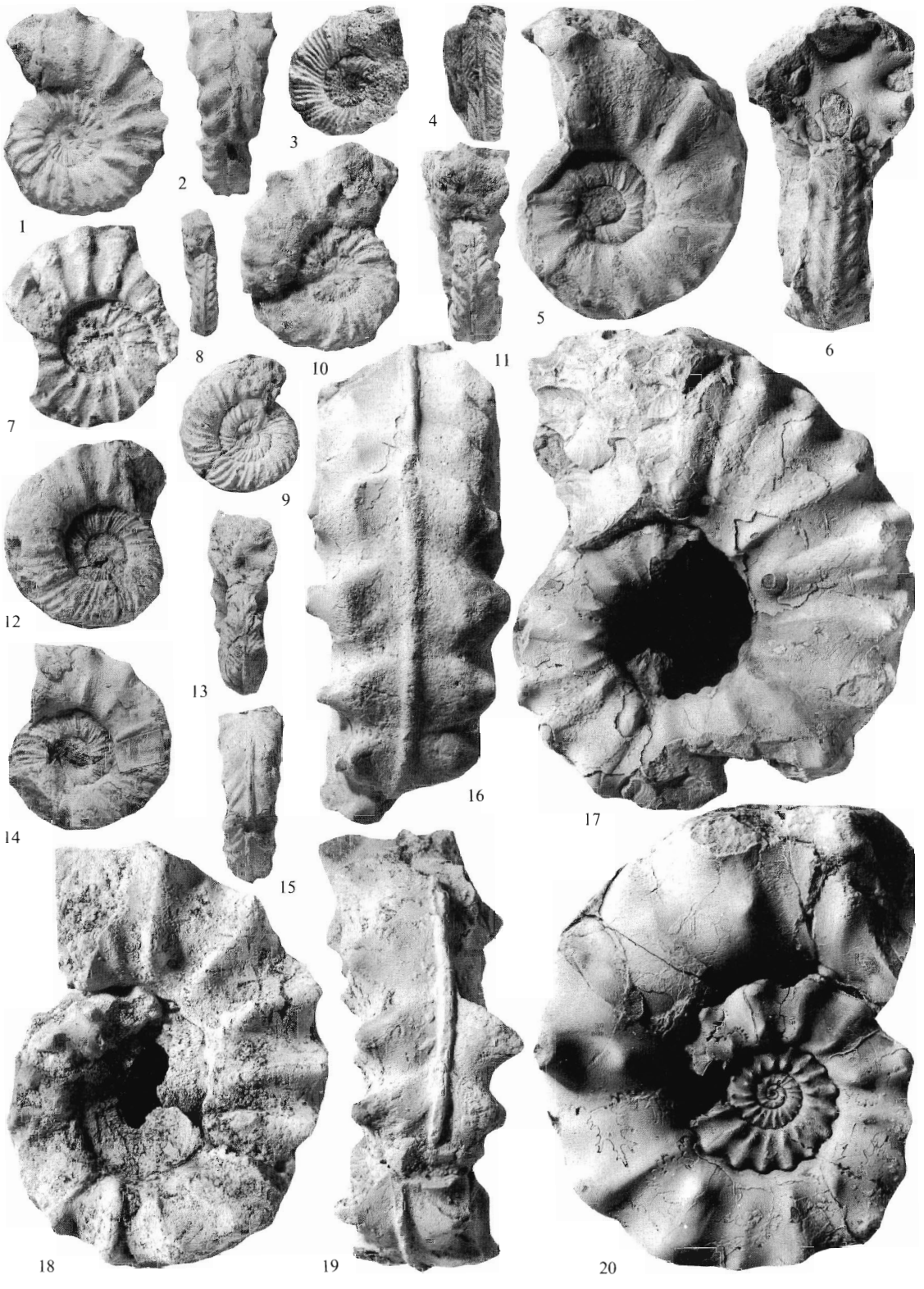


KENNEDY, *Prionocylus*

TEXT-FIG. 26. Adult (?)body-chamber of *Prionocyclus hyatti* (Stanton, 1894). USNM 420120, from the Arcadia Park Formation east of the Power Plant on Mountain Creek Lake, Dallas County, ×0·85.

EXPLANATION OF PLATE 16

Figs. 1–20. *Prionocyclus hyatti* (Stanton, 1894). 1, 2, 10, 11, lectotype, USNM 2291; 8 and 9, paralectotype, USNM 2291*a*; 12–15, paralectotype, USNM 2291*b*, from the Codell Sandstone (Pugnellus Sandstone) of Williams Creek and Poison Canyon, Huerfano Park, Colorado. 3 and 4, TMM 152; 7, USNM 420117; 18 and 19, USNM 420101; all from the Eagle Ford Condensed Zone, Oak Haven Waterfall, Walnut Creek, north of Austin, Travis County. 5 and 6, USNM 420111, from the Arcadia Park Formation of the Cedar Hill area, Dallas County. 16 and 17, USNM 420112, concretions on valley slopes south-east of Cedar Hill–Duncanville road, midway between the two towns, Dallas County. 20, USNM 420113, from the Arcadia Park Formation in Grayson County. All specimens are from the *P. hyatti* Zone, ×1.



KENNEDY, *Prionocyclus*

1976 *Prionocyclus hyatti* (Stanton); Kennedy and Cobban, pl. 8, fig. 3.
1977 *Prionocyclus hyatti* (Stanton); Kauffman, pl. 22, fig. 1; pl. 26, fig. 7.
1978 *Prionocyclus hyatti* (Stanton); Hattin, fig. 8.9, 11.
1978 *Prionocyclus hyatti* (Stanton); Hattin and Siemers, fig. 10.9, 11.
1978 *Prionocyclus hyatti* (Stanton); Kauffman, Cobban, and Eicher, pl. 5, fig. 1.
1978 *Prionocyclus hyatti* (Stanton); Young and Powell, pl. 1, figs. 1–3, 7, 8.
1979 *Prionocyclus hyatti* (Stanton); Merewether, Cobban and Cavanaugh, pl. 3, figs. 1 and 2.
1984*a* *Prionocyclus hyatti* (Stanton); Cobban, p. 85.
1986 *Prionocyclus hyatti* (Stanton); Cobban, fig. 3Q.

Types. Lectotype, by the subsequent designation of Matsumoto 1965, p. 19, is USNM 2291, the original of Stanton 1894, plate 42, figs. 5 and 6; figured paralectotype in the original of Stanton's plate 42, figs. 7 and 8 with the same registration number. They are from Codell Sandstone (*Pugnellus* Sandstone) of Williams Creek and Poison Canyon, Huerfano Creek, Colorado, illustrated here as Plate 16, figs. 1, 2, 8–15. Stanton refers to many specimens from Huerfano Park and a few from Coalville, Utah: all are paralectotypes.

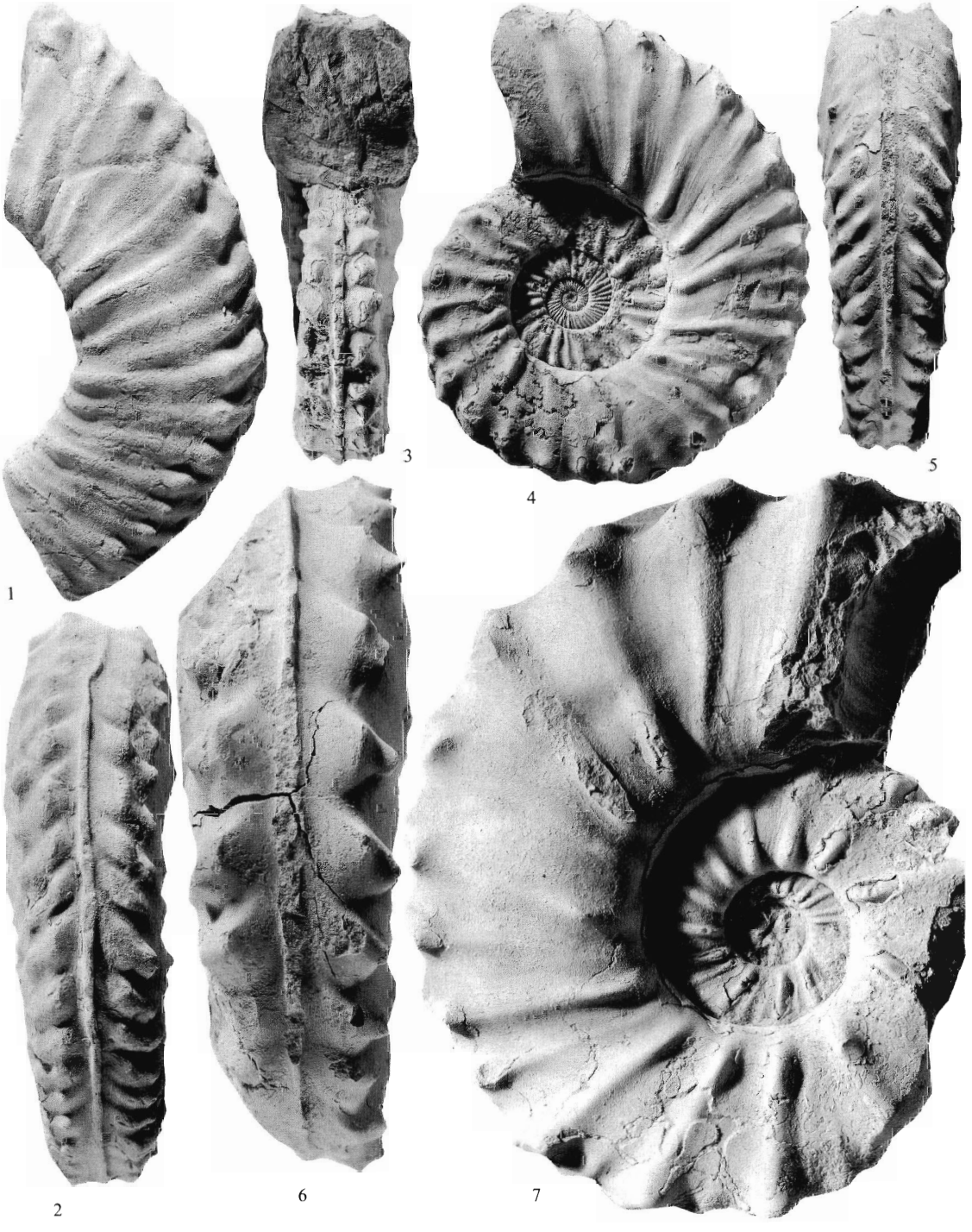
Material. Several hundred specimens, in the USNM, USGS, TMM, JPC, and OUM collections. These include the following: from temporary excavations on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, Dallas County, OUM KT 4086–4093, blocks with numerous specimens from 10 m approximately above the base of the Arcadia Park Formation; OUM KT 4024–4055, from 18·5 m approximately above the base of the Arcadia Park Formation at the same locality. From the Arcadia Park Formation, 17 m below the base of the Austin Chalk, road cuts at junction of Chalk Hill Road and Davis Street (Route 80), west of Dallas, Dallas County: OUM KT 3652–3669, 3685–3708. From the Arcadia Park Formation at Arcadia Park: numerous specimens in the J. P. Conlin Collection, now in Denver; from USGS Mesozoic Localities 22608 and D112, USNM 420105, 420119, 420124, 420127, 420130, 420154, and numerous others from 23 m below the base of the Austin Chalk, White Rock Scarp, 2 miles west of Cedar Hill, Dallas County. From concretions on valley slopes south-east of Cedar Hill–Duncanville road, midway between the two towns, Dallas County, blocks with hundreds of specimens, including USNM 420102, 420104, 420106–420109, 420112, 420114, 420116, 420118, 420121–420123, 420125, 420153; from the Cedar Hill area, Dallas County: USNM 420111. From the Eagle Ford Condensed Zone at Oak Haven Waterfall, on second north flowing branch of Walnut Creek, east of old Austin–Round Rock–Georgetown road, 8·25 miles (airline) 9° N. 30′ E. from University Campus, Travis County: USNM 420117, 420129, 420131; USGS D9529 (Powell Collection), also USNM and TMM collections; USNM 430128, 420132–420135, also TMM Collections from the same horizon at Watters Park, Travis County. All *Prionocyclus hyatti* Zone.

Dimensions.		*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
Form (a)						
USNM 420105	c	33·8(100)	15·8(46·7)	11·3(33·4)	1·40	13·4(39·6)
	ic	33·8(100)	11·7(34·6)	9·8(29·2)	1·19	13·4(39·6)
USNM 420127	c	43·3(100)	17·3(40·0)	14·6(33·7)	1·18	18·9(43·6)
	ic	43·3(100)	13·2(30·5)	13·8(31·9)	0·96	18·9(43·6)
USNM 420122	c	—(—)	56·5(—)	50·0(—)	1·13	
	ic	—(—)	44·0(—)	46·8(—)	0·94	
Form (b)						
USNM 420104	c	37·0(100)	12·2(32·9)	15·8(42·7)	0·77	10·7(28·9)
USNM 420110	c	67·0(100)	—(—)	26·3(39·3)	—	19·0(28·4)
USNM 420115	c	76·0(100)	25·0(32·9)	27·1(35·7)	0·92	30·3(39·9)
	ic	76·0(100)	22·7(29·9)	26·0(34·2)	0·87	30·3(39·9)

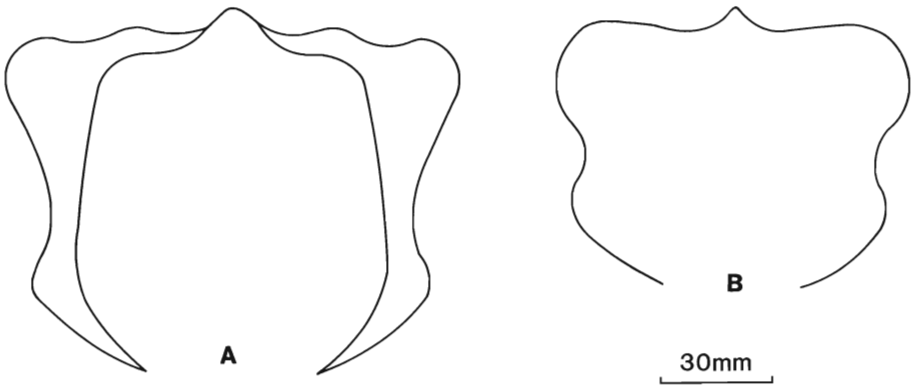
Description. Two morphotypes are recognized: Form (a) the robust form, the largest specimen of which 120 mm in diameter and still juvenile, characterized by depressed, coarse, and distantly ribbed whorls; Form (b) the

EXPLANATION OF PLATE 17

Figs. 1–7. *Prionocyclus hyatti* (Stanton, 1894). 1 and 2, USNM 420114; 3–5, USNM 420119; 6 and 7, USNM 420116. All specimens are from concretions on valley slopes south-east of Cedar Hill–Duncansville road, midway between the two towns, Dallas County, Arcadia Park Formation, *P. hyatti* Zone, × 1.



KENNEDY, *Prionocyclus*



TEXT-FIG. 27. Whorl sections of *Prionocyclus hyatti* (Stanton, 1894). A, USNM 420129; B, OUM KT 4033.

gracile form, more compressed, densely ribbed, and relatively weakly tuberculate, the largest specimen reaching the same size, but also still septate.

Form (*a*). Inner whorls evolute, compressed and rectangular up to a diameter of 10–20 mm. Umbilicus broad, relatively shallow with vertical umbilical wall, and narrowly rounded shoulder. Ornament highly variable. At one extreme (Pl. 16, fig. 20), twenty strong, distant primary ribs arise at the umbilical seam, sweep forwards over the umbilical wall and shoulder, where they develop into strong, sharp bullae. These give rise to strong, broad, straight, prorsiradiate ribs, weakened at mid-flank, but strengthened into a strong, outwards directed inner ventrolateral clavus linked by a broad rib to an aperturally displaced and slightly smaller outer ventrolateral clavus. A smooth zone separates these from a strongly nodate siphonal keel, the nodes corresponding to, but displaced aperturally of, the adjacent clavi. In this variant, ribs strengthen progressively as diameter increases. There are other variants with up to thirty ribs at this stage; as number increases they begin to differentiate into bullate primaries like those described above, and finer, non-bullate ribs that extent to the umbilical shoulder or seam, usually singly or in groups of two or three. The lectotype, USNM 22941 (Pl. 16, figs. 1, 2, 10, 11) is a form with few intercalatories; others (Pl. 16, figs. 5 and 6) have fine ribs greatly exceeding in number the bullate ones.

As size increases the distantly and coarsely ribbed nuclei grow into evolute shells with depressed whorls; there are from as few as twelve to as many as seventeen primary ribs; in some the bullae are displaced out from the umbilical shoulder as size increases giving rise to straight, narrow, strong ribs with a compressed flange-like horn that bears an outer ventrolateral clavus on either side of a coarse, strongly nodate keel (Pl. 16, figs. 16 and 17) in this respect convergent with *C. vermilionense*. In others the ribs are broader and become progressively weaker in relation to the horns, which are conical rather than flange-like, while umbilical bullae are irregularly developed (Pl. 16, fig. 20), with occasional intercalated ribs. In forms with intercalated ribs on nuclei these persist (e.g. USNM 420111; Pl. 16, figs. 5 and 6) and distant bullate and horned primaries are separated by wide areas covered by fine secondaries (well seen in Powell's specimen (1963), pl. 166, figs. 8b and 9); there are sparse inner ventrolateral horns on bullate ribs which are greatly exceeded in number by the weak, obliquely placed outer ventrolateral clavi borne by all ribs. The keel in these variants is finely crenulate in comparison with other variants of the robust form, to which they are linked by intermediates such as USNM 420128, which shows horned and bullate ribs separated by only two minor ribs and USNM 420129, which has four such ribs. In general, strength of bullae and ventrolateral horns decreases as the number of intercalatories increases, but there are exceptions such as the *Dipoloceras*-like individual shown in Plate 15, figs. 20 and 21. Suture relatively simple (text-fig. 31B).

Form (*b*). Inner whorls of the gracile form show a degree of overlapping variation with the robust form (a) already described to 10–15 mm diameter. They are, however, usually compressed with a shallow broad umbilicus, and up to forty-five more or less evenly developed ribs per whorl (Pl. 15, figs. 3–5) at one extreme to others with striking differentiation into periodic flared primaries with sharp bullae separated by up to five non-bullate secondaries that total fifty-five and perhaps more per whorl, sometimes reduced to mere striae (Pl. 15, figs. 1 and 2). In middle growth there are both compressed, high-whorled, finely and evenly ribbed forms (Pl. 15, figs. 6–8) where primaries are accompanied by intercalatories to give a total of fifty ribs per whorl, the

ribs lacking bullae, but bearing conical inner and obliquely placed and clavate outer ventrolateral tubercles on either side of a finely serrated keel and more evolute evenly and sharply ribbed forms with well-differentiated bullae (Pl. 15, figs. 18 and 19) to those where ribbing differentiates slightly (Pl. 15, figs. 20, 23, 24) to markedly (Pl. 15, figs. 18 and 19). This variation is maintained to the largest diameters seen (Pl. 17, figs. 1–7).

Discussion. The wide range of intraspecific variation shown by this species has not been previously documented. Differences from the other US Western Interior *Prionocyclus* as follows:

P. macombi Meek, 1876*b* (p. 132, pl. 2, fig. 3*a–d*; Hook and Cobban 1980, p. 46, text-fig. 5A–G). The robust form (a) overlaps to a degree in coiling, whorl section, and expansion rate with the corresponding form of *P. hyatti*, but small- and medium-sized forms never develop as massive ventrolateral horns, nor the striking differentiation into strong, umbilically bullate and horned, and weak, non-bullate hornless ribs. At maturity robust (a) forms of *P. macombi* develop a distinctly arched, rather than flattened venter. The gracile (b) form of *P. macombi* is much more compressed, higher-whorled and involute than the corresponding form of *P. hyatti* in early and middle growth, densely and very finely ribbed, the ribs often reduced to mere striae. Inner and outer ventrolateral tubercles of inner whorls are replaced by a single ventrolateral clavus at a very early stage.

P. wyomingensis Meek, 1876*a* (p. 452, footnote; for synonymy see below). The robust (a) form is rare. It combines strong ribbing with a relatively slender whorl compared to *P. hyatti*, the ribs always differentiated into bullate and strong and feeble and non-bullate. In the commoner gracile (b) form the shell is high-whorled. Juveniles have strong, close-spaced ribs, always differentiated into strong bullate, and more abundant feeble non-bullate ones, the ribs sometimes arising in groups from bullae, while many individuals develop both an umbilical and inner lateral bulla on some ribs. At maturity, the differentiation of ribbing, presence of an inner lateral bulge or tubercle and finger-like septate horn born on the inner ventrolateral tubercle are utterly distinctive. As Cobban (1984*a*, p. 87) notes the juvenile holotype of *P. reesidei* Sidwell, 1932 (p. 318, pl. 49, figs. 10 and 11) is probably a specimen of *P. wyomingensis*.

P. novimexicanus (Marcou, 1858) (p. 35, pl. 1, fig. 2; see Hook and Cobban, 1979, p. 35, fig. 3*e–h*, of which *P. w. elegans* Haas, 1946, p. 200, pl. 19, figs. 1–7, 11–14; pl. 20, fig. 4; pl. 21, figs. 1–3, 5; pl. 22, figs. 1 and 2; text-figs. 98–104 is a synonym) is a species in which the gracile (b) form is the more abundant, as in *P. wyomingensis*, which it superficially resembles although easily differentiated by the loss of the outer ventrolateral tubercle early in ontogeny. The presence of this single tubercle easily distinguishes it from the gracile form of *P. hyatti* in middle growth, as does the higher whorl, consistent differentiation of ribs into strong, bullate, and weak, non-bullate ribs that are more abundant and commonly branch from bullae on a shell more slender than *hyatti*. Some individuals possess a lateral tubercle. The rare, robust (a) form of *P. novimexicanus* shows the same rib differentiation and branching from bullae on a shell slender by comparison with the corresponding form of *P. hyatti*; massive ventrolateral horns never develop, instead there is merely an oblique clavus in adults. In both forms of *P. novimexicanus* the siphonal keel is flanked by deep and prominent grooves, a feature never shown by *P. hyatti*.

P. quadratus Cobban, 1953*b* (p. 354, pl. 48, figs. 1–8, of which the paratype of *P. reesidei* Sidwell, 1932 (pl. 49, fig. 12) may be a compressed variant (*fide* Cobban 1984*a*, p. 87) are generally more robust than *P. hyatti* with a rounded whorl, the ventral keel far more finely serrated when young but tending to become smooth at maturity; the ribs develop an incipient to weak lateral tubercle in middle and later growth.

Ammonites graysonensis Shumard, 1860 (p. 593) is, from its description, a collignoniceratid; the types were from 'septariae, embedded in the Lower Cretaceous marls in Fannin County, near Lowell's Bluff, and in Grayson County, 4 miles north of Sherman. At the latter locality it is associated with *Scaphites vermiculus*.' The latter is an Upper Cenomanian *Worthoceras*. White (1883, p. 39, pl. 18, fig. 9) reproduced a drawing of *graysonensis*, based on a photographic copy sent by Shumard to F. B. Meek and left by him to the US Geological and Geographic Survey. The figured specimen is a juvenile collignoniceratid 15 mm approximately in diameter. I was unable to trace it in the Austin Collections, while the figure shows what could either be a juvenile *P. hyatti* or *C. percarinatus*. I regard it, in consequence, as a *nomen dubium* at this time. Moreman's specimen (1927, pl. 13, fig. 1, as *C.* aff. *woollgari*) is a juvenile *P. hyatti*.

A. meekianus Shumard, 1860 (p. 592) is based on specimens from near Post Oak Creek, Grayson County, where it was said to occur with *A. swallovi* Shumard, 1860, which is a Cenomanian *Metoicoceras* (Stephenson, 1953, p. 207, pl. 51, figs. 1–3; pl. 52, figs. 1–5), although the description of *meekianus* is that of a Turonian collignoniceratid. Shumard states that the species is 'founded mainly upon fragments of the exterior volution'

(p. 593) although also mentioning young individuals. I was unable to locate Shumard's material, or those cited by Moreman (1942, p. 214) in the Austin collections, and regard it too as a *nomen dubium*.

Occurrence. *P. hyatti* Zone only. In Texas it occurs in the Eagle Ford Condensed Zone in the Austin area and in the Arcadia Park Formation of Dallas, Johnson and Grayson counties, where much of the unit belongs to the *hyatti* Zone. It extends to West Texas (e.g. Chispa Summit, Jeff Davis County) is widespread in Chihuahua, Mexico, New Mexico, Colorado, Kansas, Utah, Wyoming, South Dakota, and Montana (Cobban 1984*a*, p. 85 provides additional details).

Prionocyclus macombi Meek, 1876*b*

Plate 2, fig. 11; Plate 18, figs. 4–9; text-figs. 28 and 29B, E, J

1876*b* *Prionocyclus*? *macombi* Meek, p. 132, pl. 2, fig. 3*a–d*.
1894 *Prionocyclus*? *macombi* Meek; Stanton, p. 172, pl. 41, figs. 1–5.
1898 *Prionocyclus*? *macombi* Meek; Logan, p. 264.
1910 *Prionocyclus macombi* Meek; Grabau and Shimer, p. 228, fig. 1510*e–g*.
1925 *Prionocyclus macombi* Meek; Diener, p. 155.
1977 *Prionocyclus macombi* Meek; Kauffman, pl. 26, fig. 5.
1980 *Prionocyclus macombi* Meek; Hook and Cobban, p. 46, text-fig. 5A–G.
1984*a* *Prionocyclus macombi* Meek; Cobban, p. 86.
1986 *Prionocyclus macombi* Meek; Cobban, fig. 7D, E.

Types. The holotype is USNM 20259, the original of Meek 1876*a*, pl. 2, fig. 3, from the Juana Lopez Member of the Carlile Shale in Colfax County, New Mexico (text-fig. 28A, B).

Material. Crushed specimens on OUM KT 3903–3916, temporary exposure of South Bosque Formation in aggregate pit near South Bosque, McLennan County. *P. macombi* Zone. OUM KT 3763, from 1 m (3 ft.) below the base of the Austin Chalk, road cuts at junction of Chalk Hill Road and Davis Street (Route 80), west of Dallas, Dallas County.

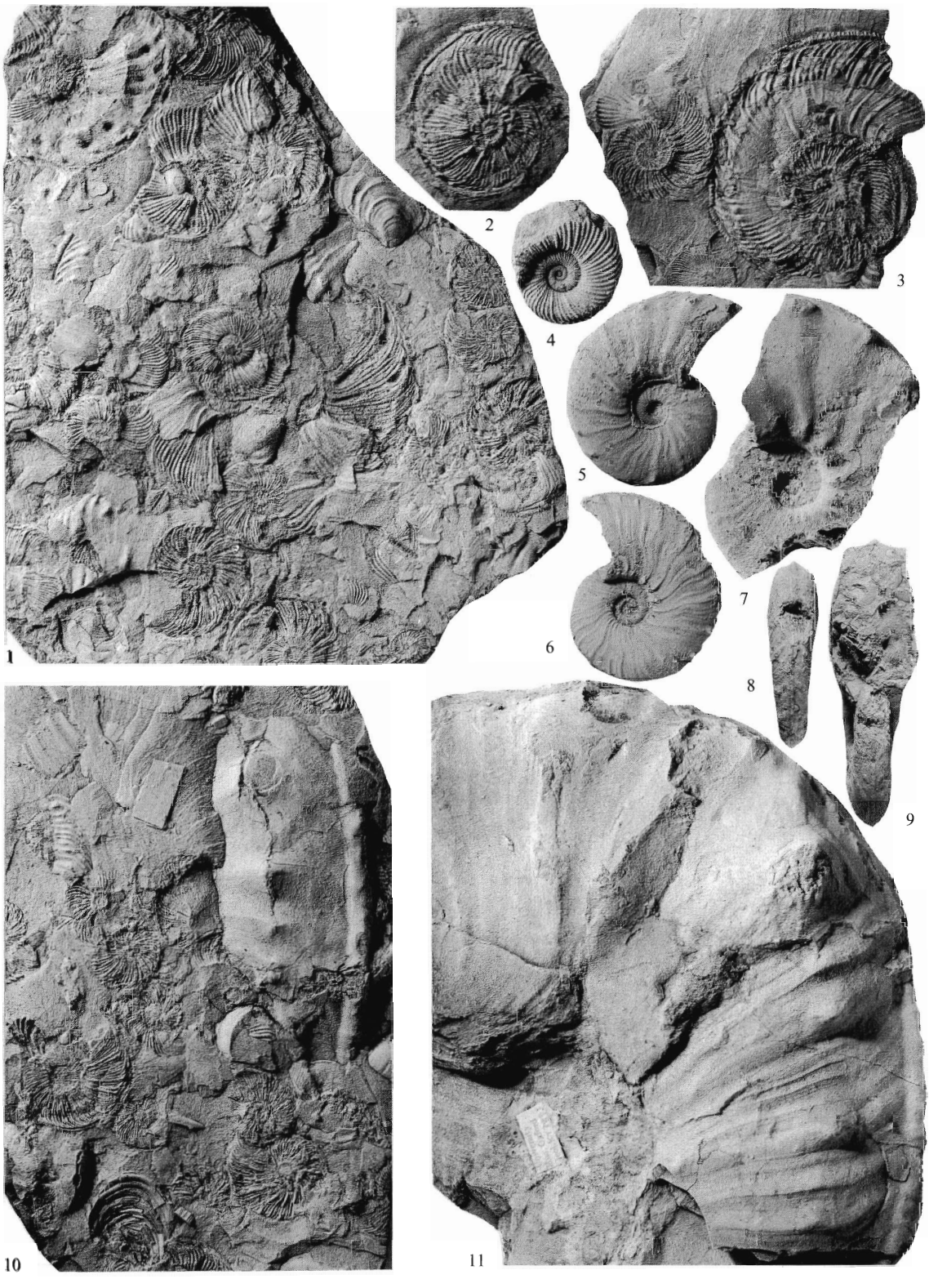
Discussion. Hook and Cobban (1980, p. 46, fig. 5*a–c*) reillustrated the holotype and other, juvenile specimens, describing the species thus: 'a moderately involute ammonite that has a narrow whorl section with flattened flanks, a gently arched venter and a keel. Ornamentation consists of slightly flexuous, prorsiradiate, weak primary and secondary ribs, which rise into clavate ventrolateral tubercles and then bend forward on the venter and disappear before reaching the keel. Primary ribs arise from umbilical bullae. The early whorls are densely ribbed, in contrast to the sparser ribbing of the later ones. The keel is notched into two or three serrations for each ventrolateral tubercle. These characters are well shown by OUM KT 3904 and 3906 (counterpart: text-fig. 29B), a specimen that bears a remarkable similarity to the original of Stanton's (1894) pl. 41, fig. 2. Also present are specimens with more distantly and stronger ribbed inner whorls, sometimes showing both inner and outer ventrolateral tubercles (text-fig. 29J) that I take to be the same species. *P. macombi* most closely resembles *P. hyatti*; differences between the two are given above.

Occurrence. Index of the *P. macombi* Zone, common in south-western Colorado and New Mexico in the US Western Interior but rare to the north; also present in central Texas.

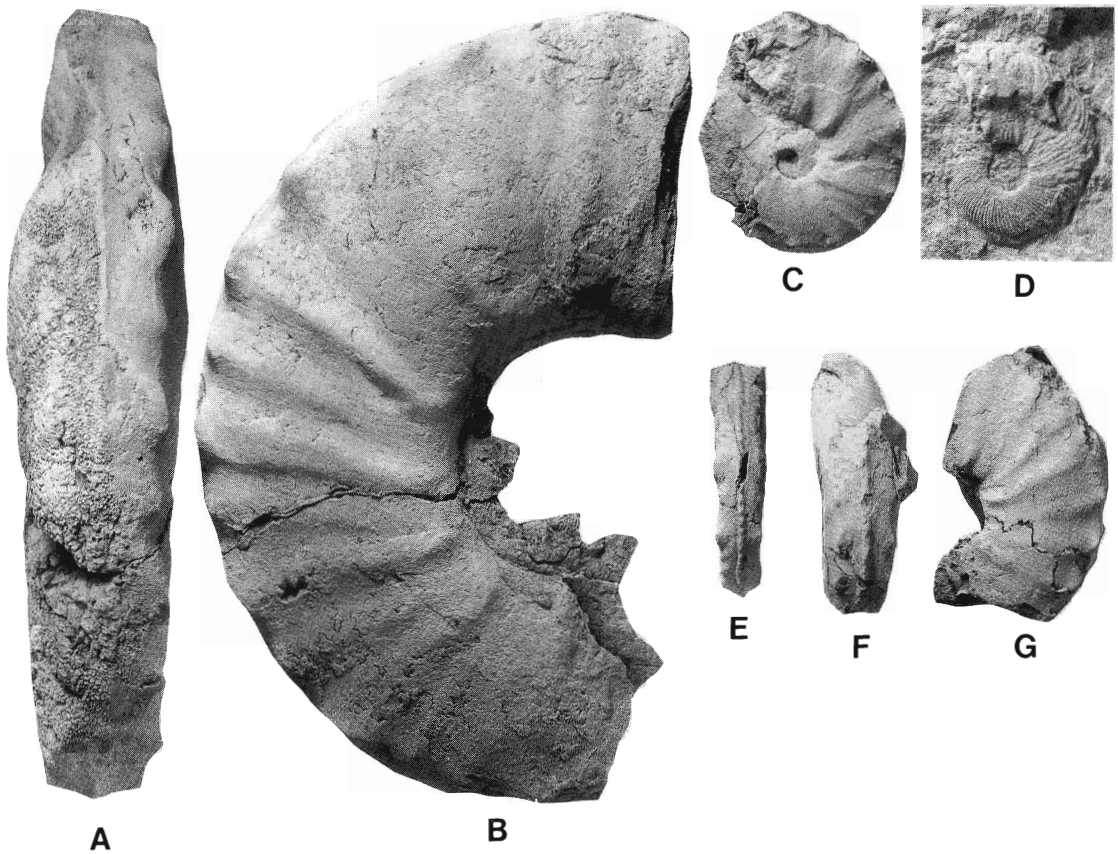
EXPLANATION OF PLATE 18

Figs. 1–3, 10, 11. *Prionocyclus bosquensis* sp. nov. 1, paratypes, OUM KT 3869; 2, paratype, OUM KT 3885; 3, holotype, OUM KT 3854; 10, paratypes, OUM KT 3868; 11, paratype, OUM KT 3873; all from the South Bosque Formation, Cement Works 6 miles south-west of Waco, McLennan County, *Scaphites whitfieldi* Zone, ×1.

Figs. 4–9. *Prionocyclus macombi* Meek, 1876*b*. 4, USNM 420139; 5, USNM 420136; 6 and 8, USNM 420138; 7 and 9, USNM 420137; all from USGS Locality 17632, near El Rado, Rio Arriba County, Carlile Shale, *P. macombi* Zone. Fig. 4 is ×3; others are ×1.



KENNEDY, *Prionocyclus*



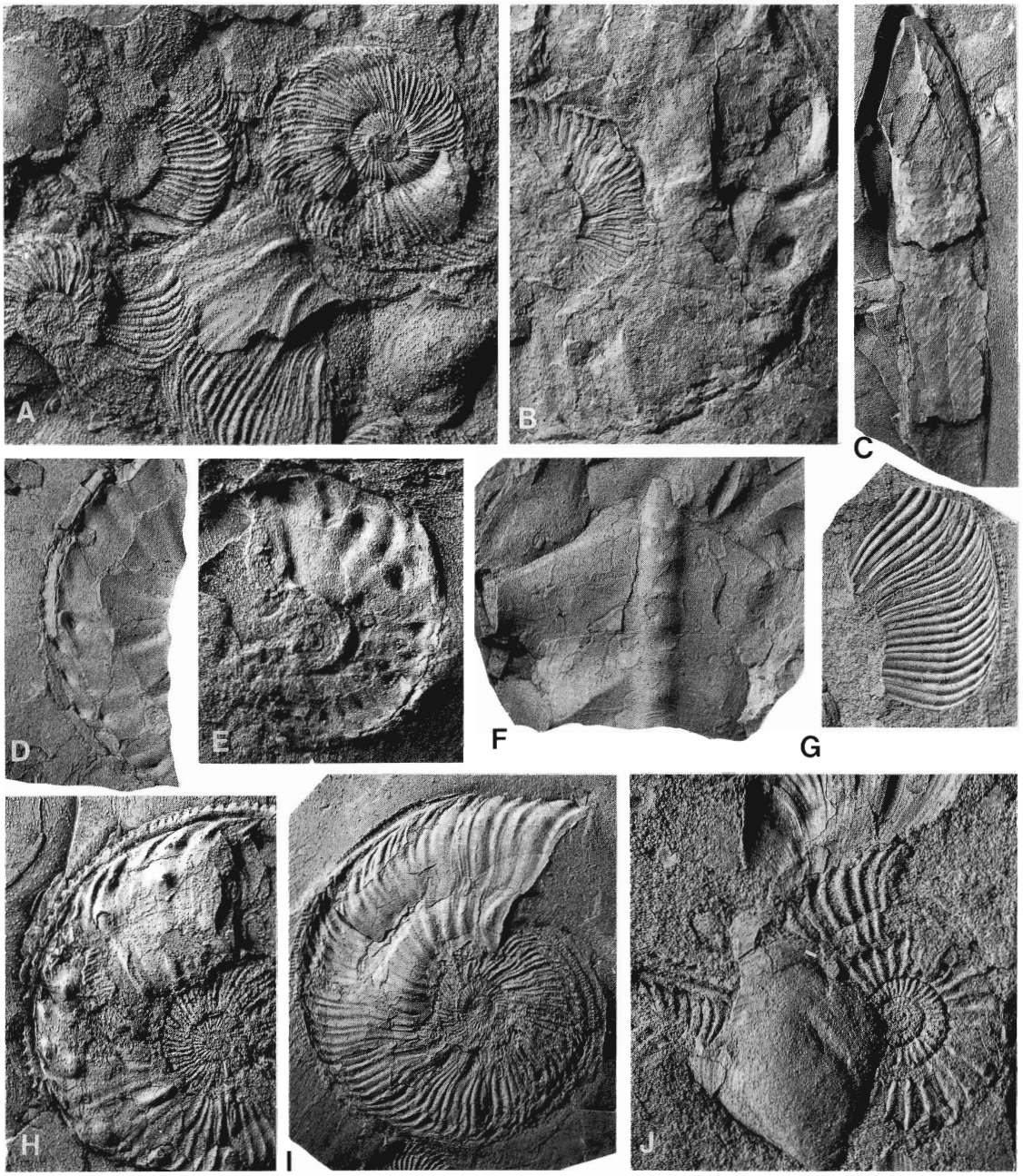
TEXT-FIG. 28. *Prionocyclus macombi* Meek, 1876*b*. A, B, holotype, USNM 20259, from the Juana Lopez Member of the Carlile Shale of Colfax County, New Mexico; see Hook and Cobban 1980 for a discussion of the actual locality of this specimen. C–G, USNM 22940, the originals of Stanton 1894, pl. 41, figs. 1–3. A–C, E–G are ×1; D is ×2.

Prionocyclus bosquensis sp. nov.

Plate 18, figs. 1–3, 10, 11; text-fig. 29A, D, F–I

Types. Holotype, OUM KT 3854 (Pl. 18, fig. 3); there are numerous paratypes: OUM KT 3788–3853, 3855–3886, slabs from the top 6–7 m of the South Bosque Formation, Cement Works 6 miles south-west of Waco, McLennan County; KT 5375–5385 are pyritic juveniles from the same locality and horizon; KT 5372*a*, *b*, were collected *in situ* 3 m below the base of the Austin Chalk at this locality; KT 5373*a*, *b*, from 1 m below the Austin *S. whitfieldi* Zone.

Description. Most specimens are 10–45 mm diameter, are crushed, and retain original aragonitic shell. Coiling is fairly involute, with U = 29%. Ornament is highly variable. At one extreme are very finely ornamented individuals. These have very dense, crowded, narrow, flexuous prorsiradiate ribs, every fifth to sixth strengthened, with a tiny umbilicolateral bulla, a bullate inner ventrolateral, and an obliquely placed outer ventrolateral tubercle. The intermediate ribs generally lack umbilical bullae, and have very faint or no inner and outer ventrolaterals. There is a strong, minutely serrated siphonal keel. A few specimens may even lack differentiated ribs and bear fine, even ornament, without tubercles; some individuals show groups of three or so ribs arising from a bulla while all specimens bear long intercalated ribs inserted on the inner flank. These specimens usually retain their outer ventrolateral tubercles. They are linked, by strengthening of tubercles and



TEXT-FIG. 29. A, D, F–I, *Prionocyclus bosquensis* sp. nov. A, paratype, OUM KT 3869; D, paratype, OUM KT 3801*a*; F, paratype, OUM KT 3870; G, paratype, OUM KT 3801*b*; H, paratype, OUM KT 3858; I, paratype, OUM KT 3821; all from the Upper Turonian *Scaphites whitfieldi* Zone, 6–7 m below the top of the South Bosque Formation, Cement Works 6 miles south-west of Waco, McLennan County. B, E, J, *P. macombi* Meek, 1876. B, OUM KT 3904; J, OUM KT 3907; from the South Bosque Formation, aggregate pit near South Bosque, McLennan County; E, OUM KT 3763, from 1 m below the base of the Austin Chalk, road cuts at junction of Chalk Hill Road and Davis Street (Route 80), west of Dallas, Dallas County. C, *Baculites yokoyamai* Tokunaga and Shimizu, 1926, from 0·5 to 2·5 m above the unconformity close to the top of the Britton Formation, *Vasoceras* (*Greenhornoceras*) *birchbyi* Zone, road cuts on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, Dallas County. C, F are × 1, others × 2.

progressive decline of the weaker, feebly tuberculate ribs to much rarer individuals with distant ribs with umbilical bullae, strong inner and weak outer ventrolaterals, the interspaces with weak to obsolete flank ribs, but short intercalated ribs on the ventrolateral shoulders and venter.

There are a few much larger fragments, with whorl heights of up to 53 mm (Pl. 18, figs. 10 and 11). All of these show strong distant ribs with umbilical bullae, prominent inner ventrolateral spines or tubercles, weak, or no outer ventrolaterals, and groups of riblets and growth striae extending from the inner ventrolateral nodes towards the mid-venter. Between these ribs are much finer intercalated riblets and lirae. There is a strong crenulate siphonal keel. Sutures not seen.

Discussion. Differentiation of ribs, occasional bunching of ribs at umbilical bullae and persistence of inner and outer ventrolateral tubercles into middle growth characterize this species. It most closely resembles *P. wyomingensis* Meek, 1876*a*, discussed above, and for which a synonymy is given below. Both show persistent inner and outer ventrolateral tubercles, but *P. bosquensis* sp. nov. never develops a lateral tubercle in addition to the umbilical while the ribs, although differentiated into bullate and non-bullate in *P. wyomingensis* are much coarser beyond 10–15 mm diameter. The abundant fine-ribbed juveniles of *P. bosquensis* bear striking resemblance to *P. novimexicanus* (Marcou, 1858) (p. 35, pl. 1, fig. 1; see Hook and Cobban 1979, p. 35, fig. 3E–L). Most, probably all, of the present collection have inner and outer ventrolateral tubercles at a stage where *P. novimexicanus* has lost the outer, while also lacking the smooth ventral furrow on either side of the keel that is characteristic of Marcou's species. It is thus a morphological, perhaps evolutionary link between *P. wyomingensis* and *P. novimexicanus*.

Occurrence. P. bosquensis occurs with numerous *Inoceramus perplexus* Whitfield, 1877, a species known from the *S. whitfieldi* to lower *P. quadratus* zones; it is here attributed to the former on morphological criteria noted above. It is known from the South Bosque area only.

Prionocyclus wyomingensis Meek, 1876*a*

Plate 14, fig. 8

1870 *Ammonites serrato-carinatus* Meek, p. 593, pl. 247, figs. 3 and 4.
1872 *Ammonites* (*Pleuroceras*) *serrato-carinatus* Meek, p. 298.
1876*a* *Prionocyclus wyomingensis* Meek, p. 452, footnote.
1880 *Prionocyclus wyomingensis* Meek; White, p. 35, pl. 15, fig. 1*a–e*.
1880 *Prionocyclus wyomingensis* Meek; Whitfield, p. 440, pl. 14, figs. 1–3.
1894 *Prionocyclus wyomingensis* Meek; Stanton, p. 171, pl. 40, figs. 1–4.
1896 *Prionocyclus wyomingensis* Meek; Gilbert, p. 565, pl. 58, figs. 1–3.
1903 *Prionocyclus wyomingensis* Meek; Johnson, p. 139.
1910 *Prionocyclus wyomingensis* Meek; Grabau and Shimer, p. 228, fig. 1510*a–d*.
1925 *Prionocyclus wyomingensis* Meek; Diener, p. 155.
? 1932 *Prionocyclus reesidei* Sidwell, p. 318 (*pars*), pl. 49, figs. 10 and 11 only.
1938 *Prionocyclus wyomingensis* Meek; Roman, p. 457, pl. 46, fig. 435.
1944 *Prionocyclus wyomingensis* (Meek); Shimer and Shrock, p. 593, pl. 247, figs. 3 and 4.
1946 *Prionocyclus wyomingensis* Meek, and varieties; Haas, *robusta* (p. 200), *non* var. *elegans* (p. 210) (= *P. novimexicanus*); pl. 18, figs. 3–6; *non* pl. 19, figs. 1–7, 11–14 (= *P. novimexicanus*); pl. 20, figs. 1–3, 5–7, *non* pl. 20, fig. 4 (= *P. novimexicanus*); pl. 21, figs. 4 and 6; *non* pl. 21, figs. 1–3, 5 (= *P. novimexicanus*); pl. 22, figs. 3–5; *non* pl. 22, figs. 1 and 2 (= *P. novimexicanus*) pl. 23, figs. 1 and 3 (in part); pl. 24, figs. 2 and 3; text-figs. 93–97, 105–108; *non* 98–104 (= *P. novimexicanus*).
1957 *Prionocyclus wyomingensis* Meek; Wright, p. 426, fig. 429, 2.
1965 *Prionocyclus wyomingensis* Meek; Matsumoto, p. 18, pl. 16, fig. 1; pl. 17, fig. 1; pl. 19, fig. 1.
1971 *Prionocyclus wyomingensis* Meek; Matsumoto, p. 132, pl. 21, fig. 2; pl. 22, fig. 1.
1975 *Prionocyclus wyomingensis* Meek; Hattin, pl. 2, fig. 11.
1976 *Prionocyclus wyomingensis* Meek; Kennedy and Cobban, pl. 11, fig. 4.
1977 *Prionocyclus wyomingensis* (Meek); Kauffman, pl. 26, figs. 2 and 3.
non 1978 *Prionocyclus wyomingensis elegans* Haas; Kauffman, Cobban, and Eicher, pl. 5, fig. 14 (= *P. novimexicanus*).

Types. Lectotype, by the subsequent designation of Matsumoto 1965, p. 18 is USNM 7729, the original of Stanton 1894, pl. 40, fig. 3; two paralectotypes have the same number and are the originals of Stanton 1894, pl.

40, figs. 1 and 2. All are from what is now known as the Wall Creek Sandstone Member of the Frontier Formation in the Medicine Bow River valley of south-east Wyoming (*fide* Cobban 1984*a*, p. 86).

Material. USNM 420140–420142, external moulds of four specimens in J. P. Conlin's Collection, collected by J. D. Powell from just below the base of the Austin Chalk in the top of the Maribel Member of the Eagle Ford Group, ditch on south side of secondary road just west of State Highway 289, 2 miles north-east of Frisco, Collins County. USNM 420155 from USGS Mesozoic Locality D9491, Panther Creek, just east of bridge on State Highway 289, 1·5 miles north of intersection with Farm Road 720, 1 mile north of Frisco, Collins County. *P. wyomingensis* Zone.

Discussion. These poorly preserved specimens show the flank ribbing typical of *P. wyomingensis–P. novimexicanus* as discussed above. I cannot determine whether they all retain clearly differentiated inner and outer ventrolateral tubercles as in *P. wyomingensis*, rather than the rounded ventrolateral shoulder of *novimexicanus*. I suspect them all to be the former; the Panther Creek specimen certainly is (Plate 6, fig. 8).

Occurrence. P. wyomingensis Zone. Very widespread in the US Western Interior from the Black Hills south to New Mexico, Trans-Pecos and central Texas. It is also known as a great rarity in Japan.

Genus PRIONOCYCLITES nov.

Type species. Prionocyclites mite gen. et sp. nov.

Diagnosis. Progenic dwarf derivative of *Prionocyclus*. Inner whorls with distant bullate primary ribs separated by groups of weaker non-bullate primaries and occasional shorter intercalated ribs, all with a ventrolateral clavus. Keel broadly undulose, not serrated. Body-chamber smooth but for distant bullate primaries and associated constrictions. Aperture constricted. Suture simple, with little-incised elements.

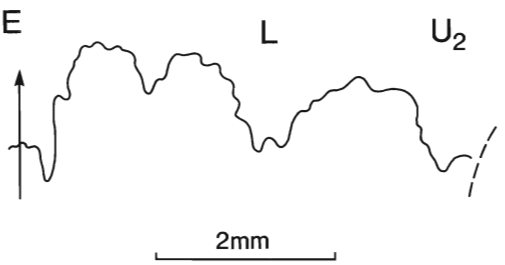
Discussion. Prionocyclites is a progenic dwarf, derived from *Prionocyclus*, the inner whorls of the two sharing many common features (compare Pl. 10, figs. 9–11 and Pl. 15, figs. 1–10, 13–15), although the adult body-chamber and simplified suture of *Prionocyclites* is utterly distinctive. The new genus is thus an analogue of *Protacanthoceras* Spath, 1923 and *Nannometoicoceras* Kennedy, 1988, both derived paedomorphically from larger ancestors. It most closely resembles *Lymaniceras* Matsumoto, 1965, here interpreted as another progenic dwarf collignoniceratid. But *Lymaniceras* has a minutely serrated keel and lacks the *Prionocyclus*-like inner whorls and paucicostate, constricted body-chamber of *Prionocyclites*.

Occurrence. Prionocyclus hyatti Zone of north-east Texas only.

Prionocyclites mite gen. et sp. nov.

Plate 10, figs. 7–11; text-fig. 30

Type. Holotype, by monotypy, USNM 420144 from the Arcadia Park Formation, Eagle Ford Group at USGS Locality 22608 (ex Renfro Collection), east of Power Plant on Mountain Creek Lake, Dallas County. *Prionocyclus hyatti* Zone.



TEXT-FIG. 30. External suture of the holotype of *Prionocyclites mite* sp. nov.; USNM 420144.

Dimensions.	*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
USNM 420144	18·2(100)	4·5(24·7)	6·8(37·4)	0·66	4·5(26·4)

Description. Holotype and only known specimen is a complete adult retaining traces of original shell. Coiling moderately evolute, with shallow umbilicus, umbilical wall low, rounded. Whorl section compressed with whorl breadth to height ratio 0·66. Flanks flattened, subparallel, with broadly rounded ventrolateral shoulders, venter with strong, blunt, undulose siphonal keel. On phragmocone there are twelve bullate ribs per whorl separated by two slightly weaker non-bullate ribs, giving a total of thirty-three to thirty-four ribs per whorl at the umbilical shoulder. Ribs are narrow, rounded, prorsiradiate, and straight on the inner flank, flexing forwards and concave over the outer flank and ventrolateral shoulder. A few short ribs intercalate on the outer flank and all ribs bear a blunt, obliquely placed ventrolateral clavus. The ribs project forwards from the clavus towards the mid-line of the venter but decline before reaching the keel. The low undulations on the keel do not correspond to the ribs; they are far fewer in number. This ornament extends on to the first part of the body-chamber but thereafter rapidly declines. The last part of the body-chamber is near-smooth between three very distant ribs that arise from prominent umbilical bullae. These ribs are narrow, rounded, and efface by the ventrolateral shoulder. They are followed by a shallow constriction, most obvious at the ventrolateral shoulder. A much stronger constriction marks the adult aperture. Suture very simple with broad, little-incised E/L and narrower L; not approximated at the end of the phragmocone.

Discussion. The only ammonites with which *Prionocyclites mite* gen. et. sp. nov. is likely to be confused are species of *Lymaniceras* Matsumoto, 1965. The type species, *L. planulatum* Matsumoto, 1965 (p. 31, pl. 6, figs. 1 and 2; pl. 7, figs. 1–5; pl. 8, figs. 1–8; text-figs. 10–16), is also a progenic dwarf, but without the distinctive differentiation of primary ribs seen in *Prionocyclites* and with a finely serrated keel. Body-chambers are utterly different.

Occurrence. As for type.

Family COILOPOCERATIDAE Hyatt, 1903, p. 88

[= Hoplitoidinae Wright, 1952, p. 221, *nom. correct. ex* Hoplitoidinés H. Douvillé, 1912, p. 305]

Genus HOPLITOIDES von Koenen, 1898, p. 53

Type species. By original designation; *Hoplitoides latesellatus* von Koenen, 1897, p. 56, pl. 6, figs. 1–3.

Hoplitoides sandovalensis Cobban and Hook, 1980*a*

Plate 2, figs. 1–7; text-figs. 31C and 32A, B

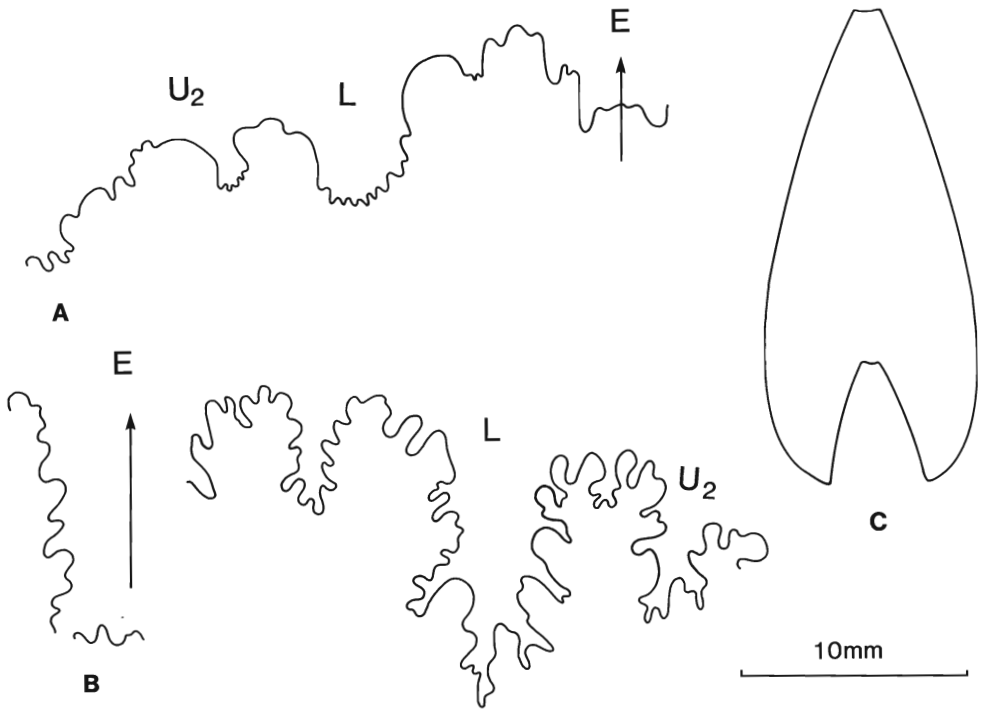
1980*a* *Hoplitoides sandovalensis* Cobban and Hook, p. 8, pl. 2; pl. 3, figs. 6–8, 12–16; pl. 4; pl. 11, fig. 1; pl. 18, figs. 4–6; text-figs. 6 and 7.

Types. Holotype, USNM 275877; paratypes, USNM 275878–275885; from the *Prionocyclus hyatti* Zone fauna of the Mancos Shale in the Rio Puerco Valley, south-west Sandoval County, New Mexico.

Material. Eight specimens: USNM 420145–420146, from the *P. hyatti* Zone fauna of the Arcadia Park Formation, 75 ft. below the base of Austin Chalk, White Rock scarp 2 miles approximately west of Cedar Hill, Dallas County; USNM 420121, on a concretion derived from the *hyatti* Zone on slopes of Ten Mile Creek valley south-east of Cedar-Hill–Duncansville road midway between these towns, Dallas County. USNM 420150–420152, without precise data, also belong here. USNM 420147–420149, from USGS Mesozoic Locality 22608, horizon as above, east of Power Plant on Mountain Creek Lake, Dallas County.

Dimensions.	*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
USNM 420146	34·0(100)	8·5(25·0)	19·7(57·9)	0·43	1·1(3·2)

Description. Specimens are juveniles only. Coiling involute, oxycone, with greatest breadth below mid-flank. Venter sulcate on mould, tabulate where shell is preserved, to a diameter of at least 34 mm. There are very faint feebly prorsiradiate straight ribs on the inner flank which strengthen on the outer flank where they increase by intercalation and are blunt and prorsiradiate, numbering twelve to thirteen per half whorl. Suture (text-fig. 31) deeply incised, with sagging, sinuous course, L broad, divided into deep lobules.



TEXT-FIG. 31. External sutures; A, *Spathites* (*Spathites*) *puercoensis* (Herrick and Johnson, 1900*a*), USNM 420088. B, *Prionocyclus hyatti* (Stanton, 1894), USNM 420113. C, whorl section of *Hoplitoides sandovalensis* Cobban and Hook, 1980, USNM 420146.

Discussion. These tiny specimens match closely with the smaller paratypes of *H. sandovalensis* (e.g. Cobban and Hook, 1980*a*, pl. 3, figs. 6–8). This species is an intermediate between *Hoplitoides* and *Coilopoceras*; it differs from other species of the former in its high degree of compression and complex suture, as discussed by Cobban and Hook (1980*a*, p. 9) and from the latter in having a tabulate/sulcate venter in early ontogeny rather than acute throughout. Adults of *H. sandovalensis* and *C. springeri* Hyatt, 1903 are indistinguishable if early whorls are not visible.

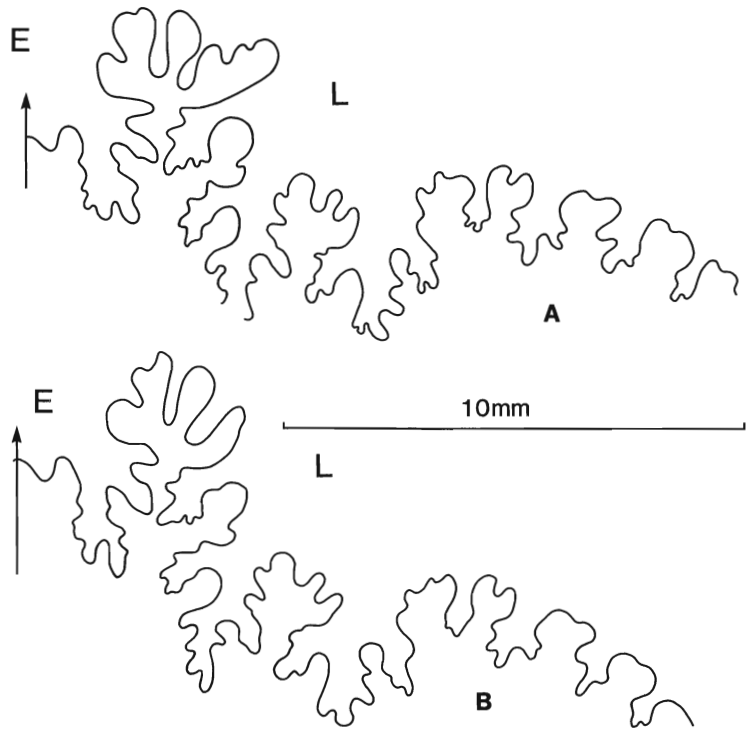
Occurrence. P. hyatti Zone, *H. sandovalensis* Subzone of south-west Sandoval County New Mexico and north-central Texas.

Genus COILOPOCERAS Hyatt, 1903, p. 91

[= *Namadoceras* Vredenberg, 1907, p. 121; *Glebosoceras* Reyment, 1954, p. 161]

Type species. By original designation; *Coilopoceras colleti* Hyatt, 1903, p. 91, pl. 10, figs. 5–21; pl. 11, fig. 1.

Discussion. See Cobban and Hook (1980*a*) and Kennedy and Wright (1984) for reviews of this genus. Wherever large populations are available species occur as two forms, one slender and feebly ornamented, the other stout with strong ornament. These have been taken as a dimorphic pair, but no size differences have been recognized between them so that the terms macroconch and microconch cannot be applied. The holotypes of *C. colleti* and *C. novimexicanum* Hyatt, 1903 (a synonym; *fide* Cobban and Hook) demonstrate this dimorphism in the type species; they are shown in text-fig. 35.



TEXT-FIG. 32. External sutures of *Hoplitoides sandovalensis* Cobban and Hook, 1980, USNM 420145.

Coilopoceras springeri Hyatt, 1903

Plate 13, figs. 4–7; text-figs. 24H, I, 33, 34

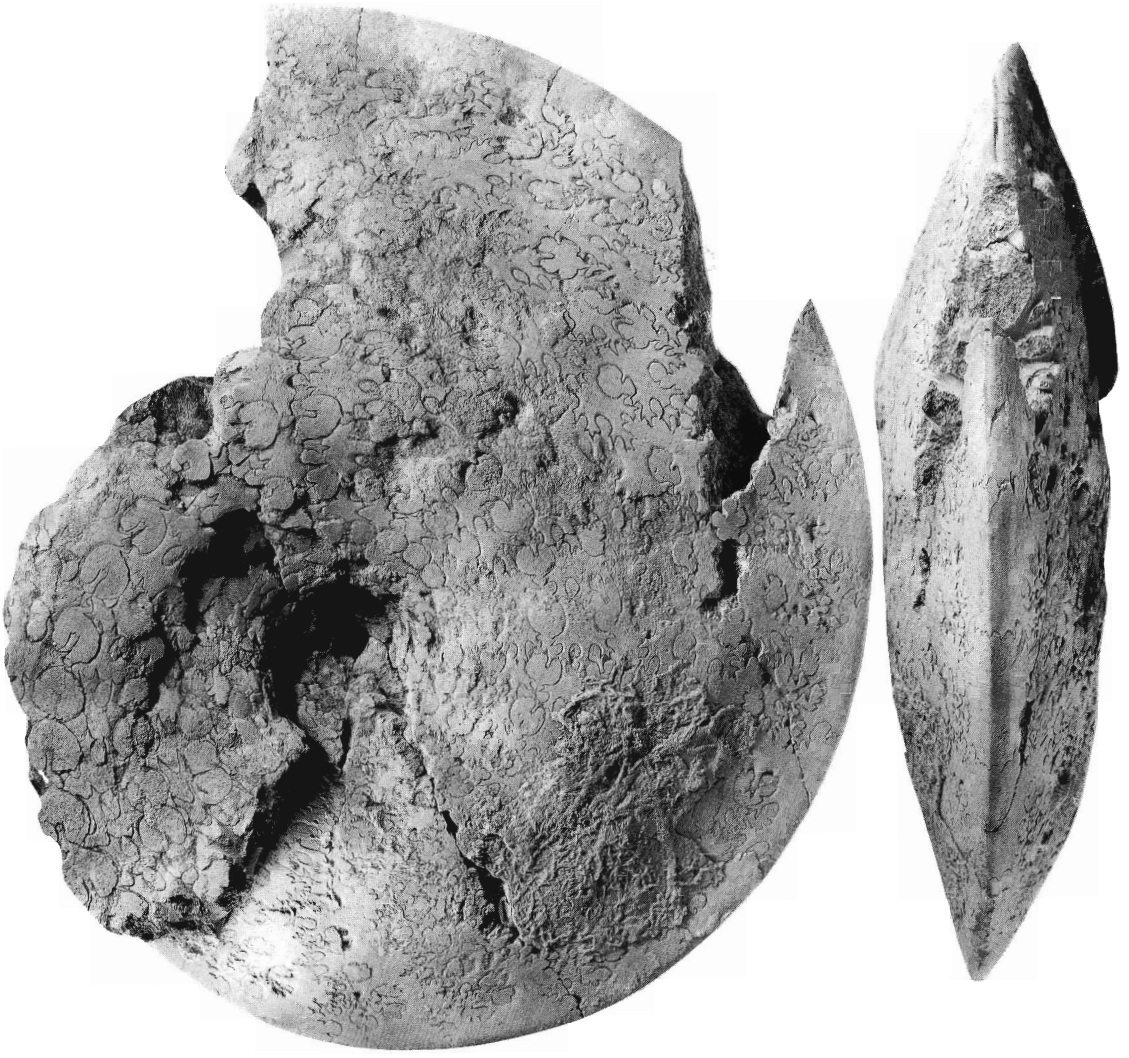
1903 *Coilopoceras springeri* Hyatt, p. 96, pl. 12, figs. 1–3.
1931 *Coilopoceras eaglefordense* Adkins, p. 46, pl. 4, figs. 4 and 8; pl. 5, fig. 1.
1931 *Coilopoceras chispaense* Adkins, p. 48, pl. 4, figs. 5 and 7; pl. 5, fig. 2.
1931 *Coilopoceras* sp. aff. *C. springeri* Hyatt; Adkins, p. 51, pl. 5, fig. 3.
1978 *Glebsoceras chispaense* (Adkins); Young and Powell, pl. 4, fig. 2; pl. 5, fig. 6.
1978 *Coilopoceras eaglefordense* Adkins; Young and Powell, pl. 5, figs. 4 and 5.
1980*a* *Coilopoceras springeri* Hyatt; Cobban and Hook, p. 16, pl. 1, figs. 5 and 6; pl. 3, figs. 9–11; pl. 6, figs. 9 and 10; pl. 18, figs. 7–10; pl. 19, figs. 1–9; text-figs. 11–13.

Holotype. By monotypy, the original of Hyatt, 1903, pl. 12, figs. 1–3, from [Rit du Plain] Rio del Plano, Colfax County, New Mexico.

Material. More than 100 specimens in the TMM, USNM, and JPC collections from the Eagle Ford Condensed Zone around Austin, in particular from Oak Haven Waterfall on second north-flowing branch of Walnut Creek, east of the old Austin–Round Rock–Georgetown road on Oak Haven Estate, Travis County, Texas.

Dimensions.	*D*	*Wb*	*Wh*	*Wb : Wh*	*U*
USNM 420156	175(100)	56(32)	87(49·7)	0·64	27·3(15·6)
USNM 420157	215(100)	64(29·8)	120(55·8)	0·53	27·0(12·6)
USNM 420158	360(100)	100(27·8)	190(52·8)	0·53	29·0(8·1)

Discussion. This species is described at length by Cobban and Hook (1980*a*), to which the reader is



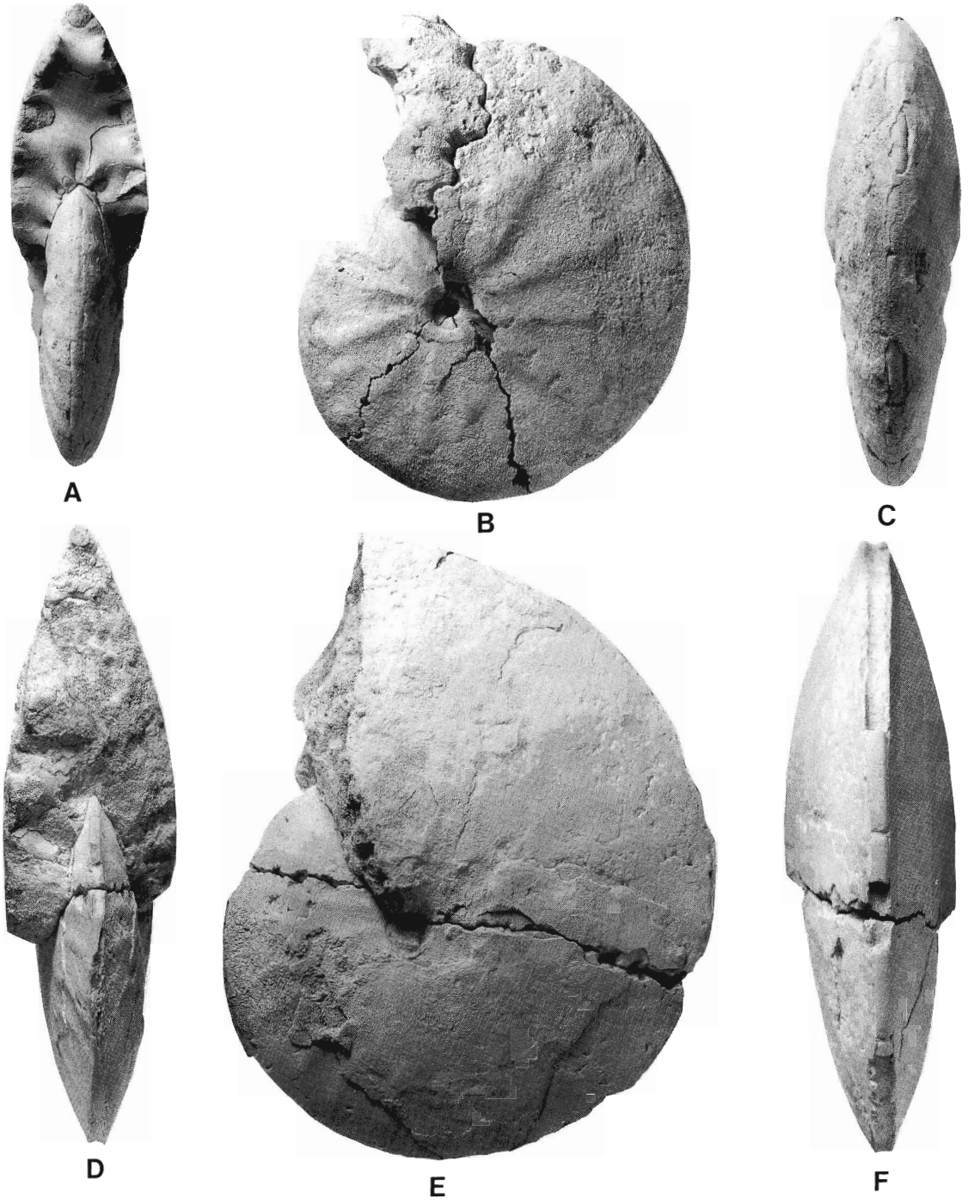
TEXT-FIG. 33. *Coilopoceras springeri* Hyatt, 1903. USNM 420157; ×0·6; the original is 220 mm in diameter.

referred. The material before me is all in the form of phosphatized internal moulds of whole and fragmentary phragmocones, the largest 360 mm in diameter. The oxycone shell form with acute venter is developed from a whorl height of 7 mm onwards in USNM 420162, and at slightly larger diameters in other specimens, but it is not entirely certain that all the large fragments studied belong here rather than to *H. sandovalensis* (see above) when their innermost whorls are unknown. In middle and later growth stages, compressed, involute, smooth or feebly ribbed (Pl. 13 figs. 6 and 7; text-fig. 33) as well as stouter, more evolute strongly ribbed forms with about twelve ribs per whorl (Pl. 13, figs. 4 and 5; text-fig. 34) can be recognized, the same dimorphism as is found in other *Coilopoceras* species (Cobban and Hook 1980*a*; Kennedy and Wright 1984).

Robust forms of *C. springeri* can be distinguished from the corresponding form of *C. colleti* by their lack of a distinctive ventrolateral tubercle (Cobban and Hook 1980*a*, text-fig. 9). These and the smoother form (rather uncommon in *colleti*) also differ on sutural characteristics. L/U_2 is

TEXT-FIG. 34. *Coilopoceras springeri* Hyatt, 1903. USNM 420156; ×1.

asymmetrically bifid in *C. colleti* whereas in *C. springeri* the three divisions of the ventral half of this saddle enlarge and there are thus five large lobules (text-fig. 24H, I) compared to two (divided into two smaller units) in *C. colleti* (Cobban and Hook 1980*a*, text-fig. 10). *C. inflatum* Cobban and Hook, 1980*a* (p. 19, pl. 1, figs. 9–11; pl. 11, fig. 2; pls. 12–17; pl. 18, figs. 1–3, 11–13; pls. 20 and 21; text-figs.



TEXT-FIG. 35. *Coilopoceras colleti* Hyatt, 1903. A–C, holotype; D–F, holotype of *C. novimexicanum* Hyatt, 1903; both specimens are in the Collection of the Museum of Comparative Zoology, Harvard and are from near Carthage, New Mexico. × 1.

14 and 15) is a very inflated species with a lanceolate whorl section, developing pronounced ventrolateral tubercles.

Occurrence. *P. hyatti* Zone, *C. springeri* Subzone of New Mexico, west and north-east Texas.

Coilopoceras inflatum Cobban and Hook, 1980*a*

1980*a* *Coilopoceras inflatum* Cobban and Hook, p. 19, pl. 1, figs. 9–11; pl. 11, fig. 2; pls. 12–17; pl. 18, figs. 1–3, 11–13; pls. 20 and 21; text-figs. 14 and 15.

Holotype. USNM 275920, the original of Cobban and Hook, 1980*a*, p. 19, pl. 11, fig. 2, from the *P. wyomingensis* Zone, *S. warreni* Subzone at USGS Mesozoic Locality D2055 in Valencia County, New Mexico.

Material. OUM KT 3882–3886, from the South Bosque Formation 6–7 m below the base of the Austin Chalk, brickpit 6 miles south-west of Waco, McLennan County. *S. whitfieldi* Zone.

Discussion. The largest specimen shows strong radial ribs; the remainder are crushed juveniles. See Cobban and Hook (1980*a*) for differences from other species.

Occurrence. *P. wyomingensis* Zone of New Mexico and Chispa Summit in Trans-Pecos Texas; *S. whitfieldi* Zone in central Texas.

Suborder ANCYLOCERATINA Wiedmann, 1966, p. 54
Superfamily TURRILITACEAE Gill, 1871, p. 3
Family HAMITIDAE Gill, 1871, p. 3
Genus METAPTYCHOCERAS Spath, 1926, p. 80

Type species. By original designation; *Ptychoceras smithi* Woods, 1896, p. 74, pl. 2, figs. 1 and 2.

Metaptychoceras reesidei (Cobban and Scott, 1973)

Plate 19, fig. 13

1937 *Neoptychoceras* sp. Dane, Pierce, and Reeside, p. 214.
1973 *Hemiptychoceras reesidei* Cobban and Scott, p. 45, pl. 17, figs. 7 and 8.
1975 *Hemiptychoceras reesidei* Cobban and Scott; Hattin, pl. 5, fig. D.
1983 *Hemiptychoceras* cf. *reesidei* Cobban and Scott; Förster, Meyer, and Risch, p. 130, pl. 3, figs. 9 and 10.
1984*b* *Metaptychoceras reesidei* (Cobban and Scott); Cobban, p. 18, pl. 4, fig. 7.

Holotype. USNM 163823, from the Upper Cenomanian, *Sciponoceras gracile* Zone, Bed 67 of the Bridge Creek Limestone Member, Rock Canyon, Colorado (USGS Mesozoic Locality D6472).

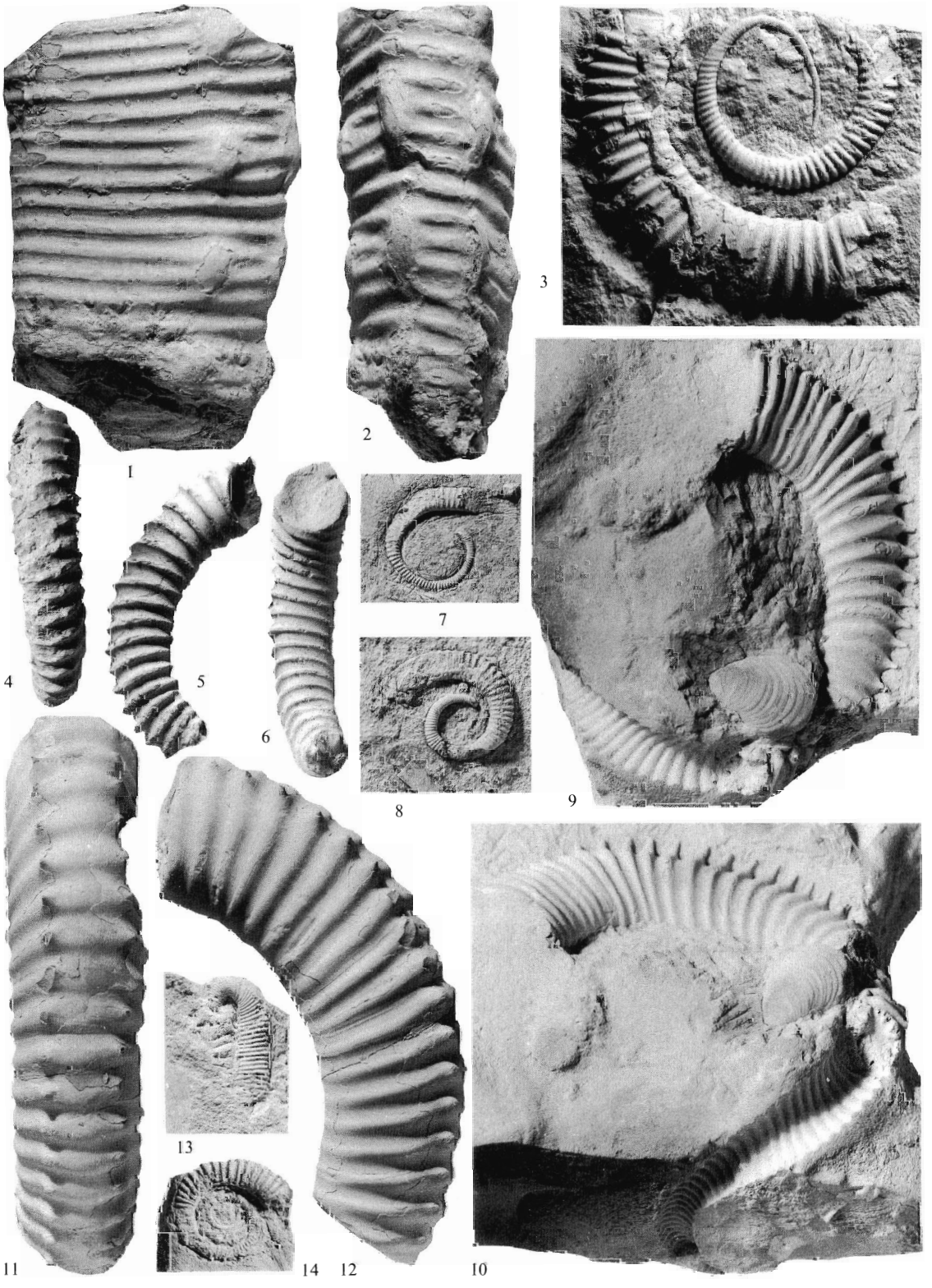
EXPLANATION OF PLATE 19

Figs. 1 and 2. *Anisoceras* aff. *plicatile* (J. Sowerby, 1819). USNM 411525; Texcrete Quarries, Dallas County.

Figs. 3–12, 14. *Allocrioceras annulatum* (Shumard, 1860). 3, USNM 411526, from the same horizon and locality as the original of figs. 1 and 2. 4–6, USNM 411527, from California Crossing on Elm Fork of Trinity River, Dallas County, 7, USNM 411578, from 2·5 miles south of Britton; 8, USNM 411529, from USGS Mesozoic Locality 22602, 3·5–4 miles north-west of Midlothian on Soap Creek, Ellis County. 9 and 10, microconch, USNM 411530, from USGS Mesozoic Locality 22610, 2 miles west of Ledbetter Drive on Five Mile Road, Dallas County. 11 and 12, macroconch, USNM 411530, from Texcrete Quarries. 14, USNM 411532, from 2·5 miles south of Britton on old Britton–Midlothian road, Ellis County.

Fig. 13. *Metaptychoceras reesidei* (Cobban and Scott, 1973). USNM 411524; 2·5 miles south of Britton on the old Britton–Midlothian road, Ellis County.

All specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation of north-east Texas. Fig. 3 is × 3; remainder, × 1.



KENNEDY, *Anisoceras, Allocrioceras, Metaptychoceras*

Material. USNM 411524, from the Upper Cenomanian, *S. gracile* Zone, Britton Formation, on east bank of stream approximately 2·5 miles south of Britton on the old Britton–Midlothian road, Ellis County.

Description. Like holotype and paratype, this specimen consists of the final hook and shaft. Whorl section compressed, ribbing very fine indeed on the hook, terminated abruptly at a wide interspace succeeded by a strong rib and then a pronounced constriction. On the preserved section of the final shaft, some 18 mm long, ribs are coarser, straight, and prorsiradiate with their maximum development over the venter. The rib index is 5–6.

Discussion. This specimen agrees with the types in style of ribbing and density, differing only in the broad interspace, rib, and constriction separating densely ribbed hook and sparser ribbed final shaft. Such irregularities of ornament are common on curved portions of hamitids and I regard it as of no great significance. The *Hemiptychoceras* sp. of Kauffman and Powell (*in* Kauffman *et al.* 1977, p. 99, pl. 9, fig. 5; text-fig. 7) is somewhat older, with coarser ornament on the final shaft.

Occurrence. Upper Cenomanian *S. gracile* Zone and correlatives in north-central Texas, Colorado and, possibly, Regensburg in the German Federal Republic.

Metaptychoceras crassum sp. nov.

Plate 21, figs. 11, 12, 16–18, 21–24

1931 *Metaptychoceras* n. sp. aff. *M. smithi* (H. Woods); Adkins, p. 64.
1951 *Metaptychoceras* Adkins and Lozo. p. 155.

Types. Holotype, TMM 1633TX/1; paratypes, TMM 1633TX/2–10; from the South Bosque Formation, 'Anthill B, 17·5 feet above waterfall limestone, Cloice Branch', McLennan County. Paratypes, TMM 1634TX/1–14 are from 'Anthill A, 33·5 ft. above waterfall limestone, Cloice Branch', McLennan County, *Prionocyclus hyatti* Zone.

Material. TMM Locality 2313, eleven specimens from the South Bosque Formation, *P. hyatti* Zone, Potato Hill on Bosque Escarpment north-east of South Bosque Station, McLennan County; TMM Locality 1629TX/1, a specimen from the same unit on the east bank of Lake Waco, McLennan County; TMM Locality 1631TX, thirteen specimens from the same unit, anthills on Cement Plant Creek, McLennan County, all *P. hyatti* Zone.

Description. Very small, coiling ptychoceratid, with three slowly expanding closely adpressed parallel shafts. Initial shaft smooth, partially covered by later two shafts and protruding beyond final hook (Pl. 21, fig. 17). Ornament on penultimate and final shafts strong, transverse on shafts but prorsiradiate to rectiradiate on hooks. Rib index 4–6, ribs coarse, regular in most specimens but irregular in others. Some interspaces deepened and constriction-like. Sutures not seen.

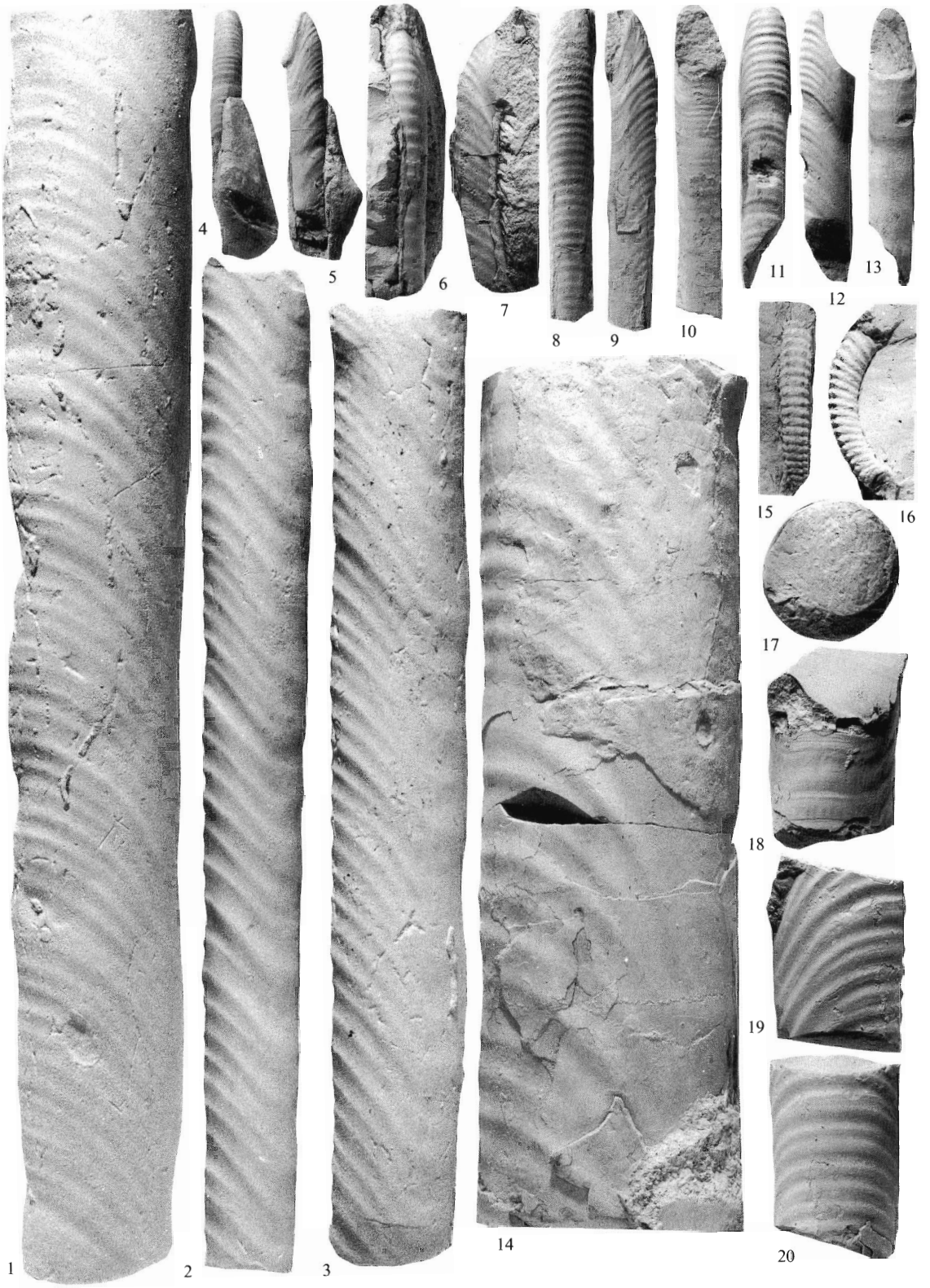
Discussion. Specimens have whorl heights of 1·5 mm or less at the final hook, and a maximum of 3 mm on the largest shaft fragment seen. Size and low rib density distinguish the species from *Metaptychoceras reesidei* (Cobban and Scott, 1973) (p. 45, pl. 17, figs. 7 and 8) of the *S. gracile* Zone. *M. smithi* (Woods, 1896) (p. 74, pl. 2, figs. 1 and 2; Wright 1979, p. 284, pl. 1, figs. 1 and 2) of the Upper Turonian is much larger with finer, delicate ribbing.

EXPLANATION OF PLATE 20

Figs. 1–14, 17–20. *Sciponoceras gracile* (Shumard, 1860). 1–3, 14, 17–20, are macroconchs; 4–13 are microconchs. 1–3, USNM 411536–411538, from 1·5 to 1·8 miles south-east of Britton on Rogers Farm, Ellis County. 4 and 5, USNM 411539, from Texcrete Quarries, Dallas County. 6 and 7, USNM 411540, from the same locality as the originals of figs. 1–3. 8–10, USNM 411541 from Newton Branch, 3·75 miles south of Britton on old Britton–Midlothian Road, Ellis County. 11–13, USNM 411542; 14, USNM 411543; 18–20, USNM 411544; from Texcrete Quarries, Dallas County.

Figs. 15 and 16. *Allocrioceras* sp. USNM 411535, from the same locality as the previous specimen.

All specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation in north-east Texas, × 1.



KENNEDY, *Sciponoceras*, *Allocrioceras*

Occurrence. As for types. Also present in the *P. hyatti* Zone fauna of the Chispa Summit Formation at the type locality, Chispa Summit in Jeff Davis County, Texas.

Metaptychoceras annulatum sp. nov.

Plate 21, figs. 26, 28–30

Types. Holotype, USNM 420163, paratypes, USNM 420164–420168; all from the South Bosque Formation, *Scaphites whitfieldi* Zone at USGS Mesozoic Locality D9524, Atco Cement Quarry, 6 miles south-west of Waco, McLennan County.

Description. Small, maximum observed length 17·5 mm. Coiling ptychoceratid, with three closely adpressed shafts. First shaft smooth, as is first part of second shaft. Last part of second shaft and final shaft ornamented by very distant, narrow, and shallow annular constrictions flanked by adapical and adapertural collar ribs. There are occasional single ribs between collar ribs. Sutures not seen.

Discussion. Ornament of very distant constrictions and associated collar ribs on the last half of the shell distinguishes *M. annulatum* from all other described species of the genus and of *Hemiptychoceras* Spath, 1925*b*.

Occurrence. As for types.

Metaptychoceras sp. A

Plate 21, fig. 27

Material. OUM KT 4122, from the Britton Formation 0·5 to 2·0 m above the intraformational unconformity, road cuts on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, Dallas County, Texas. *Vascoceras* (*Greenhornoceras*) *birchbyi* Zone.

Description and Discussion. Specimen is crushed and consists of parts of the final and penultimate shaft and hook; the maximum preserved length is 10·5 mm. Both shafts are ornamented by transverse ribs; the rib index is 4 at the greatest diameter preserved. The species is half the size of *M. reesidei*

EXPLANATION OF PLATE 21

Figs. 1–10, 13, 14, 25. *Worthoceras minor* sp. nov. 1 and 2, holotype, TMM 1629TX/1; 3, paratype, TMM 1629TX/2; 4, paratype, TMM 1629TX/3; 5, paratype, TMM 1629TX/4; 7, paratype, TMM TX/5; 8, paratype, TMM TX/6; 9, paratype, TMM 1629TX/7; 10, paratype, TMM 1629TX/8; 13, 14, 25, paratype, TMM 1629TX/9; all from the South Bosque Formation, east bank of Lake Waco, McLennan County. 6, from USGS Mesozoic Locality D9439, Arcadia Park Formation, road cut on State Highway 121, top of hill just south of Timber Creek, 2 miles south of Lewisville, Denton County. All *Prionocyclus hyatti* Zone.

Figs. 11, 12, 16–18, 21–24. *Metaptychoceras crassum* sp. nov. 11 and 12, paratype, TMM 1633TX/2; 16–18, paratype, TMM 1633TX/3; 21 and 22, paratype, TMM 1633TX/4; 23 and 24, paratype, TMM 1633TX/5; all from the South Bosque Formation on Cloice Branch, McLennan County. *P. hyatti* Zone.

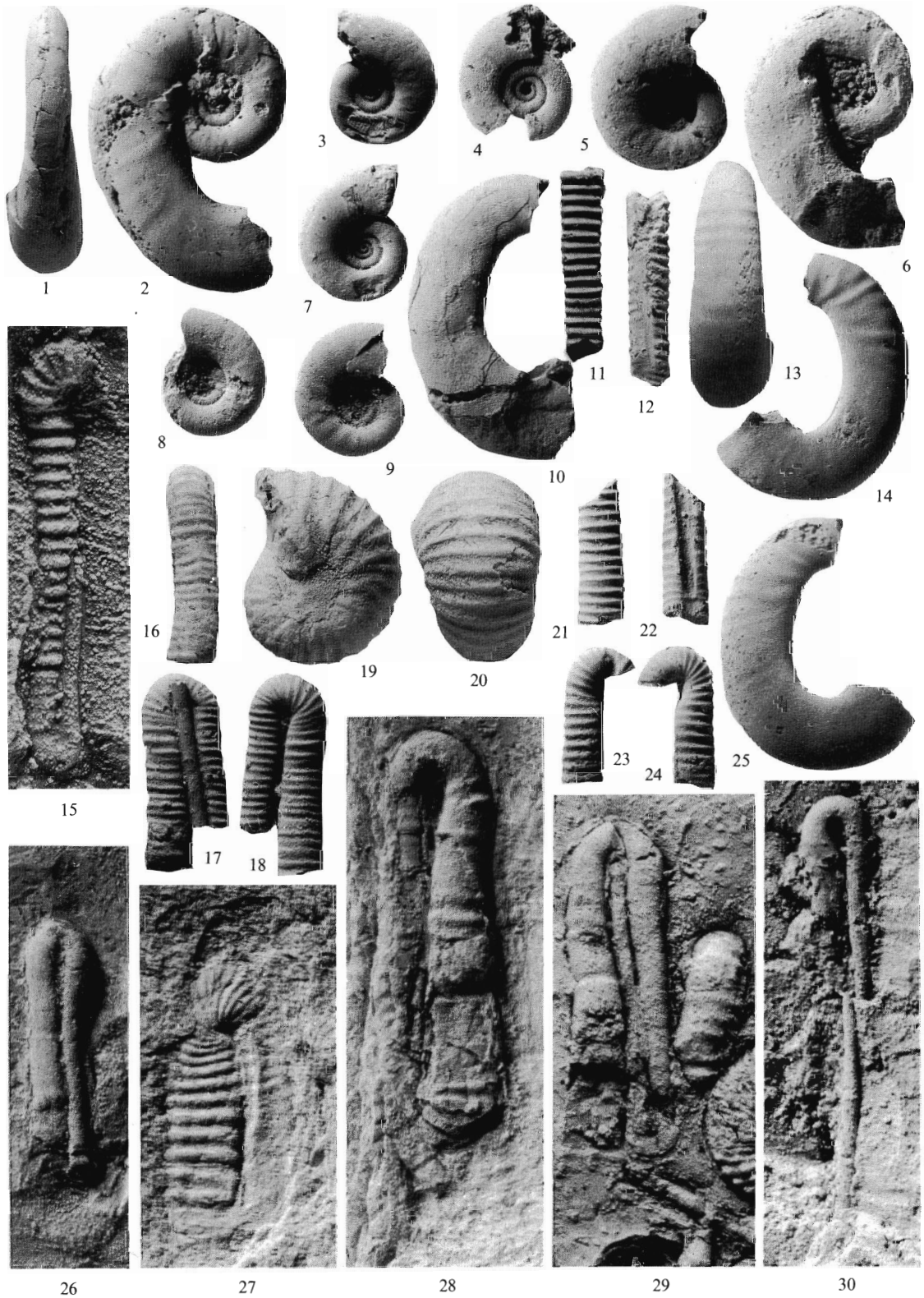
Fig. 15. *Metaptychoceras* sp. B. USNM 420169, from the South Bosque Formation at USGS Mesozoic Locality D9524, Acto Cement Quarry, 6 miles south-west of Waco, McLennan County. *Scaphites whitfieldi* Zone.

Figs. 19 and 20. *S.* (*Scaphites*) *carlilensis* Morrow, 1935. USNM 420182, from concretions on valley slopes south-east of Cedar Hill–Duncansville road, midway between the towns, Dallas County. Arcadia Park Formation. *P. hyatti* Zone.

Figs. 26, 28–30. *M. annulatum* sp. nov. 26, paratype, USNM 420168; 28, holotype, USNM 420163; 29, paratype, USNM 420164; 30, paratype, USNM 420165. All are from the same horizon and locality as the original of fig. 15.

Fig. 27. *Metaptychoceras* sp. A. OUM KT 4122, from the Britton Formation, 0·5–2 m above the intraformational unconformity, road cuts on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, Dallas County. *Vascoceras* (*Greenhornoceras*) *birchbyi* zone.

Figs. 19 and 20 are ×2; the remainder are ×4·5.



KENNEDY, *Worthoceras, Metaptychoceras, Scaphites*

(Cobban and Scott, 1973) (p. 45, pl. 17, figs. 7 and 8) of the *Sciponoceras gracile* Zone and much larger than *H. crassum* sp. nov., described above. It appears to represent a new species, but the material is inadequate for full description; it is left in open nomenclature at this time.

Occurrence. As for material.

Metaptychoceras sp. B

Plate 21, fig. 15

Material. USNM 420169, from the South Bosque Formation at USGS Mesozoic Locality D9524, Atco Cement Quarry, 6 miles south-west of Waco, McLennan County, Texas. *Scaphites whitfieldi* Zone.

Description and Discussion. Specimen consists of the first two closely adpressed shafts of a *Metaptychoceras* with a maximum preserved length of 15 mm. The initial shaft is smooth, the second shaft ornamented by coarse, blunt, rounded ribs separated by slightly wider interspaces; the rib index is 2·5–3. This specimen appears to be a further new species of *Metaptychoceras*, coarseness and style of ribbing distinguishing it from all others. Having only a single incomplete specimen, I leave it in open nomenclature at this time.

Occurrence. As for material.

Genus PUEBLOITES Cobban and Scott, 1973, p. 45

Type species. By original designation; *Helicoceras*? *corrugatum* Stanton, 1894, p. 165, pl. 35, fig. 5.

Puebloites corrugatus (Stanton, 1894)

Plate 3, figs. 8 and 9; Plate 9, fig. 4

1894 *Helicoceras*? *corrugatum* Stanton, p. 165, pl. 35, fig. 5.
1898 *Helicoceras*? *corrugatum* Stanton; Logan, p. 462, pl. 100, fig. 3.
1973 *Puebloites corrugatus* (Stanton); Cobban and Scott, p. 45, pl. 18, figs. 6–19; text-fig. 17.
1977 *Puebloites corrugatus* (Stanton); Kauffman, pl. 18, figs. 7 and 8.

Holotype. By monotypy, the original of Stanton 1894, p. 165, pl. 35, fig. 5, from the Greenhorn Limestone of Huerfano Park, Colorado.

Material. USNM 411467, from USGS Mesozoic Locality D9433, Britton Formation, Upper Cenomanian, *Sciponoceras gracile* Zone, Texcrete Quarries, Dallas County and USNM 411468 from USGS Mesozoic Locality 22604, bed of first creek north-east of Britton, 2·5 miles on farm road, Ellis County.

Description. Smaller specimen is slightly distorted. Coiling appears to have been helicoid. Whorl section compressed oval with whorl breadth to height ratio of 0·85. Ornament consists of sharp, narrow, crowded ribs (rib index is 10), weak and transverse on dorsum, strengthening over dorsolateral region, sweeping forwards across flanks, curving back over lateroventral region and passing more or less straight across venter, where ribs are at maximum strength. Larger specimen is crushed, with a rib index of 11 approximately.

Discussion. The smaller specimen (Pl. 3, figs. 8 and 9) closely resembles material from Colorado figured by Cobban and Scott (1973). The larger (Pl. 9, fig. 4) resembles large fragments from the Bridge Creek Limestone Member of the Greenhorn Limestone at USGS Mesozoic Locality D1308, east of Colorado Highway 115 and south of Beaver Creek in the south-west quarter of Section 22, Township 185, Range 68 W., Fremont County, Colorado.

Occurrence. Upper Cenomanian, *S. gracile* Zone of north-east Texas and Colorado.

Family ANISOCERATIDAE Hyatt, 1900, p. 587
[= Algeritidae Spath, 1925*b*, p. 190]
Genus ANISOCERAS Pictet, 1854, p. 705

Type species. By original designation; *Hamites saussureanus* Pictet, 1847, p. 374, pl. 13, figs. 1–4.

Anisoceras sp. nov. aff. *plicatile* (J. Sowerby, 1819)

Plate 19, figs. 1 and 2

1971 *Anisoceras plicatile* (J. Sowerby); Cobban, p. 4, pl. 1, figs. 4–7; text-fig. 2.

Material. USNM 411525, from the Upper Cenomanian, *S. gracile* Zone fauna of the Britton Formation of Texcrete Quarries, Dallas County.

Description. The specimen is uncrushed with aragonitic shell preserved and is mostly body-chamber, with traces of the final septum visible. Whorl section compressed oval, whorl breadth to height ratio 0·61, with greatest breadth at mid-flank approximately. Rib index 12–13, ribs narrowly rounded and approximately the same width as interspaces. They pass straight across dorsum, flanks, and venter and are only slightly weakened on the dorsum. Groups of three ribs are linked at a large clavus placed high on the flank, whence they loop to a somewhat larger ventrolateral clavus to which a fourth rib attaches on the apertural side. Ribs continue across the venter, all four linking to the opposed ventral clavus. There are two to three intercalated ribs between tuberculate groups on the flank and one to two on the venter. Suture deeply incised, typical for genus.

Discussion. This large fragment exceeds in size all known European specimens referred to *Anisoceras plicatile*, from which it also differs in having pronouncedly clavate tubercles and a compressed, rather than circular whorl section. Furthermore, *A. plicatile* is restricted to the Middle and lower Upper Cenomanian and all known specimens retain a helicoid element in their coiling. The present specimen and those from the *S. gracile* Zone in Colorado (Cobban 1972, p. 4, pl. 1, figs. 4–7; text-fig. 2) probably represent a new species but more material is required for proper description.

Occurrence. Upper Cenomanian, *S. gracile* Zone of north-central Texas and Colorado.

Genus ALLOCRIOCERAS Spath, 1926, p. 80

Type species. By original designation; *Crioceras ellipticum* Woods, 1896, p. 84 (*non* Mantell), renamed *Allocrioceras woodsi* Spath, 1939, p. 598 = *Hamites angustus* J. de C. Sowerby, 1850, p. 346, pl. 29, fig. 12.

Allocrioceras dentonense Moreman, 1942

Plate 3, figs. 4 and 5

1942 *Allocrioceras dentonense* Moreman, p. 209, pl. 34, fig. 4; text-fig. 2H.
1963 *Allocrioceras dentonense* Moreman; Swensen, p. 78, pl. 1, figs. 7 and 8; pl. 3, fig. 3.
1965 *Allocrioceras dentonense* Moreman; Clark, p. 32, pl. 1, figs. 7 and 8; pl. 5, fig. 3; text-fig. 12*b*.
1987 *Allocrioceras dentonense* Moreman, 1942; Kennedy, Wright, and Hancock, p. 62, pl. 10, figs. 13 and 14.

Type. Holotype, by monotypy, is UTA 19808, from the Britton Formation, Upper Cenomanian, *S. gracile* Zone, small ravine south of Lewisville–Hebron road, 3·5 miles east of Lewisville Station, Ellis County.

Description. Holotype is a short fragment only; whorl section compressed (Wb : Wh ratio 0·74 approximately) with rounded dorsum and broadly rounded venter in intercostal section but flattened venter in costal section. Rib index 5–6; ribs effaced on dorsum, straight and rectiradiate to prorsiradiate on flank, where they strengthen markedly. Each bears a small, sharp ventrolateral tubercle, linked across the venter by a broad, strong rib that may show incipient splitting and looping (Pl. 3, fig. 4). Sutures not seen.

Discussion. The holotype and only known Texas *gracile* Zone specimen shows weakening of ribs towards the larger end suggesting it may be close to the adult aperture. This is a rather doubtful species, differing from *A. annulatum* (Shumard, 1860), described further below, in being much more compressed and having a higher rib index than most specimens of that species.

Occurrence. Upper Cenomanian, *S. gracile* Zone of north-central Texas and possibly Utah; basal Turonian, *Pseudaspidoceras flexuosum* Zone of Hudspeth County, West Texas.

Allocrioceras larvatum (Conrad, 1855)

Plate 22, figs. 6 and 7

1855 *Hamites larvatus* Conrad, p. 265.
1987 *Allocrioceras larvatum* (Conrad, 1855); Kennedy, Wright, and Hancock, p. 63, pl. 10, figs. 1–8 (with full synonymy).

Holotype. By monotypy, Philadelphia Academy of Sciences Collections no. 4790, from the Upper Cenomanian, *S. gracile* Zone, Britton Formation of Dallas County, Texas.

Description. Holotype is a curved body-chamber fragment 36 mm long; coiling appears to have been planispiral. Whorl section compressed (whorl breadth to height ratio 0·83), oval in intercostal section with greatest breadth close to mid-flank. Costal section with broadly rounded dorsum and flanks and flat venter. Rib index 4; ribs distant, very weak on dorsum, strengthening over dorsolateral area, strong, coarse, and markedly rectiradiate on flanks, feebly concave. Ribs strengthen further on venter, with a nontuberculate rib alternating with a more elevated one with strong ventrolateral tubercles.

Discussion. *A. larvatum* differs from all other species in having alternately tuberculate and nontuberculate ribs on the body-chamber. It is known from a single specimen (the holotype) only in north-east Texas although abundant in the basal Turonian of west Texas (Kennedy *et al.* 1987). It is not inconcievable that attribution of the holotype to the Britton is an error.

Occurrence. Upper Cenomanian, *S. gracile* Zone, Britton Formation in north-east Texas; basal Turonian, *P. flexuosum* Zone, Hudspeth County, west Texas.

Allocrioceras annulatum (Shumard, 1860)

Plate 19, figs. 3–12, 14; Plate 22, figs. 1 and 2; Plate 24, fig. 2; text-fig. 36

1860 *Ancyloceras annulatus* Shumard, p. 595.
1978 *Allocrioceras annulatum* (Shumard); Kauffman, pl. 19, figs. 1 and 2.
1981 *Allocrioceras annulatum* (Shumard, 1860); Wright and Kennedy, p. 111, pl. 32, figs. 3–7 (with full synonymy).
1984*b* *Allocrioceras annulatum* (Shumard); Cobban, p. 16, pl. 2, fig. 4.

EXPLANATION OF PLATE 22

Figs. 1 and 2. *Allocrioceras annulatum* (Shumard, 1860), USNM 411533, from California Crossing on the Elm Fork of Trinity River, Dallas County.

Fig. 3. *Kanabiceras septemseriatum* (Cragin, 1893). USNM 411499, from Texcrete Quarries, Dallas County, showing prominent ventral constriction.

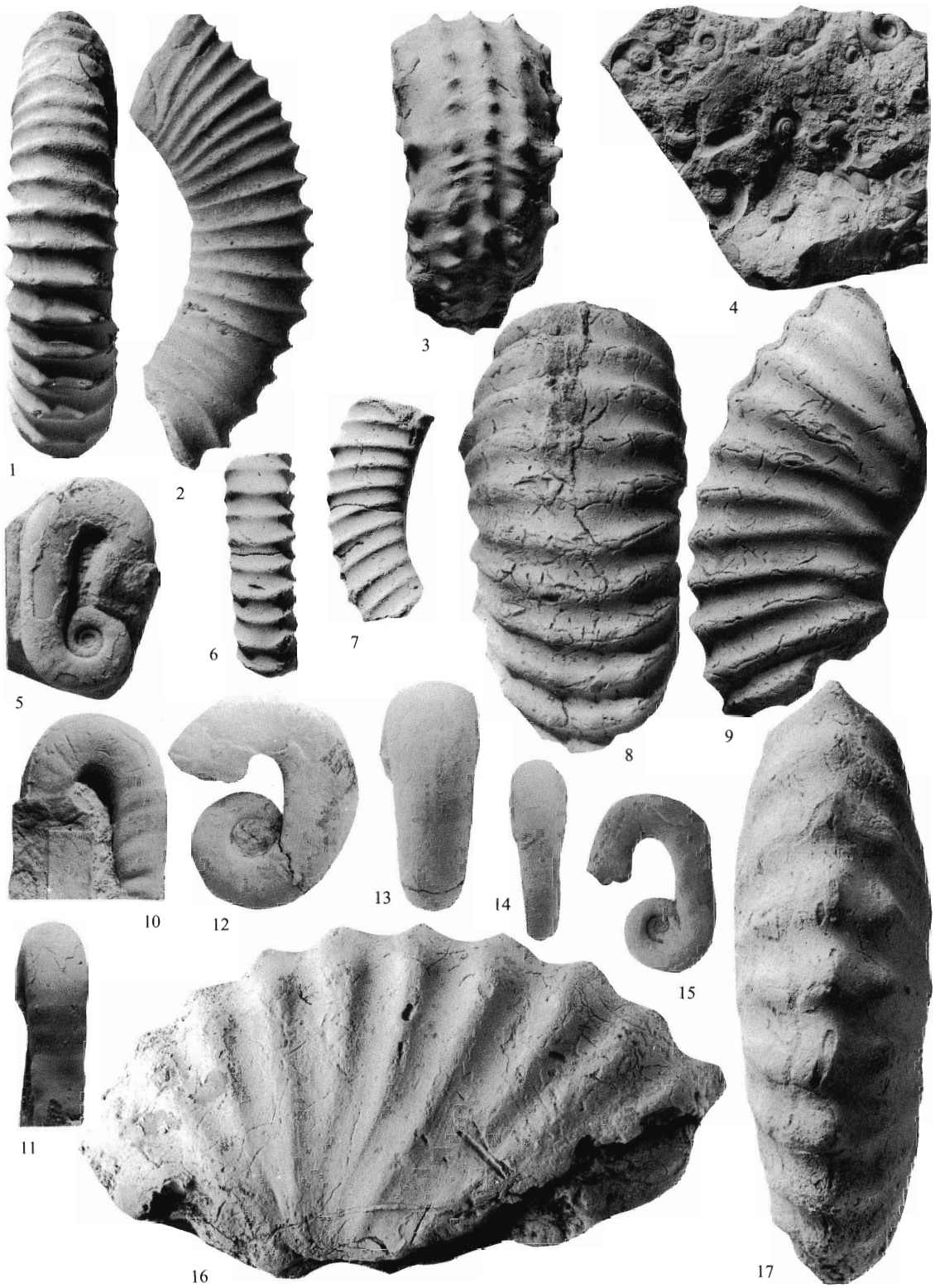
Figs. 4, 5, 10–15. *Worthoceras vermiculus* (Shumard, 1860). 4, USNM 411545, from USGS Mesozoic Locality 22604, first creek north-east of Britton, 2·5 miles on Farm Road, Ellis County, showing characteristic mass occurrence. 5, USNM 411546, from Newton Branch, 3·75 miles south of Britton on old Britton–Midlothian road, Ellis County, a complete microconch with lappet. 10 and 11, USNM 411547, from USGS Mesozoic Locality 22604, first creek north-east of Britton, 2·5 miles on farm road, Ellis County. 12 and 13, TMM 19812, the holotype of *W. gibbosum* Moreman, 1942, 0·5 miles east of Britton–Midlothian highway, 2·7 miles south of Britton, Ellis County. 14 and 15, the neotype, TMM 19827, from the same locality as the original of figs. 14 and 15.

Figs. 6 and 7. *A. larvatum* (Conrad, 1855). The holotype, Philadelphia Academy of Science Collections no. 4790, from Dallas County.

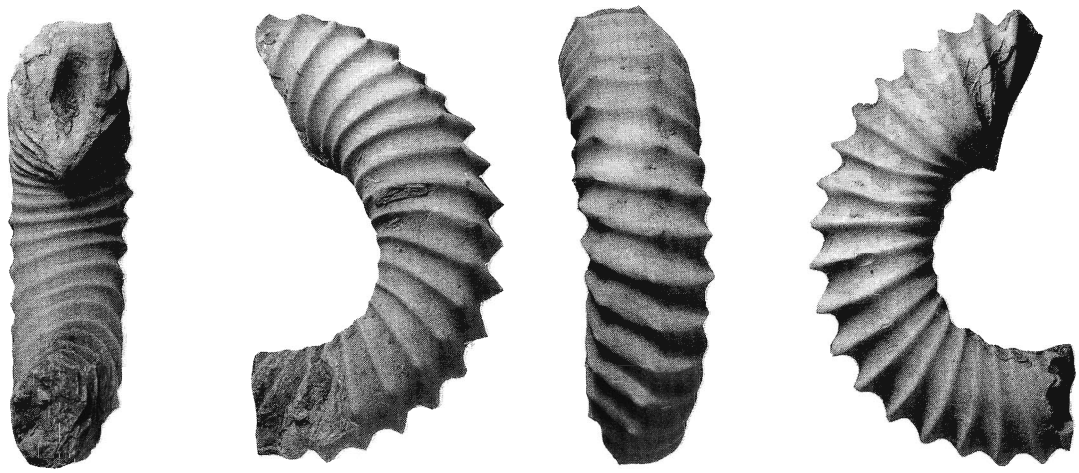
Figs. 8 and 9. *Pseudocalycoceras angolaense* (Spath, 1931). USNM 411480, from outcrops 1·5–1·8 miles south-east of Britton on Rogers Farm, Ellis County.

Figs. 16 and 17. *Metoicoceras geslinianum* (d'Orbigny, 1850). UTA 19810, the holotype of *Barroisiceras trinodosum* Moreman, 1942, from bluffs on Indian Creek, 5·5 miles east of Lewisville station on the Hebron Road, Denton County.

All specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation of north-east Texas. Figs. 5, 10–15 are ×2; remainder are ×1.



KENNEDY, *Allocrioceras*, *Kanabiceras*, *Worthoceras*, *Pseudocalycoceras*, *Metoicoceras*



TEXT-FIG. 36. *Allocrioceras annulatum* (Shumard, 1860). USNM collections, a specimen from California Crossing on Elm Fork of Trinity River, Dallas County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation. All figures are natural size.

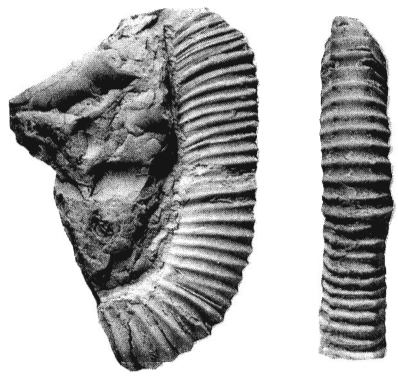
Types. Shumard's syntypes were from what is now known as the Britton Formation, Upper Cenomanian, *S. gracile* Zone of Shawnee Creek, Grayson County and are now lost.

Material. Several hundred specimens from the Britton Formation of north-east Texas in the JPC, JDP, USGS, USNM, UTA, OUM, and BMNH collections, not listed separately.

Description. The protoconch (Pl. 24, fig. 2) is succeeded by a smooth, slowly expanding straight, thereafter slightly curved shaft up to 16·0 mm long and 0·5 mm in diameter (Pl. 19, figs. 3 and 14; Pl. 24, fig. 2). Ribs appear after this stage, the expansion rate increases and an initial elliptical coil (Pl. 19, figs. 3, 7, 8, 14) forms the apex to a low helix, diameter varying from 6·5 to 8 mm with, in some cases, the initial shaft extending beyond the coil. Whorl section varies from circular to compressed at this stage, which is succeeded by a second helical coil, generally 15 mm or so in diameter with depressed whorls and a rib index of 3 to 5, the ribs prorsiradiate but because of the helicoid coiling crossing the venter obliquely. There follow three more whorls, much more loosely helicoid that the initial whorls (Pl. 19, figs. 9 and 10). These later whorls vary from circular to compressed and there are both coarse-ribbed and fine-ribbed individuals (compare Pl. 19, figs. 9–12 and Pl. 22, figs. 1 and 2). Those with a near-circular section have a rib index of as little as 3, those with compressed whorls an index of up to 5. Because of the increase in translation rate as size increases, ribbing modifies by crowding and attenuating across the dorsum, strengthening on the flank, where it is prorsiradiate, and sometimes slightly convex (text-fig. 36). The earliest whorls lack tubercles, which appear at variable whorl heights (Cobban and Scott (1973, p. 52) cite 2·0 to 10·0 mm in well-preserved material from Utah). The tubercles are small and rounded (Pl. 19, fig. 4) to feebly clavate (Pl. 19, fig. 11) in most specimens, but rare individuals show these to be the septate bases to short spines (Pl. 19, figs. 9 and 10), a previously unrecognized feature of the genus.

The terminal portion of the last whorl of adult specimens uncoils yet further (Pl. 19, figs. 9–12; Pl. 22, figs. 1 and 2) and varies from compressed (Wb : Wh = 0·84) to circular; the largest body-chamber seen occupies half a whorl. Maturity is indicated by crowding and weakening of ribs and loss of tubercles. It occurs at a whorl height of 20–25 mm in what I take to be microconchs (Pl. 19, figs. 9 and 10; Pl. 22, figs. 1 and 2) while larger specimens without a trace of such modification (Pl. 19, figs. 11 and 12) I take to be incomplete macroconchs.

Discussion. Cobban and Scott (1973, p. 51) showed the better-known *A. pariense* White, 1877 (p. 39, pl. 18, fig. 10) to be a synonym of *annulatum*, a view with which I concur, and reillustrated the holotype (Cobban and Scott, 1973, pl. 20, figs. 1–3). These authors describe the ventral connection between tubercles as a pair of low riblets; strictly speaking the ventral rib becomes flattened with raised edges in their material, a feature seen only occasionally in the Texas specimens (e.g. text-fig.



TEXT-FIG. 37. *Allocrioceras conlini* sp. nov. Holotype, USNM 411534, from the Upper Cenomanian *Sciponoceras gracile* Zone fauna of the Britton Formation at USGS Mesozoic Locality 22613, California Crossing on Elm Fork of Trinity River, Dallas County. × 1.

36). As noted above *A. dentonense* may be an extreme form of *A. annulatum* with very compressed whorl section and well-differentiated ventral riblets between tubercles.

A. larvatum is easily distinguished from the present species by the regular alternation of tuberculate and nontuberculate ribs (Pl. 22, figs. 6 and 7), while abundant material from the basal Turonian of west Texas (Kennedy *et al.* 1987 p. 63, pl. 10, figs. 1–8) shows a quite different mode of coiling, apparently planispiral. As with that species the early growth stages of *A. annulatum* that lack tubercles look like juvenile *Hamites*.

Occurrence. Upper Cenomanian, *S. gracile* Zone and correlatives in north-central and west Texas, New Mexico, Arizona, Colorado, Kansas, Utah, and Wyoming in the USA, northern Mexico, southern England, and Haute Normandie in France.

Allocrioceras conlini sp. nov.

Text-fig. 37

Holotype. USNM 411534, from USGS Mesozoic Locality 22613, California Crossing on Elm Fork of Trinity River, Dallas County, Britton Formation, Upper Cenomanian, *S. gracile* Zone.

Diagnosis. A compressed *Allocrioceras* ornamented by straight prorsiradiate ribs with periodic constrictions and associated flared collars.

Description. The holotype is a J-shaped body-chamber fragment 47 mm long. Coiling planispiral, whorl section compressed oval intercostally with whorl breadth to height ratio 0·86. Costal whorl section is also oval, but with relatively broad arched venter and obtusely angular ventrolateral shoulder. Ribs annular, narrow, straight or almost imperceptibly flexed, sharp, narrower than interspaces; rib index 4 or 5. All bear small delicate ventral tubercles, no wider than the rib, connected over the venter by a strong rib, elevated over the siphonal line giving a near-fastigiate profile. Ornament modifies on curved portion of shell: ribs strengthen, become feebly convex, and rursiradiate. The most distinctive feature of the species is the presence of broad constrictions, succeeded by a pronounced flared rib. Sutures not seen.

Discussion. Constrictions, flared ribs, and whorl profile distinguish *A. conlini* from contemporaneous *A. annulatum* and *dentonense*, while in addition, *A. larvatum* has alternately tuberculate and nontuberculate ribs. Indeed, of described species it resembles only *A. strangulatum* Wright, 1979 (p. 291, pl. 1, figs. 12–14; pl. 2, fig. 1) known only from the Upper Turonian of southern England and the German Federal Republic (= *C. ellipticum* (Mantell) of Schlüter (1876 pl. 30, figs. 11 and 12 *non* pl. 43, figs. 1 and 2)); the latter has feebler constrictions, ribs that are flexuous and sometimes almost biconvex, and a significantly narrower venter.

Occurrence. As for type.

Allocrioceras sp.

Plate 20, figs. 15 and 16

Material. USNM 411535, from the Britton Formation, Upper Cenomanian, *Sciponoceras gracile* Zone, Texcrete Quarries, Dallas County.

Discussion. A curved fragment 26 mm long, with a maximum whorl height of 4·5 mm is unusual in having inner and outer ventrolateral tubercles on one flank and a single row on the other. I presume it to be pathological.

Occurrence. As for material.

Family BACULITIDAE Gill, 1871, p. 3

Genus SCIPONOCERAS Hyatt, 1894, p. 578

[= *Cyrtochilus* Meek, 1876*a*, p. 392 *non* Jakowlew 1875, p. 252; *Cyrtochilella* Strand, 1929, p. 8]

Type species. By original designation; *Hamites baculoides* Mantell, 1822, p. 123, pl. 23, figs. 6 and 7.

Sciponoceras gracile (Shumard, 1860)

Plate 20, figs. 1–14, 17–20; text-fig. 38

1860 *Baculites gracilis* Shumard, p. 596.

1981 *Sciponoceras gracile* (Shumard, 1860); Wright and Kennedy, p. 112, pl. 31, figs. 1–3; pl. 32, figs. 8 and 11; text-fig. 38A–Q (with full synonymy).

1983 *Sciponoceras gracile* (Shumard); Kennedy and Juignet, p. 22, figs. 18*a–d* and 32*i–p* (with additional synonymy).

1984 *Sciponoceras gracile* (Shumard, 1860); Kennedy, Amédro, Badillet, Hancock, and Wright, p. 41, fig. 2*a–d*.

Types. Shumard's types are lost, but are presumed to be from the Upper Cenomanian *S. gracile* Zone fauna of the Britton Formation. The locality given by Shumard is Grayson County.

Material. Several hundred specimens; the species is common at all cited localities in north-central Texas and material studied in the USGS, USNM, TMM, BMNH, and OUM collections is not listed separately.

Discussion. This is the commonest ammonite in the Britton clays of north-central Texas, and at some localities is a local rock-former. Cobban and Scott (1973) and Wright and Kennedy (1981) have provided basic accounts of the species based on rather poor material from chalks and chalky limestones. The Texas material is undeformed, and shows a range of interesting features, including striking dimorphism. None of the specimens studied show the protoconch and initial whorl, but beyond this, the whorl section is generally circular up to a diameter of 2·0 mm, after which the whorls commonly become slightly compressed. The characteristic ventral ribs generally appear at a diameter of 3·0–4·0 mm with prominent constrictions regularly spaced at a distance of 1 to 1·5 diameters and five to seven ribs between constrictions. The species is strongly dimorphic. Microconchs develop a hooded aperture at whorl heights of between 7·3 and 11·7 mm in the present collection (Pl. 20, figs. 4–13). Ribs strengthen on the venter towards the aperture, a dorsal constriction develops, and the aperture itself may be distinctly flared. Accompanying these adults are much larger individuals with whorl heights of up to 41·5 mm (Pl. 20, figs. 1–3, 14, 18–20) on the body-chamber, these I take to be macroconchs. Only one (Pl. 20, figs. 18–20) shows traces of a mouth border, which is parallel to the growth lines and may thus be that of a juvenile.

This remarkable dimorphism clarifies the relationship between *S. gracile* and *S. kossmati* Nowak, 1908 (p. 348) of authors. The latter species is based on the *Baculites* aff. *bohemicus* of Kossmat (1895, p. 154, pl. 19, fig. 18) and was differentiated from other species on sutural details. As Wright and Kennedy (1981, p. 114) note, the latter are less than convincing, while other details of the figured fragment give limited clues to its affinities; the age is given as 'untere Trichinopoly group' and the associated ammonites (Kossmat 1898, p. 133 (198)) indicate a horizon quite high in the Turonian (see

TEXT-FIG. 38. *Sciponoceras gracile* (Shumard, 1860). Slab showing typical mass occurrence. J. P. Conlin Collection no. 7490, from 1·5 to 1·8 miles south-east of Britton, Ellis County. Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation. × 1.

also Sastry *et al.* 1968), the *Lewesiceras vaju* Zone of Indian workers. In contrast, the *S. kossmati* from California (Matsumoto 1959, p. 106, pl. 31, figs. 2 and 3; text-figs. 4–6) occur associated with *Euomphaloceras septemseriatum*, a *gracile* Zone species, and probably belong here, as do some contemporary Japanese specimens (Matsumoto and Obata 1963) referred to *S. kossmati*.

Occurrence. Upper Cenomanian *S. gracile* Zone and correlatives. Abundant in north-east and west Texas; Arizona, New Mexico, Colorado, Kansas, Wyoming, Montana, Utah, and California in the USA, northern Mexico, southern England, northern France, southern Germany, and, possibly, Angola.

Genus BACULITES Lamarck, 1799, p. 80

[= *Homaloceratites* Hupsch, 1768, p. 110 (*non. binomen.*); *Euhomaloceras* Spath, 1926, p. 80]

Type species. *Baculites vertebralis* Lamarck, 1801, p. 103, by subsequent designation of Meek 1876*a*, p. 391.

Baculites yokoyamai Tokunaga and Shimizu, 1926

Plate 23, figs. 8–10; text-fig. 29C

1926 *Baculites* (*Lechites*) *yokoyamai* Tokunaga and Shimizu, p. 195, pl. 22, fig. 5; pl. 26, fig. 11.
1931 *Baculites besairiei* Collignon, p. 37, pl. 5, figs. 6–9; pl. 9, fig. 16.
1959*a* *Baculites* cf. *yokoyamai* Tokunaga and Shimizu; Matsumoto, p. 118, text-fig. 26.
1963 *Baculites yokoyamai* Tokunaga and Shimizu; Matsumoto and Obata, p. 30, pl. 8, fig. 5; pl. 10, figs. 1–6; pl. 11, figs. 1, 4, 5; pl. 12, fig. 3; pl. 14, fig. 4; text-figs. 72–87.
1965*b* *Baculites besairiei* Collignon, p. 18, pl. 420, figs. 1745 and 1746.
1973 *Baculites* cf. *B. yokoyamai* Tokunaga and Shimizu; Cobban and Scott, p. 48, pl. 20, figs. 15–21.
1975 *Baculites* cf. *B. yokoyamai* Tokunaga and Shimizu; Hattin, pl. 8, figs. F and H.
1977 *Baculites* cf. *B. yokoyamai* Tokunaga and Shimizu; Kennedy, text-fig. 17.1, 2.
1978 *Baculites* cf. *B. yokoyamai* Tokunaga and Shimizu; Hattin, fig. 6.2.
1978 *Baculites* cf. *B. yokoyamai* Tokunaga and Shimizu; Hattin and Siemers, text-fig. 7.2.
1980*b* *Baculites yokoyamai* Tokunaga and Shimizu; Cobban and Hook, p. 13, pl. 4, figs. 9 and 10.
1983 *Baculites yokoyamai* Tokunaga and Shimizu; Cobban and Hook, p. 7, pl. 1, figs. 1–7.
1984*b* *Baculites yokoyamai* Tokunaga and Shimizu; Cobban, p. 14, pl. 1, figs. 5 and 6.
1986 *Baculites yokoyamai* Tokunaga and Shimizu; Cobban, fig. 3H, I.

EXPLANATION OF PLATE 23

Figs. 1–7, 13–19, 22–25. *Scaphites* (*Scaphites*) *carlilensis* Morrow, 1935. 1 and 2, USNM 73654, the original of Adkins 1928, pl. 24, figs. 1 and 2, from the Eagle Ford Condensed Zone on Bouldin Creek, Austin, Travis County. 3 and 4, TMM 873TX2, from the same horizon and locality. 5–7, TMM 19828, the holotype of *S. pygmaeus* Moreman, 1942, from the same horizon on the Austin campus; 13–15, the holotype of *S. arcadiensis* Moreman, 1942, TMM 19815, from the Arcadia Park Formation, 1 mile south of Arcadia Park, Dallas County; 16 and 17, USNM 420179; 18 and 19, USNM 420180; 22 and 23, USNM 420178; 24 and 25, USNM 420181; all from concretions on valley slopes south-east of Cedar Hill–Duncansville road, midway between the towns, Dallas County. Arcadia Park Formation, *Prionocyclus hyatti* Zone.

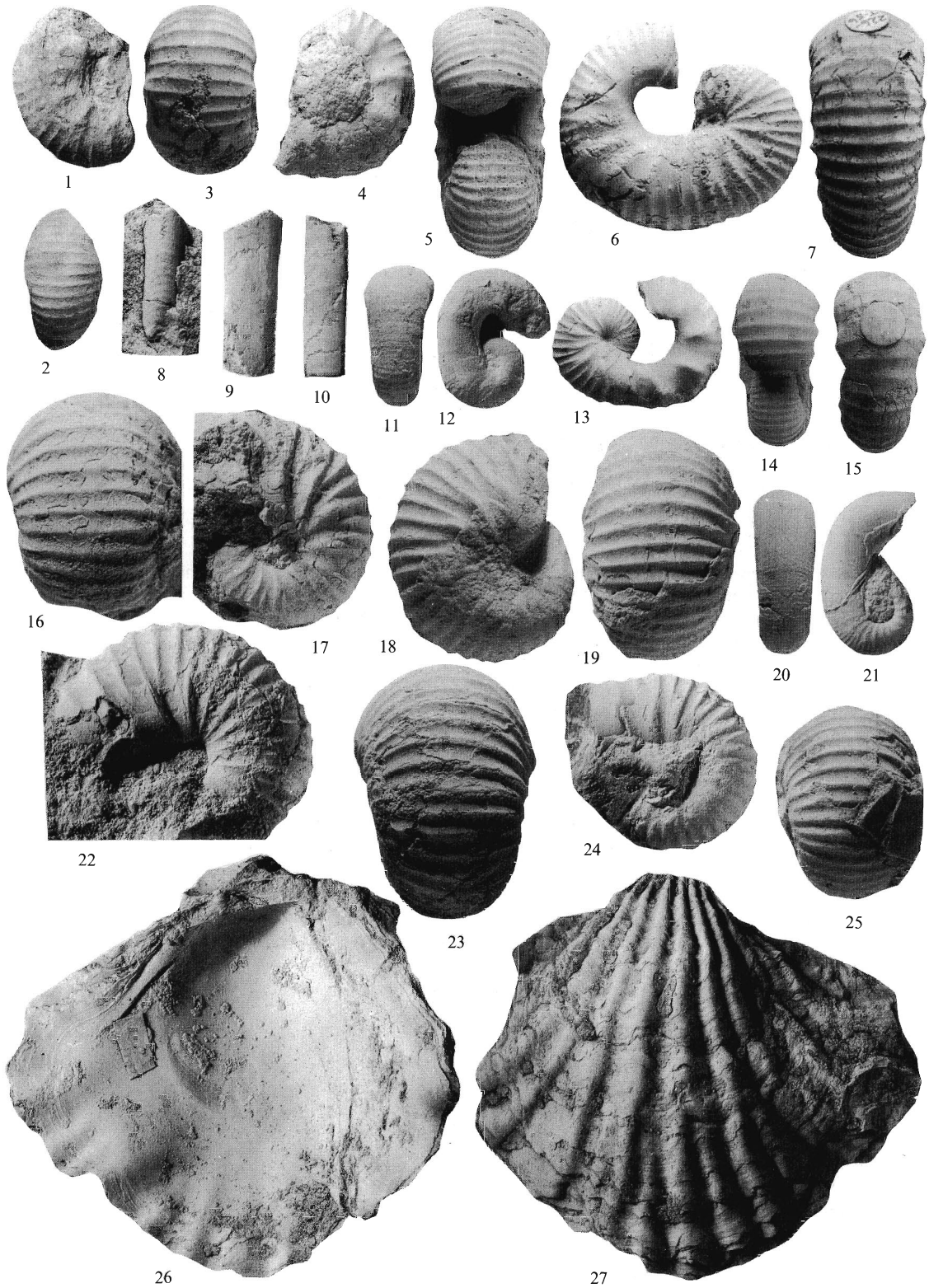
Figs. 8–10. *Baculites yokoyamai* Tokunaga and Shimizu, 1926. 8, USNM 420171; 9 and 10, USNM 420172; from the Eagle Ford Condensed Zone, Oak Haven Waterfall, Walnut Creek, north of Austin, Travis County. *P. hyatti* Zone.

Figs. 11 and 12. *S.* (*Pteroscaphites*) *inaffectus* Crick, 1979. USNM 420175, from concretions on Ten Mile Creek Valley, south-east of Cedar Hill–Duncansville road, midway between the two towns, Dallas County. Arcadia Park Formation, *P. hyatti* Zone.

Figs. 20 and 21. *Yezoites* cf. *delicatulus* (Warren, 1930). USNM 420174; horizon and locality as for the previous specimen.

Figs. 26 and 27. *Nicaisolopha bellaplicata bellaplicata* (Shumard, 1860). OUM KT 3759, from the Arcadia Park Formation, 3 m below the base of the Austin Chalk, road cuts at junction of Chalk Hill Road and Davis Street (Route 80), west of Dallas, Dallas County, *P. hyatti* Zone.

Figs. 11, 12, 16–25 are ×2; remainder ×1.



KENNEDY, *Scaphites*, *Baculites*, *Yezoites*, *Nicaisolopha*

Types. The holotype was destroyed during World War II (*fide* Matsumoto and Obata, 1963, p. 30). Matsumoto and Obata (1963) have designated a specimen in the Kyushu University Collections (GK H 4580) neotype; it is from the Coniacian *Inoceramus uwajimensis* Zone of the Bannosawa, Hokkaido, Japan.

Material. OUM KT 4140–4143, 4146–4149, 4151–4152, from the Britton Formation, 0·5–2·5 m above the intraformational unconformity, road cuts on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, Dallas County. *Vascoceras* (*Greenhornoceras*) *birchbyi* Zone. OUM KT 5367, from the Eagle Ford Condensed Zone, Oak Haven Waterfall on Walnut Creek, 8·25 miles (airline) N. 9° 30′ E. from University Campus, Austin, Travis County. USNM 420170–420173 from the Eagle Ford Condensed Zone, Watters Park, north of Austin, Travis County.

Description. Specimens from the Eagle Ford Condensed Zone are phosphatized moulds with a low expansion rate and ovoid whorl section, the dorsum broadly rounded, the venter narrowly rounded, the greatest breadth below mid-flank, the whorl breadth to height ratio 0·73. Some specimens are smooth, others show faint ribbing, convex on the outer flank, and crossing the venter in a broad convexity. Ornament is much better preserved on crushed specimens retaining shell from the uppermost part of the Britton Formation near Dallas. Growth lines are concave on the inner flank but concave on the outer, where they strengthen into fine ribs which cross the venter in a broad convexity.

Discussion. Whorl section and ornament show these specimens to be the widely occurring US Western Interior form referred to as *B. yokoyamai* by previous authors. The only other US interior species with which this is likely to be confused is *B. undulatus* d'Orbigny, 1850 (p. 190; see Matsumoto and Obata 1963, p. 28, pl. 8, fig. 4; pl. 9, figs. 1–5; pl. 11, figs. 2 and 3; text-figs. 62–71), which has much coarser ribs.

Occurrence. The type occurrence is in the Coniacian of Hokkaido, Japan; it also occurs in the Coniacian of Madagascar. The name is used for feebly ornamented *Baculites* from the Turonian of the US Western Interior. It ranges throughout the whole of the stage and is known from Wyoming, Montana, Colorado, Kansas, New Mexico, west and north-central Texas.

Superfamily SCAPHITACEAE Gill, 1871, p. 3

[*nom. transl.* Wright and Wright, 1951, p. 13, *ex* Scaphitidae Gill, 1871, p. 3]

Family SCAPHITIDAE Gill, 1871, p. 3

Discussion. I am particularly grateful to Dr C. W. Wright for clarifying my thoughts in this area, and what follows draws heavily on his ideas.

Only two species of scaphitid are recognized in the Britton fauna, but they highlight some interesting problems associated with the striking dimorphism shown by the group. Makowski (1963) recognized dimorphism, chiefly difference in size, in *Hoploscaphites constrictus* (J. Sowerby, 1817). Cobban (1969) amplified this conclusion and recognized dimorphism in a wide range of US scaphitids. His work showed that although macroconchs were generally larger than microconchs there was in fact a size overlap, but the two could be reliably separated because microconchs had a slender body-chamber with concave umbilical wall and the shaft concave in profile, not concealing the umbilicus of the spire, whereas macroconchs had stout body-chambers, a convex umbilical wall, and a shaft that concealed part of the umbilicus of the spire, commonly associated with a pronounced umbilical bulge. These criteria also apply to the type species of *Hoploscaphites* Nowak, 1911 (Kennedy 1986 provides a recent account), *Scaphites* Parkinson, 1811 (Kennedy 1986), *Trachyscaphites* Cobban and Scott, 1964 (see Cobban 1973), and *Acanthoscaphites* Nowak, 1911 (Kennedy and Summesberger 1987). In contrast are species such as *S. brittonensis* Moreman, 1942 that are known only as macroconchs. These co-occur in the Britton with a small lappeted form, named *S. minutus* Moreman, 1942. In the Seabee Formation of Alaska Cobban and Gryc (1961) described two similar associations in the Turonian, of what they called *S. delicatulus* Warren, 1930 (exclusively macroconchs and here regarded as the senior synonym of *S. brittonensis*) and *Otoscaphites seabeensis* Cobban and Gryc, 1961 (a lappeted microconch) above and of *S. subdelicatulus* Cobban and Gryc, 1961 (exclusively macroconchs) and *O. perrini* (Anderson, 1902) (a lappeted microconch) below. In

Minnesota Cobban (1983) recognized, in the Middle Turonian, an association of *S. delicatulus sloani* Cobban, 1983 (exclusively macroconchs) and *O. seabeensis* Cobban and Gryc, 1961 (lappeted microconchs). It seems an inescapable conclusion that this represents a second type of dimorphism in scaphitids, and this is confirmed in my view by material figured by Tanabe (1977*a*, *b*) and Wright (1979) who describe co-occurring *Scaphites* species that have exclusively macroconch characters seen in other scaphitids and *Otoscaphites* with lappets and other features indicative of microconchs in unlappeted species.

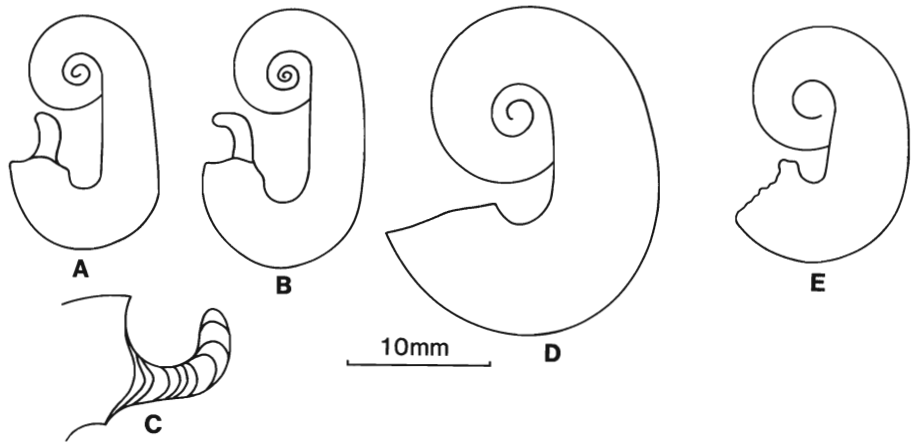
The abundant *Worthoceras* from the Britton fall into two distinct groups that have identical early whorls but differ in that the small form, *W. vermiculus* (Shumard, 1860) has a body-chamber shaft that is slender, and does not conceal the umbilicus of the spire and an aperture with pronounced lappets while the co-occurring large form, *W. gibbosum* Moreman, 1942, has a stout body-chamber that partially conceals the umbilicus of the spire and a simple aperture. These co-occur in Texas, Colorado (Cobban and Scott 1973), and south Germany (Förster *et al.* 1983) and again appear to be dimorphs.

If this conclusion is accepted, it will be seen that *Yezoites* Yabe, 1910, *Otoscaphites* Wright, 1953, and *Hyposcaphites* Wiedmann, 1965 have type species based on microconchs. The type species of *Yezoites*, *S. perrini* Anderson, 1902 (p. 114, pl. 2, figs. 71–73) has *Scaphites* of *delicatulus* group as the corresponding macroconch. The type species of *Otoscaphites*, *Ammonites bladensis* Schlüter, 1871 (p. 30, pl. 10, figs. 5 and 6) has *S. pseudoequalis* Wright *non* Yabe (Wright 1979, p. 305, pl. 3, fig. 5; pl. 7, fig. 1; see Kaplan *et al.* 1987) as the corresponding macroconch. The type species of *Hyposcaphites*, *H. stephanoceratoides* Yabe, 1909, p. 442 (= *Olcostephanus* sp. of Jimbo 1894, p. 179 (33), pl. 25 (9), fig. 8) is a synonym of *S. perrini* according to Yabe (1910, p. 172 (14), pl. 15 (1), figs. 28 and 29; text-fig. 3) and Matsumoto (1963), a view with which I agree, so that *Yezoites* and *Hyposcaphites* are synonyms. I can equally see no significant generic differences between the type species of *Otoscaphites* and *Yezoites* and regard the former as a junior synonym of the latter.

Pteroscaphites, with *S. auriculatus* Cobban, 1952 (p. 30, pl. 10, figs. 11–17) as type species, has quite different apertural modifications to the forms discussed above, with ventrolateral and siphonal projections that are produced by the pinching in of the mouth border on either side of the mid-ventral line. On coiling and body-chamber form, it is a microconch. Wright believed it derived from *S. larvaeformis* Meek and Hayden, 1859 (p. 58; see Meek 1876*a*, p. 418, pl. 6, fig. 6), itself a microconch without apertural modification. *S. auriculatus* co-occurs with *S. preventricosus* Cobban, 1952 (p. 26, pl. 9, figs. 1–16) and *S. impendicostatus* Cobban, 1952 (p. 28, pl. 11, figs. 1–14). The last named is a macroconch, of which the corresponding microconch is *S. impendicostatus erucoides* Cobban, 1952 (p. 29, pl. 11, figs. 15–28) (*fide* Cobban 1969, p. 8), the former is also a macroconch, of which *S. preventricosus sweetgrassensis* Cobban, 1952 (p. 27, pl. 10, figs. 18–25) is the co-occurring macroconch. I conclude that the macroconch of *P. auriculatus* has yet to be recognized.

These conclusions have a marked effect on certain published views on scaphitid evolution and classification, the most obvious of which is that the worthoceratid development of Wiedmann (1965) showing supposed recoiling in the sequence *W. platydorsum* → *W. vermiculus* → *W. gibbosum* is invalidated; his 'atrophic *similaris* stock' parallel to the main *equalis* lineage is two macroconchs and a microconch (1965, p. 420, text-fig. 4) while *S. yonekuri* Yabe, 1910, which is shown as a link between Upper Albian *S. hilli* Adkins and Winton, 1920 and *S. similaris* Stoliczka, 1865 of the Cenomanian is actually a Coniacian species and a macroconch *Yezoites* (Kennedy and Juignet 1983, p. 67; see also Marcinowski 1980, p. 264).

I am uncertain of the status to accord to genera with lappeted microconchs. At one extreme is the maintenance of subfamily Otoscaphitinae Wright, 1953 for *Worthoceras* and *Yezoites*; at the other, *Yezoites* (as *Otoscaphites* and *Hyposcaphites*) has been treated as a subgenus of *Scaphites* (Wiedmann, 1965) and *Worthoceras* afforded a home in the Ptychoceratidae Gill, 1871 (Wiedmann 1965). I here provisionally follow Wright (1957, 1981) in regarding Scaphitinae and Otoscaphitinae as separate on the grounds that *Yezoites* (= *Otoscaphites*) has lappeted microconchs as already discussed, while associated macroconchs, although close to *Scaphites* have, in many cases, a pronounced thickened lip to the aperture which provides a criterion for macroconch differentiation.



TEXT-FIG. 39. *Worthoceras vermiculus* (Shumard, 1860). A–C, microconchs; D–E, macroconchs. A is USNM 411553; B, C (the latter a detail showing growth lines on the lappet) are USNM 411554; D is USNM 411552; E is USNM 411551. Scale applies to A, B, D, E only.

Genus WORTHOCERAS Adkins, 1928, p. 218

Type species. By original designation; *Macroscaphites platydorsus* Scott, 1924, p. 18, pls. 5, 6; pl. 9, fig. 6.

Worthoceras vermiculus (Shumard, 1860)

Plate 22, figs. 5, 10–15; Plate 24, figs. 22–33; text-fig. 39

1860 *Scaphites vermiculus* Shumard, p. 419.
1876*a* *Macroscaphites vermiculus* Shumard; Meek, p. 419.
1883 *Scaphites vermiculus* Shumard; White, p. 39, pl. 18, fig. 8*a*.
1928 *Scaphites vermiculus* Shumard; Adkins, pp. 220, 259.
1931 *Scaphites* sp. aff. *africanus* Pervinquière; Adkins, p. 63, pl. 2, figs. 11 and 12.
1939 *Scaphites rochatianus* d'Orb.; Dacqué, p. 89, pl. 16, fig. 34.
1942 *Worthoceras vermiculum* (Shumard); Moreman, p. 214, pl. 34, figs. 12 and 13; text-fig. 2*p*.
1942 *Worthoceras gibbosum* Moreman, p. 215, pl. 34, figs. 7 and 8; text-fig. 2*q*.
1951 *Worthoceras* Adkins and Lozo, pl. 5, fig. 2.
1965 *Worthoceras gibbosum* Moreman; Wiedmann, p. 441, pl. 60, fig. 3; text-fig. 10*h*.
1965 *Worthoceras vermiculum* (Shumard); Wiedmann, p. 440, pl. 59, fig. 8; pl. 60, figs. 1 and 2; text-fig. 10*e–g*.
1965 *Worthoceras vermiculum* (Shumard); Clark, p. 62, pl. 4, figs. 9–11 (with additional synonymy).
1965 *Worthoceras gibbosum* Moreman; Clark, p. 63, pl. 4, figs. 13–15; text-fig. 22*b*.
1973 *Worthoceras gibbosum* Moreman; Cobban and Scott, p. 43, pl. 17, fig. 2.
1973 *Worthoceras vermiculum* (Shumard); Cobban and Scott, p. 43.
1975 *Worthoceras vermiculum* (Shumard); Hattin, p. 44, pl. 5, figs. A, F, K.
1977 *Worthoceras gibbosum* Moreman; Kauffman, pl. 17, fig. 7.
1978 *Worthoceras vermiculum* (Shumard); Hattin, p. 185, text-fig. 5.7.
1978 *Worthoceras vermiculum* (Shumard); Hattin and Siemers, p. 29, text-fig. 6.7.
non 1980 *Worthoceras vermiculum* (Shumard); Marcinowski, p. 248, pl. 2, figs. 5 and 6.
1983 *Worthoceras vermiculum* (Shumard, 1860); Förster, Meyer, and Risch, p. 129, pl. 1, figs. 1–9.
1984*b* *Worthoceras vermiculus* (Shumard); Cobban, p. 16, pl. 2, fig. 5.
? 1987 *Worthoceras* cf. *vermiculus* (Shumard, 1860); Kennedy, Wright, and Hancock, p. 64, pl. 8, fig. 5.

Neotype. TMM 19827, designated by Moreman (1942, p. 214). It is from the Upper Cenomanian, *Sciponoceras gracile* Zone, Britton Formation, 0·5 miles east of the Britton–Midlothian highway, 2·7 miles south of Britton, Ellis County (Pl. 22, figs. 14 and 15). The holotype, by monotypy, of *W. gibbosum* Moreman, 1942, is TMM 19812, from the same horizon and locality as the neotype of *W. vermiculus* (Pl. 22, figs. 12 and 13).

Material. More than 300 specimens, mostly juveniles, from the Britton Formation, Upper Cenomanian, *S. gracile* Zone of north-east Texas; not listed separately, the majority are from USGS Mesozoic Locality 22604 (*ex* Renfro Collection), first Creek north-east of Britton, 2·5 miles on farm road, Ellis County. Also from Texcrete Quarries, Dallas County; Newton Branch, 3·75 miles south of Britton on old Britton–Midlothian road, Ellis County; outcrops 1·5 to 1·8 miles south-east of Britton, on and east of Rogers Farm, Ellis County; east bank of stream 2·5 miles south of Britton on old Britton–Midlothian road, Ellis County; California Crossing on Elm Fork of Trinity River, Dallas County; Creek 4–4·5 miles south of Britton, when Cotton Belt Railroad crossed farm road from Britton to Midlothian, Ellis County (*ex* Renfro Collection).

Description. Microconchs are 12·5–17·5 mm long when complete, with a spire up to 8 mm in diameter comprising 3·5 whorls (Pl. 22, figs. 24 and 33); very evolute, serpenticone, smooth, with prorsiradiate growth lines only or with low, feeble fold-like prorsiradiate flank ribs. Shaft straight or feebly flexed at beginning, long, with concave dorsum, compressed, with flattened subparallel flanks and broadly rounded venter smooth but for prorsiradiate growth lines, convex across umbilical shoulder and flank and crossing venter in broad convexity (Pl. 22, figs. 5 and 15; Pl. 24, fig. 32) or with low, broad fold-like ribs on flanks separated by broad, shallow constriction-like interspaces than efface on outer flank in some (Pl. 24, fig. 33) or cross venter in others (Pl. 22, figs. 10 and 11). Final hook expands slightly. Growth lines become markedly flexuous, convex at mid-flank, concave on outer and convex over venter. Lateral convexity produced into a long lappet with strong convex growth lines, initially elongated normal to mouth border but ultimately turning through 90°, towards venter and inwards towards median plane of symmetry (text-fig. 39). Feeble apertural constriction may develop, most obvious in dorsolateral area. Macroconch (Pl. 22, figs. 12 and 13; Pl. 24, figs. 25–30) 15·5–21·4 mm long; spire up to 11·5 mm in diameter. Inner whorls of spire like those of microconch; outer whorl generally stouter, more rapidly expanding, ornamented by prorsiradiate growth striae or low, broad flank ribs (Pl. 24, figs. 25–30). Shaft much stouter than in microconch, expands more rapidly; much shorter in proportion to spire. Dorsum concave, flanks flattened, subparallel, with broadly rounded venter. Ornament varies from convex prorsiradiate growth lines (Pl. 24, fig. 29) to low, broad, fold-like ribs, as in microconch (Pl. 24, fig. 33). Final hook robust, loosing ribs in most specimens. Aperture may be preceded by broad shallow constriction; margin entire, without lappets (text-fig. 39).

Discussion. *W. vermiculus* differs from the Albian *W. worthense* (Adkins, 1920) (p. 71, pl. 2, figs. 23–26; text-fig. 3) in being much larger and having a compressed flat-sided rather than depressed reniform cross-section to the shaft. *W. platydorsum* (Scott, 1924) (p. 18, pls. 5 and 6; pl. 9, fig. 6) is also much smaller than *W. vermiculus*, has a much smaller spire in relation to shaft and hook and, as the name indicates, a flat dorsum. I have not seen material of the species, which is from the Albian of Texas (Duck Creek Formation) and am uncertain of its affinities with *W. worthense*. *W. rochatianum* (d'Orbigny, 1850) (Roman and Mazerin 1913, p. 9, pl. 13, figs. 1 and 2; Wiedmann 1965, pl. 60, figs. 5 and 6) is a larger species (Roman and Mazerin figure a specimen at least 27 mm long) with rather different relative proportions, a smaller spire, and much longer shaft than the present species. All the material I have seen from Uchaux, the type locality is poorly preserved in detail; apertures are unknown and dimorphism as yet undescribed.

Material from the Middle Cenomanian of the Crimea described by Marcinowski (1980, p. 247, pl. 2, figs. 1–4, 7–9 as *W. rochatianum*; p. 248, pl. 2, figs. 5 and 6 as *W. vermiculum*) belong to neither of these species, being intermediate in size between *vermiculus* and *worthense* and showing a very markedly flexuous shaft.

Occurrence. Upper Cenomanian *Sciponoceras gracile* Zone and correlatives, north-east and west Texas, New Mexico, Colorado, Kansas, and Wyoming in the US Western Interior, the German Federal Republic, Eastbourne, Sussex, England (field record only), and south-east France (Thomel Collection; OUM KZ 15674). It or an allied form occurs in the Upper Cenomanian *Neocardioceras juddii* Zone in south-west New Mexico (*fide* Cobban 1984*b*, p. 16) and there is a doubtful specimen from the basal Turonian *Pseudaspidoceras flexuosum* Zone in west Texas (Kennedy *et al.* 1987, p. 64, pl. 8, fig. 5).

Worthoceras minor sp. nov.

Plate 21, figs. 1–10, 13, 14, 25

1951 *Worthoceras* Adkins and Lozo, p. 155.

Types. Holotype, TMM 1629TX/1; paratypes, TMM 1629TX/2–10 from the South Bosque Formation, east bank of Lake Waco, McLennan County, *Prionocyclus hyatti* Zone.

Material. Numerous specimens from the South Bosque Formation: five specimens from Locality TMM 1630TX, 'Tater Hill Creek, 2 feet above waterfall limestone'; six specimens from Locality TMM 1631TX, 'Anthill 1, 13 feet above top of Cloice, Brickyards' (on Cement Plant Creek); seventy specimens from Locality TMM 1633TX, 'Anthill B, 17·5 ft. above waterfall ls., Cloice Branch'; thirty-seven specimens from Locality TMM 1632TX, 'Anthill B, South Bosque, 20 ft. above waterfall ls., Cement Plant Creek'; eighty specimens from Locality TMM 1634TX, 'Anthill A, 33·5 feet above waterfall, Cloice Branch', all in McLennan County; USNM 420176 from USGS Mesozoic Locality D9437, Arcadia Park Formation, road cut on State Highway 121 in top of hill just south of Timber Creek, 2 miles south of Lewisville, Denton County; all *P. hyatti* Zone.

Description. Very small; largest microconch seen 9·9 mm long; largest macroconch 14·5 mm long. Spire very evolute, whorls with shallow dorsal impressed zone, low, flattened umbilical wall, narrowly rounded umbilical shoulder, flattened flanks, broadly rounded ventrolateral shoulder and venter; whorl section varies from compressed to depressed. Some specimens are smooth; others bear weak to strong low, broad ribs. These are prorsiradiate, convex on the inner flank, feebly concave to straight on the outer flank and transverse on the venter; the ribs occasionally bifurcate. Similar ornament is present on the shaft, and equally variable in strength, generally declining on the final hook. None of the specimens preserve the aperture and macroconchs are identified by their broader shaft, which partially conceals the umbilicus of the spire.

Discussion. Size alone distinguishes *W. minor* sp. nov. from the most closely related species, *W. vermiculus*, described above, where microconchs are 12·5–17·5 mm long and macroconchs 15·5–21·4 mm long, while the whorls of the latter are much stouter, the ribs generally weaker and never bifurcate, declining over the venter. The very small specimens of *W.* cf. *vermiculus* from the Lower

---

EXPLANATION OF PLATE 24

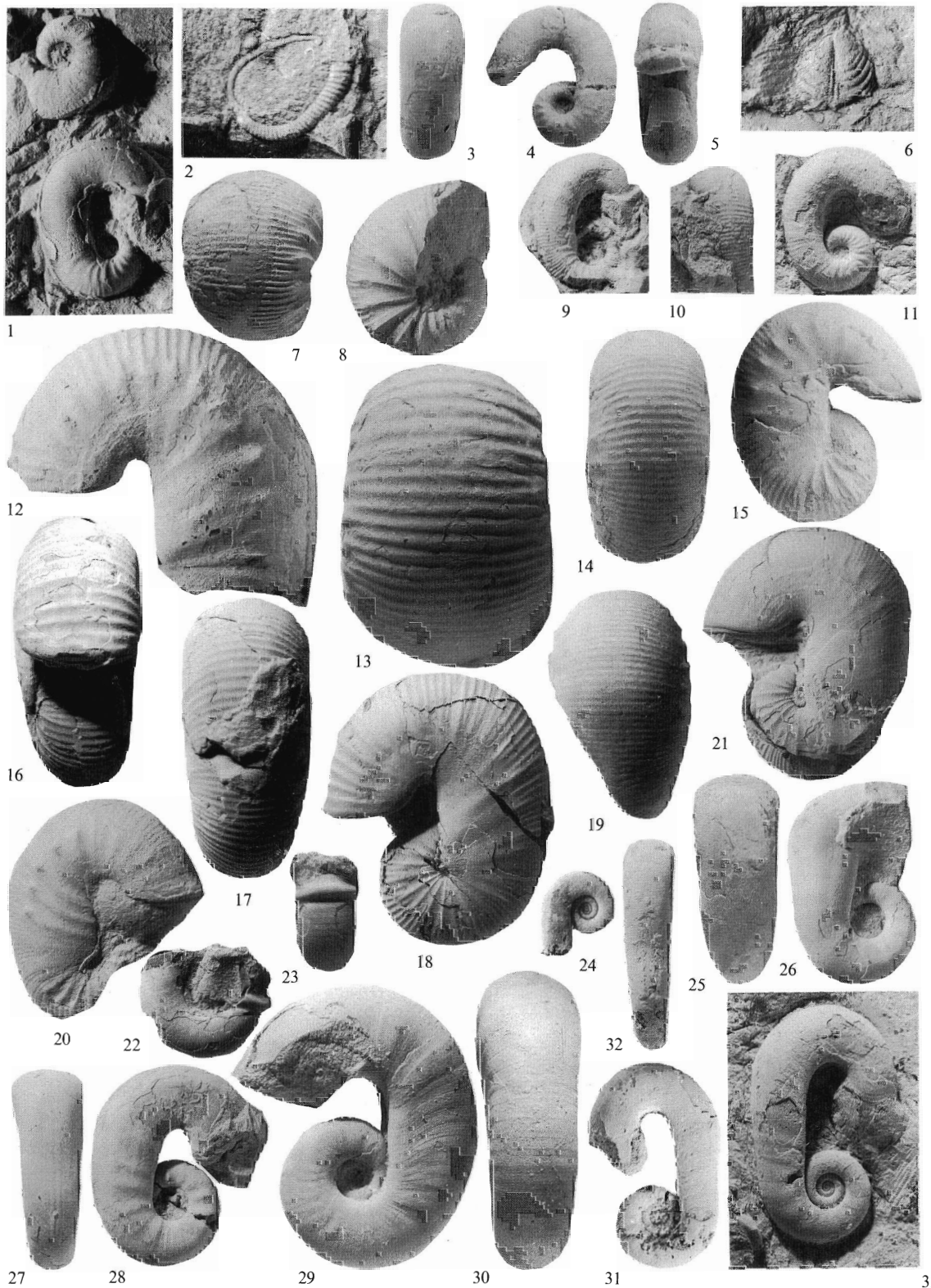
Figs. 1, 3–5, 7–23. *Yezoites delicatulus* (Warren, 1930). 1, 3–5, 9–11, are microconchs, the remainder macroconchs. 1, USNM 411555, from east bank of stream 2·5 miles south of Britton on Old Britton–Midlothian road, Ellis County. 3–5, TMM 19814, the holotype of *Scaphites minutus* Moreman, 1942, from 0·5 miles east of Britton–Midlothian Highway, 2·7 miles south of Britton, Ellis County. 7 and 8, USNM 411556, from Texcrete Quarries, Dallas County. 9, USNM 411557, probably from Dallas County. 10 and 11, USNM 411558, from USGS Mesozoic Locality 22604. 12 and 13, USNM 411559, from the same locality as figs. 7 and 8. 14 and 15, TMM 19813, the holotype of *S. brittonensis* Moreman, 1942, from the same horizon and locality as figs. 3–5. 16–18, USNM 411560, from the same locality as figs. 7 and 8. 19 and 20, USNM 411561, from the same locality as figs. 7 and 8. 21, USNM 411562, from the same locality as figs. 7 and 8. 22 and 23, USNM 411548, from the same locality as figs. 7 and 8.

Fig. 2. *Allocrioceras annulatum* (Shumard, 1860). USNM 411434, from tributary to Newton Branch, 3·75 miles south of Britton on old Britton–Midlothian road, Ellis County.

Fig. 6. Anaptychus, USNM 411564, from USGS Mesozoic Locality D9465, exposures on Valley View Lane, 400 m south of Royal Lane and State Highway 114, Dallas County.

Figs. 24–33. *Worthoceras vermiculus* (Shumard, 1860). 24, 31–33, microconchs; 25–30, macroconchs. 24, USNM 411549; 25 and 26, USNM 411550; 27 and 28, USNM 411551; all from the same locality as figs. 7 and 8. 29 and 30, USNM 411552, from USGS Mesozoic Locality 22609, 1 mile south of intersection of Highways 661 and 287, Ellis County. 31 and 32, USNM 411553, from the same locality as figs. 7 and 8. 33, USNM 411554, from USGS Mesozoic Locality 22606, south of Britton, Ellis County.

All specimens are from the Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation of north-east Texas. Fig. 6 is ×1; others ×2.



KENNEDY, *Yezoites*, *Allocrioceras*, *Worthoceras*, anaptychus

Turonian *Pseudaspidoceras flexuosum* Zone of Trans-Pecos Texas may be closer to the present species than to *vermiculus* (Kennedy *et al.* 1987, p. 64, pl. 8, fig. 9).

Occurrence. *Prionocyclus hyatti* Zone of central Texas and Chispa Summit in Trans-Pecos Texas.

Genus and Subgenus SCAPHITES Parkinson, 1811, p. 145

Type species. *Scaphites equalis* J. Sowerby, 1813, p. 53, pl. 18, figs. 1–3.

Scaphites (*Scaphites*) *carlilensis* Morrow, 1935

Plate 21, figs. 19, 20; Plate 23, figs. 1–7, 13–19, 22–25.

1928 *Scaphites* sp. aff. *aequalis* var. *turonensis* Roman and Mazerin, 1920; Adkins, p. 258, pl. 24, figs. 1 and 2.
1935 *Scaphites carlilensis* Morrow, p. 466, pl. 50, fig. 4.
1935 *Scaphites pygmaeus* Morrow, p. 465, pl. 50, fig. 2.
1942 *Scaphites arcadiensis* Moreman, p. 216, pl. 34, fig. 3.
1942 *Scaphites pygmaeus* Morrow; Moreman, p. 216, pl. 34, figs. 5 and 6.
1949 *Scaphites morrowi* Jeletzky, p. 330.
1952 *Scaphites arcadiensis* Moreman; Cobban, p. 21, pl. 2, figs. 1–8.
1952 *Scaphites carlilensis* Morrow; Cobban, p. 21, pl. 2, figs. 9–23.
1952 *Scaphites morrowi* Jeletzky; Cobban, p. 21.
1962 *Scaphites carlilensis* Morrow; Hattin, p. 79, pl. 23, figs. B–D, G, H.
1965 *Scaphites carlilensis* Morrow; Hattin, fig. 4.1.
1977 *Scaphites carlilensis* Morrow; Kauffman, pl. 22, figs. 3 and 4.
1978 *Scaphites carlilensis* Morrow; Hattin, fig. 8.10.
1978 *Scaphites carlilensis* Morrow; Hattin and Siemers, fig. 10.10.
1978 *Scaphites* (*Scaphites*) *arcadiensis* (M) Moreman; Crick, p. 9, pl. 1, figs. 1–3.
1978 *Scaphites* (*Scaphites*) *arcadiensis* (M) Moreman; Crick, p. 10, pl. 1, figs. 4 and 5.
1978 *Scaphites* (*Scaphites*) *carlilensis* (M) Morrow; Crick, p. 12, pl. 1, figs. 6 and 7.
1978 *Scaphites* (*Scaphites*) *carlilensis* (M) Morrow; Crick, p. 12, pl. 1, figs. 8–10.
1978 *Scaphites* (*Scaphites*) *hattini* (M) Crick, p. 13, pl. 2, figs. 1–3.
1978 *Scaphites* (*Scaphites*) *hattini* (m) Crick, p. 14, pl. 2, figs. 4 and 5.
1978 *Scaphites* (*Scaphites*) *mitchellensis* (M) Crick, p. 15, pl. 2, figs. 6 and 7.
1978 *Scaphites* (*Scaphites*) *mitchellensis* (m) Crick, p. 15, pl. 2, figs. 8 and 9.
1978 *Scaphites* (*Scaphites*) *inflexus* (M) Crick, p. 16, pl. 2, figs. 10 and 11.
1978 *Scaphites* (*Scaphites*) *inflexus* (m) Crick, p. 17, pl. 2, figs. 12 and 13.

Types. The holotype of *S. carlilensis* is the original of Morrow 1935, pl. 50, fig. 4, from the top of the Blue Hill Shale of Mitchell County, Kansas, *P. hyatti* Zone. The holotype of *S. pygmaeus* is the original of Morrow 1935, pl. 50, fig. 2, from the same horizon and locality; both are in the Geology Museum of the University of Kansas, Lawrence. The holotype of *S. arcadiensis* is the original of Moreman 1942, pl. 34, fig. 3, TMM 19828, from the Arcadia Park Formation, 1 mile south of Arcadia Park, Dallas County, *P. hyatti* Zone. The holotype of *S. minutus* is the original of Moreman 1942, pl. 34, figs. 5 and 6, TMM 19815, Eagle Ford Condensed Zone, University of Texas Campus, Austin, Travis County, *P. hyatti* Zone.

Material. More than fifty specimens in the OUM, TMM, USGS, USNM, and Conlin collections, not listed separately. The species occur widely in the *P. hyatti* Zone faunas of the Arcadia Park Formation in the Dallas area and in the Eagle Ford Condensed Zone in the Austin area.

Description. Macroconchs are up to 37·5 mm long. Spire very involute, with depressed, reniform whorl section. Coarse primary ribs, six to seven per half whorl, arise at the umbilical seam and strengthen over the inner flank. They bifurcate around mid-flank, while there are occasional intercalated ribs; all ribs strengthen over the venter, where they are sharp, narrow, and separated by slightly wider interspaces. The umbilical wall of the shaft partially conceals the umbilicus of the spire. Shaft decorated by coarse, prorsiradiate primary ribs that are markedly convex, bifurcating just outside mid-flank, where occasional intercalated ribs are inserted. All ribs strengthen over the venter, where they are generally transverse. Umbilical and inner flank ribbing declines on the final hook.

Microconchs are up to 25 mm long. Spire ornament is as in the macroconch. On the shaft, which does not occlude the umbilicus of the spire, there are very distant coarse, prorsiradiate flank ribs that bifurcate outside mid-flank and coarsen over the venter, where they are transverse.

Discussion. Co-occurring macroconchs and microconchs are referred to *S. arcadiensis* and *S. minutus* in Texas and *S. carlilensis* and *S. morrowi* (= *pygmaeus* Morrow, 1935 *non* Holzapfel, 1888) in the US Western Interior. I can see no significant differences between the two occurrences and regard them as one and the same species. I also regard all of the *S.* (*Scaphites*) from the Blue Hill Member of the Carlile Shale of Kansas described by Crick (1978) as no more than variants of this species. The very coarse ribbing of *S.* (*S.*) *carlilensis* readily distinguishes it from all other North American mid-Cretaceous species.

Occurrence. P. hyatti Zone of north-east, central, and Trans-Pecos Texas, New Mexico, Kansas and northwards to north-west central Montana.

Scaphites larvaeformis Meek and Hayden, 1859

1859 *Scaphites larvaeformis* Meek and Hayden, p. 58.
1925 *Scaphites larvaeformis* Meek and Hayden; Diener, p. 200 (with synonymy).
1952 *Scaphites larvaeformis* Meek and Hayden; Cobban, p. 19, pl. 1, figs. 4–15 (with synonymy).
1952 *Scaphites larvaeformis* Meek and Hayden var. *obesus* Cobban, p. 20, pl. 1, figs. 16–22.
1956 *Scaphites larvaeformis* Meek and Hayden; Cobban, Rohrer, and Erdmann, text-fig. 1A.
1960 *Scaphites larvaeformis* Meek and Hayden; Easton, fig. 11.28, 1*a*, *b*.
1977 *Scaphites larvaeformis* Meek and Hayden; Kennedy, text-fig. 18.3, 4.
1977 *Scaphites larvaeformis* Meek and Hayden; Kauffman, pl. 23, figs. 1 and 2.
1987 *Scaphites larvaeformis* Meek and Hayden; Landman, p. 225.

Holotype. By monotypy, USNM 229, from the Middle Turonian, *Collignoniceras woollgari* Zone fauna of the Black Hills.

Material. OUM KT4095, an external mould from the *C. woollgari* Zone, Kamp Ranch Limestone Member of the Arcadia Park Formation, temporary excavations on Loop 12, east of Furlong Road, just south of Route 80, west of Dallas, Dallas County.

Discussion. The specimen shows part of the spire and straight shaft. The former bears convex prorsiradiate primary ribs that increase by branching and intercalation around mid-flank. The latter bears strongly convex distant primary ribs that bifurcate around mid-flank from bullate swellings and loop across outer flank and venter, accompanied by intercalatories. The specimen closely matches the original of Cobban 1952, pl. 1, figs. 8–12, a microconch. The macroconch of the species is represented by var. *obesus* Cobban, 1952 (p. 20, pl. 1, figs. 16–22).

Occurrence. This is a *C. woollgari* Zone species known from Montana, Kansas, north-east Wyoming, South Dakota, and now from north-east central Texas.

Subgenus PTEROSCAPHITES Wright, 1953

Type species. Scaphites auriculatus Cobban, 1952, p. 30, pl. 10, figs. 11–17; by original designation.

Scaphites (*Pteroscaphites*) *inaffectus* Crick, 1979

Plate 23, figs. 11 and 12

1979 *Scaphites* (*Pteroscaphites*) *inaffectus* Crick, p. 99, text-fig. 2*a–c*.

Holotype. By monotypy; University of Kansas Museum of Invertebrate Palaeontology Collections no. 105819, from the *P. hyatti* Zone, Carlile Shale of Kansas.

Material. USNM 420175, from the *P. hyatti* Zone fauna of the Arcadia Park Formation, slopes of Ten Mile Creek Valley, south-east of Cedar Hill–Duncanville road, midway between the two towns, Dallas County.

Description. Specimen is a complete adult microconch 10 mm long. Spire with depressed coronate whorl section, marked angulation between flattened flank and broadly rounded venter. Inner flank smooth, venter crossed by low, broad, blunt convex ribs. Three nodes develop on the last part of the spire, linked over the venter by pairs of ribs. Shaft straight, short; where shell surface is preserved the venter bears low, broad, transverse ribs, which strengthen around the final hook. A strong primary flank rib appears at the beginning of the final hook, giving rise to three of the ventral ribs, while the other, finer ribs also extend down the flank. Apertural margin not preserved.

Discussion. This specimen has a short shaft, tuberculate spire, and strong ribbing on the final hook, all features differentiating it from microconchs of *Yezoites delicatulus* from the Texas Cenomanian–Turonian. Rather it is a *Pteroscaphites* conspecific with the monotypic *S.* (*Pteroscaphites*) *inaffectus* Crick, 1979. Differences between this and other species are fully reviewed by Crick, to whom reference should be made.

Occurrence. Prionocyclus hyatti Zone of Kansas and north-east Texas.

Genus YEZOITES Yabe, 1910, p. 167

[= *Otoscaphites* Wright, 1953, p. 476; *Hyposcaphites* Wiedmann, 1965, p. 436]

Type species. Scaphites perrini Anderson, 1902, p. 114, pl. 2, figs. 71–73, by the subsequent designation of Diener (1925, p. 213).

Yezoites delicatulus (Warren, 1930)

Plate 24, figs. 1, 3–5, 7–21

1930 *Scaphites delicatulus* Warren, p. 66, pl. 3, fig. 3; pl. 4, figs. 7 and 8.
1942 *Scaphites brittonensis* Moreman, p. 215, pl. 34, figs. 1 and 2; text-fig. 2*r*.
1942 *Scaphites minutus* Moreman, p. 216, pl. 34, figs. 9 and 10; text-fig. 2*s*.
non 1947 *Scaphites delicatulus* Warren; Warren, p. 123, pl. 29, fig. 5.
non 1952 *Scaphites delicatulus* Warren var. *greenhornensis* Cobban, p. 18, pl. 1, figs. 1–3.
1952 *Scaphites minutus* Moreman; Cobban, p. 23.
non 1953 *Otoscaphites minutus* Moreman; Wright, p. 475.
1961 *Scaphites delicatulus* Warren; Cobban and Gryc, p. 182, pl. 37, figs. 16–24; text-fig. 2*a–c*.
1965 *Otoscaphites minutus* (Moreman); Clark, p. 63, pl. 4, figs. 5–7; text-fig. 22*c*.
1965 *Scaphites* (*Pteroscaphites*) *minutus* Moreman; Wiedmann, p. 435, pl. 5, fig. 5; text-fig. 6*b*.
non 1983 *Scaphites delicatulus sloani* Cobban, p. 8, pl. 5, figs. 12–15, 18–23.
1983 *Otoscaphites seabeensis* Cobban and Gryc; Cobban, p. 11, pl. 5, figs. 6–11, 16, 17.
1984*b* *Scaphites* (*Pteroscaphites*) *minutus* Moreman; Cobban, p. 16, pl. 2, fig. 9.

Types. The syntypes of *S. delicatulus* are in the Collections of the University of Alberta Geological Museum, and are from the Smoky River Shale, precise age unknown, in the Peace River area of west central Alberta. The lectotype, here designated is no. 419, the original of Warren 1930, pl. 4, figs. 7 and 8. The holotype of *S. brittonensis* is TMM 19813 (Pl. 24, figs. 16 and 17), from the Upper Cenomanian *Sciponoceras gracile* Zone, Britton Formation, 0·5 miles east of the Britton–Midlothian highway, 2·7 miles south of Britton, Ellis County, Texas. The holotype of *Scaphites minutus* Moreman, 1942 (Pl. 24, figs. 4–6) is TMM 19814, from the same horizon and locality as the previous specimen.

Material. More than fifty specimens. JPC unregistered (numerous specimens) and OUM KT 1694, from the Britton Formation, Upper Cenomanian *Sciponoceras gracile* Zone, Texcrete Quarries, Dallas County; four specimens from the same horizon at USGS Mesozoic Locality 22604 (ex Renfro Collection), first creek north-east of Britton, 2·5 miles on farm road, Ellis County. Numerous imprecisely localized specimens in the Conlin Collection.

Description. Microconchs 10–12 mm long (Pl. 24, figs. 1, 3–5, 9–11). Spire with depressed whorls, broad umbilicus, umbilical wall inclined outwards. Ornamented by numerous primary ribs of variable strength, prorsiradiate on inner flank, flexed back and concave on outer flank, dividing into two to three secondaries with additional intercalatories. Shaft of body-chamber very depressed, with broadly rounded venter. Flanks and venter ornamented by feeble, prorsiradiate ribs that increase by division and intercalation to give venter covered in delicate weak, transverse ribs that vary from distinct where shell is present (Pl. 24, figs. 9–11) to nearly invisible

on the mould (Pl. 24, figs. 3–5). Aperture preceded by weak constriction and strong collar, with prominent lateral lappets (Pl. 24, figs. 1, 9, 11, 22, 23).

Macroconchs (Pl. 24, figs. 7, 8, 12–21) 17–30 mm long. Spire with depressed coronate whorls, strong primary ribs that branch on the outer flank where intercalatories are inserted, giving venter covered by fine, dense ribs (Pl. 24, fig. 7). Shaft and hook of body-chamber much stouter and more robust than in microconch. Flank ribs straight, prorsiradiate, distant, well differentiated (Pl. 24, fig. 20) to obsolete (Pl. 24, fig. 21), increasing by division and intercalation over venter, with strong (Pl. 24, figs. 12, 15, 20), weak (Pl. 24, fig. 21), or no (Pl. 24, fig. 18) feebly bullate tubercles at point of division on last part of body-chamber.

Discussion. Microconchs are much rarer than macroconchs and show much less range of variation. The exact age of the holotype is unknown, but it agrees in size, whorl proportions, and ornament with present material. *Scaphites delicatulus greenhornensis* Cobban, 1952 (p. 18, pl. 1, figs. 1–3) was separated from *delicatulus* because of the smaller size, pointed tubercles, and uniform spacing of ribs over the whole of the body-chamber. It is younger than the present material, coming from the Lower Turonian. Other specimens occur in the *Fagesia*-dominated *Pseudaspidoceras flexuosum* Zone fauna of Montana (USGS Mesozoic Locality 20937) and are all coarser ribbed than the present collection. *S. subdelicatulus* Cobban and Gryc, 1961 (p. 179, pl. 37, figs. 1–15) of which *Otoscaphites perrini* (Anderson, 1902) of Cobban and Gryc (1961, p. 183, pl. 38, figs. 1–12) is the microconch, is imprecisely dated but close to the present material in age, if not actually contemporary with it. Macroconchs are 17·8–33 mm long, microconchs 11·5–15 mm long. The macroconchs have bullae rather than the tubercles of *delicatulus* and a much more depressed, reniform whorl section (Wb : Wh up to 1·5) while the microconchs reach a much larger size and have again a very depressed whorl section when compared to the present material.

The Alaskan *S. delicatulus* of Cobban and Gryc (1961, p. 182, pl. 37, figs. 16–24; text-fig. 2*a*, *b*, *c*) are Lower Turonian and younger than the present material and reach a much larger size (up to 45 mm: USGS 26560). The whorls of the spire are very depressed and coronate with strong ribs on the inner flank, strong flank tubercles, and ventral ribs. The associated microconch, *O. seabeensis* Cobban and Gryc, 1961 reaches 20 mm in length and is utterly different from the present material, with a remarkable coronate spire, very depressed body-chamber with wide concave umbilical wall meeting the flank at a sharp ridge, and strong tubercles on that ridge. This material differs from the Texas material and the name *seabeensis* is available. This name should probably also be applied to the Middle Turonian material from Minnesota described by Cobban (1983), where similar microconchs (described as *O. seabeensis*—loc. cit., p. 11, pl. 5, figs. 6–11, 16, 17) occur with macroconchs up to 37 mm long. The latter, described as *S. d. sloani* Cobban, 1983 (p. 8, pl. 5, figs. 12–15, 18–23), have strong inner flank primary ribs, and were differentiated from other forms by a smooth area separating primary ribs from weak tubercles, although later collecting has revealed a specimen without this smooth zone that overlaps with the Alaskan material and the large specimen figured as *S. delicatulus* by Warren in 1947 (p. 123, pl. 29, fig. 5—38 mm long).

The sequence *subdelicatulus/perrini* (oldest) → *delicatulus greenhornensis subdelicatulus/seabeensis* → *subdelicatulus sloani/seabeensis* (youngest) seem to be an evolving lineage linked by their distinctive dimorphism and ornament, notably depressed whorls and strong lateral carina on the body-chamber. They are probably to be regarded as subspecies of a long-ranging species of which *perrini* Anderson, 1902 (p. 114, pl. 2, figs. 71–73) is the oldest name. All differ in detail, especially in the form of the microconchs, from the Texas *gracile* Zone material and for the present I retain it as a separate species, using Warren's name.

Occurrence. Upper Cenomanian, *Sciponoceras gracile* Zone, Britton Formation in north-east Texas. The types, from Alberta, are imprecisely dated.

Yezoites cf. delicatulus (Warren, 1930)

Plate 23, figs. 20 and 21

Material. USNM 420174, from the *Prionocyclus hyatti* Zone fauna of the Arcadia Park Formation, slopes of Ten Mile Creek Valley, south-east of Cedar Hill–Duncanville road, midway between the two towns, Dallas County.

Discussion. Yezoites delicatulus and the problems surrounding it are reviewed above. The present specimen is a near-complete adult microconch 12 mm long. The spire is coronate, with strong, distant prorsiradiate primaries that strengthen into incipient bullae around mid-flank, where they bifurcate and, accompanied by intercalatories, cross the venter in a broad convexity. Ornament declines markedly on the body-chamber, the mould of which shows delicate ribbing, most obvious on the venter but declining on the first part of the final hook. The specimen closely resembles the holotype of *Scaphites minutus* Moreman, 1942 (p. 216, pl. 34, figs. 9 and 10; text-fig. 25; see Wiedmann 1965, pl. 58, fig. 5). If correctly identified, the present specimen extends the range of the species group into the *P. hyatti* Zone.

Occurrence. As for material.

Incertae Sedis

Plate 4, fig. 3; Plate 24, fig. 6

Material. USNM 411563, from the Britton Formation, Upper Cenomanian, *Sciponoceras gracile* Zone, tributary to Newton Branch, 3·75 miles south of Old Britton–Midlothian road, Ellis County. USNM 411564, from the same horizon at USGS Mesozoic Locality D9465, exposures along Valley View Lane 400 m south of Royal Lane and State Highway 114, Dallas County.

Remarks. These well-preserved unmineralized ammonite jaws are the only specimens known from the Britton. They closely resemble contemporaneous specimens from the Plenus Marls of Merstham, Surrey and Folkestone, Kent in southern England. The identity of the associated ammonite genus is unknown.

Occurrence. As for material.

Acknowledgements. I thank J. M. Hancock, R. Parish, and P. Scholle for assistance in the field, W. A. Cobban and C. W. Wright for valuable discussion and the staff of the Geological Collections, Oxford University Museum and Department of Earth Sciences, Oxford, for technical assistance. The financial support of the Natural Environment Research Council, Royal Society, and Lindemann Trust (English Speaking Union) is gratefully acknowledged.

REFERENCES

ADKINS, W. S. 1920. The Weno and Pawpaw Formations of the Texas Comanchean. *Bull. Univ. Tex.* **1856,** 1–177, pls. 1–11 (misdated 1918).

—— 1928. Handbook of Texas Cretaceous fossils. Ibid. **2838,** 1–383, pls. 1–37.

—— 1931. Some Upper Cretaceous ammonites in western Texas. Ibid. **3101,** 35–72, pls. 2–5.

—— 1933. Mesozoic Systems in Texas. *In* SELLARDS, E. H., ADKINS, W. S. and PLUMMER, F. B. (eds.) The Geology of Texas, vol. 1, stratigraphy. Ibid. **3232,** 240–518.

—— 1949. Eagle Ford Condensed Zone in Travis County, Texas. *Guidebook, 17th Annual Field Meeting, Shreveport Geological Society*, 95–98.

—— and LOZO, F. E. 1951. Stratigraphy of the Woodbine and Eagle Ford, Waco area, Texas. *In* LOZO, F. E. and PERKINS, B. F. (eds.). The Woodbine and adjacent strata of the Waco area of central Texas. A symposium. *Fondren Sci. Ser.* **4,** 101–169, pls. 1–6.

—— and WINTON, W. M. 1920. Palaeontological correlation of the Fredricksburg and Washita formations in north Texas. *Univ. Texas Bull.* **1945,** 1–128, pls. 1–22.

ANDERSON, F. M. 1902. Cretaceous Deposits of the Pacific Coast. *Proc. Calif. Acad. Sci.* (3) Geol. **2,** 1–154, pls. 1–12.

ARKHANGUELSKY, A. D. 1916. The Upper Cretaceous Molluscs of Turkestan. Part I. *Trudy geol. kom.* **152,** 1–57, pls. 1–8. [In Russian.]

AVNIMELECH, M. A. and SHORESH, R. 1962. Les cephalopodes cénomaniens des environs de Jérusalem. *Bull. Soc. géol. Fr.* (7) **4,** 528–535, pl. 15.

BARROIS, C. and GUERNE, J. DE. 1878. Description de quelques espèces nouvelles de la Craie de l'Est du Bassin de Paris. *Annls. Soc. géol. N.* **5,** 42–64, 3 pls.

BASSE, E. 1940. Les cephalopodes crétacés des massifs côtiers syriens. Part 2. *Notes Mém. Haute Com. Syrie-Liban*, **3,** 411–472, pls. 1–9.

—— 1952. Ammonoïdes. *In* PIVETEAU, J. (ed.). *Traité de Paléontologie*, **2,** 522–555; 581–688, 24 pls. Paris.

BAYLE, É. 1878. Fossiles principaux des terrains. *Explication de la Carte Géologique de France*, **4** (1), (Atlas), 158 pls. Service de la Carte Géologique detailée, Paris.

BESKOVSKI, S. 1977. Sur la classification de la famille Desmoceratidae Zittel, 1895 (Ammonoidea, Crétacé). *C.r. Acad. Bulg. Sci.* **30,** 891–894.

BODYLEVSKYA, V. I. and SHULINGA, N. I. 1958. Jurassic and Cretaceous faunas of the lower Yenesei River, USSR. *Trudy nauchno-issled. Inst. Geol. Arkt.* **93,** 1–196. [In Russian.]

BÖHM, J. 1895. Review of A. de Grossouvre: Recherches sur la craie supérieure. 2nd part. *Neues Jb. Min. Geol. Paläont.* **1895,** 2, 360–366. [In German.]

—— 1898. Uber *Ammonites pedernalis* V. BUCH. *Z. dt. geol. Ges.* **1898,** 183–201, pls. 5–7.

BREISTROFFER, M. 1947. Notes de nomenclature paléozoologiques. *Proc. verb. mens. Soc. Sci. Dauphiné*, **26** (195), 5 pp. (unpaginated).

—— 1953. Commentaires taxonomiques. *In* BREISTROFFER, M. and DE VILLOUTREYS, O. Les ammonites albiennes de Peille (Alpes-Maritimes). *Trav. Lab. géol. Grenoble*, **30,** 69–75 (1952 imprint).

BROWN, C. W. and PIERCE, R. L. 1962. Palynologic correlations in Cretaceous Eagle Ford Group, northeast Texas. *Bull. Am. Ass. Petrol. Geol.* **46,** 2133–2147.

BRUNNSCHWEILER, R. O. 1966. Upper Cretaceous ammonites from the Carnarvon Basin of Western Australia. 1. The heteromorph Lytoceratina. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* **58,** 1–58, pls. 1–8.

CASEY, R. 1960. *Hengestites*, a new genus of Gault ammonites. *Palaeontology*, **2,** 200–209, pl. 29.

—— 1965. A monograph of the Ammonoidea of the Lower Greensand. Part 6. *Palaeontogr. Soc.* [*Monogr.*], 399–546, pls. 69–70.

CHIPLONKAR, G. W. and GHARE, M. A. 1976. Palaeontology of the Bagh Beds—Part VII: Ammonoidea. *Bull. Earth Sci.* (for 1976), **4** and **5,** 1–10, 2 pls.

———— 1977. Palaeontology of the Bagh beds: part X—Scaphitidae. *Proc. Indian Acad. Sci.* **85B,** 67–76, 2 pls.

CLARK, D. L. 1960. *Parapuzosia* in the north Texas Cretaceous. *Jl Paleont.* **34,** 233–236, pl. 34.

—— 1965. Heteromorph ammonoids from the Albian and Cenomanian of Texas and adjacent areas. *Mem. geol. Soc. Am.* **95,** 1–99, pls. 1–24.

COBBAN, W. A. 1952. Scaphitoid cephalopods of the Colorado group. *US geol. Surv. Prof. Pap.* **239,** 1–42, pls. 1–21 (1951 imprint).

—— 1953*a*. Cenomanian ammonite fauna from the Mosby Sandstone of central Montana. Ibid. **243-D,** 45–55, pls. 6–12.

—— 1953*b*. A new species of *Prionocyclus* from Upper Cretaceous Carlile shale. *Jl Paleont.* **27,** 353–355, pl. 48.

—— 1961. The ammonite family Binneyitidae Reeside in the Western Interior of the United States. Ibid. **35,** 737–758, pls. 87–89.

—— 1969. The late Cretaceous Ammonites *Scaphites leei* Reeside and *Scaphites hippocrepis* (DeKay) in the Western Interior of the United States. *US geol. Surv. Prof. Pap.* **619,** 1–27, pls. 1–5.

—— 1972. New and little-known ammonites from the Upper Cretaceous (Cenomanian and Turonian) of the Western Interior of the United States. Ibid. **699,** 1–24, pls. 1–18 (1971 imprint).

—— 1973. The late Cretaceous ammonite *Trachyscaphites pulcherrimus* (Roemer) in New Jersey and Texas. *Jl Res. US geol. Surv.* **1,** 695–700.

—— 1976. Ammonite record from the Mancos Shale of the Castle Valley–Woodside area, east-central Utah. *Brigham Young Univ. geol. Stud.* **22,** 117–126, 2 pls.

—— 1977. Characteristic marine molluscan fossils from the Dakota Sandstone and intertongued Mancos Shale, west-central New Mexico. *US geol. Surv. Prof. Pap.* **1009,** 1–30, pls. 1–29.

—— 1983. Molluscan fossil record from the northeastern part of the Upper Cretaceous seaway, western interior. Ibid. **1271,** 1–24, pls. 1–15.

—— 1984*a*. Mid-Cretaceous ammonite zones, Western Interior, United States. *Bull. geol. Soc. Denmark*, **33,** 71–89.

—— 1984*b*. Molluscan record from a mid-Cretaceous borehole in Weston County, Wyoming. *Prof. Pap. US geol. Surv.* **1271,** 1–24, pls. 1–5.

—— 1986. Upper Cretaceous molluscan record from Lincoln County, New Mexico. In *Southwestern Section of AAPG Transactions and Guidebook of 1986 convention*, 77–89. New Mexico Bureau of Mines and Mineral Resources, Socorro.

—— 1987. The Upper Cretaceous (Cenomanian) ammonites *Metengonoceras dumbli* (Cragin) and *M. acutum* Hyatt. *Bull. US geol. Surv.* **1690,** C1–C7, 3 pls.

——and GRYC, G. 1961. Ammonites from the Seabee formation (Cretaceous) of northern Alaska. *Jl Paleont.* **35,** 176–190, pls. 37–38.

——and HOOK, S. C. 1980*a*. The Upper Cretaceous (Turonian) ammonite family Coilopoceratidae Hyatt from the western interior of the United States. *US Geol. Surv. Prof. Pap.* **1192,** 1–28, pls. 1–21.

————1980*b*. *Collignoniceras woollgari woollgari* (Mantell) ammonite fauna from Upper Cretaceous of Western Interior, United States. *Mem. Inst. Min. Technol. New Mex.* **37,** 1–51, pls. 1–12 (1979 imprint).

————1983. Mid-Cretaceous (Turonian) ammonite fauna from Fence Lake area, west-central New Mexico. Ibid. **41,** 1–50, pls. 1–14.

——ROHRER, W. L. and ERDMANN, C. E. 1956. Discovery of the Carlile (Turonian) ammonite *Collignoniceras woollgari* in northwestern Montana. *Jl Paleont.* **30,** 1269–1272.

——and SCOTT, G. R. 1964. Multinodose scaphitid cephalopods from the lower part of the Pierre Shale and equivalent rocks in the conterminous United States. *Prof. Pap. US geol. Surv.* **483-E,** 1–13, pls. 1–4.

————1973. Stratigraphy and ammonite fauna of the Graneros Shale and Greenhorn Limestone near Pueblo, Colorado. Ibid. **645,** 1–108, pls. 1–41 (1972 imprint).

COLLIGNON, M. 1937. Ammonites Cénomaniennes du sud-ouest de Madagascar. *Annls. géol. Serv. Min. Madagascar*, **8,** 29–72, pls. 1–11.

——1965*a*. *Atlas des fossiles caractéristiques de Madagascar* (*Ammonites*) XII (*Turonien*), iv+82 pp., pls. 376–413. Service Géologique, Tananarive.

——1965*b*. *Atlas des fossiles caractéristiques de Madagascar* (*Ammonites*), XII (*Coniacian*), vii+88 pp., pls. 414–454. Service Géologique, Tananarive.

CONRAD, T. A. 1855. Descriptions of eighteen new Cretaceous and Tertiary fossils. *Proc. Philadelphia Acad. Nat. Sci.* **7,** 265–268.

COOPER, M. R. 1978. Uppermost Cenomanian–basal Turonian ammonites from Salinas, Angola. *Ann. S. Afr. Mus.* **75** (5), 51–152.

CRAGIN, F. W. 1893. A contribution to the invertebrate paleontology of the Texas Cretaceous. *Tex. geol. Surv.* 4th Annual Report (1892), 139–246, pls. 24–46.

CRICK, R. 1978. Morphological variation in the ammonite *Scaphites* of the Blue Hill Member, Carlile Shale, Upper Cretaceous, Kansas. *Paleont. Contr. Univ. Kansas*, **88,** 1–28, 2 pls.

——1979. A pteroscaphitid (Cephalopoda, Ammonoidea) from the Upper Cretaceous (Turonian) of Kansas. *Jl Paleont.* **53,** 98–102.

DACQUÉ, E. 1939. Die fauna der Regensburg-Keltheimer Oberkreide (mit ausschluss der Spongien und Bryozoen). *Abh. Bayer. Akad. Wiss.* NS **45,** 1–218, pls. 1–17.

DANE, C. H., PIERCE, W. G. and REESIDE, J. B. 1937. The stratigraphy of the Upper Cretaceous rocks north of the Arkansas River in eastern Colorado. *US geol. Surv. Prof. Pap.* **186-K,** 207–232.

DEKAY, J. E. 1828. Report on several fossil multilocular shells from the state of Delaware: with observations on a second specimen of the new fossil genus EURYPTERUS. *Ann. Lyceum nat. Hist.* **2,** 273–279, pl. 5, figs. 2–5 only.

DIENER, C. 1925. Ammonoidea neocretacea. *Fossilium Cat.* (1: Animalia), **29,** 1–244.

DOUVILLÉ, H. 1879. Note accompagnant le présentation de l'Atlas de t. iv de l'explication de la carte géologique de France de E. Bayle & R. Zeiller. *Bull. Soc. géol. Fr.* (3) **7,** 91–92.

——1890. Sur la classification des ceratites de la Craie. Ibid. (3) **18,** 275–292.

——1912. Évolution et classification des Pulchelliidés. Ibid. (4) **11,** 285–320 (1911 imprint).

——1931. Contribution à la géologie de l'Angola. Les ammonites de Salinas. *Bolm. Mus. Lab. miner. geol. Univ. Lisb.* **1,** 17–46, pls. 1–4.

EASTON, W. H. 1960. *Invertebrate Palaeontology*, xii+701 pp. Harper, New York.

FERAY, D. E. and YOUNG, K. 1949. Walnut Creek, Watters Park area, Travis County, Texas. Bureau of Economic Geology Locality 226-T-37 etc. *Guidebook, 17th Annual Field Meeting, Shreveport Geological Society*, 33–38.

FIEBER, F. X. 1853. Synopsis der europäischen Orthopteren mit besonderes Rücksicht der Böhmischen Arten. *Lotos*, **3,** 90–104, 115–129, 138–154, 168–176, 184–188, 201–207, 232–238, 252–261.

FÖRSTER, R., MEYER, R. and RISCH, H. 1983. Ammoniten und planktonische Foraminiferen aus den Eibrunner Mergeln (Regensburger Kreide, Nordöstbayern). *Zitteliana*, **10,** 123–141, 3 pls.

GILBERT, G. K. 1896. The underground water of the Arkansas Valley in eastern Colorado. *17th Rep. US geol. Surv.* Part 2, 551–601.

GILL, T. 1871. Arrangement of the Families of Mollusks. *Smithson, misc. Collns.* **227,** xvi+49 pp.

GRABAU, A. W. and SHIMER, H. W. 1910. *North American Index Fossils; Invertebrates*, **2,** xv+909 pp. A. G. Seiler and Co., New York.

GROSSOUVRE, A. DE. 1894. Recherches sur la craie supérieure. 2, Paléontologie. Les ammonites de la craie supérieure. *Mém. Serv. Cart géol. dét. Fr.* 264 pp., 39 pls. (1893 imprint).

——1912. Le Crétacé de la Loire-Inférieure et de la Vendée. *Bull. Soc. Sci. nat Ouest Fr.* (3), **2,** 1–38, pls. 1–3.
HAAS, O. 1946. Intraspecific variation in, and ontogeny of, *Prionotropis woollgari* and *Prionocyclus wyomingensis*. *Bull. Amer. Mus. nat. Hist.* **86,** 141–224, 24 pls.
HATTIN, D. E. 1962. Stratigraphy of the Carlile Shale (Upper Cretaceous) in Kansas. *Bull. Kans. geol. Surv.* **156,** 1–155, 27 pls.
——1965. *Upper Cretaceous stratigraphy, paleontology, and paleoecology of western Kansas*, 69 pp. State Geological Survey of Kansas, field conference guidebook for the Geological Society of America.
——1975. Stratigraphy and depositional environment of Greenhorn Limestone (Upper Cretaceous) of Kansas. *Bull. Kansas Univ. geol. Surv.* **209,** 1–128, 10 pls.
——1978. Upper Cretaceous stratigraphy, paleontology and paleoecology of western Kansas with a section on the Pierre Shale by W. A. Cobban. *Mount. Geologist*, **14,** 175–218.
——and SIEMERS, C. 1978. *Guidebook. Upper Cretaceous stratigraphy and depositional environments of western Kansas*, 102 pp. Kansas Geological Survey, Lawrence, Kansas.
HEINZ, R. 1935. Unterkreide-Inoceramen von der Kapverden-Insel Maio. *Neues Jb. Miner. Geol. Paläont.* Beil-Bd. **73,** 302–311.
HENDERSON, J. 1908. New species of Cretaceous invertebrates from northern Colorado. *Proc. US natn. Mus.* **34,** no. 1611, 259–264, pl. 13.
HENDERSON, R. A. 1973. Clarence and Raukumara Series (Albian–?Santonian) Ammonoidea from New Zealand. *Jl R. Soc. NZ*, **3,** 71–123.
HERRICK, C. L. and JOHNSON, D. W. 1900*a*. Geology of the Albuquerque Sheet. *Bull. Univ. New Mex. geol. Ser.* **1,** 1–67, 32 pls.
————1900*b*. The Geology of the Albuquerque Sheet. *Bull. Denison Univ. Sci. Labs.* **2,** 175–239, pls. 27–32.
HILL, R. T. 1887. The topography and geology of the Cross Timbers and surrounding regions in northern Texas. *Am. Jl Sci.* (3) **33,** 291–303.
HOEPEN, E. C. N. VAN. 1955. Turonian–Coniacian ammonites from Zululand. *S. Afr. Jl Sci.* **51,** 361–377.
——1968. New Ammonites from Zululand. *Ann. geol. Surv. S. Afr.* **4,** 183–186, 7 pls. (1965 imprint).
HOLZAPFEL, E. 1887–1888. Die Mollusken der Aachener Kreide. *Palaeontographica*, **34,** 29–180, pls. 4–21.
HOOK, S. C. and COBBAN, W. A. 1979. *Prionocyclus novimexicanus* (Marcou)—common Upper Cretaceous guide fossil in New Mexico. *Rep. Inst. Min. Technol. New Mex.* **1977–1978,** 34–42.
————1980. Some guide fossils in Upper Cretaceous Juana Lopez Member of Mancos and Carlile Shales, New Mexico. Ibid. **1978–1979,** 38–49.
————1982. *Spathites puercoensis* (Herrick and Johnson)—common Upper Cretaceous guide fossil in Rio Puerco valley, New Mexico. Ibid. **1980–1981,** 36–39.
HOWARTH, M. K. 1985. Cenomanian and Turonian ammonites from the Novo Redondo area, Angola. *Bull. Br. Mus. nat. Hist.* (Geol.), **39,** 73–105.
HUPSCH, J. W. C. A. F. 1768. *Neue in der Naturgeschichte der Niederdeutschlands gemachte Entdeckungen einiger selten und Wenig bekanten versteinerten schaalthiere*, 159 pp., 9 pls. Der Metternichisschen Buchhandlung, Frankfurt and Leipzig.
HYATT, A. 1889. Genesis of the Arietidae. *Smithson. Contr. Knowl.* **673,** xi+238 pp., 14 pls.
——1894. Phylogeny of an Acquired Characteristic. *Proc. Am. Phil. Soc.* **32,** 349–647, pls. 1–14.
——1900. Cephalopoda. *In* ZITTEL, K. A. VON. 1896–1900. *Textbook of Palaeontology*, transl. EASTMAN, C. R., 502–604. Macmillan, London and New York.
——1903. Pseudoceratites of the Cretaceous. *Monogr. US geol. Surv.* **44,** 1–351, pls. 1–47.
ILYIN, V. D. 1957. *Arkhangelskiceras* gen. nov. from the Upper Cretaceous deposits of western Uzbekistan. *Dokl. Akad. Nauk.* SSR, **113,** 424–427. [In Russian.]
——1959. Stratigraphy of the Upper Cretaceous deposits of West Uzbekistan and adjacent regions of Turkmenia. *Trud VNIGNI*, Leningrad, 181–222, 8 pls. [In Russian.]
IMMEL, H. and SEYED-EMAMI, K. 1985. Die Kreideammoniten des Glaukonitkalkes (O. Alb-O. Cenoman) des Kolah-Qazi-Gebirges südöstlich von Esfahan (Zentraliran). *Zitteliana*, **12,** 87–137, 7 pls.
JACOB, C. 1907. Études paléontologiques et stratigraphiques sur la partie moyenne des terrains crétacés dans les Alpes françaises et les régions voisines. *Annls. Univ. Grenoble*, **19** (2), 221–534, 6 pls. (Published also in 1908 in *Trav. Lab. Géol. Univ. Grenoble*, **8** (2), 280–590, 6 pls. and later in 1908 in *Bull. Soc. Statist. Sci. nat. Arts ind. Dép. Isère* (*Grenoble*), (4) **10,** 201–514, 6 pls.)
JAKOWLEW, B. 1875. Hemiptera and Homoptera of the Russian Fauna. *Bull. Soc. Nat. Moscou*, **49,** 248–285. [In Russian.]
JELETZKY, J. A. 1949. *Scaphites morrowi*, new name for *Scaphites pygmaeus* Morrow, 1935, non Holzapfel, 1888. *Jl Paleont.* **23,** 330.

JIMBO, K. 1894. Beiträge zur Kenntniss der fauna der Kreideformation von Hokkaido. *Paläont. Abh.* NS **2,** 147–194, pls. 17–25.

JOHNSON, D. W. 1903. The geology of the Cerillos Hills, New Mexico. *Contr. Dep. Geol. Columbia Univ.* **10,** 1–221, pls. A–U, 1–14.

JONES, T. S. 1938. Geology of Sierra de la Peña and paleontology of the Indidura Formation, Coahuila, Mexico. *Bull. geol. Soc. Am.* **49,** 69–150, pls. 1–13.

JUKES-BROWNE, A. J. 1896. VI. Critical remarks on some of the fossils. *In* JUKES-BROWNE, A. J. and HILL, W. A delimitation of the Cenomanian: being a comparison of the corresponding beds in south-western England and northern France. *Q. Jl geol. Soc. Lond.* **52,** 99–178, pl. 5.

KAPLAN, U., KENNEDY, W. J. and WRIGHT, C. W. 1987. Turonian and Coniacian Scaphitidae of northwestern Europe. *Geol. Jb.* A**103,** 5–39, 6 pls.

KAUFFMAN, E. G. 1965. Middle and late Turonian oysters of the *Lopha lugubris* group. *Smithson. misc. Collns.* **148,** 92 pp., 8 pls.

—— 1977. Illustrated guide to biostratigraphically important Cretaceous macrofossils, western interior basin, U.S.A. *Mount. Geologist*, **14,** 225–274, 32 pls.

—— COBBAN, W. A. and EICHER, D. L. 1978. Albian through Lower Coniacian strata, biostratigraphy and principal events, western interior United States. *Ann. Mus. Hist. nat. Nice*, **4,** XXIII, 1–52, 17 pls. (1976 imprint).

—— HATTIN, D. E. and POWELL, J. D. 1977. Stratigraphic, paleontologic, and paleoenvironmental analysis of Upper Cretaceous rocks of Cimarron County, northwestern Oklahoma. *Mem. geol. Soc. Am.* **149,** 1–149, pls. 1–12.

KENNEDY, W. J. 1971. Cenomanian ammonites from southern England. *Spec. Pap. Palaeont.* **8,** 1–133, pls. 1–64.

—— 1977. Ammonite evolution. *In* HALLAM, A. (ed.). *Patterns of Evolution*, 251–330. Elsevier, Amsterdam, Oxford, New York.

—— 1986. The ammonite fauna of the Calcaire a *Baculites* (Upper Maastrichtian) of the Cotentin Peninsula (Manche, France). *Palaeontology*, **29,** 25–83, pls. 1–16.

—— AMÉDRO, F., BADILLET, G., HANCOCK, J. M. and WRIGHT, C. W. 1984. Notes on late Cenomanian and Turonian ammonites from Touraine, western France. *Cret. Res.* **5,** 29–45.

—— —— and COLLETÉ, C. 1986. Late Cenomanian and Turonian ammonites from Ardennes, Aube and Yonne, eastern Paris Basin. *Neues Jb. Geol. Paläont. Abh.* **172,** 193–217.

—— and COBBAN, W. A. 1976. Aspects of ammonite biology, biogeography and biostratigraphy. *Spec. Pap. Palaeont.* **17,** 1–94, pls. 1–11.

—— —— 1988*a*. Mid-Turonian ammonite faunas from northern Mexico. *Geol. Mag.* **125,** 20 pp.

—— —— 1988*b*. The Upper Cretaceous ammonite *Romaniceras Spath*, 1923 in New Mexico. *Bull. New Mex. St. Bur. Mines Miner. Resour.* **114,** 23–34.

—— and JUIGNET, P. 1973. First record of the ammonite family Binneyitidae Reeside, 1927 in Western Europe. *Jl Paleont.* **47,** 900–902.

—— —— 1981. Upper Cenomanian ammonites from the environs of Saumur and the provenance of the types of *Ammonites vibrayeanus* and *Ammonites geslinianus*. *Cret. Res.* **2,** 19–49.

—— —— 1983. A revision of the Ammonite Faunas of the Type Cenomanian. I. Introduction, Ancyloceratina. Ibid. **4,** 3–83.

—— —— 1984. A revision of the ammonite faunas of the type Cenomanian. 2. The families Binneyitidae, Desmoceratidae, Engonoceratidae, Placenticeratidae, Hoplitidae, Schloenbachiidae, Lyelliceratidae and Forbesiceratidae. Ibid. **5,** 93–161.

—— —— and HANCOCK, J. M. 1981. Upper Cenomanian ammonites from Anjou and Vendée, western France. *Palaeontology*, **24,** 25–84, pls. 3–17.

—— and KLINGER, H. C. 1975. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite superfamily Haploceratacea Zittel, 1884. *Ann. S. Afr. Mus.* **77,** 85–121.

—— and SUMMESBERGER, H. 1987. Lower Maastrichtian ammonites from Nagoryanȳ, Ukranian SSR. *Beitr. Paläont. Oest.* **13,** 25–78, 16 pls.

—— and WRIGHT, C. W. 1983. *Ammonites polyopsis* Dujardin, 1837 and the Cretaceous ammonite family Placenticeratidae Hyatt, 1900. *Palaeontology*, **26,** 855–873, pls. 85–87.

—— —— 1984. The Cretaceous ammonite *Ammonites requienianus* Orbigny, 1841. Ibid. **27,** 281–293, pls. 35–37.

—— —— 1985. Evolutionary patterns in late Cretaceous Ammonites. *Spec. Pap. Palaeont.* **33,** 131–143.

—— —— and HANCOCK, J. M. 1980*a*. The european species of the Cretaceous ammonite *Romaniceras* with a revision of the genus. *Palaeontology*, **23,** 325–362, pls. 39–50.

——————— 1980*b*. Collignoniceratid ammonites from the mid-Turonian of England and northern France. Ibid. **23,** 557–603, pls. 62–77.
——————— 1980*c*. Origin, evolution and systematics of the Cretaceous ammonite *Spathites*. Ibid. **23,** 821–837, pls. 104–106.
——————— 1987. Basal Turonian ammonites from west Texas. Ibid. **30,** 27–74, pls. 1–10.
KLINGER, H. C. and KENNEDY, W. J. In press. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite family Placenticeratidae Hyatt, 1900. *Ann. S. Afr. Mus.*
KOENEN, A. VON. 1897–1898. Ueber Fossilien der unteren Kreide am Ufer des Mungo in Kamerun. *Abh. K. Ges. Wiss Göttingen*, **1,** 1–65, 7 pls. (1–48, pls. 1–4, 1897; 49–65, pls. 5–7, 1898).
KOSSMAT, F. 1895–1898. Untersuchungen uber die Sudindische Kreideformation. *Beitr. Pälaont. Geol. Öst.-Ung.* **9** (1895): 97–203 (1–107), pls. 15–25 (1–11); **11** (1897); 1–46 (108–153), pls. 1–8 (12–19); **11** (1898): 89–152 (154–217), pls. 14–19 (20–25).
KUMMEL, B. and DECKER, J. M. 1954. Lower Turonian Ammonites from Texas and Mexico. *Jl Paleont.* **28,** 310–319, pls. 30–33.
KULLMANN, J. and WIEDMANN, J. 1970. Significance of sutures in phylogeny of Ammonoidea. *Paleont. Contr. Univ. Kansas*, **44,** 1–32.
LAHUSEN, J. 1884. Description of two ammonite species from the Amudara Valley, 133–135. *In* ROMANOWSKY, G. Material on the Geology of Turkestan, **2,** xii + 159 pp., 23 pls. St. Petersburg, The Academic Press. [In Russian.]
LAMARCK, J. P. B. A. DE M. DE. 1799. Prodrome d'une nouvelle classification des coquilles. *Mém. Soc. Hist. nat. Paris*, for 1799, 63–90.
—— 1801. *Systéme des Animaux sans vertebrès* . . . vii + 432 pp. Deterville, Paris.
LANDMAN, N. H. 1987. Ontogeny of Upper Cretaceous (Turonian–Santonian) scaphitid ammonites from the Western Interior of North America: systematics, developmental patterns, and life history. *Bull. Am. Mus. nat. Hist.* **185,** 117–241.
LAUBE, G. C. and BRUDER, G. 1887. Ammoniten der böhmischen Kreide *Palaeontographica*, **33,** 217–239, pls. 23–29.
LEONHARD, R. 1897. Die Fauna der Kreideformation in Oberschlesian. Ibid. **44,** 11–70, pls. 2–6.
LEWY, Z., KENNEDY, W. J. and CHANCELLOR, G. R. 1984. Co-occurrence of *Metoicoceras geslinianum* (d'Orbigny) and *Vascoceras cauvini* Chudeau (Cretaceous Ammonoidea) in the Southern Negev (Israel) and its stratigraphic implications. *Newsl. Stratigr.* **13,** 67–76.
LOGAN, W. N. 1898. The invertebrates of the Benton, Niobrara and Fort Pierre Groups. *Univ. geol. Surv. Kans.* **4,** (Paleont.) (Upper Cretaceous 8), 431–518, pls. 86–120.
MCLEARN, F. H. 1937. The fossil zones of the Upper Cretaceous Alberta Shale. *Trans. R. Soc. Can.* (3) **31,** 112–120.
MCNULTY, C. JR. 1954. Fish Bed Conglomerate and Sub-Clarksville Sand, Grayson and Fannin Counties, Texas. *Bull. Am. Ass. Petrol. Geol.* **38,** 335–337.
—— 1965. Lithology of the Eagle Ford–Austin contact in northeast Texas. *Tex. Jl Sci.* **17,** 46–55.
—— 1966. Nomenclature of uppermost Eagle Ford Formation in northeastern Texas. *Bull. Am. Ass. Petrol. Geol.* **50,** 374–379.
MAKOWSKI, H. 1963. Problems of sexual dimorphism in ammonites. *Palaeont. pol.* **12,** 1–92, pls. 1–20.
MANTELL, G. A. 1822. *The fossils of the South Downs; or illustrations of the geology of Sussex*, xvi + 327 pp., 42 pls. Lupton Relfe, London.
MARCINOWSKI, R. 1980. Cenomanian ammonites from German Democratic Republic, Poland, and the Soviet Union. *Acta geol. Polonica*, **30,** 215–325, 20 pls.
MARCOU, J. 1858. *Geology of North America; with two reports on the prairies of Arkansas and Texas, the Rocky Mountains of New Mexico and the Sierra Nevada of California*, 144 pp., 9 pls. Zurcher and Furrer, Zurich.
MATSUMOTO, T. 1959*a*. Upper Cretaceous Ammonites of California. Part II. *Mem. Fac. Sci. Kyushu Univ.*, Ser. D. Geol. Special Volume, **1,** 1–172, 41 pls.
—— 1959*b*. The Upper Cretaceous Ammonites of California. Part 1. Ibid. **8,** 91–171, pls. 30–45.
—— 1960. On some type ammonites from the Gulf Coast Cretaceous. *Sci. Rep. Fac. Sci. Kyushu Univ. Geol.* **5,** 36–49. [In Japanese.]
—— 1963. *In* MATSUMOTO, T. (ed.). A survey of fossils from Japan illustrated in classical monographs (primarily a nomenclatorial revision). *Palaeontological Society of Japan, 25th Anniversary Volume*, 57 pp., 68 pls.
—— 1965. A monograph of the Collignoniceratidae from Hokkaido. Part 1. *Mem. Fac. Sci. Kyushu Univ.*, Ser. D. Geol. **16,** 1–80, pls. 1–18.

MATSUMOTO, T. 1969. *In* MATSUMOTO, T., MURAMOTO, T. and TAKAHASKI, T. Selected Acanthoceratids from Hokkaido. Ibid. **19,** 251–296, pls. 25–38.

—— 1971. A monograph of the Collignoniceratidae from Hokkaido. Part V. Ibid. **21,** 129–162, pls. 2–24.

—— and MILLER, H. W. 1958. Cretaceous ammonites from the Spillway excavation of Cedar Bluff Dam, Trego County, Kansas. *Jl Paleont.* **32,** 351–356, pls. 44–45.

—— and MURAMOTO, T. 1969. *In* MATSUMOTO, T., MURAMOTO, T. and TAKAHASHI, T. Selected Acanthoceratids from Hokkaido. *Mem. Fac. Sci. Kyushu Univ.*, Ser. D. Geol. **19,** 251–296, pls. 25–38.

—— —— and TAKAHASHI, I. 1969. Selected acanthoceratids from Hokkaido. Ibid. **19,** 251–296, pls. 25–38.

—— and OBATA, I. 1963. A monograph of the Baculitidae from Japan. *Ibid.* **13,** 1–116, pls. 1–27.

MEEK, F. B. 1870. A preliminary list of fossils, collected by Dr. Hayden in Colorado, New Mexico and California, with brief descriptions of a few of the new species. *Proc. Am. phil. Soc.* **11,** 425–431.

—— 1872. Preliminary Palaeontological Report, consisting of lists of fossils with descriptions of some new types etc., 287–318. *In* HAYDEN, F. V. *Preliminary report of the United States Geologic Survey of Wyoming and Portions of Contiguous Territories* (*Being a Second Annual report of Progress*) *conducted under the auspices of the Secretary of the Interior by F. V. Hayden, United States Geologist*, 511 pp. Government Printing Office, Washington (1871 imprint).

—— 1876*a*. A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country. *In* HAYDEN, F. V. *Report of the United States Geological Survey of the Territories*, **9,** lxiv + 629 pp., 45 pls.

—— 1876*b*. Descriptions of Cretaceous fossils collected on the San Juan exploring expedition under Captain J. N. Macomb, U.S. Engineer, *In* MACOMB, J. N. *Report of the exploring expedition from Santa Fe, New Mexico, to the junctions of the Grand and Green Rivers of the Great Colorado of the West in 1859*, 119–133, 2 pls. Engineers Dept. US Army, Washington.

—— and HAYDEN, F. V. 1859. Description of new organic remains collected in Nebraska Territory in the year 1897 by Dr. F. V. Hayden. *Proc. Acad. nat. Sci. Philad.* **10,** 41–59.

MEREWETHER, E. A., COBBAN, W. A. and CAVANAUGH, E. T. 1979. Frontier Formation and equivalent rocks in eastern Wyoming. *Mount Geologist*, **16,** 67–101, 4 pls.

MICHELIN, H. 1838. Note sur une argile dépendant du Gault. *Mem. Soc. géol. France*, (1) **3,** 97–103, pl. 12.

MOREAU, P., FRANCIS, I. H. and KENNEDY, W. J. 1983. Cenomanian ammonites from northern Aquitaine. *Cret. Res.* **4,** 317–339.

MOREMAN, W. L. 1927. Fossil zones of the Eagle Ford of north Texas. *Jl Paleont.* **1,** 89–101, pls. 13–16.

—— 1933. *In* ADKINS, W. S., pp. 425–426 (see above).

—— 1942. Paleontology of the Eagle Ford group of north and central Texas. *Jl Paleont.* **16,** 192–220, pls. 31–34.

MORROW, A. L. 1935. Cephalopods from the Upper Cretaceous of Kansas. Ibid. **9,** 463–473, pls. 49–53.

NEUMAYER, M. 1875. Die Ammoniten der Kreide und die Systematik der Ammonitiden. *Z. dt. geol. Ges.* **27,** 854–942.

NORTON, G. H. 1965. The surface geology of Dallas County. Pp. 40–125. In *The Geology of Dallas County*. 211 pp., + map. Dallas Geological Society, Dallas.

NOWAK, J. 1908. Untersuchungen über Cephalopoden der oberen Kreide in Polen. I. Teil. Genus *Baculites* Lamarck. *Bull. int. Acad. Sci. Lett. Cracovie, Cl. Sci. math, nat.* (B), **1908,** 326–353, pl. 14.

—— 1911. Untersuchungen über die cephalopoden der oberen Kreide in Polen. II. Teil. Die skaphiten. Ibid. **1911,** 547–589, pls. 32 and 33.

—— 1913. Untersuchungen über die cephalopoden der oberen Kreide in Polen. III. Teil. Ibid. **1913,** 335–415, pls. 40–45.

ORBIGNY, A. D'. 1840–1842. *Paléontologie française: Terrains crétacés*. **1,** *Céphalopodes*. 1–120 (1840); 121–430 (1841); 431–662 (1842), 148 + 3 pls. Masson, Paris.

—— 1850. *Prodrome de Paléontologie stratigraphique universelle des animaux mollusques et rayonnés*. Vol. 2. 428 pp. Masson, Paris.

ORLOV, YU. A. 1958. Mollusca–Cephalopoda II. Ammonoidea (Ceratitida and Ammonitida), Endocochlia, Coniconchia. *Osnovy Paleontologii*, **6,** 359 pp., 71 + 7 pls. [In Russian.]

PARKINSON, J. 1811. *Organic Remains of a Former World. Vol. 3*. xvi + 479 pp., 22 pls. Sherwood, Neily and Jones, London.

PESSAGNO, E. 1969*a*. Upper Cretaceous stratigraphy of the western Gulf Coast area, Mexico, Texas, and Arkansas. *Mem. geol Soc. Am.* **111,** 1–139, pls. 1–60.

—— 1969*b*. Cenomanian–Turonian (Eaglefordian) stratigraphy in the western Gulf Coast plain area. *Proc. Ist Int. Conf. Planktonic Microfossils, Geneva*, **1,** 509–525.

PETRASCHECK, W. 1902. Die Ammoniten der sächsischen Kreideformation. *Beitr. Paläont. geol. Ost.-Ung.* **14,** 131–162, pls. 7–12.

PHANSALKAR, V. G. 1978. A study of the genus *Calycoceras* Hyatt from the Upper Cretaceous rocks of the Trichinopoly district, south India. *Recent Researches in Geology*, **4,** (festschrift Chiplonkar), 208–224, 3 pls.

PICTET, F. J. 1847. *In* PICTET, F. J. and ROUX, W. 1847–1854. Description des mollusques fossiles qui se trouvent dans les Grès Verts des environs de Genève. *Mém. Soc. Phys. Hist. nat. Genève*, **11** (1847), 257–412; **12** (1849), 21–151; **13** (1852), 73–173; **14** (1854), 279–341; 51 pls.

—— 1854. *In* PICTET, F. J. and ROUX, W. 1847–1854 (see above).

POWELL, J. D. 1963*a*. Cenomanian–Turonian (Cretaceous) ammonites from Trans-Pecos Texas and northeastern Chihuahua, Mexico. *Jl Paleont.* **37,** 309–322, pls. 31–34.

—— 1963*b*. Turonian (Cretaceous) ammonites from northeastern Chihuahua. Ibid. 1217–1232, pls. 166–171.

—— 1968. Woodbine–Eagle Ford Transition, Tarrant Member. In *Field Trip Guidebook. Second Annual Meeting, South-Central Section, Geological Society of America Inc.* 27–43. University of Texas, Arlington.

PRATHER, J. K. 1902. A preliminary report on the Austin Chalk underlying Waco, Texas, and the adjoining territory. *Trans. Tex. Acad. Sci.* **4,** 115–122.

REESIDE, J. B. 1928. Cephalopods from the lower part of the Cody Shale of Oregon Basin, Wyoming. *US geol. Surv. Prof. Pap.* **150-A,** 1–19, pls. 1–8.

—— and WEYMOUTH, A. A. 1931. Mollusks from the Aspen Shale (Cretaceous) of southwestern Wyoming. *Proc. US natn. Mus.* **78** (17), 1–24, pls. 1–4.

RENZ, O. 1982. *The Cretaceous ammonites of Venezuela*, 132 pp., 40 pls. Maraven, Basel.

REYMENT, R. A. 1954. New Turonian (Cretaceous) ammonite genera from Nigeria. *Colon. geol. Surv. Min. Resour. Divn*, **4,** 149–164, 4 pls.

ROEMER, F. 1852. *Die Kreidebildungen von Texas und ihre organischen Einschlüsse*, 100 pp., 10 pls. Adolph Marcus, Bonn.

ROMAN, F. 1938. *Les ammonites jurassiques et crétacés. Essai de genera*, 554 pp., 53 pls. Masson, Paris.

—— and MAZERAN, P. 1913. Monographie paléontologique de la faune du Turonien du bassin d'Uchaux et de ses dépendances. *Archs Mus. Hist. nat. Lyon*, **12,** 1–137, pls. 1–11.

SASTRY, M. V. A., RAO, B. R. J. and MAMGAIN, V. D. 1968. Biostratigraphic zonation of the Upper Cretaceous formations of Trichinopoly district, South India. *Mem. geol. Soc. India*, **2,** 10–17, 4 pls.

SCHLOTHEIM, E. F. VON. 1820. *Die Petrefaktenkünde auf ihrem jetzigen Standpunkte durch die Beschreibung seiner Sammlung . . .*, lxii + 437 pp. Becker'schen Buchhandlung, Gotha.

SCHLÜTER, C. 1871–1876. Cephalopoden der oberen deutschen Kreide. *Palaeontographica*, **21,** 1–24, pls. 1–8 (1871); **21,** 25–120, pls. 9–35 (1872); **24,** 1–144 (121–264) + x, pls. 36–55 (1876).

SCOTT, G. 1924. Some gerontic ammonites of the Duck Creek Formation. *Texas Christian Univ. Quart.* **1** (1), 1–31, 9 pls.

—— 1927. Études stratigraphiques et paléontologiques sur les terrains crétacés du Texas. *Trav. Lab. géol. Univ. Grenoble*, **14,** 77–298, 3 pls.

SEITZ, O. 1935. Die Variabilitat des *Inoceramus labiatus* Schlotheim. *Geol. Jb.* **55,** 429–474, pls. 36–40 (1934 imprint).

SHARPE, D. 1853–1857. Description of the fossil remains of Mollusca found in the Chalk of England. I, Cephalopoda. *Palaeontogr. Soc.* [*Monogr.*], 1–26, pls. 1–10 (1853); 27–36, pls. 11–16 (1855); 37–68, pls. 17–27 (1857).

SHIMER, H. W. and SHROCK, R. R. 1944. *Index fossils of North America*, ix + 837 pp. Wiley, New York.

SHUMARD, B. F. 1860. Descriptions of new Cretaceous fossils from Texas. *Trans. Acad. Sci. St. Louis*, **1,** 590–610.

SIDWELL, R. 1932. New species from the Colorado Group, Cretaceous, in south central Wyoming. *Jl Paleont.* **6,** 312–318, pls. 48–49.

SILVER, B. A. 1963. The Bluebonnet Member, Lake Waco Formation (Upper Cretaceous), central Texas . . . a lagoonal deposit. *Baylor Geological Studies, Bull.* **4,** 1–46.

SMITH, C. 1981. Calcareous Nannoplankton and Stratigraphy of Late Turonian, Coniacian and early Santonian age of the Eagle Ford and Austin Groups of Texas. *US geol. Surv. Prof. Pap.* **1075,** 1–96, pls. 1–6.

SOWERBY, J. 1812–1822. *The Mineral Conchology of Great Britain*, **1,** pls. 1–9 (1812), pls. 10–44 (1813), pls. 47–78 (1814), pls. 79–102 (1815); **2,** pls. 103–114 (1815), pls. 115–150 (1816), pls. 151–186 (1817), pls. 187–203 (1818); **3,** pls. 204–221 (1818), pls. 222–253 (1819), pls. 254–271 (1820), pls. 272–306 (1821); **4,** pls. 307–318 (1821), pls. 319–383 (1822). London.

SOWERBY, J. DE C. 1823–1846. *The Mineral Conchology of Great Britain* (continued), **4,** pls. 384–407 (1823); **4,** pls. 408–443 (1823), pls. 444–485 (1824), pls. 486–503 (1825); **6,** pls. 504–544 (1826), pls. 545–580 (1827), pls. 581–597 (1828), pls. 598–609 (1829); **7,** pls. 610–618 (1840), pls. 619–623 (1841), pls. 624–628 (1843), pls. 629–643 (1844), pls. 644–648 (1846). London.

SOWERBY, J. DE C. 1850. Description of the shells of the Chalk Formation, 346–359, pls. 27–29. *In* DIXON, F. *The Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex*, 1st edn., xvi+423 pp., 45 pls. Smith, Brighton.

SPATH, L. F. 1922*a*. On the Senonian ammonite fauna of Pondoland. *Trans. R. Soc. S. Afr.* **10,** 113–147, pls. 5–9.

—— 1922*b*. On Cretaceous Ammonoidea from Angola, collected by Professor J. W. Gregory, D.Sc., F.R.S. *Trans. R. Soc. Edinb.* **53,** 91–160, 4 pls.

—— 1923. On the ammonite horizons of the Gault and contiguous deposits. *Summ. Progr. geol. Surv. Lond.* for 1922, 139–149.

—— 1924. On a new ammonite (*Engonoceras iris* n. sp.) from the Gault of Folkestone. *Ann. Mag. nat. Hist.* (9) **14,** 504–508.

—— 1925*a*. Sur quelques ammonites du Gault nomées par P. Reynès. *Annls Mus. Hist. nat. Marseille*, **20,** 97–106, pl. 4.

—— 1925*b*. On Upper Albian Ammonoidea from Portuguese east Africa, with an appendix on Upper Cretaceous ammonites from Maputoland. *Ann. Transv. Mus.* **11,** 179–200, pls. 28–37.

—— 1926. On new ammonites from the English Chalk. *Geol. Mag.* **63,** 77–83.

—— 1931. A monograph of the Ammonoidea of the Gault. Part 10. *Palaeontogr. Soc.* [*Monogr.*], 411–442, pls. 43–48.

—— 1939. A monograph of the Ammonoidea of the Gault. Part 13. Ibid. 541–608, pls. 59–64.

STANTON, T. W. 1894. The Colorado formation and its invertebrate fauna. *Bull. US geol. Surv.* **106,** 1–288, pls. 1–45.

STEPHENSON, L. W. 1918. A contribution to the geology of northeastern Texas and southern Oklahoma. *US geol. Surv. Prof. Pap.* **120,** 129–163.

—— 1953. Larger invertebrate fossils of the Woodbine Formation (Cenomanian) of Texas. Ibid. **242,** 1–226, pls. 1–59 (1952 imprint).

—— 1955. Basal Eagle Ford fauna (Cenomanian) in Johnson and Tarrant Counties, Texas. Ibid. **274-C,** 53–67, pls. 4–7.

STOLICZKA, F. 1863–1866. The fossil cephalopoda of southern India. Ammonitidae with revision of the Nautilidae etc. *Mem. geol. Surv. India*, (1), *Palaeont. Indica*, **3** (1), 41–56, pls. 26–31 (1863); (2–5), 57–106, pls. 32–54 (1864); (6–9), 107–154, pls. 55–80 (1865); (10–13), 155–216, pls. 81–94 (1866).

STRAND, E. 1929. Zoological and palaeontological nomenclatorial notes. *Latv. Univ. Rak.* **20,** 3–29.

SWENSEN, A. J. 1963. Anisoceratidae and Hamitidae (Ammonoidea) from the Cretaceous of Texas and Utah. *Geol. Stud. Brigham Young Univ.* **9,** 53–82, 5 pls. (misdated 1962).

TAFF, J. A. and LEVERETT, S. 1893. Report on the Cretaceous area north of the Colorado River. *Texas Geological Survey 4th Annual Report*, part 1, 239–354.

TAKAYANAGI, Y. and MATSUMOTO, T. 1981. Recent advances in the Cretaceous Biostratigraphy of Japan by coordinating mega- and micro-fossils. *Rec. Progr. Nat. Sci. Japan*, **6,** 125–137.

TANABE, K. 1977*a*. Functional evolution of *Otoscaphites puerculus* (Jimbo) and *Scaphites planus* (Yabe), Upper Cretaceous ammonites. *Mem. Fac. Sci. Kyushu Univ.*, Ser. D. Geol. **23,** 367–407, pls. 62–64.

—— 1977*b*. Mid-Cretaceous scaphitid ammonites from Hokkaido. *Spec. Pap. palaeont. Soc. Japan*, **21,** 11–22, pl. 1.

THOMEL, G. 1969. Réflexions sur les genres *Eucalycoceras* et *Protacanthoceras* (Ammonoidea). *C.r. hébd. Seánc. Acad. Sci., Paris*, (D), **268,** 649–652.

—— 1972. Les Acanthoceratidae Cénomaniens des châines subalpines méridionales. *Mém. Soc. géol. France*, NS **116,** 1–204, pls. 1–88.

TOKUNAGA, S. and SHIMIZU, S. 1926. The Cretaceous formation of Futaba in Iwaki and its fossils. *Jl Fac. Sci. Univ. Tokyo*, sect. 2, **1,** 181–212, pls. 21–27.

UHLIG, V. 1910. Himalayan Fossils. The fauna of the Spiti Shales. *Mem. geol. Surv. India, Palaeont. Indica*, (15) **4** (2), 133–306, pls. 19–48*a*; (3), 307–395, pls. 77–91.

VALENTINE, P. C. 1984. Turonian (Eaglefordian) stratigraphy of the Atlantic Coastal Plain and Texas. *US geol. Surv. Prof. Pap.* **1315,** 1–21.

VREDENBERG, E. W. 1907. The ammonites of the Bagh Beds. *Rec. geol. Surv. India*, **36,** 109–125, pls. 14–17.

WARREN, P. S. 1930. New species of fossil from Smoky River and Dunvegan Formations, Alberta. *Rep. Alberta Res. Council geol. Surv.* **21,** 57–68, pls. 3–7.

—— 1947. Cretaceous fossil horizons in the Mackenzie River Valley (Canada). *Jl Paleont.* **21,** 118–123, pls. 29–30.

—— and STELCK, C. R. 1940. Cenomanian and Turonian faunas, Pouce-Coupe District, Alberta and British Columbia. *Trans. R. Soc. Can.* (3), **23** (4), 143–152, pls. 1–4.

WEDEKIND, R. 1916. Über Lobus, Suturallobus und Inzision. *Zentbl. Miner. Geol. Paläont.* **1916,** 185–195.
WHITE, C. A. 1877. Report upon the invertebrate fossils collected in portions of Nevada, Utah, Colorado, New Mexico, and Arizona, by parties of the expeditions of 1871, 1872, 1873 and 1874, with descriptions of new species. *Rep. US geog. and geol. Surveys. W. 100th Mer.* **4,** (1), 219 pp., 21 pls.
—— 1880. Contributions to paleontology, no. 2; Cretaceous fossils of the western states and territories; advance print from: *Rep. US geol. Surv. Territ.* **12,** 1–39, 9 pls.
—— 1883. Contributions to invertebrate paleontology, no. 2; Cretaceous fossils of the western states and territories. Ibid. 5–39, pls. 11–19.
WHITFIELD, R. P. 1877. Preliminary report on the paleontology of the Black Hills, containing descriptions of new species of fossils from the Potsdam, Jurassic, and Cretaceous formations of the Black Hills of Dakota. *US Geog. Geol. Surv. Rocky Mtn. Region*, 49 pp.
—— 1880. Paleontology of the Black Hills of Dakota. *In* NEWTON, H. and JENNEY, W. P. Report on the geology and resources of the Black Hills of Dakota. Ibid. 325–468, 16 pls.
WIEDMANN, J. 1960. Le Crétacé supérieur de l'Espagne et du Portugal et ses céphalopodes. *C.r. Congrès des Sociétés Savantes-Dijon, 1959: Colloque sur le Crétacé supérieur français*, 709–764, 8 pls.
—— 1965. Origin, limits and systematic position of *Scaphites*. *Palaeontology*, **8,** 397–453, pls. 53–60.
—— 1966. Stammesgeschichte und system den posttriadischen ammonoideen; ein überblick. *Neues Jb. Geol. Paläont. Abh.* **125,** 49–79, pls. 1–2; **127,** 13–81, pls. 3–6.
WOODS, H. 1896. The Mollusca of the Chalk Rock: Part 1. *Q. Jl geol. Soc. Lond.* **52,** 68–98, pls. 2–4.
WOLLEBEN, J. A. 1967. Senonian (Cretaceous) mollusca from Trans-Pecos Texas and northeastern Chihuahua, Mexico. *Jl Paleont.* **41,** 1150–1165, pls. 147–152.
WRIGHT, C. W. 1952. A classification of the Cretaceous ammonites. *Jl Paleont.* **26,** 213–222.
—— 1953. Notes on Cretaceous Ammonites. I. Scaphitidae. *Ann. Mag. nat. Hist.* (12) **6,** 473–476.
—— 1957. *In* MOORE, R. C. (ed.). *Treatise on Invertebrate Paleontology. Part L, Mollusca 4, Cephalopoda, Ammonoidea*, xxii + 490 pp. Geological Society of America and University of Kansas Press, New York and Lawrence, Kansas.
—— 1963. Cretaceous ammonites from Bathurst Island, Northern Australia. *Palaeontology*, **6,** 597–614, pls. 81–89.
—— 1979. The ammonites of the English Chalk Rock (Upper Turonian). *Bull. Br. Mus. nat. Hist.* (Geol.), **31,** 281–332, 7 pls.
—— 1981. Cretaceous Ammonoidea. *In* HOUSE, M. R. and SENIOR, J. (eds.). The Ammonoidea. *Systematics Association Special Volume*, **12,** 157–174.
—— and KENNEDY, W. J. 1980. Origin, evolution and systematics of the dwarf acanthoceratid *Protacanthoceras* Spath, 1923 (Cretaceous Ammonoidea). *Bull. Br. Mus. nat. Hist.* (Geol.), **34,** 65–107.
—— —— 1981. The Ammonoidea of the Plenus Marls and the Middle Chalk. *Palaeontogr. Soc.* [*Monogr.*], 1–148, pls. 1–32.
—— —— 1984. The Ammonoidea of the Lower Chalk. Part 1. Ibid. 1–126, pls. 1–40.
—— —— 1986. The Ammonoidea of the Lower Chalk. Part 2. Ibid. 127–217, pls. 41–55.
—— —— in press. The Ammonoidea of the Lower Chalk. Part 3. Ibid.
—— —— and WRIGHT, E. V. 1951. A survey of the fossil Cephalopoda of the Chalk of Great Britain. Ibid. 1–41.
YABE, H. 1909. Zur Stratigraphie und Paläontologie der oberen Kreide von Hokkaido und Sachalien. *Z. dt. geol Ges. Abh.* **61,** 402–444.
—— 1910. Die Scaphiten aus der Oberkreide von Hokkaido. *Beitr. Paläont. Geol. Ost.-Ung.* **23,** 159–174, pl. 15.
—— 1927. Cretaceous stratigraphy of the Japanese islands. *Sci. Rep. Tohoku Imp. Univ.* (2) **11,** 27–100, pls. 3–9.
YOUNG, K. 1957. Cretaceous ammonites from eastern Apache county, Arizona. *Jl Paleont.* **31,** 1167–1174, pls. 149–150.
—— and POWELL, J. D. 1978. Late Albian–Turonian correlations in Texas and Mexico. *Ann. Mus. Hist. nat. Nice*, **4,** 1–36, 9 pls. (1976 imprint).
ZÁZVORKA, V. 1958. Acanthoceras Kallesi n. sp. (Ammonoidea) ze spodního turonu na bílé hoře v praze (Střední Čechy) a Acanthoceras sharpei n. sp. zanglické Křidy. *Čas. naród. Mus.* **127,** 38–45.
ZITTEL, K. A. 1884. *Handbuch der Palaeontologie* . . . Abt. 1, 2 (Lief 3), *Cephalopoda*, 329–522. R. Oldenbourg, Munich and Leipzig.
—— 1895. *Grundzüge der Palaeontologie* (*Palaeozoologie*). vii + 972 pp. R. Oldenbourg, Munich and Leipzig.

Typescript received 10 September 1987
Revised typescript received 27 January 1988

W. J. KENNEDY
Geological Collections, University Museum
Parks Road, Oxford OX1 3PW