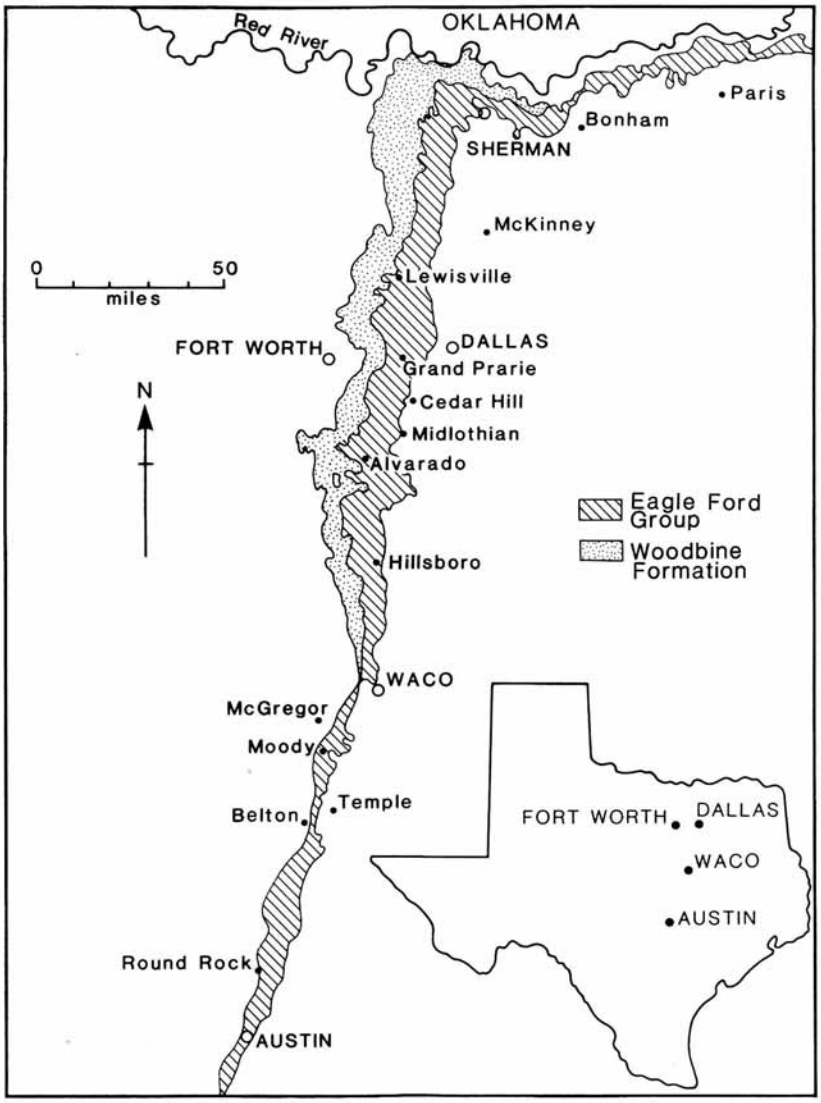
CENOMANIAN AMMONITE FAUNAS FROM THE WOODBINE FORMATION AND LOWER PART OF THE EAGLE FORD GROUP, TEXAS

by W. J. KENNEDY *and* W. A. COBBAN

ABSTRACT. The ammonite faunas of the Woodbine Formation and lower part of the Eagle Ford Group of north-east and central Texas can be referred to five successive zonal assemblages of the standard sequence recognized for the southern part of the US Western Interior. The upper lower Cenomanian *Forbesiceras brundrettei* zone is represented by a limited assemblage in old collections believed to be from the Pepper Shale Member of the Woodbine, and from the Waco area. The middle Cenomanian *Conlinoceras tarrantense* zone is represented in the Tarrant Formation of the Eagle Ford in the area west of Dallas. The succeeding *Acanthoceras bellense* zone is a new biostratigraphic unit in the area, occurring only at the base of the Bluebonnet Member of the Lake Waco Formation of the Eagle Ford Group near Belton in Bell County. It yields *Anagaudryceras involvulum* (Stoliczka, 1865), *Puzosia* (*Puzosia*) sp., *Forbesiceras* cf. *chevillei* (Pictet and Renevier, 1866), *Acanthoceras bellense* Adkins, 1928, *Calycoceras* (*Newboldiceras*) sp., *Conlinoceras* sp., *Paraconlinoceras leonense* (Adkins, 1928), *Cunningtoniceras lonsdalei* (Adkins, 1928), *Hamites cimarronensis* (Kauffman and Powell, 1977), *Sciponoceras*? sp., and *Turrilites* (*Turrilites*) *acutus* Passy, 1832. The *Acanthoceras amphibolum* zone is represented by the type species in the Lewisville Member of the Woodbine. The Six Flags Limestone Member of the Woodbine and the lower part of the bentonitic member of the Eagle Ford Group yield the index species and *Tarrantoceras* west of Dallas. A more diverse assemblage occurs in the basal Eagle Ford Group of Johnson and Tarrant Counties and the Lewisville Member from Bell County southwards. The highest fauna described is that of the *Plesiacanthoceras wyomingense* zone, known only from the Templeton Member of the Woodbine in the northeastern part of the study area. Two genera, *Paraconlinoceras* and *Plesiacanthoceratoides*, are new.

ROCKS of mid-Cenomanian age outcrop widely in north-east and central Texas from the Red River on the Texas/Oklahoma border in the north to the Austin area 400 km (250 miles) to the south (text-fig. 1). They encompass the Woodbine Formation and its southerly correlative the Pepper Shale; the Tarrant Formation and lower part of the Britton Formation of the Eagle Ford Group; and correlative parts of the Lake Waco Formation of the Eagle Ford Group to the south. Ammonites were first described from this interval by Shumard (1860), Cragin (1893) and Hyatt (1903). The first comprehensive account was that of Adkins (1928). The fauna of the Woodbine Formation was monographed by Stephenson (1953*a*, *b*) and that of the basal Eagle Ford Group in Johnson and Tarrant counties by the same author in 1955. As detailed below, unravelling the relative stratigraphic position of the faunas is complicated by the fact that beds with ammonites are of limited stratigraphic and geographic extent, especially in the Woodbine Formation, the bulk of which is of fluvio-deltaic and marginal marine origin (Oliver 1971), and the sequence is cut through by regional unconformities (Stephenson 1929). Whereas precise ammonite zonation has been established for the mid-Cenomanian of the US Western Interior (Cobban 1984), it has thus far proved impossible to extend this to central Texas (Young and Powell 1978). As we show below, the bulk of the Texas faunas are readily placed in the standard zonation. The taxonomic revision of the fauna reveals interesting patterns of evolution in certain of the endemic taxa which mirror those of contemporaneous Old World faunas.

[Palaeontology, Vol. 33, Part 1, 1990, pp. 75–154, 17 pls.]



TEXT-FIG. 1. Locality map showing the outcrop of the Woodbine Formation and Eagle Ford Group, and some of the more important localities mentioned in the text.

AMMONITE ZONATION

Adkins (1933) was unable to recognize a satisfactory zonation in the Woodbine. He recognized three zones in his Cenomanian part of the Eagle Ford; in ascending order these had *Acanthoceras tarrantense* Adkins, 1928, *Acanthoceras wintoni* Adkins, 1928 and *Eucalycoceras bentonianum* (Cragin, 1893) as indices. As will be shown below the first two are synonyms, and *E. bentonianum* is a *Sumitomoceras* of the *Sciponoceras gracile* zone. Moreman (1942) proposed a more complex system for the Tarrant Formation; it was referred to an *Acanthoceras inaequiplicatus* zone, subdivided in ascending order into subzones of *Mantelliceras sellardsi* Adkins, 1928, *Acanthoceras wintoni* Adkins, 1928, *Acanthoceras sherborni* Spath, 1926*a*, *Acanthoceras alvaradoense* Moreman, 1942 and *Metoicoceras swallovi* Shumard, 1860. *Acanthoceras inaequiplicatus* of Moreman is a synonym of *Conlinoceras tarrantense*, as is *A. wintoni*; the *A. sherborni* of Moreman is a synonym of *A. bellense* Adkins, 1928, and *A. alvaradoense* is a synonym of *Acanthoceras amphibolum* Morrow, 1935. The species are thus in the correct stratigraphic sequence except for *M. sellardsi*, which is a *Tarrantoceras* that co-occurs with *A. amphibolum*. The most recent zonation is that of Young and Powell (1978):

Upper Cenomanian	*Kanabiceras septemseriatum* zone *Acanthoceras alvaradoense* zone *Eucalycoceras bentonianum* zone *Conlinoceras tarrantense* zone
Lower Cenomanian	*Forbesiceras brundrettei* zone *Budaiceras hyatti* zone *Graysonites lozoi* zone *Plesioturrilites brazoensis* zone

It should be noted that Young (1986) has since referred to the *F. brundrettei* zone as the lowermost zone of the middle Cenomanian. As will be shown below, *F. brundrettei* is best regarded as lower Cenomanian, and as already noted, *E. bentonianum* is a *Sciponoceras gracile* zone *Sumitomoceras* (e.g. *septemseriatum* Zone of Young and Powell).

We used a modified version of the standard southern Western Interior zonal sequence of Cobban (1984), Cobban *et al.* (1989) and Kennedy (1988), as follows:

Upper Cenomanian	*Nigericeras scotti* zone *Neocardioceras juddii* zone *Burroceras clydense* zone *Sciponoceras gracile* zone *Metoicoceras mosbyense* zone *Calycoceras canitaurinum* zone
Middle Cenomanian	*Plesiacanthoceras wyomingense cobbani* zone *Acanthoceras amphibolum* zone *Acanthoceras bellense* zone *Conlinoceras tarrantense* zone
Lower Cenomanian (part)	*Forbesiceras brundrettei* zone *Acompsoceras inconstans* zone *Budaiceras hyatti* zone

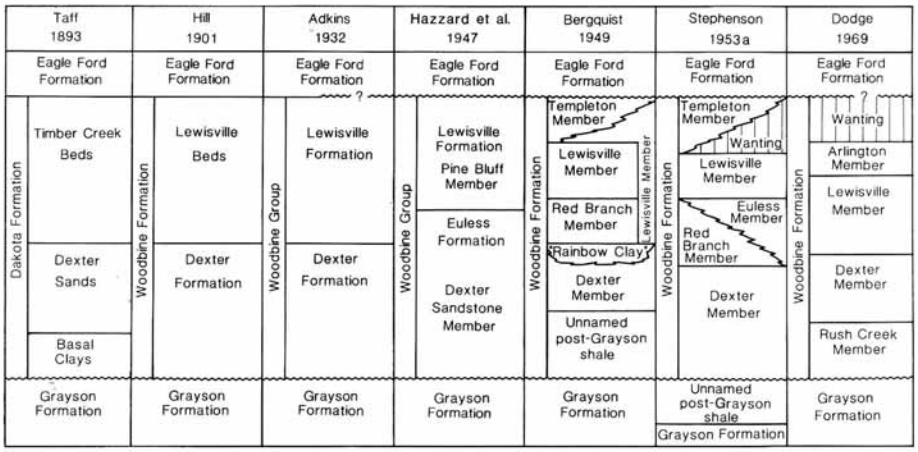
Two subzones can be recognized in the *A. amphibolum* zone, characterized by the restricted form of the zonal index below and the subspecies *fallense* above. Characteristic faunas of, and criteria for recognizing, this sequence are to be found in Cobban (1984) and Kennedy (1988). The only departure is the insertion of an *A. bellense* zone into the sequence. This is based upon the presence, in Bell County, of a distinctive assemblage immediately below the *A. amphibolum* zone with the

following fauna: *Anagaudryceras involvulum* (Stoliczka, 1865), *Puzosia* (*Puzosia*) sp., *Forbesiceras* cf. *chevillei* (Pictet and Renevier, 1866), *Acanthoceras bellense* Adkins, 1928, *Calycoceras* (*Newboldiceras*) sp., *Conlinoceras* sp., *Paraconlinoceras leonense* (Adkins, 1928), *Cunningtoniceras lonsdalei* (Adkins, 1928), *Hamites cimarronensis* (Kauffman and Powell, 1977), *Sciponoceras*? sp. and *Turrilites* (*Turrilites*) *acutus* Passy, 1832.

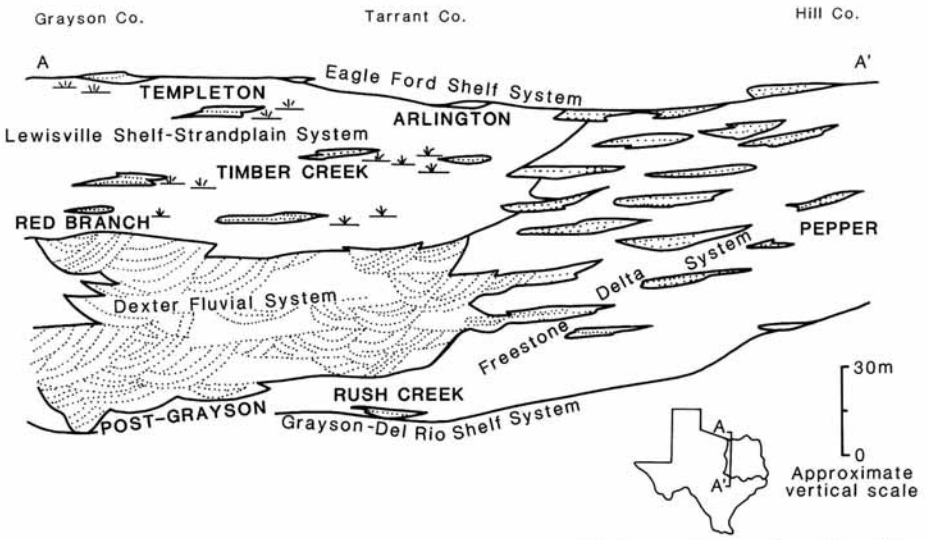
STRATIGRAPHY

Woodbine Formation

The name Woodbine was first used by Hill (1902) for exposures at Woodbine in eastern Cooke County, Texas. Detailed accounts of previous work and measured sections are to be found in Adkins (1933), Bergquist (1949), Adkins and Lozo (1951), and Stephenson (1953*a*, *b*). Dodge (1969) summarized the complex nomenclature of the various members recognized by previous workers (reproduced here as text-fig. 2). The Woodbine rests unconformably on upper Albian Main Street Formation or lower Cenomanian Grayson Marl from the Texas/Oklahoma border south to Bosqueville in McLennan County, beyond which it rests upon the lower Cenomanian Buda Limestone through the remainder of the study area. Its upper limit is also a discontinuity. Identifiable ammonites are of limited distribution within the Woodbine, the bulk of the formation being of fluviodeltaic origin. Text-figure 3 shows a diagrammatic representation of the outcrop stratigraphic relations taken from the work of Oliver (1971). The formation is 152 m (500 feet) thick in the Red River area, 91 m (300 feet) at the Tarrant–Johnson county line and reduced to less than 10 m south of the Brazos River, where it is replaced by a wholly shale sequence, the Pepper Shale. Adkins and Lozo (1951) cite 5·5 m (18 feet) on the Johnson–Hill County Line and reduction to zero on the San Marcos arch (for definition see Adkins 1933, p. 266) between Austin and San Antonio. Oliver (1971) recognized three principal depositional systems in the Woodbine: a fluvial system, a high-destructive delta system and a shelf-strandplain system. The fluvial system is represented at outcrop by the Dexter fluvial system, which is dominant north and northeast of a line from Dallas to Tyler. It yields no ammonites. Migration of the drainage network to the east throughout Woodbine delta building and continued subsidence of the area previously occupied by the fluvial system resulted in submergence of much of that area during deposition of the Lewisville shelf-



TEXT-FIG. 2. Stratigraphic nomenclature of the Woodbine Formation of previous workers, redrawn from Dodge (1969).



TEXT-FIG. 3. Diagrammatic Woodbine outcrop section, Grayson to Hill County, Texas, redrawn from Oliver (1971).

strandplain system. This yields a few specimens of the early form of *Acanthoceras amphibolum* Morrow, 1935 on Walnut Creek, 0·3 miles north of Gordonville in Grayson County. To the south and southwest, the high-destructive delta system, the Freestone Delta System of Oliver, persists throughout the Woodbine section; portions outcrop in Johnson to Falls Counties, but most of the unit is subsurface. There are no ammonites.

The Tarrant problem. Beds between typical sandstones of the Woodbine and typical shales of the Britton Formation of the Eagle Ford Group in Tarrant County were described by Moreman (1933) as the 'Tarrant sandy clay and limestone' and as the 'Tarrant formation' by the same author in 1942, where he regarded them as the basal unit of the Eagle Ford. Adkins and Lozo (1951, p. 123) refer to it as a 'fictitious lithic unit'. Stephenson (1953*a*, p. 14) believed the Tarrant to be part of the Lewisville Member of the Woodbine, and described the ammonite fauna as such, presenting, in the same year (1953*b*, p. 53) clear evidence that the Tarrant was older than the Bluebonnet Member of the Lake Waco Formation of the Eagle Ford Group in Bell County. Moreman and some others equated the Tarrant and the base of the Eagle Ford in Bell County, and some faunal lists in the literature (e.g. Moreman 1942) include elements from both units. Brown and Pierce (1962), Norton (1965) and Powell (1968) all return to Moreman's view, classifying it with the Eagle Ford. Resolution of this dichotomy of opinion is beyond the scope of this discussion, and irrelevant to it. The unit is referred to as the Eagle Ford here for convenience only. The critical section for this account is that described by Powell (1968), between the north- and south-bound lanes of Texas Highway 360 between Randol Mill Road and the Dallas–Fort Worth Turnpike and Six Flags Park in northeast Arlington, between Dallas and Fort Worth:

Britton Member	Feet
Clay: dark-grey weathering pale greyish-orange calcareous, hard and rather brittle when dry, bentonitic; contains thin, discontinuous lenses of qtz siltite and calcsiltite along with streaks and beds of white to orange bentonite up to 8 inches thick.	18

Sandy flags: reddish-brown quartz-bearing calcarenite, calcite cement, locally hard and resistant, 1 inch to 3 inches thick; contains fish debris, mainly *Ptychodus whipplei*, lamnid shark and teleost fragments; lucinid clams, *Inoceramus pictus*, *Acanthoceras* cf. *A. wintoni* impressions, *Eucalycoceras*? sp. and *Tarrantoceras*? impressions. Calcareous clay as above. 1

Silty clay and flags: silty clay, light olive-grey to dark-grey, non-calcareous, with silt laminae and tuffaceous? sand. Flags, quartz-bearing, reddish-brown calcsiltite as above, occurring in top 3 feet of unit. 7

Sandy clay: light to dark bluish-grey, silty streaks, mottled and streaked with limonite stain and jarosite; top of unit is 1 to 4 inches tuffaceous? sandstone, with feldspar and mica. Base of unit is soft, clayey quartz sand. 5

Tarrant Member

Sandstone: yellowish- and greyish-brown, very fine to fine quartzose, with few chert pebbles and locally abundant phosphatic granules; burrowed, local calcareous cement; grades downward into grey to yellowish-brown gypsiferous sandy clay (2 feet). 4·5

Sandstone: yellowish-grey to brown, very fine quartzose, with large crustacean burrows (*Callianassa*?), *Acanthoceras wintoni*, *Eucalycoceras* sp., tellinid clams; contains wave ripples trending N–S, and current cross-laminations. 2

Sandstone and shale: sandstone, yellowish-brown, very fine to fine quartzose, in beds ranging in thickness from 3 to 8 inches. Shale, bluish-grey and yellowish-grey, silty with calcareous quartz siltstone flags 1 to 3 inches thick. Shale and sandstone complexly interbedded and contain *A. wintoni*, *A. tarrantense*, *Epengonoceras dumbli*, *Phelopteria dalli*, *Exogyra columbella*, *Ostrea subradiata*, mactrid and other clams. Base of Tarrant not exposed. 6

Total section measured 43·5

Brown and Pierce (1962) showed the base of the Tarrant to be a marked unconformity with a basal phosphatic conglomerate in the Dallas area. Observations by J. M. Hancock and W. J. Kennedy in 1972 indicate that the 'Sandy flags' of the Britton Member of Powell's section correspond to the 'Six Flags limestone' of Norton (1965). The base includes phosphatic pebbles and vertebrate debris, and may be an unconformity. It yields *Tarrantoceras* and *Acanthoceras* of the *amphibolum* group, as do the overlying shales; a prominent bentonite 1·5 m (5 feet) above the Six Flags Limestone Member is identified as the X bentonite of the Western Interior (itself an *A. amphibolum* zone marker) by Kauffman, Hattin and Powell (1977, p. 26).

It should be noted that Norton (1965) draws the Tarrant/Britton boundary at the top of the Six Flags limestone and Powell (1968) 3·65 m (12 feet) below it.

The Templeton Member. Higher biostratigraphic horizons are indicated by the ammonites from the Templeton Member of the Woodbine, a clay and shale unit up to 24 m (80 feet) thick and present from central Denton County northwards to Grayson County and east to eastern Lamar County. Ammonites occur in three different and widely separated parts of the outcrop and it is impossible to put them all in relative sequence from evidence from Texas alone.

The first occurrence is at locality 1540 of Stephenson (1953*a*) (= USGS localities 14092, 14560, 17163, 18236 and 18971, also represented by OUM KT3937–3989), gullies just south of the old Sherman Highway, 4·5 km (2·8 miles) south-east of the centre of Whitesboro, Grayson County, some 13·7 m (45 feet) below the base of the Eagle Ford. The fauna is: *Metengonoceras dumbli*, *Tarrantoceras cuspidum* (Stephenson, 1953*a*), *Metoicoceras latoventer* Stephenson, 1953*a*, and *Hamites* sp. *M. dumbli* first appears in the *Conlinoceras tarrantense* zone in Texas and ranges to the *Sciponoceras gracile* zone in western Europe (Kennedy *et al.* 1981; Kennedy and Juignet 1984; Cobban 1987*a*). *Metoicoceras* aff. *latoventer* is recorded from west-central New Mexico by Cobban (1977*a*) in association with what may be a *Calycoceras canitaurinum* zone fauna, providing a possible date for this assemblage.

Ammonites are abundant at the type locality of the Templeton, locality 164 of Stephenson (1953*a*) (= USGS locality 20314, also represented by OUM KT4300–4346), bluffs along Templeton Branch of Cornelius Creek, Cooke County, some 37 km (23 miles) to the east. Stephenson places this 6·1 m (20 feet) above the top of the Lewisville Member, and thus probably a little lower in the lithologic sequence than the previous locality. The fauna is: *Metengonoceras dumbli* (common), *M. latoventer* (as represented by USNM 105986, a paratype of *Plesiacanthoceras* [*Mammites*] *bellsanum* (Stephenson, 1953*a*)), *Metoicoceras crassicostae* Stephenson, 1953*a* and *Plesiacanthoceras bellsanum* (Stephenson, 1953*a*). The last named is closely allied to but distinct from the form described by Cobban (1977*a*, p. 25, pl. 13, figs 1 and 2) as *P.* aff. *wyomingense* and later named *P. wyomingense cobbani* Atabekian, 1985 (p. 87). *Metoicoceras* comparable to *crassicostae* occur in the *P. wyomingense* zone of the northern part of the Western Interior (Cobban, 1987*a*, p. C5). We conclude that this is a *P. wyomingense* zone assemblage.

The third assemblage is the most problematic. It comes from localities around Arthur City and on the banks of the Red River in Lamar County, 112·6 km (70 miles) east-north-east of the others, corresponding to localities 201, 202, 203 and 207 of Stephenson (1953*a*), including the celebrated outcrop at Slate Shoals in the bed of the Red River, 13 km (8 miles) east of Arthur City, and now completely overgrown. The fauna is *Metengonoceras dumbli* and *Metoicoceras swallovi* (Shumard, 1860). The former is long-ranging (see above), the latter is known only from this area, and we cannot place it in sequence.

The Pepper Shale. This unit extends from the Brazos River southwards until it is cut out on the San Marcos arch between Austin and San Antonio. The type locality is in bluffs along Bird Creek (also referred to as Pepper Creek in the literature), 6·4 km (4 miles) east-north-east of Belton in Bell County, where it is 7·2 m (23·5 feet) thick, and rests unconformably on lower Cenomanian Del Rio Clay. Ammonites from the unit were discussed by L. F. Spath in 1933 (*in* Adkins 1933, p. 419), foraminifers by Plummer (*in* Adkins 1933) and Loeblich (1946), and molluscs by Stephenson (1953*b*). The last named and Adkins and Lozo (1951) provide detailed descriptions of the type and other sections. Spath's observations on the ammonites he examined for Adkins give no indications of precise age, whilst we have failed to relocate the material. Stephenson (1953*b*) described only a baculitid and an indeterminate acanthoceratid fragment. Our own collecting from the type locality yielded only an indeterminate turrilitid (OUM KT4985). All that can be said with certainty is that the Pepper is post-Del Rio Clay and pre-*Acanthoceras bellense* zone, for the latter fauna occurs at the base of the Bluebonnet Member of the overlying Lake Waco Formation. As noted below, old USGS collections with a lower Cenomanian *Forbesiceras brundrettei* zone fauna from the Waco area may be from the Pepper.

Eagle Ford Group

Dallas–Fort Worth area. Relations of the lower part of the Eagle Ford Group to the Woodbine Formation in the Dallas–Fort Worth area are discussed by Kennedy (1988). The Tarrant Formation of Moreman (1927, 1942) is a concretion-bearing sandy shale unit usually less than 15 m (50 feet) thick. As already noted, Stephenson (1953*a*) included it in the Lewisville Member of the Eagle Ford. The Tarrant rests with a sharp contact on what Dodge (1969) termed the Arlington Member (of the Woodbine) and yields (in the lower part) a *Conlinoceras tarrantense* zone fauna; the index species is common as is *Metengonoceras dumbli*, with *Paraconlinoceras barcusi* (Jones, 1938), *Cunningtoniceras inerme* (Pervinquière, 1907) (= *Acanthoceras eulessanum* (Stephenson, 1953*a*)), *Forbesiceras conlini* Stephenson, 1953*a* and *Turrilites dearingi* Stephenson, 1953*a* rare. The Six Flags Limestone Member (Norton 1965) and at least the basal 1·5 m of the succeeding bentonitic sub-member of the Britton Formation are of *A. amphibolum* zone age, yielding the index species and *Tarrantoceras sellardsi* (Adkins, 1928). No higher zonal indicators are known up to the *Sciponoceras gracile* zone.

Johnson and Tarrant Counties. Stephenson (1955) described a small fauna from the lower part of the

Eagle Ford Group at four localities in these two counties. The most important is on Walnut Creek, 7·6 km (4·75 miles) east-north-east of Mansfield in Tarrant County (Stephenson 1955, p. 54).

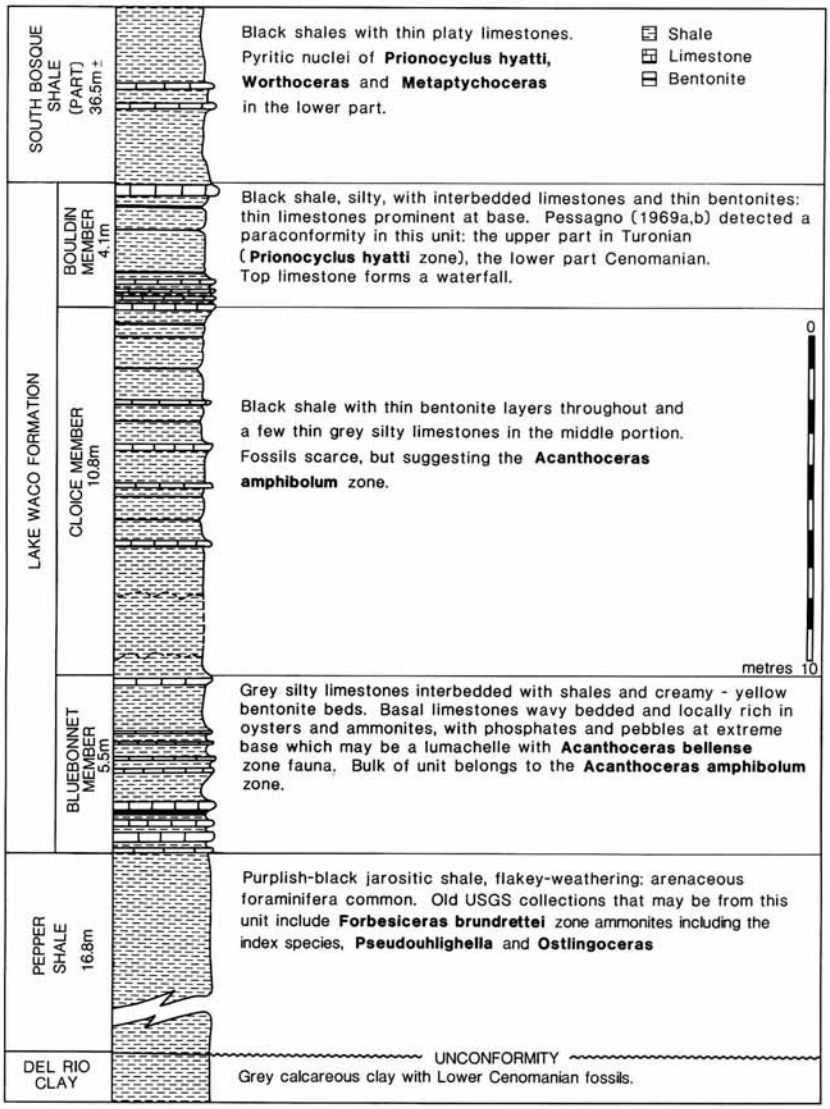
The Woodbine/Eagle Ford contact is an unconformity, and loose concretions from Stephenson's bed 5 of the Eagle Ford yield an abundant fauna. Many concretions are a solid mass of imbricated valves of *Inoceramus arvanus* Stephenson, 1953*a*, with rarer ammonites of the *Acanthoceras amphibolum* zone: *Borissiakoceras orbiculatum* Stephenson, 1955, *Moremanoceras straini* Kennedy, Cobban and Hook, 1988, *Acanthoceras amphibolum*, *Cunningtoniceras johnsonanum* (Stephenson, 1955), *Plesiacanthoceratoides vetula* (Cobban, 1987*b*), *Turrilites* (*Turrilites*) *acutus* Passy, 1832, and *Anisoceras* cf. *plicatile* (J. Sowerby, 1819). Stream outcrops at a higher horizon yield a similar fauna in interbedded shales and shelly sandstones.

The Waco area. The Eagle Ford Group in this area is described in detail by Adkins and Lozo (1951), with important additional observations in Brown and Pierce (1962) and Pessagno (1969*a*, *b*). The sequence differs markedly from that around Dallas, with the appearance of significant developments of limestones in the lower part of the succession. The *Forbesiceras brundrettei* zone is represented by old collections from a number of localities in this area. Although labelled 'Del Rio' they are from the Woodbine/Eagle Ford outcrop, but cannot be referred with confidence to Woodbine versus Eagle Ford, although probably from the Pepper Shale (Woodbine equivalent). The old brickpit on Cloice Branch yielded, to L. W. Stephenson, T. W. Stanton and J. B. Reeside, Jr. in 1927 the following from '12–15 feet below top of Del Rio' (USGS locality 14592): *Moremanoceras elgini* (Young, 1958), *Forbesiceras brundrettei* (Young, 1958), *Ostlingoceras brandi* Young, 1958. A collection from USGS locality 14598 'Upper Member of Del Rio Clay $\frac{1}{2}$ mile east of South Bosque, near railroad' includes *Ostlingoceras davisense* Young, 1958 and *F. brundrettei*. The Eagle Ford rests with marked unconformity on Pepper Shale (text-fig. 4). The basal shale of the Eagle Ford 45 cm (1·5 feet) thick on Pepper Creek (Adkins and Lozo 1951, p. 130, figs. 8, 13), is overlain by the Lake Waco Formation, some 18–24 m (60 to 80 feet) thick, and divided into three members. The lowest, Bluebonnet Member, is discussed in detail by Silver (1963), who described it as 3 to 6 m (10 to 20 feet) of limestones, shales and bentonites, restricted to all or portions of Bell, Falls, McLennan, Limestone and Hill Counties. He interpreted it as a lagoonal sequence, and noted that ammonites were restricted to the lower part. He gives a series of detailed sections, which supplement those of Adkins and Lozo (1951). The key section is on Bird Creek (Pepper Creek) and environs, 6·4 km (4 miles) east-north-east of Belton in Bell County. A discontinuous concretionary phosphatic pebble/shell conglomerate no more than 30 cm thick yields a diverse *Acanthoceras bellense* zone fauna: *Anagaudryceras involvulum*, *Puzosia* sp., *Forbesiceras* cf. *chevillei*, *Acanthoceras bellense*, *Cunningtoniceras lonsdalei*, *Calycoceras* (*Newboldiceras*) sp., *Conlinoceras* sp., *Paraconlinoceras leonense*, *Hamites cimarronensis*, *Turrilites acutus*, and *Sciponoceras*? sp.

Ammonites of the *A. amphibolum* zone are common in the succeeding flaggy limestones at this locality, and for several metres above. The OUM collections include the index species, numerous *Tarrantoceras sellardsi* and *Moremanoceras straini*. This same assemblage occurs widely elsewhere in the Waco area. A collection from USGS locality 14591, labelled 'Lower part of Eagle Ford Clay, 7·5 feet above base of Eagle Ford' and presumably from the Bluebonnet Member in an old brickpit on Cloice Branch, 1·3 km (0·8 mile) east of South Bosque, McLellan County, yielded abundant *M. straini*, *A. amphibolum*, *T. sellardsi* and *Hamites cimarronensis*.

The Cloice Member of the Lake Waco Formation is predominantly shale, 10·8 m (35·5 feet) thick at the type locality on Cloice Branch; Adkins and Lozo (1951) cite it as yielding similar faunas to the Bluebonnet.

The Bouldin Member of the Lake Waco Formation is a sequence of interbedded greyish white to brownish silty limestones and silty shales with bentonites, 2·8 m (9·25 feet) thick at the type locality on Bouldin Creek between Milton Street and Barton Springs Road, Austin (Adkins and Lozo 1951, p. 121), and 4·1 m (13·5 feet) on Cloice Branch, east of South Bosque (Adkins and Lozo 1951, fig. 18). Adkins and Lozo (1951, p. 142) record '*Eucalycoceras*, *Metoicoceras* and *Mantelliceratidae*'. Pessagno (1969*a*, *b*) concluded that there was an unconformity 3–4·25 m (10–14



TEXT-FIG. 4. The Pepper Shale (Woodbine equivalent) and lower part of the Eagle Ford Group on Cloice Branch, southwest of Waco, McLennan County (after Adkins and Lozo 1951).

feet) from the top of the Lake Waco Formation. The Blue Cut section (Adkins and Lozo 1951, p. 136) shows *Prionocyclus hyatti* occurring in the top Lake Waco/basal South Bosque Formation transition; there are no records of post-*A. amphibolum* and pre-*P. hyatti* zone fossils in this area and the break may thus be of this extent.

Austin area. Adkins (1933, p. 436) records 3·7 m (12 feet) of black limestone flags and shale with '*Exogyra columbella*, *Mantelliceras* n.sp. (compressed), *Acanthoceras* sp. (strongly cornute), *Eucalycoceras leonense* Adkins, *Austiniceras* n.sp., *Eucalycoceras bentonianum* Cragin (?), *Metoicoceras* sp. (?)'. From his usage elsewhere, this is an *A. amphibolum* zone fauna, confirmed by a fine specimen of *Tarrantoceras sellardsi* from USGS Locality 14609, Public Road 1·8 km (1·1 miles) south-south-east of Round Rock in Williamson County approximately 10 miles north of Austin.

SYSTEMATIC PALAEONTOLOGY

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 D.C.
TMM: University of Texas Memorial Museum, Austin, Texas.
UMM: University of Michigan Museum of Paleontology, Ann Arbor, Michigan.

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 millimetres; D = diameter, Wb = whorl breadth, Wh = whorl height, U = umbilicus, c = costal, ic = intercostal. Figures in parentheses refer to percentages 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 that include illustrations of material or important systematic, stratigraphic or geographic information are included.

Order AMMONOIDEA Zittel, 1884, pp. 355, 392
Suborder LYTOCERATINA Hyatt, 1889, p. 7
Superfamily TETRAGONITACEAE Hyatt, 1900, p. 568
Family GAUDRYCERATIDAE Spath, 1927, p. 66
Genus ANAGAUDRYCERAS Shimizu, 1934, p. 67
(= *Paragaudryceras* Shimizu, 1934, p. 67; *Murphyella* Matsumoto, 1972, p. 208)

Type species. By original designation: *Ammonites sacya* Forbes, 1846, p. 113, pl. 14, fig. 9.

Anagaudryceras involvulum (Stoliczka, 1865)

Plate 1, figs. 17–19

1865 *Ammonites involvulus* Stoliczka, p. 150, pl. 75, fig. 1 (*involutus* in explanation of plate).
1865 *Ammonites sacya* Forbes; Stoliczka, p. 154, pl. 76, fig. 3 only.
1895 *Lytoceras* (*Gaudryceras*) *involvulus* (Stoliczka); Kossmat, p. 32.
1935 *Gaudryceras* (*Anagaudryceras*) *utaturense* Shimizu, p. 176.
1956 *Anagaudryceras involvulum* (Stoliczka); Collignon, p. 68.
1966 *Anagaudryceras involvulum* (Stoliczka); Howarth, p. 219, pl. 1, figs. 1 and 2.
1975 *Anagaudryceras involvulum* (Stoliczka); Kennedy and Juignet, p. 77, fig. 1.
1976 *Anagaudryceras involvulum* (Stoliczka); Juignet and Kennedy, p. 49, pl. 1, figs. 1 and 2.
1984 *Anagaudryceras involvulum* (Stoliczka, 1865); Wright and Kennedy, p. 50, pl. 2, fig. 2; text-figs. 1C and F.

Type. Holotype is Stoliczka's original specimen (1865 pl. 75, fig. 1) from the Utatur Group of Odium, South India, by monotypy.

Material. USNM 420184, from the basal shell bed of the Bluebonnet Member on Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County, middle Cenomanian *Acanthoceras bellense* zone.

Dimensions	D	Wb	Wh	Wb:Wh	U
USNM 420184	68·5 (100)	28·5 (41·6)	29·3 (42·8)	0·07	23·5 (34·3)

Description. Coiling is moderately involute with U = 34% of diameter, and of moderate depth. Whorl section is slightly compressed (Wb:Wh = 0·97), with greatest breadth just outside the umbilical shoulder. The umbilical wall is rounded, the inner flanks broadly rounded, the outer flanks flattened and convergent, the venter broadly arched. The shell surface is worn, and no trace of ornament survives, nor are the sutures visible.

Occurrence. The species is known from both the lower and middle Cenomanian, with records from southern India, Angola, Haute-Normandie in France, Devon, England, and central Texas.

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 mirabilis* Arkhanguelsky, 1916, p. 55, pl. 8, figs. 2 and 3.

Borissiakoceras orbiculatum Stephenson, 1955

Plate 1, figs. 1–14

1955 *Borissiakoceras orbiculatum* Stephenson, p. 64, pl. 6, figs. 1–4.
1961 *Borissiakoceras orbiculatum* Stephenson; Cobban, p. 750, pl. 88, figs. 15–44; text-figs. 5a–f.
1988 *Borissiakoceras orbiculatum* Stephenson; Kennedy, p. 18, pl. 1, figs. 23–26 (with synonymy).

Holotype. USNM 108832 from the basal Eagle Ford Group on Walnut Creek, 7·6 km (4·75 miles) north-east of Mansfield, Texas, *Acanthoceras amphibolum* zone.

Material. Ten specimens, USNM 420185 to 420191 from USGS Mesozoic locality D12626, loose concretion at roadside 8·9 km (5·5 miles) north-east of Mansfield, Johnson County. Nine specimens, USNM 420192 to 420193 from USGS Mesozoic locality D9502, concretion in field 0·5 km (0·3 mile) north-north-west of Lillian, Johnson County. USNM 420194 from a concretion in a crop field, 1·6 km (1 mile) north of Lillian, Johnson County. Horizon as for type.

Discussion. This species is described at length by Cobban (1961). Stephenson (1955) based his description on 3 specimens only; the present collection includes both smooth and nodate variants as in the largest, Black Hills assemblage of the species (Cobban 1961, p. 750, pl. 88, figs. 15–41; text-figs. 5a–f).

Occurrence. *Acanthoceras amphibolum* zone of Wyoming, Colorado, Kansas and Texas. *Sciponoceras gracile* zone of north-central Texas.

Genus JOHNSONITES Cobban, 1961

Type species. *Johnsonites sulcatus* Cobban, 1961, p. 743, pl. 87, figs. 1–18; text-figs. 3a–g, by original designation.

Johnsonites sp.

1953*a* *Euhoplites* sp. Stephenson, p. 198, pl. 45, figs. 5 and 6.

Material. USNM 105961, from the Lewisville Member of the Woodbine Formation on Timber Creek, 3·5 km (2·25 miles) south-west of Lewisville, Denton County.

Discussion. Cobban (1961, p. 746) notes that this specimen differs from *J. sulcatus* only by the forwardly arched growth lines on the venter. *J. sulcatus* is best known from the *Conlinoceras gilberti* zone of Wyoming and southern Colorado.

Occurrence. As for material.

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
(*nom. transl.* Matsumoto, 1938, p. 190; *ex* Desmoceratidae Zittel, 1895)
Genus MOREMANOCERAS Cobban, 1972, p. 465

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

Moremanoceras straini Kennedy, Cobban and Hook, 1988

Plate 1, fig. 25; Plate 2, figs. 1–3, 9–23, 26–28, 31–33

?1955	*Desmoceras*? sp. Stephenson, p. 58, pl. 4, figs. 12 and 13.
1977*a*	*Desmoceras* (*Pseudouhligella*) aff. *D. japonicum* Yabe; Cobban, p. 22, pl. 11, figs. 1–6, 9, 10.
1977*b*	*Desmoceras* (*Pseudouhligella*) aff. *D. japonicum* Yabe; Cobban, fig. 4a–e.
1988	*Moremanoceras straini* Kennedy, Cobban and Hook, p. 36, fig. 1a–g, i, t.

Types. Holotype is USNM 416051 by original designation; paratypes USNM 416052–416060, from the base of the Boquillas Formation, *Acanthoceras amphibolum* zone, Cerro de Cristo Rey, New Mexico, the originals of Kennedy, Cobban and Hook, 1988, fig. 1c and d.

EXPLANATION OF PLATE 1

Figs. 1–14. *Borissiakoceras orbiculatum* Stephenson, 1955. 1–3, USNM 420185; 4–6, USNM 420186; 7 and 8, USNM 420187; 9, USNM 420188; 10, USNM 420189; 11–13, USNM 420190, from USGS Mesozoic locality D12626, loose concretion at roadside 8·9 km (5·5 miles) north-east of Mansfield, Johnson County. 14, USNM 420192, from USGS Mesozoic locality D9502, concretion in field 0·5 km (0·3 mile) north-north-west of Lillian, Johnson County. All ×2 from the basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone.

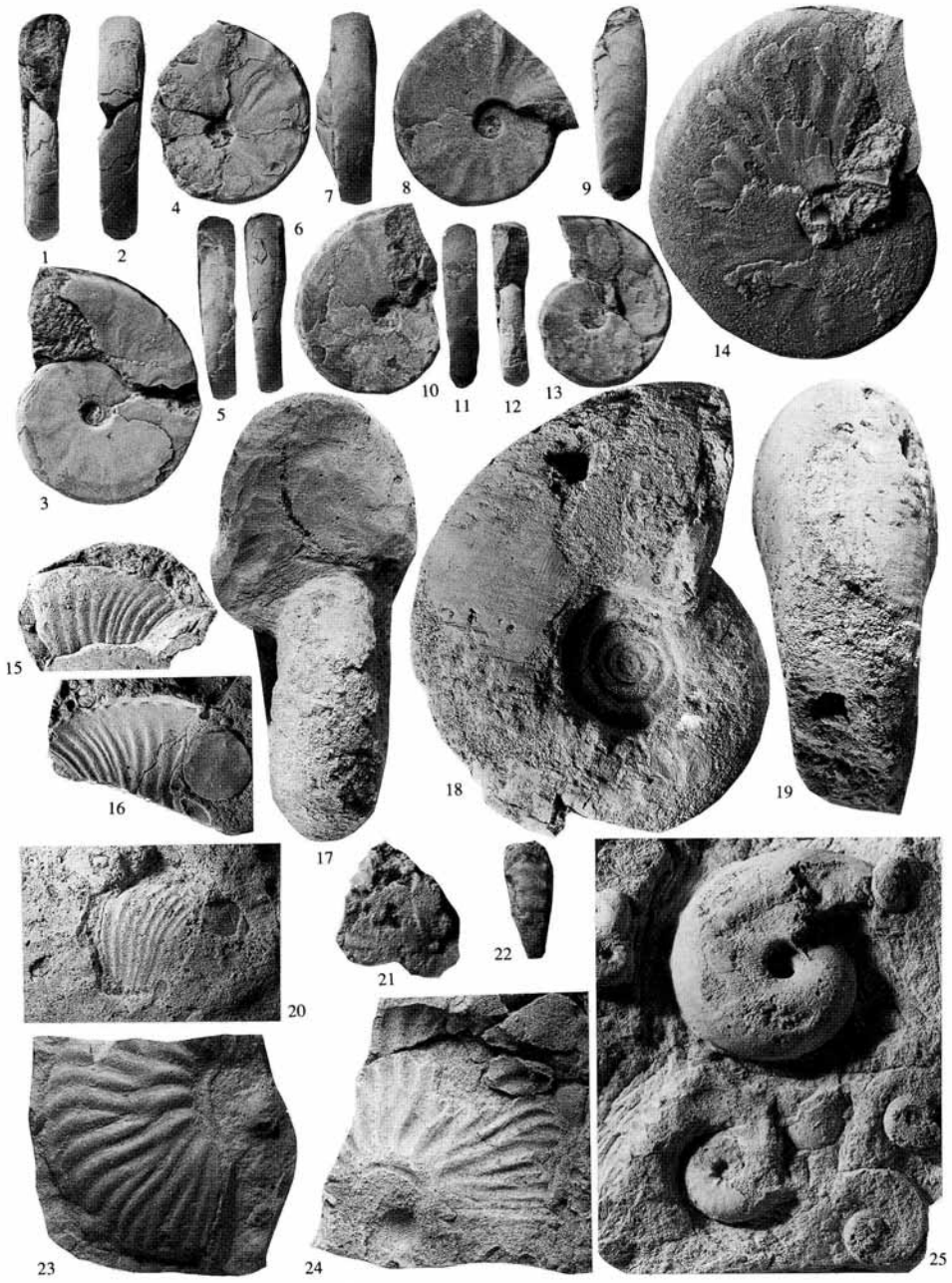
Figs. 15 and 16, 20, 23 and 24. *Forbesiceras brundrettei* (Young, 1958). 15 and 16, USNM 424120; 20, USNM 424121; 23 and 24, USNM 424122 all from USGS locality 14592, old brickpit on Cloice Branch, 1·3 km (0·8 mile) east of South Bosque, McLennan County. *F. brundrettei* zone, Pepper Shale (inferred).

Figs. 17–19. *Anagaudryceras involvulum* (Stoliczka, 1865). USNM 420184, from the basal shell bed of the Bluebonnet Member on Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County. *Acanthoceras bellense* zone.

Figs. 21 and 22. *Forbesiceras* cf. *chevillei* (Pictet and Renevier, 1866). USNM 420211, horizon and locality as for the originals of figs. 17–19.

Fig. 25. *Moremanoceras straini* Kennedy, Cobban and Hook, 1988. USNM 420210, from the Bluebonnet Member on Cloice Branch, east of South Bosque, McLennan County. *Acanthoceras amphibolum* zone.

Figures 1–14 are ×2; the remainder are ×1.



KENNEDY and COBBAN, Cenomanian ammonites

Material. Abundant specimens, including USNM 420195 to 420204 from USGS Mesozoic locality D 12626, 8·9 km (5·5 miles) north-east of Mansfield, Johnson County. Four specimens, USNM 420205 from USGS Mesozoic locality D9502, concretions in field 0·5 km (0·3 mile) north-north-west of Lillian, Johnson County. Four specimens, USNM 420206 to 420207 from 0·3 km (0·2 mile) south of Mountain Creek, 6·1 km (3·8 miles) northeast of the town square in Alvarado, Johnson County. All basal Eagle Ford Group, middle Cenomanian *Acanthoceras amphibolum* zone.

Numerous specimens, USNM 420208 to 420209, from 7·2 km (4.5 miles) south of McGregor on western slope of eastern Moody Hills, opposite Bagett's Station, McLennan County; USNM 420210 from Cloice Branch east of South Bosque, McLennan County, all Bluebonnet Member of Lake Waco Formation, *Acanthoceras amphibolum* zone.

Dimensions	D	Wb	Wh	Wb:Wh	U
USNM 420203	17·2 (100)	8·7 (50·6)	7·5 (43·6)	1·16	2·3 (13·4)
USNM 420195	21·0 (100)	10·0 (47·6)	8·7 (41·4)	1·14	3·9 (18·6)
USNM 420202	29·8 (100)	13·4 (45·0)	12·6 (42·3)	1·06	7·3 (24·5)
USNM 420196	30·3 (100)	13·0 (42·9)	14·6 (48·1)	0·89	6·9 (22·7)

Description. Involute with small, deep umbilicus, umbilical ratio increasing with growth (see table of dimensions). Umbilical wall flattened, umbilical shoulder narrowly rounded. Whorl section initially depressed, becoming compressed in middle and later growth. Inner flanks flattened, subparallel, outer flanks convergent, venter arched, rounded. The internal mould is smooth but for traces of growth striae and constrictions, 5–6 per whorl, flanked by variability developed collar ribs. Constrictions are feebly concave over umbilical shoulder and inner flank, convex across mid-flank and concave on the outer flank where they strengthen markedly, projecting forwards over the ventrolateral shoulder, shallowing and narrowing, to cross the siphonal line in a narrow linguoid peak. The associated collar ribs are generally prominent only on the ventrolateral shoulder. At small diameters, the venter is evenly rounded. From approximately 25 mm onwards a blunt, rounded siphonal keel appears, flanked by shallow grooves, its crest marked by the linguoid peak of the growth lines.

Few well-preserved specimens have shell present. Those that do show little or no trace of constrictions or collars, and have a more conspicuous keel.

Sutures moderately incised, with symmetrically bifid E/L, trifid L and small, little-incised auxiliary lobes.

Discussion. Moremanoceras elgini (Young, 1958, p. 292, pl. 39, figs. 4–20, 24 and 25, 30 and 31; text-figs. 1a–e) is more compressed when young, develops thickened collar ribs from 15 mm diameter and strong, distant flank and ventrolateral ribs when mature. It never develops a keel. *Moremanoceras* sp. nov. of the *Calycoceras canitaurinum* zone of the Black Hills, New Mexico and

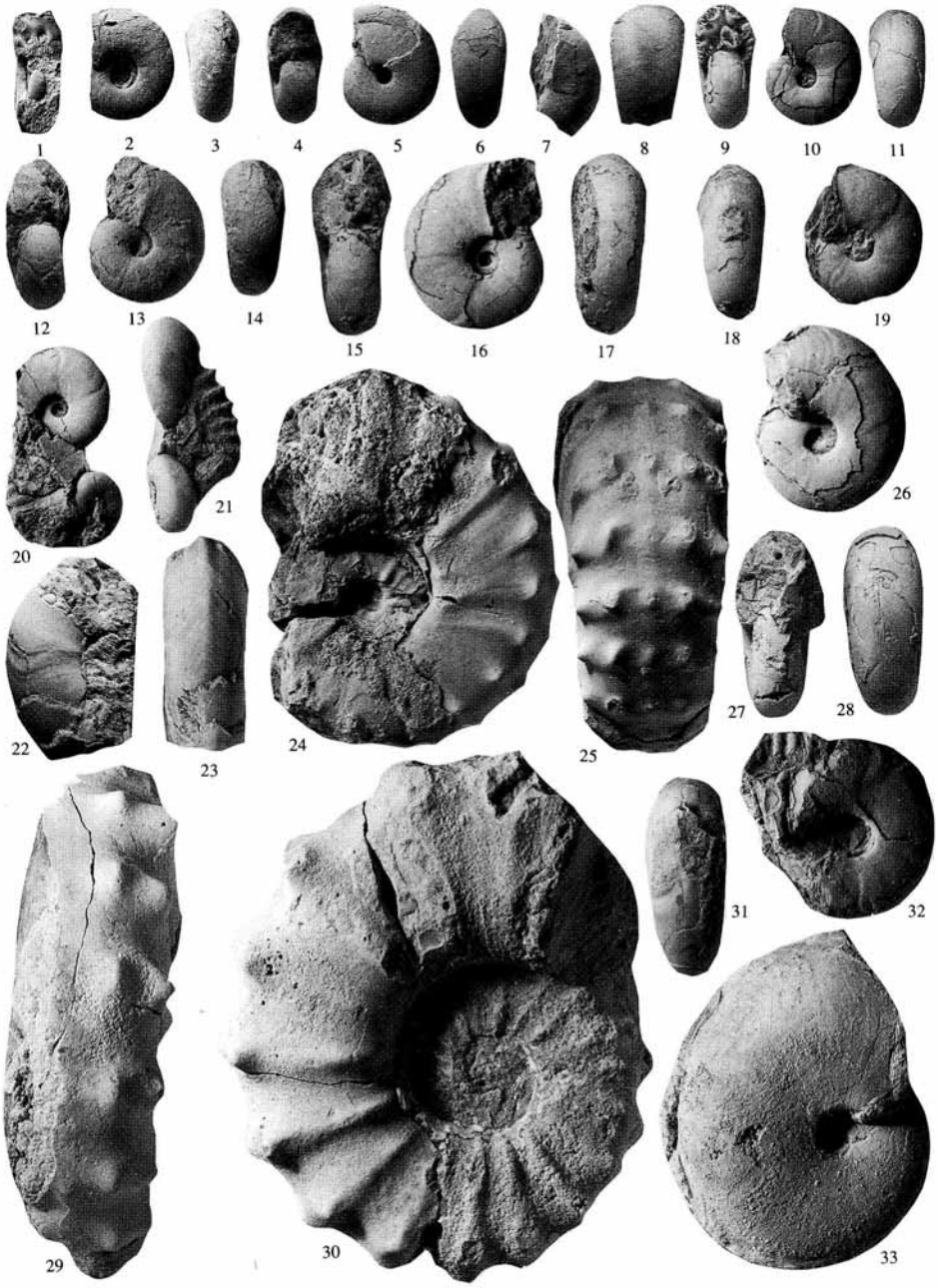
EXPLANATION OF PLATE 2

Figs. 1–3, 9–23, 26–28, 31–33. *Moremanoceras straini* Kennedy, Cobban and Hook, 1988. 1–3, USNM 108830, the original of Stephenson (1955, pl. 4, figs. 12 and 13) from USGS locality 11740 Walnut Creek, east-north-east of Mansfield, Tarrant County. 9–11, USNM 420195; 15–17, USNM 420196; 18 and 19, USNM 420197; 20 and 21, USNM 420198; 22 and 23, USNM 420199; 26–28, USNM 420200; 31 and 32, USNM 420201, all from USGS Mesozoic locality 12626, loose concretion, 8·9 km (5·5 miles) north-east of Mansfield, Johnson County. 12–14, USNM 420206, from USGS Mesozoic locality D9502, 0·5 km (0·3 miles) north-north-west of Lillian, Johnson County. All specimens are from the basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone. 33, USNM 420208, from the Bluebonnet Member, 7·2 km (4·5 miles) south of McGregor on western slope of eastern Moody Hills, McLennan County. *Acanthoceras amphibolum* zone. 4–6, USNM 105959 from USGS locality 14560, gullies south of old Sherman highway, 4·5 km (2·8 miles) east of Whitesboro, Grayson County. 7 and 8, USNM 105960, from USGS locality 13799, Golden Bluff, Red River, 4·8 km (3 miles) east of Arthur City, Lamar County. *Plesiacanthoceras wyomingense* zone.

Figs. 4–8. *Plesiacanthoceras bellsanum* (Stephenson, 1953*a*). 4–6, USNM 105959, from USGS locality 14560 on the old Sherman road, east of Whitesboro, Grayson County; 7 and 8, USNM 105960, from Golden Bluff, Lamar County. Both from the Templeton Member, *P. wyomingense* zone.

Figs. 24, 25, 29, 30. *Acanthoceras bellense* Adkins, 1928. 24 and 25, USNM 420212; 29 and 30 USNM 420214, both from the basal shell bed of the Bluebonnet Member on Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County. *Acanthoceras bellense* zone.

Figures 4–8 are ×2; the remainder are ×1.



KENNEDY and COBBAN, *Moremanoceras, Plesiacanthoceras Acanthoceras*

Trans-Pecos Texas has a sharper keel, present from an earlier ontogenetic stage, strong concave ribs on the ventrolateral shoulder and is homoeomorphous with certain *Damesites* species. The type species, *M. scotti* (Moreman, 1942, p. 208, pl. 33, fig. 8; text-fig. 20) (see Cobban 1972, p. 6, pl. 2, figs. 1–23; text-figs. 3–5) of the *Sciponoceras gracile* zone lacks a siphonal ridge or keel and has a much smaller umbilicus and distant collar ribs that extend to the umbilical shoulder.

Occurrence. Acanthoceras amphibolum zone of central and Trans-Pecos Texas.

Subfamily PUZOSIINAE Spath, 1922*a*, p. 126
Genus and Subgenus PUZOSIA Bayle 1878, explanation of pls. 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, pl. 79, figs. 1–3, by subsequent designation by H. Douvillé 1879, p. 91. See Wright and Kennedy (1984, p. 54) for discussion of the type species.

Puzosia (*Puzosia*) sp.

Material. OUM KT4986 from the base of the Bluebonnet Member, Pepper Creek, south-east of Interstate 35, 4·3 km (2·75 miles) north-east of Leon River Bridge, Bell County. *Acanthoceras bellense* zone.

Description. Specimen is a septate fragment only, with a maximum preserved whorl height of 69 mm. Only ventral ornament is preserved. It consists of coarse distant strong ribs with at least 15 much weaker ribs between.

Discussion. Puzosia has not been previously recognized in the mid-Cenomanian of the US Western Interior and Gulf Coast. The fragment is specifically indeterminate.

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* Hoplitidae 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)).

Genus METENGONOCERAS Hyatt, 1903, p. 179
(= *Epengonoceras* Spath, 1924, p. 308)

Type species. Metengonoceras acutum Hyatt, 1903 (p. 184, pl. 26, fig. 8; pl. 27, figs and 2).

Metengonoceras dumbli (Cragin, 1893)

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, 5B–F (with full synonymy).
1987*a* *Metengonoceras dumbli* (Cragin); Cobban, p. C2, pl. 1, figs. 3–6, 8; pl. 2. figs. 1–3, 9, 10; text-fig. 1 (with additional synonymy).
1988 *Metengonoceras dumbli* (Cragin, 1893); Kennedy, p. 37 (with additional synonymy).

Discussion. We have seen several hundred specimens from the *Conlinoceras tarrantense* zone of the Tarrant Formation and the *Plesiacanthoceras wyomingense* zone of the Templeton Member in central Texas, but none from the *Acanthoceras bellense* or *A. amphibolum* zones. This species is fully described by previous recent authors. Specimens from the *Dunveganoceras pondi* to *Metoicoceras*

mosbyense zones of Minnesota (Cobban 1983, p. 11, pl. 6; pl. 7, fig. 8; pl. 8, figs. 6 and 7) are better referred to *M. acutum* Hyatt, 1903 (p. 184, pl. 26, fig. 8; pl. 27, figs. 1 and 2), also known from the *Sciponoceras gracile* zone of north central Texas. Differences between the two are given by Cobban (1987*a*) and Kennedy (1988).

Occurrence. C. tarrantense and *P. wyomingense* zones in central Texas. *A. amphibolum* zone near Pueblo, Colorado. *Sciponoceras gracile* zone correlative in Sarthe and Loire-Atlantique, France; also recorded from Niger and Nigeria, the former probably better referred to *M. acutum*.

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 FORBESICERATIDAE Wright, 1952, p. 220
(*nom. transl.* Wright 1955, p. 573; ex Forbesiceratinae Wright, 1952, p. 220)

Genus FORBESICERAS, Kossmat, 1897, p. 125
(*pro Discoceras* Kossmat, 1895, p. 179 (83) (*non* Barrande, 1867, p. 177); *Cenomanites* Haug, 1898, p. 78; *Neopulchellia* Collignon, 1929, p. 5)

Type species. Ammonites largilliertianus d'Orbigny, 1841 (p. 320, pl. 95), by subsequent designation of Diener (1925, p. 180).

Forbesiceras brundrettei (Young, 1958)

Plate 1, figs. 15 and 16, 20, 23, 24

1958 *Neopulchellia brundrettei* Young, p. 289, pl. 39, figs. 1–3; 26–28, 33, 35–38; pl. 40, figs. 6, 9, 11; text-figs. 1f, i, k, m.
1959 *Neopulchellia brundrettei* Young; Young, pl. 1, figs. 4, 7 and 8; pl. 3, fig. 4.
1978 *Forbesiceras brundrettei* (Young); Young and Powell, p. 15, pl. 3, figs. 1, 2, 6.
1983 *Forbesiceras brundrettei* (Young); Hook and Cobban, p. 52.
1984 *Forbesiceras brundrettei* (Young); Wright and Kennedy, p. 92.

Type. Holotype is TMM 10734, the original of Young 1958, pl. 39, figs. 35–37, from the base of the Boquillas Formation on the north-east flank of the Davis Mountains in Jeff Davis County, Trans-Pecos Texas.

Material. USNM 424120–424122 from USGS locality 14592, old brickpit on Cloice Branch 1·3 km (0·8 miles) east of South Bosque, McLennan County. One specimen from USGS locality 14598, 0·8 km (0·5 mile) east of South Bosque, near railroad, McLennan County. Probably from the Pepper Shale, *F. brundrettei* zone.

Discussion. F. brundrettei is a highly distinctive species, characterized by its crowded flexuous, sometimes bidichotomous ribs, terminating at ventral clavi on either side of a smooth venter, features that distinguish it from *Forbesiceras* species described by Wright and Kennedy (1984). The present specimens show the mature character of weakening and crowding of ribs at disparate sizes, which we take to indicate dimorphism.

Occurrence. F. brundrettei zone of central and Trans-Pecos Texas only.

Forbesiceras cf. *chevillei* (Pictet and Renevier, 1866)

Plate 1, figs. 21 and 22

compare:

1866 *Ammonites chevillei* Pictet and Renevier, p. 102, pl. 4, fig. 2.
1984 *Forbesiceras chevillei* (Pictet and Renevier, 1866); Wright and Kennedy, p. 93, pl. 13, fig. 2; pl. 15, figs. 1 and 2; text-fig. 17.

Material. USNM 420211 from the basal shell bed of the Bluebonnet Member of the Lake Waco Formation of the Eagle Ford Group on Bird Creek, 4·4 km (2·75 miles) north-east of the Leon River Bridge, south-east of Interstate 35, Bell County. *Acanthoceras bellense* zone.

Description. Specimen is a wholly septate fragment with a maximum preserved whorl height of 17·5 mm, the whorl section compressed with greatest breadth just outside the umbilical shoulder, the inner flanks broadly rounded, the outer flattened and convergent, the venter narrow and flat. There are very distant, narrow, prorsiradiate ribs on the inner to middle flank; broad, flat concave ribs on the outer flank are an estimated 4–5 times as numerous and terminate in pronounced ventral clavi, linked across the venter by a broad, rounded transverse rib.

Discussion. The distinctive ornament of this fragment matches that of the early stage of *F. chevillei*, with which it is compared (e.g. Wright and Kennedy 1984, pl. 15, fig. 1).

Occurrence. As for material *F. chevillei* is known from southern England, Spain, Switzerland, Turkmenian SSR, Nigeria, Madagascar and Zululand. It ranges from lower to lower middle Cenomanian *Mantelliceras mantelli* to *Acanthoceras rhotomagense* zones of the European standard.

Forbesiceras conlini Stephenson, 1953*a*

1953*a* *Forbesiceras conlini* Stephenson, p. 205, pl. 56, fig. 1; pl. 57, figs. 2–6.

Types. Holotype is USNM 105987, the original of Stephenson 1953*a* (pl. 57, figs. 5 and 6); there are two paratypes, all from the Tarrant Formation, branch of Big Bear Creek, 2·4 km (1·5 miles) east of Euless, Tarrant County. *Conlinoceras tarrantense* zone.

Discussion. We have nothing to add to Stephenson's careful account of this species. It most closely resembles *F. baylissi* Wright and Kennedy, 1984 (p. 22, pl. 13, figs 4 and 5) but has much larger and stronger lateral tubercles.

Occurrence. As for types.

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 ACANTHOCERAS Neumayr, 1875, p. 929

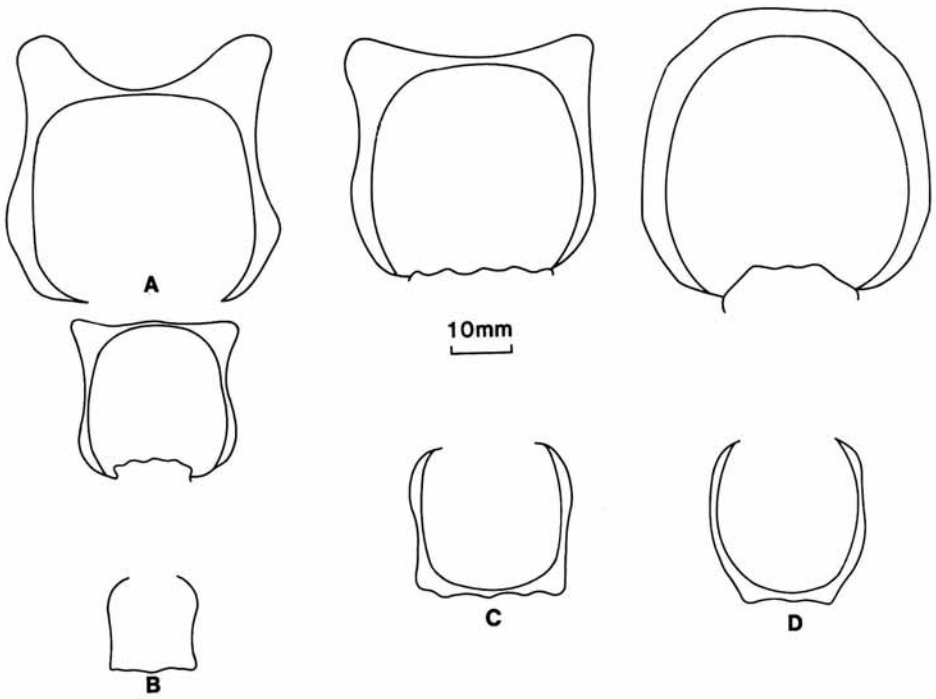
(= *Metacanthoplites* Hyatt, 1900, p. 589 (objective synonym); *Alternacanthoceras* Marcinowski, 1979, p. 61)

Type species. *Ammonites rhotomagensis* Brongniart, 1822, pp. 83, 391, pl. 6, fig. 2, by the subsequent designation of de Grossouvre, 1894, p. 27.

Acanthoceras bellense Adkins, 1928

Plate 2, figs. 24, 25, 29, 30; Plate 9, figs. 31 and 32; Plate 12, figs. 4, 7; text-figs. 5A, C, 6C, 7–10.

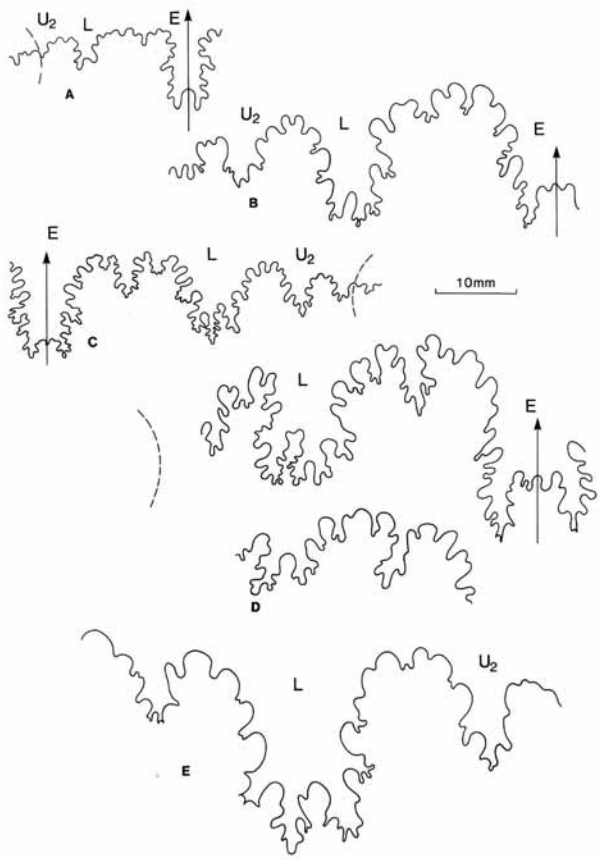
1928 *Acanthoceras bellense* Adkins, p. 245, pl. 30, figs. 1 and 2.
1928 *Acanthoceras stephensoni* Adkins, p. 246, pl. 31, figs. 1 and 2.
1928 *Acanthoceras* n. sp. 6 aff. *Cunningtoni* var. *cornutum* Kossmat, 1895; Adkins, p. 247, pl. 5, fig. 1.



TEXT-FIG. 5. Whorl sections of: A and C, *Acanthoceras bellense* Adkins, 1928, TMM 19803, 4211; B, *Acanthoceras amphibolum* Morrow, 1935, USNM 104971, D, *Conlinoceras tarrantense* (Adkins, 1928), TMM 2424.

?1928 *Acanthoceras* n. sp. 7. Adkins, p. 247.
1942 *Acanthoceras* aff. *rhotomagense* (Defrance); Moreman, p. 201.
1942 *Acanthoceras* aff. *hunteri* Kossmat; Moreman, p. 203.
1942 *Acanthoceras validum* Moreman, p. 203, pl. 32, fig. 1; text-fig. 2 j.
1942 *Acanthoceras* aff. *sherborni* Spath; Moreman, p. 203, pl. 32, fig. 3; text-fig. 29.
1942 *Acanthoceras bellense* Adkins; Moreman, p. 203.
1942 *Acanthoceras stephensoni* Adkins; Moreman, p. 204.
1942 *Acanthoceras* aff. *cunningtoni* (Sharpe); Moreman, p. 204.
1942 *Acanthoceras* aff. *cunningtoni* var. *cornutum* Kossmat; Moreman, p. 204.
1942 *Acanthoceras pepperense* Moreman, p. 204, pl. 32, fig. 5; text-fig. 2 m.
1959 *Acanthoceras* n. sp. aff. *A. turneri* White, Adkins; Matsumoto, p. 84, text-fig. 37.
1959 *Acanthoceras* sp. Matsumoto, p. 84 (*?pars*), ? text-fig. 38.
1959 *Acanthoceras pepperense* Moreman; Matsumoto, p. 86, text-fig. 39.
1959 *Acanthoceras* n. sp. Adkins; Matsumoto, p. 86.
1978 *Euomphaloceras lonsdalei* Adkins; Young and Powell, pl. 5, fig. 7 only, *non* pl. 7, fig. 1.
1987 *Acanthoceras bellense* Adkins, 1928; Wright and Kennedy, p. 190, text-fig. 66a.
1987*b* *Acanthoceras bellense* Adkins; Cobban, p. 5, pl. 1, figs. 18, 19; pl. 2, figs. 1–29; text-fig. 5.

Types. The holotype of *Acanthoceras bellense* Adkins, 1928 (p. 245, pl. 30, figs. 1 and 2) is TMM 34034, by original designation. The holotype of *Acanthoceras stephensoni* Adkins, 1928 (p. 246, pl. 31, figs. 1 and 2) is TMM 34033, by original designation. The holotype of *Acanthoceras validum* Moreman, 1942 (p. 203, pl. 32, fig. 1; text-fig. 2j) is TMM 19802, by original designation. The holotype of *Acanthoceras pepperense* Moreman,



TEXT-FIG. 6. External sutures. A, *Tarrantoceras sellardsi* (Adkins, 1928), USNM 400771. B and E, *Acanthoceras amphibolum* Morrow, 1935, USNM 105971, 8629. C, *Acanthoceras bellense* Adkins, 1928, USNM 388109. D, *Conlinoceras tarrantense* (Adkins, 1928), USNM 105962.

1942 (p. 204, pl. 32, fig. 5; text-fig. 2 m) is TMM 19803, by original designation. All are from the basal shell bed of the Bluebonnet Member on Bird Creek at its intersection with the old Belton-Temple Highway, Bell County, *Acanthoceras bellense* zone.

Dimensions		D	Wb	Wh	Wb:Wh	U
USNM 420212	c	57·5 (100)	29·0 (50·4)	23·5 (40·8)	1·23	18·2 (31·7)
holotype	c	87·5 (100)	— (—)	38·2 (43·7)	—	24·5 (28·0)
USNM 420213	c	113 (100)	56·5 (50·0)	50·5 (44·7)	1·12	31·2 (27·6)
	ic		50·5 (—)	49·0 (—)	1·03	

Description. Coiling fairly evolute, umbilicus comprising around 30% of diameter, of moderate depth, with rounded wall. Whorls massive, slowly expanding. Intercostal whorl section depressed trapezoidal with greatest breadth just outside umbilical shoulder, inner flanks rounded, outer flanks flattened, convergent, ventrolateral

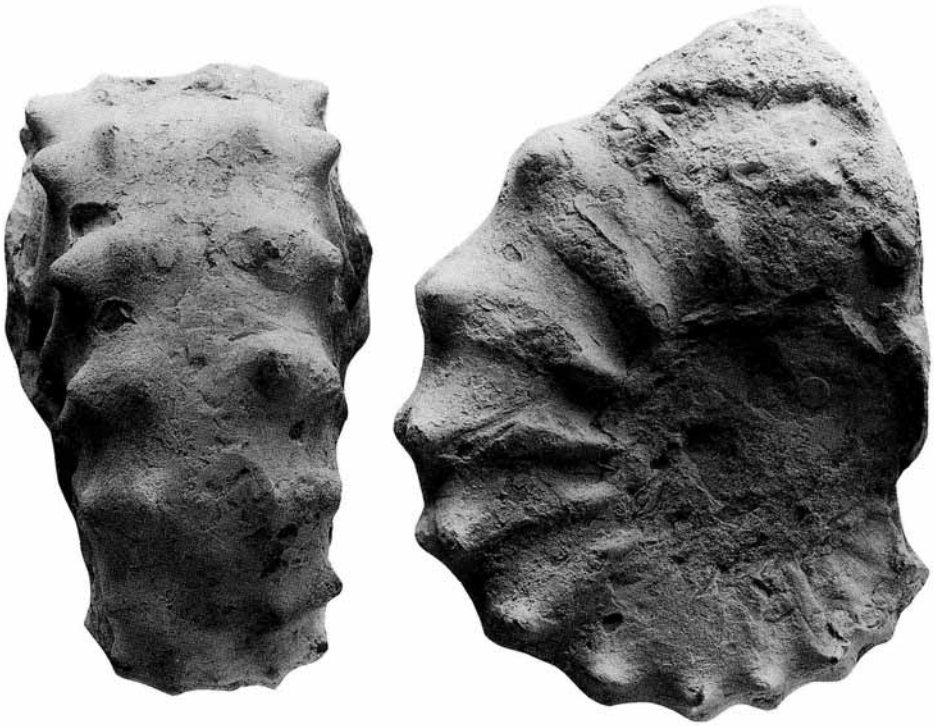
TEXT-FIG. 7. *Acanthoceras bellense* Adkins, 1928. TMM 19802, the holotype of *Acanthoceras validum* Moreman, 1942, a macroconch, from the basal shell bed of the Bluebonnet Member on Bird Creek, Bell County. Reduced ×0.6.

shoulders broadly rounded, venter flattened. At the smallest diameters visible, in the umbilical region of larger specimens, flank ornament consists of bullate primary ribs alternating with shorter ribs or non-bullate primaries, the ribs totalling 8–9 per half whorl. In middle growth all the ribs are long, from a whorl height of 12 mm approximately. In middle growth ornament is highly variable. The holotype represents the feebly ornamented extreme, specimens like those referred to as *Acanthoceras* aff. *sherborni* by Moreman (1942, pl. 32, fig. 3) the robustly ornamented extreme. Most specimens have 17–20 primary ribs per whorl. These ribs arise at the umbilical seam, are broad and distant, and strengthen into weak (Pl. 2, fig. 24) to strong (Pl. 2, fig. 30) bullae, perched just outside the umbilical shoulder. The bullae give rise to straight, broad, prorsiradiate ribs, weak (Pl. 2, fig. 24) to strong (Pl. 2, fig. 30), which terminate in inner ventrolateral tubercles that are initially clavate but become conical and horn-like as size increases. A broad, low rib connects these to a clavate outer ventrolateral tubercle, corresponding to which is a clavate siphonal tubercle, borne on a low siphonal ridge. Occasional specimens may show a non-tuberculate ventral intercalatory. In the holotype the ribbing becomes progressively wider spaced as size increases, and the umbilical bulla weakens and moves out to an inner flank position, while growth lirae and striae are prominent on the well-preserved shell surface. This same outward migration is shown by robustly ornamented individuals (Pl. 2, fig. 30) and is a characteristic of middle growth. At the same time, the rib linking inner and outer ventrolateral tubercles strengthens, and the siphonal clavi decline. Ultimately, the mature phragmocone develops a highly characteristic section, with inflated inner flanks in costal section, concave mid- to outer flanks and a flat-topped horn produced by coalescence of inner and

TEXT-FIG. 8. *Acanthoceras bellense* Adkins, 1928. TMM 34033, the holotype of *Acanthoceras* n. sp. of Adkins, 1928, from the basal shell bed of the Bluebonnet Member on Bird Creek, Bell County. Natural size.

outer ventrolateral tubercles. The venter is depressed between these horns, with a low siphonal ridge persisting. On the adult body chamber, this ornament is progressively modified; umbilical bullae migrate out to mid-flank and decline, the rib flaring at their site, while the flat-topped horn changes into a pointed, outward-directed projection with an evenly concave ventral region between. The holotype of *Acanthoceras validum* Moreman, 1942 (text-fig. 7) seems to be an incomplete adult macroconch with a maximum preserved costal whorl height of 111 mm, the original of *Acanthoceras* n. sp. of Adkins (1928, pl. 27, fig. 2), an incomplete microconch with a costal whorl height of 72 mm at the base of the body chamber.

Suture line (text-fig. 6C) with broad bifid E/L, narrower L and broad L/U_2.



TEXT-FIG. 9. *Acanthoceras bellense* Adkins, 1928. TMM 34033, the holotype of *Acanthoceras stephensoni* Adkins, 1928, from the base of the Bluebonnet Member on Bird Creek in Bell County. Reduced ×0.75.

Discussion. Numerous names have been applied to *Acanthoceras* from the base of the Bluebonnet Member in Bell County. Given the normal range of variation shown by acanthoceratines (Wright and Kennedy 1987) and the continuous varation shown by the present assemblage, it is apparent that the holotype of *A. bellense* (Pl. 9, figs. 31 and 32) is a feebly ornamented juvenile, the holotype of *A. stephensoni* (text-fig. 9) a robustly ornamented adult macroconch phragmocone, the holotype of *A. pepperense* (text-fig. 10) a near complete adult microconch and the holotype of *A. validum* (text-fig. 7) an adult macroconch with some body chamber. All these are linked by the same pattern of tubercles and rib development and siphonal ridge; apparent differences reflect variation and dimorphism alone.

Individuals of the *A. bellense* fauna from central Texas show superficial resemblances to the equally variable *Acanthoceras rhotomagense* faunas of western Europe and the *Acanthoceras flexuosum* (Crick, 1907) group from South Africa, but adults are easily distinguished and population structures are different, as discussed by Wright and Kennedy (1987, pp. 189–190).

The siphonal ridge and occasional intercalated ventral ribs, plus traces of looped riblets between ventral horns shown by some of the present specimens that are referred to *A. bellense* (e.g. USNM

420213) are features that develop consistently in *Cunningtoniceras* Collignon, 1937. Co-occurring *Cunningtoniceras lonsdalei* (Adkins, 1928, p. 244, pl. 26, fig. 5; pl. 27, fig. 3; see p. 121 herein) is probably derived from *A. bellense*, just as *C. inerme* (Pervinquière, 1907) is derived from *Acanthoceras rhotomagense* (Brongniart, 1822). Juvenile *C. lonsdalei* are easily separated from juvenile *A. bellense*: the former have 1 or 2 ventral clavi corresponding to 1 outer ventrolateral on the primary ribs and 2 ventral ribs intercalated between primaries, each with siphonal and, in some cases, outer ventrolateral tubercles.

Occurrence. Acanthoceras bellense zone, known only from central Texas and eastern Wyoming.

Acanthoceras amphibolum (Morrow, 1935)

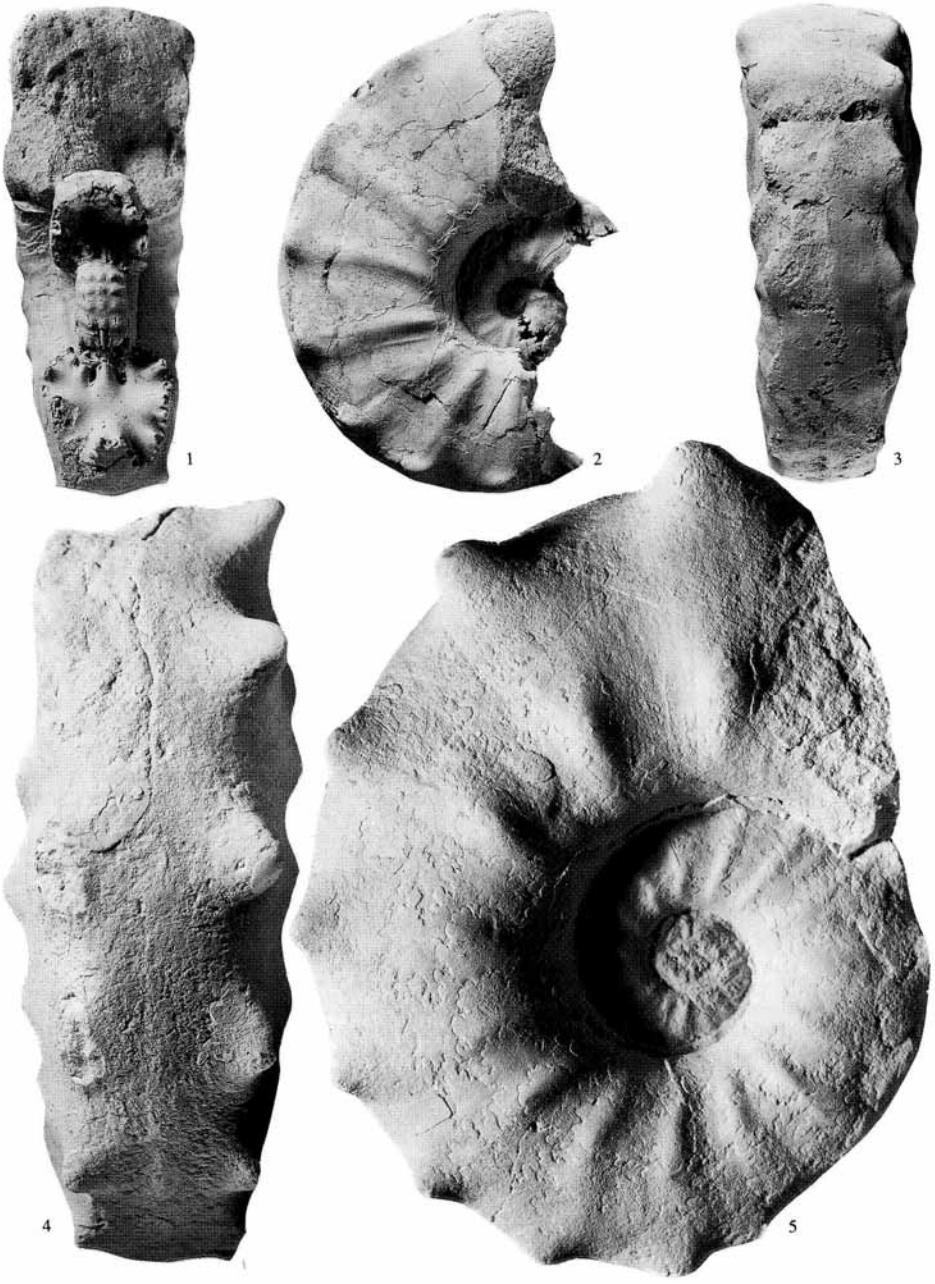
Plate 3, figs. 1–5; Plate 4, figs. 1–17; text-figs. 5B, 6B and E, 11–14

1877 *Ammonites loevianus* White, p. 201, pl. 19, fig. 1.
1935 *Acanthoceras*? *amphibolum* Morrow, p. 470, pl. 49, figs. 1–4; 6; pl. 51, figs. 3 and 4; text-fig. 4.
1942 *Acanthoceras alvaradoense* Moreman, p. 205, pl. 32, fig. 6; text-figs. 2o and t.
1953*a* *Acanthoceras hazzardi* Stephenson, p. 201, pl. 48, figs. 1 and 2; pl. 49, fig. 4.
1955 *Euomphaloceras alvaradoense* (Moreman); Stephenson, p. 63, pl. 7, figs. 1–9.
1960 *Acanthoceras amphibolum* Morrow; Matsumoto, p. 41, text-fig. 5b–d.
1960 *Acanthoceras hazzardi* Stephenson; Matsumoto, p. 41, text-fig. 5a.
1960 *Acanthoceras alvaradoense* Moreman; Matsumoto, p. 41, text-fig. 6a–c.
1963 *Paracanthoceras amphibolum* (Morrow); Haas, p. 18.
1964 *Plesiacanthoceras* [*amphibolum* (Morrow)]; Haas, p. 610.
1965 *Plesiacanthoceras amphibolum* (Morrow); Hattin, pl. 4, figs. J and K; pl. 5, figs. C–F.
1965 *Plesiacanthoceras amphibolum* (Morrow); Hattin, text-fig. 3 (8).
1966 *Acanthoceras amphibolum* Morrow; Matsumoto and Obata, p. 45, text-figs. 4–6.
1966 *Acanthoceras hazzardi* Stephenson; Matsumoto and Obata, p. 45, text-fig. 7.
1968 *Plesiacanthoceras* [*amphibolum* Morrow]; Laporte, text-fig. 6–10H.
1969 *Acanthoceras amphibolum* Morrow; Matsumoto, Muramoto and Takahashi, p. 226, pl. 31, fig. 1a and b.
1973 *Acanthoceras amphibolum* Morrow; Cobban and Scott, p. 65 (*pars*).
1977*a* *Acanthoceras alvaradoense* Moreman; Cobban, p. 24, pl. 6, figs. 1–7, 11–20; text-fig. 6.
1977*b* *Acanthoceras alvaradoense* Moreman; Cobban, p. 219, figs. 3A–I.
1977*b* *Acanthoceras amphibolum* Morrow; Cobban, p. 219, figs. 4N–Q.
1977 *Acanthoceras amphibolum* Morrow; Hattin, p. 183, fig. 13.
1978 *Acanthoceras amphibolum* Morrow; Hattin and Siemers, fig. 5 (14).
1979 *Acanthoceras alvaradoense* Moreman; Merewether, Cobban, and Cavanaugh, pl. 1, figs. 3–7.
1985 *Acanthoceras amphibolum* Morrow; Zaborski, p. 35, figs. 38–41.
1987*b* *Cunningtoniceras amphibolum* (Morrow); Cobban, p. 9, pls. 4–8, pl. 9, figs. 48–63.
1988 *Acanthoceras amphibolum* Morrow; Kennedy, Cobban and Hook, p. 38, figs. 1w–z, cc–ff, 2a and b.

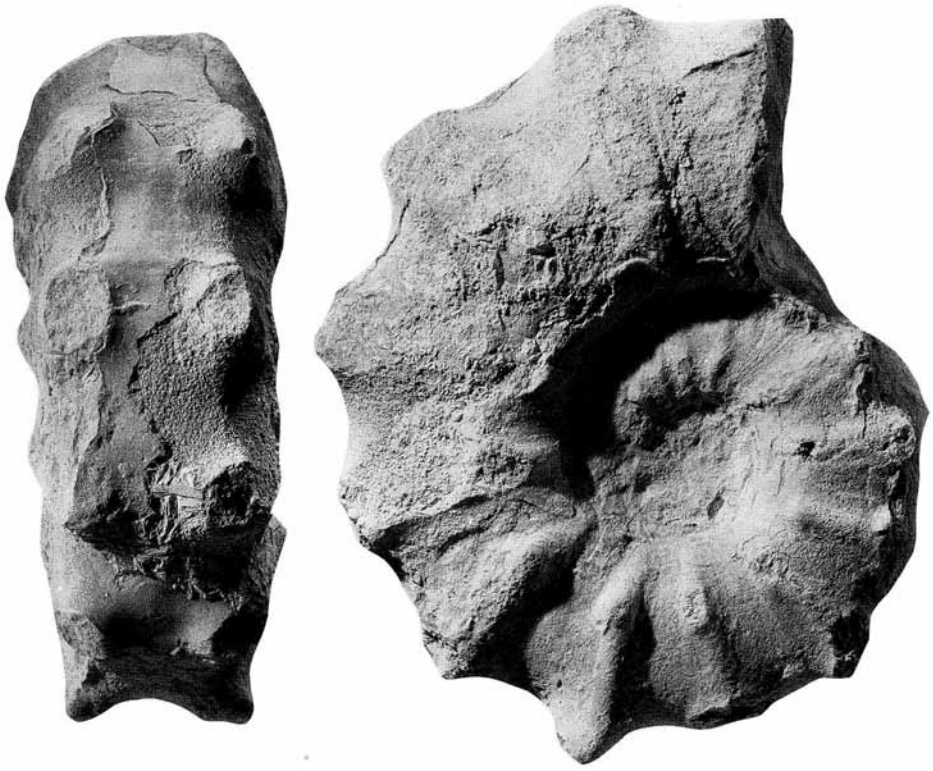
EXPLANATION OF PLATE 3

Figs. 1–5. *Acanthoceras amphibolum* (Morrow, 1935). 1–3, USNM 420223, a topotype of *Acanthoceras hazzardi* Stephenson, 1953*a*, from USGS locality 18975, headwater branch of Walnut Creek, 0·5 km (0·3 mile) north of Gordonville, Grayson County, from the Lewisville Member, *Acanthoceras amphibolum* zone. 4 and 5, the holotype of *Ammonites loevianus* White, 1877 (p. 201, pl. 19, fig. 1), USNM 8629, from Ojo de los Cuervas, New Mexico. Specimen is inferred to be from the Paguate Tongue of the Dakota Sandstone.

All figures are × 1.



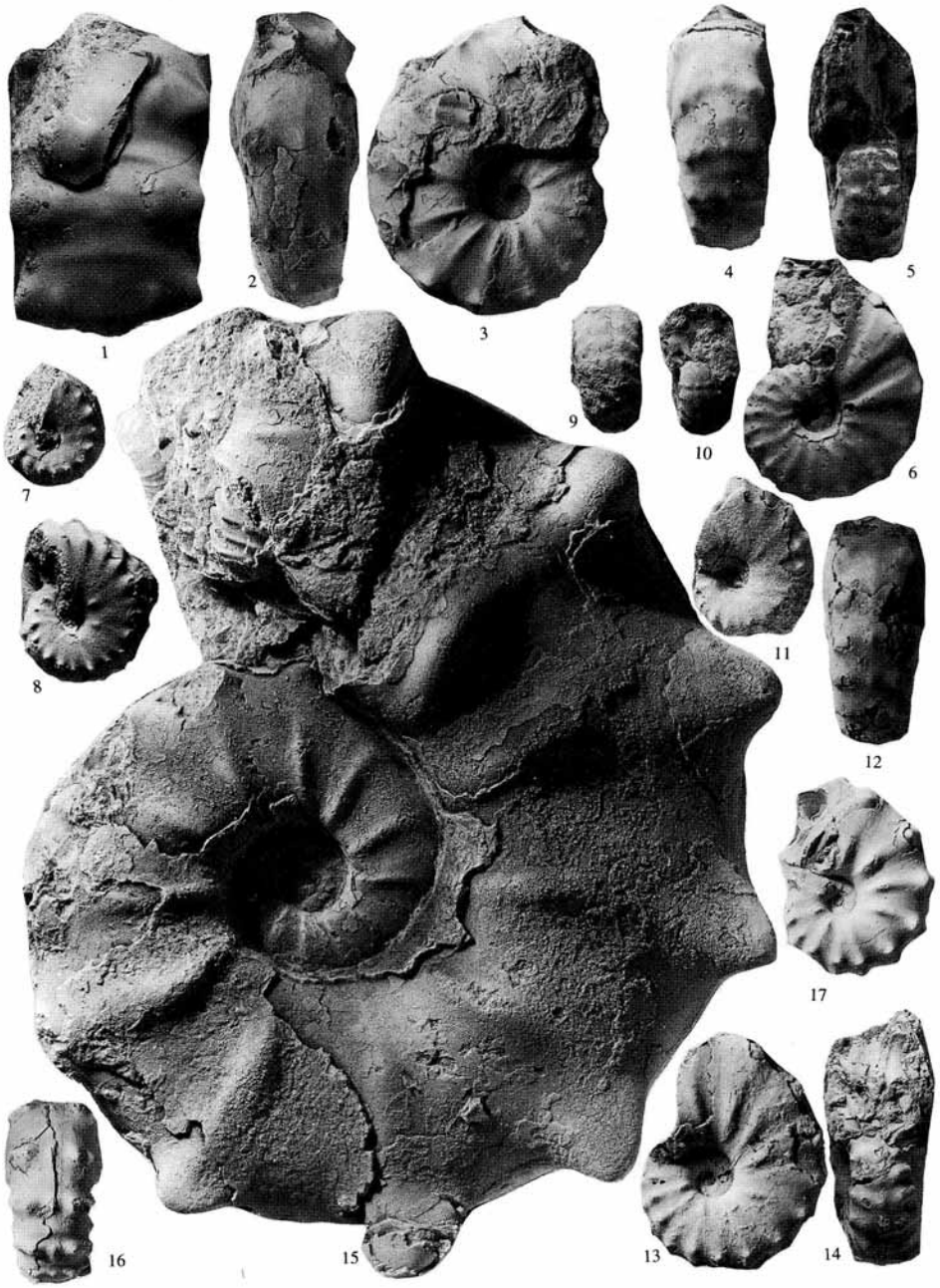
KENNEDY and COBBAN, *Acanthoceras*



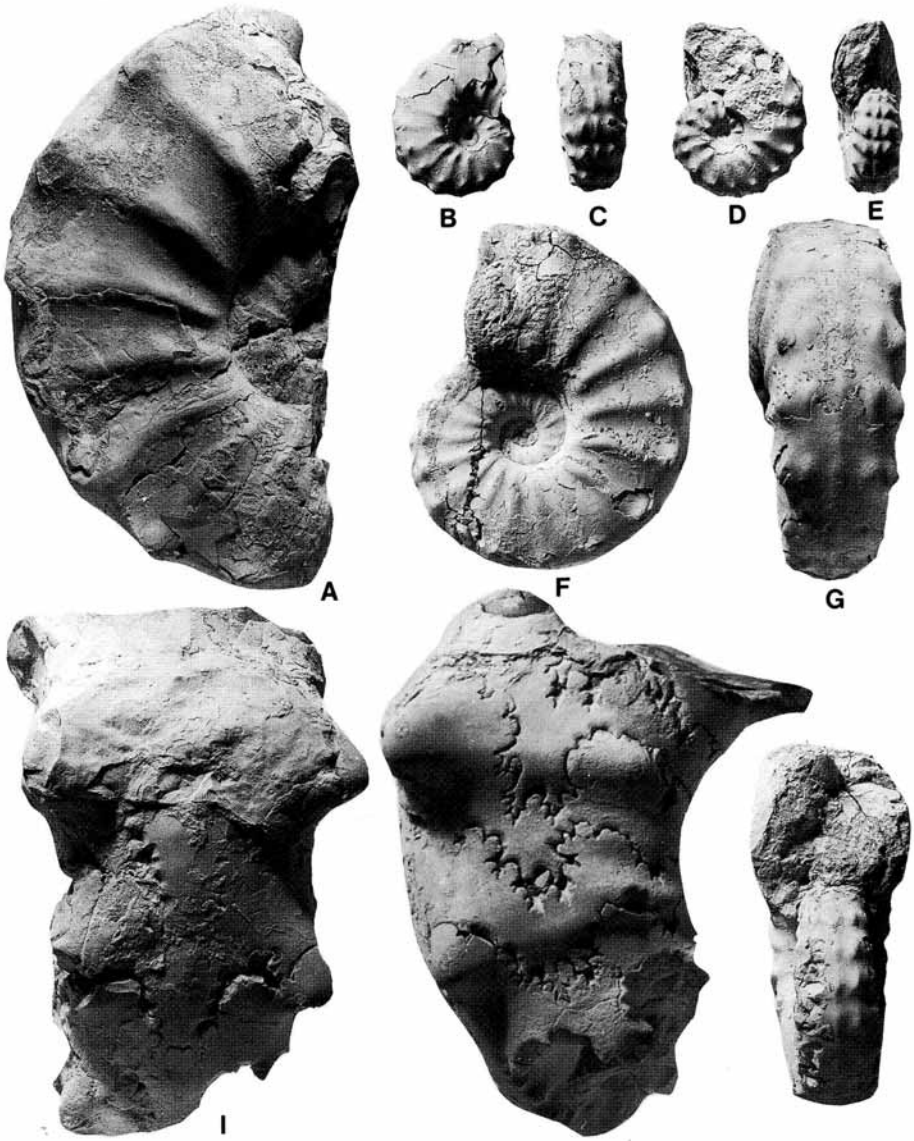
TEXT-FIG. 10. *Acanthoceras bellense* Adkins, 1928. TMM 19803, the holotype of *Acanthoceras pepperense* Moreman, 1942, from the basal shell bed of the Bluebonnet Member on Bird Creek, Bell County. Reduced ×0.65.

EXPLANATION OF PLATE 4

Figs. 1–17. *Acanthoceras amphibolum* (Morrow, 1935). 1 is USNM 420224, from USGS locality 13577, branch south of Belton-Temple Road, 1·6 km (1 mile) east of Midway Church, Bell County. Note striking intercalated ventral ribs. Bluebonnet Member (inferred). 2 and 3, USNM 420217; 4–6, USNM 420216; 7, USNM 420225; 8, USNM 420227; 9–11, USNM 420226; 12–14, USNM 420230, concretions in gully in cotton field 1·6 km (1 mile) north of Lillian, west of Lillian–Retta road, Johnson County. 15, USNM 420228, from 0·3 km (0·2 mile) south of Mountain Creek, 6·1 km (3·8 miles) north-east of town square in Alvarado, Johnson County. 16 and 17, USNM 420229, from USGS Mesozoic locality D12626, loose concretion, 8·9 km (5·5 mile) north-east of Mansfield, Tarrant County. All basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone. Figures 7–11 are ×2; the remainder are ×1.



KENNEDY and COBBAN, *Acanthoceras*



TEXT-FIG. 11. *Acanthoceras amphibolum* Morrow, 1935. A, B–E, I, J, paratypes, F–H the holotype, all from the Graneros Shale on the south bank of the Smoky Hill River, south of Wilson, Kansas, all in the collections of the Geology Museum of the University of Kansas, and figured natural size.

Types. Lectotype, here designated, is the original of Morrow (1935, pl. 49, fig. 3) from the Graneros Shale near Wilson, Kansas, as are four figured syntypes (text-fig. 11). All middle Cenomanian *Acanthoceras amphibolum* zone. Specimens are in the University of Kansas and USNM Collections. The holotype of *Acanthoceras alvaradoense* Moreman, 1942 (p. 205, pl. 32, fig. 6; figs. 20 o and t) is TMM 19801, from the basal Eagle Ford Group (termed Tarrant by Moreman, 1942) 6·4 km (4 miles) south of Alvarado in Johnson County (text-fig. 12).

The holotype of *Acanthoceras hazzardi* Stephenson, 1953*a* is USNM 105971 from the Lewisville Member of the Woodbine Formation, headwater of Walnut Creek, 0·5 km (0·3 mile) north of Gordonville, Grayson County. All *Acanthoceras amphibolum* zone.

Material. Numerous specimens in the USGS, USNM and OUM Collections from concretions low in the Eagle Ford Group notably at USGS Mesozoic locality D12626, 8·9 km (5·5 miles) north-east of Mansfield, Tarrant County; USGS D9502, concretions in field 0·3 miles north-north-west of Lillian, Johnson County; USGS 11740, 14580, 14582, Walnut Creek, Tarrant County; USGS 14583, field 4 km (2·5 miles) north-east of Alvarado, Johnson County; USGS 24510, 1·6 km (1 mile) north of Lillian, Johnson County; east of Old Highway, 6·4 km (4 miles) south of Alvarado, Johnson County. All middle Cenomanian *Acanthoceras amphibolum* zone. A topotype (USNM 420223) of *Acanthoceras hazzardi* is from USGS Locality 18975 (see above for details).

Dimensions		D	Wb	Wh	Wb:Wh	U
USNM 420216	c	33·4 (100)	15·0 (44·9)	14·8 (44·3)	1·01	7·3 (21·9)
USNM 420217	c	35·6 (100)	17·0 (47·8)	16·8 (47·2)	1·01	7·4 (20·8)
USNM 420218	c	45·0 (100)	20·4 (45·3)	20·2 (44·9)	1·0	9·5 (21·1)
USNM 420219	c	93·2 (100)	40·0 (42·9)	41·3 (44·3)	0·97	28·3 (30·4)
	ic	91·0 (100)	35·5 (39·0)	37·3 (41·0)	0·95	28·3 (31·1)
USNM 420220	c	166 (100)	68·0 (41·0)	68·5 (41·3)	0·99	49·0 (29·5)
	ic	160 (100)	60·5 (37·8)	63·5 (39·7)	0·95	49·0 (30·6)
USNM 420221	c	133 (100)	56·0 (42·1)	54·0 (40·6)	1·04	45·5 (34·2)
(adult microconch)	ic	125 (100)	47·5 (38·0)	47·0 (37·6)	1·01	45·5 (36·4)

Description. Very small specimens match those illustrated by Cobban (1977*a*, 1987*b*). At a diameter of 12 mm they have 17–19 ribs per whorl, alternately long and short, the primaries feebly bullate or not, with conical inner ventrolateral and clavate outer ventrolateral and siphonal tubercles on all ribs; there are prominent constrictions. As size increases, the ribs are differentiated markedly, with 14–17 primary ribs per whorl. These arise at feeble umbilical bullae, are straight and prorsiradiate, with a strong conical inner ventrolateral tubercle and clavate outer ventrolateral and siphonal tubercles on a broad transverse rib. Between are short intercalated ventral ribs, 1 or sometimes 2 in number, with outer ventrolateral and siphonal tubercles only, and sometimes with only siphonals. A pronounced siphonal ridge links tubercles at this stage. These secondary ribs disappear by 40–50 mm diameter, although there may be a trace of the siphonal clavi, and a marked siphonal ridge. Thereafter, the outer ventrolateral clavi decline, and the inner ventrolaterals strengthen into a clavate horn, sometimes linked across the venter to the corresponding horn by a pair of feeble riblets. The horns strengthen through late ontogeny, so that the outer whorls of adults have 12–14 distant primary ribs, effaced at mid-flank, with bullae that migrate from umbilical to inner lateral position, strong ventrolateral horns with a markedly concave venter in intercostal section, the venter smooth but for a low siphonal ridge and feeble riblets looping between horns or intercalating (text-figs. 13 and 14).

There are few adults in the present collections. A complete microconch USNM 420221 is 133 mm in diameter; the ornament described above extends onto the adult body chamber, with the final rib strengthened markedly to give a broad ventral flange instead of the concavity of the preceding ribs. A fragmentary macroconch (USNM 420222) shows exactly the same adult modification; with a whorl height of over 100 mm, its estimated diameter was 330 mm.

Suture line with broad bifid E/L narrower L and broad L/U_2 (text-fig. 6B and E).

Discussion. *Acanthoceras alvaradoense* and *hazzardi* are clear synonyms of *A. amphibolum*. Two subspecies of *A. amphibolum* can be recognized; all the present material belongs to the earlier form, *A. amphibolum amphibolum*. The late form, *A. amphibolum fallense* Cobban, 1987*b*, lacks multiplication of ventral ornament and has ventrolateral and siphonal tubercles that are clavate rather than nodate. The multiplication of ventral ribbing on juveniles of the older form of

TEXT-FIG. 12. *Acanthoceras amphibolum* Morrow, 1935. TMM 19801, the holotype of *Acanthoceras alvaradoense* Moreman, 1942, from the basal part of the Eagle Ford Group 6·4 km (4 miles) south of Alvarado, Johnson County. Natural size.

Acanthoceras amphibolum prompted Cobban (1987*b*) to assign the species to *Cunningtoniceras* Collignon, 1937 which has this type of ornament. The present authors now believe that there are separate lineages of *Cunningtoniceras* and *Acanthoceras*, and that *amphibolum*, although not typical, is best assigned to *Acanthoceras*. *A. amphibolum* evolved from *A. bellense*. They differ most obviously in the much earlier loss of differentiated inner and outer ventrolateral tubercles in *A. amphibolum*, where a massive horn develops, and the equally early loss of the siphonal tubercles.

Ammonites loevianus White, 1877 (p. 201, pl. 19, fig. 1) the original of which is shown as Pl. 3, figs. 4 and 5, is an *Acanthoceras amphibolum*, from Ojo de los Cuervas, New Mexico. The name has never been used since White's original account and should be suppressed under the plenary powers of the International Commission on Zoological Nomenclature to whom application has been made.

Occurrence. *Acanthoceras amphibolum* zone. Trans-Pecos and central Texas, New Mexico, Kansas, Colorado, Wyoming, South Dakota, Montana. Middle Cenomanian of Japan and Nigeria.

TEXT-FIG. 13. *Acanthoceras amphibolum* Morrow, 1935. USNM 420220, from the basal part of the Eagle Ford Group, 1·6 km (1 mile) north of Lillian and west of the Lillian–Retta road, Johnson County. Reduced ×0·8.

Genus CALYCOCERAS Hyatt, 1903, p. 589

(= *Metacalycoceras* Spath, 1926*a*, p. 83; ICZN rejected name no. 1265)

Type species. ICZN Opinion 557, 1959, name no. 1633; *Ammonites navicularis* Mantell, 1822 (p. 198, pl. 22, fig. 5).

Subgenus NEWBOLDICERAS Thomel, 1972, p. 105.

Type species. *Acanthoceras newboldi* Kossmat, 1897, p. 5 (112), pl. 1(12), figs. 2, 3; pl. 3(14), fig. 2, by original designation.

TEXT-FIG. 14. *Acanthoceras amphibolum* Morrow, 1935. USNM 420231, from the basal part of the Eagle Ford Group, 1·6 km (1 mile) north of Lillian and west of the Lillian–Retta road, Johnson County. Reduced ×0·8.

Calycoceras (*Newboldiceras*) sp.

Plate 11, figs. 3 and 4

1928 *Acanthoceras* n. sp. 2 (aff. *turneri* C. A. White); Adkins, p. 246, pl. 30, figs. 3 and 4.
1942 *Acanthoceras* aff. *turneri* White, Adkins; Moreman, p. 202.
1959 *Acanthoceras* n. sp. aff. *turneri* White, Adkins; Matsumoto, p. 84, text-fig. 37.

Material. TMM 34032, from the basal shell bed of the Bluebonnet Member, Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County. *Acanthoceras bellense* zone.

Discussion. What appears to be the only *Newboldiceras* known from the Gulf Coast region is a fragmentary specimen 110 mm in diameter. There are 12–13 ribs per half whorl, all of them long and extending from the umbilical shoulder, showing weak differentiation into feebly bullate and non-bullate, with blunt inner and clavate outer ventrolateral tubercles, the venter crossed by broad, bar-like ribs with a trace of a siphonal clavus. It most closely resembles *C*. (*N*.) *newboldi* (Kossmat, 1897, p. 5(112), pl. 1(12), figs. 2 and 3; pl. 3(14), fig. 2), but has a much lower rib density, 12–13

per half whorl versus 20 in the type material at comparable diameters. The Texas specimen is left in open nomenclature at this time.

Occurrence. As under material.

Genus CONLINOCERAS Cobban and Scott, 1973, p. 61

Type species. *Calycoceras* (*Conlinoceras*) *gilberti* Cobban and Scott, 1973 (p. 61, pl. 1; pl. 2, figs. 5–9, 13–18; pl. 3, figs. 5–7, 11; text-figs. 23 and 24).

Discussion. *Conlinoceras* was originally proposed as a subgenus of *Calycoceras*. The inner whorls of the type species are, however, quite distinct from those of the early subgenera of *Calycoceras*, rather being identical in style of ornament (notably the clavate ventral and ventrolateral tuberculation) and whorl section with *Acanthoceras rhotomagense* (e.g. Pl. 7, figs. 1–13, 23–25). Some middle growth stages of *Conlinoceras tarrantense* (Adkins, 1928) were actually placed in the synonymy of *A. rhotomagense* by Kennedy and Hancock (1970). In contrast, the outer whorls, with their rounded section, loss of tubercles and alternately long and short distant ribs (Pl. 5, figs. 1 and 2) are homoeomorphous with those of *Calycoceras* (*Proeucalycoceras*) Thomel, 1972. On the evidence of the inner whorls, we regard *Conlinoceras* as an independent genus allied to *Acanthoceras* and endemic to the US Western Interior and Gulf Coast Region.

Conlinoceras tarrantense (Adkins, 1928)

Plate 5, figs. 1–5; Plate 6, figs. 7–12; Plate 7, figs. 1–13, 15, 23–25; text-figs. 5D, 6D, 15–17.

1893	*Buchiceras inaequiplicatus* Shumard (probably in part); Cragin, p. 233.
?1927	*Acanthoceras rotomagense* (Defrance); Scott, p. 617, pl. 2, figs. 1 and 2.
1927	*Acanthoceras* aff. *rhotomagense* (Defrance); Moreman, p. 92, pl. 13, fig. 1.
1928	*Metacalycoceras* (?) *tarrantense* Adkins, p. 241, pl. 28, fig. 3; pl. 29, fig. 1.
1928	*Acanthoceras wintoni* Adkins, p. 243, pl. 25, figs. 2 and 3.
1942	*Acanthoceras wintoni* Adkins; Moreman, p. 202.
1942	*Acanthoceras inaequiplicatum* (Adkins); Moreman, p. 201, pl. 32, fig. 2.
1951	*Acanthoceras tarrantense* (Adkins); Adkins and Lozo, pl. 2, fig. 2.
1953*a*	*Acanthoceras tarrantense* (Adkins); Stephenson, p. 198, pl. 45, figs. 9 and 10; pl. 46, figs. 2–4.
1953*a*	*Acanthoceras tarrantense nitidum* Stephenson, p. 199, pl. 50, figs. 5 and 6.
1953*a*	*Acanthoceras wintoni* Adkins; Stephenson, p. 200, pl. 45, figs. 7 and 8; pl. 46, fig. 1; pl. 47, figs. 1 and 2.
1970	*Acanthoceras wintoni* Adkins; Kennedy and Hancock, p. 487.
1973	*Calycoceras* (*Conlinoceras*) *tarrantense* (Adkins); Cobban and Scott, p. 62.
1973	*Acanthoceras adkinsi* Stephenson; Cobban and Scott, p. 62.
1977*a*	*Calycoceras* (*Conlinoceras*) *tarrantense* (Adkins); Cobban, p. 22, pl. 3, fig. 9; pl. 4, figs. 1–3, 6.
1977*b*	*Calycoceras* (*Conlinoceras*) *tarrantense* (Adkins); Cobban, p. 219, fig. 21.
1978	*Conlinoceras tarrantense* (Adkins, 1928); Young and Powell, pl. 4, figs. 1, 5.

Types. Holotype of *C. tarrantense* is TMM 2424, from the Tarrant Formation '2 miles (not more than 1·5 miles) east of Tarrant Station, Tarrant County'. The holotype of *C. tarrantense nitidum* Stephenson, 1953*a* is USNM 105965, from the Tarrant Formation 14·5 km (9 miles) north of Arlington, Tarrant County. The holotype of *Acanthoceras adkinsi* Stephenson, 1953*a* is USNM 105968, from the Tarrant Formation, on a branch north of Chicago, Rock Island and Pacific Railroad, 1·6 km (1 mile) west of Dallas County Line, Tarrant County. The holotype of *Acanthoceras wintoni* Adkins, 1928 is TMM 2426, from the Tarrant Formation on Big Bear Creek, 4·8 km (3 miles) north-east of Tarrant Station, Tarrant County. All *Conlinoceras tarrantense* zone.

Name of species. Under the Rules of the International Commission on Zoological Nomenclature, *tarrantense* and *adkinsi* of Adkins are deemed to have been published simultaneously. As first revising authors Cobban and Scott (1973, p. 62) selected the name *tarrantense*.

Dimensions		D	Wb	Wh	Wb:Wh	U
USNM 420232	c	13·2 (100)	7·5 (56·8)	6·1 (46·2)	1·23	2·1 (15·9)
USNM 420233	c	21·2 (100)	10·7 (50·5)	10·1 (47·6)	1·06	— (—)
USNM 420234	c	25·0 (100)	14·2 (56·8)	12·4 (49·6)	1·15	4·2 (16·8)
USNM 420235	c	27·2 (100)	16·8 (61·8)	13·0 (47·8)	1·29	5·3 (19·5)
USNM 420236	c	29·5 (100)	16·2 (54·9)	15·6 (52·9)	1·04	4·9 (16·6)
USNM 420237	c	29·7 (100)	17·0 (59·9)	15·0 (50·5)	1·13	— (—)
USNM 420238	c	32·0 (100)	16·5 (51·6)	16·5 (51·6)	1·0	5·9 (18·4)
USNM 420239	c	40·4 (100)	21·0 (50·7)	19·9 (49·3)	1·06	8·9 (22·0)
USNM 420240	c	47·2 (100)	— (—)	23·3 (49·4)	—	9·6 (20·3)
USNM 420241	c	49·8 (100)	26·0 (52·2)	23·6 (47·4)	1·13	10·7 (21·5)
USNM 420242	c	56·1 (100)	23·4 (41·7)	24·9 (44·4)	0·93	11·6 (20·7)
USNM 420243	c	60·8 (100)	33·2 (54·6)	26·4 (43·4)	1·26	14·2 (23·4)
USNM 420244	c	63·7 (100)	— (—)	28·5 (44·7)	—	14·7 (23·1)
USNM 420245		64·7 (100)	30·8 (47·6)	31·4 (48·5)	0·98	12·6 (19·5)
USNM 420246		66·2 (100)	30·9 (46·7)	28·9 (43·7)	1·07	13·4 (20·2)
USNM 420247	c	83·6 (100)	42·7 (51·5)	39·8 (47·6)	1·07	19·1 (22·8)
USNM 420248	c	101·2 (100)	49·7 (49·1)	45·4 (44·9)	1·09	27·4 (27·1)
USNM 420249		125·5 (100)	59·2 (47·2)	56·5 (45·0)	1·05	32·4 (25·8)
USNM 420250		146·0 (100)	60·0 (41·1)	62·0 (42·5)	0·97	41·2 (28·2)
USNM 420251		157·0 (100)	67·0 (42·7)	66·5 (42·4)	1·0	38·0 (24·2)
USNM 420252		205·0 (100)	80·5 (39·3)	90·0 (43·9)	0·89	61·0 (29·8)

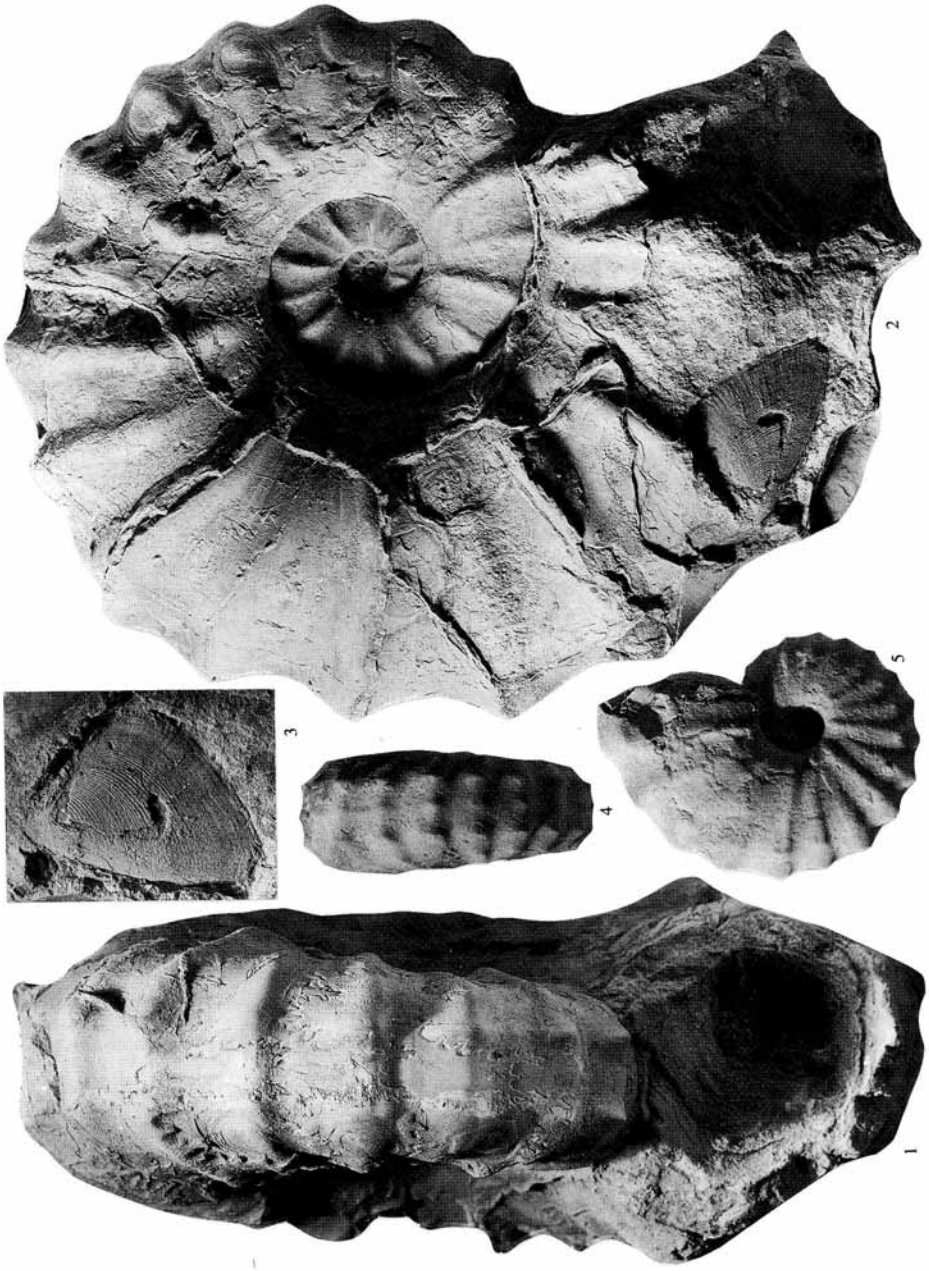
Material. More than 100 specimens from the Lewisville Member of the Woodbine Formation, in the Dallas–Fort Worth area and elsewhere in north-central Texas in the USNM, USGS, JPC and OUM Collections, not listed separately.

Description. The typical shell form and ornament of the middle growth stages are already present from 12 mm diameter and extend to approximately 100 mm diameter. Coiling is evolute, the umbilicus comprising 16–20% of diameter, the figure increasing through ontogeny. The whorl section varies from compressed to depressed (Wb:Wh varies from 1·23–0·98). The umbilicus is quite shallow, with a rounded umbilical wall on moulds, and a broadly rounded umbilical shoulder. The whorls are quadrate in intercostal section, with the greatest breadth below mid-flank, the sides and venter flattened, the ventrolateral shoulders broadly rounded. The costal section is trapezoidal in compressed forms, polygonal in depressed ones, with the greatest breadth at the umbilical bullae. Robust individuals have as few as 17 ribs per whorl, gracile ones up to 22. Primary and secondary ribs alternate very regularly. Primaries arise at the umbilical seam and strengthen into a weak to strong umbilical bulla which migrates outwards and declines in strength through ontogeny. In gracile specimens it may disappear at an early stage; in robust specimens it persists. Secondary ribs arise low on the flank. All ribs are straight and recti- to feebly prorsiradiate, and develop conical pointed inner ventrolateral tubercles. A low broad rib connects these to strong, long inner ventrolateral clavi, linked across the venter by a broad, low rib to significantly weaker siphonal clavi.

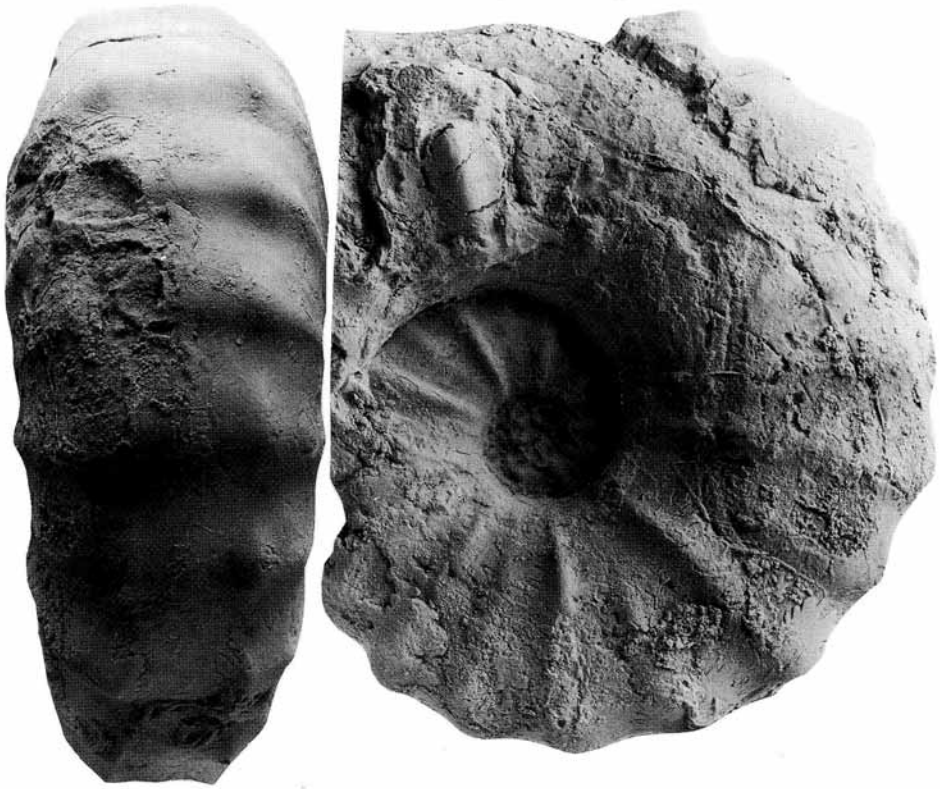
This ornament undergoes progressive modification in middle growth. The umbilical bullae decline at a variable rate, and migrate outwards to the inner flank. The ribs broaden and coarsen, the inner ventrolateral tubercles decline and ultimately disappear, the outer ventrolateral coarsening and persisting. The siphonal clavi also decline so that, by the beginning of the adult whorl there are none or only feeble umbilical bullae, strong ventrolateral clavi and none or only a trace of a weak siphonal clavus. The umbilical ratio increases progressively on the outer whorl, and the umbilical wall flattens markedly, so that the ribs appear to arise on the inner flank. They change from straight to feebly convex in many specimens, while the ventral ribbing

EXPLANATION OF PLATE 5

Figs. 1–5. *Conlinoceras tarrantense* (Adkins, 1928). 1–3, USNM 420253, from 2·4 km (1·5 miles) east of Euless, south bank of tributary to Big Bear Creek, Tarrant County. Note anaptychus in 2 and 3. 4 and 5, USNM 420240, from USGS locality 22614, 6·4 km (4 miles) south-east of Euless, Tarrant County. Both specimens are from the Tarrant Formation, *Conlinoceras tarrantense* zone. Figs. 3–5 are ×1; figures 1 and 2 are reduced ×0·75.



KENNEDY and COBBAN, *Conlinoceras*



TEXT-FIG. 15. *Conlinoceras tarrantense* (Adkins, 1928). TMM 2426, the holotype of *Acanthoceras wintoni* Adkins, 1928, from the Tarrant Formation, Big Bear Creek, near Dallas County line, Tarrant County. Natural size.

strengthens on the body chamber so that the costal ventral profile changes from concave to tabulate with a strong bar-like rib crossing the venter, into which the ribs are progressively assimilated. The last few ribs of the adult body chamber weaken somewhat and crowd, and the venter becomes rounded. Specimens regarded as macroconchs (USNM 420252) are adult at up to 200 mm diameter. Adult microconchs are 150 mm diameter or less.

Suture line with broad, bifid E/L narrower L and broad L/U_2.

One adult, USNM 420253, preserves part of the jaw apparatus in the body chamber (Pl. 5, figs. 1 and 2). The shell is 185 mm in diameter, the lower jaw 40 mm long at the symphysis, with fine concentric growth lines as well as radial striations, most conspicuous on the lateral and outer edges. It is preserved as a blackened film and is unmineralized.

Discussion. The abundant material before us is highly variable, demonstrating the holotype of *Metacalycoceras*? *tarrantense* Adkins, 1928 (p. 241, pl. 28, fig. 3; pl. 29, fig. 1; see Stephenson 1953*a*, pl. 45, figs. 9 and 10; pl. 46, fig. 2 for better photographs) to be an incomplete macroconch of a rather average morphology, while the holotype of *Acanthoceras wintoni* Adkins, 1928 (p. 243, pl. 25, figs. 2 and 3) is merely more compressed and feebly, if as distantly ribbed (text-fig. 15). *Acanthoceras adkinsi* Stephenson, 1953*a* (p. 200, pl. 47, figs. 3 and 4) is no more than a juvenile of the gracile form

TEXT-FIG. 16. *Conlinoceras tarrantense* (Adkins, 1928). USNM 105968, the holotype of *Acanthoceras adkinsi* Stephenson, 1953*a*, from the Tarrant Formation, branch north of Chicago, Rock Island and Pacific railroad near Dorothy Siding, Tarrant County. Natural size.

with dense ribbing (text-fig. 16). *Acanthoceras tarrantense nitidum* Stephenson, 1953*a* (p. 199, pl. 50, figs. 5 and 6) is another variant with well-differentiated tubercles on the inner whorls which link to the robust individuals shown here as Pl. 6, figs. 7–12; Pl. 7, figs. 23–25.

Conlinoceras tarrantense and *C. gilberti* are closely allied. They differ chiefly in that *C. gilberti* has much higher, stronger ribs. '*Acanthoceras*' *barcusi* Jones, 1938 (p. 117, pl. 6, figs. 2, 3, 8, 9) is a much smaller species that also comes from the Tarrant Formation of north central Texas. The two differ in the much more spinose inner whorls of '*A.*' *barcusi* which have a rounded rather than flattened venter, persistence of all tubercles to the middle of the adult body chamber and rounded venter at maturity.

Text-fig. 17 shows a remarkable pathological specimen of *C. tarrantense* with rursiradiate ribbing and no tubercles on the outer whorl. This specimen is the basis for the occurrence of *Paracalycoceras* in Texas cited in the *Treatise* (Wright 1957).

Occurrence. *Conlinoceras tarrantense* zone, Tarrant Formation of central Texas; Oak Canyon Member and Cubero Tongue of Dakota Sandstone in west-central New Mexico.

Conlinoceras sp.

Text-fig. 18

Discussion. A species of *Conlinoceras* is represented by a fragment from the *Acanthoceras bellense* zone on Bird Creek in Bell County. USNM 420255 corresponds to the coarse ribbed variants of *C. tarrantense*, with striking differentiation into primary and secondary ribs.

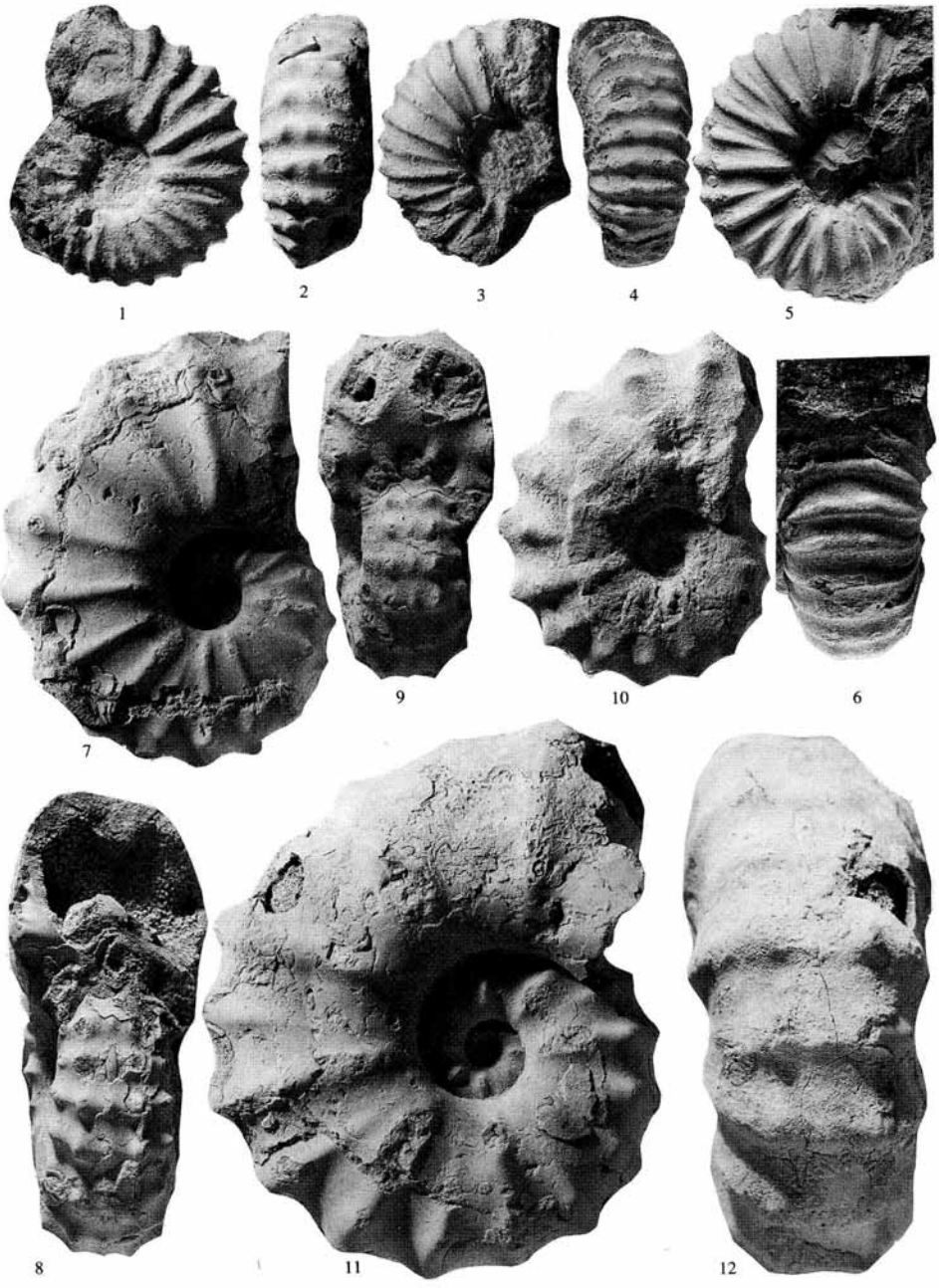
TEXT-FIG. 17. *Conlinoceras tarrantense* (Adkins, 1928). USNM 420254, from the Tarrant Formation, tributary to Big Bear Creek, 2·4 km (1·5 miles) east of Euless, Tarrant County. This pathological specimen is the basis for the *Treatise* record of *Paracalycoceras* in Texas. Reduced ×0·9.

EXPLANATION OF PLATE 6

Figs. 1–6. *Paraconlinoceras leonense* (Adkins, 1928). 1 and 2, USNM 420260; 3 and 4, USNM 420261, both from USGS locality 13577, branch south of Belton-Temple road, 1·6 km (1 mile) east of Midway Church, Bell County. 5 and 6, the holotype, TMM 34051, from near the Belton-Temple Highway, Bell County. All specimens are from the basal shell bed of the Bluebonnet Member, *Acanthoceras bellense* zone.

Figs. 7–12. *Conlinoceras tarrantense* (Adkins, 1928). 7 and 8, USNM 420244; 9 and 10, USNM 420241; 11 and 12, USNM 420248, all from USGS locality 22614, 6·4 km (4 miles) south-east of Euless, Tarrant County; all from the Tarrant Formation, *Conlinoceras tarrantense* zone.

All figures are ×1.



KENNEDY and COBBAN, *Paraconlinoceras, Conlinoceras*

Genus PARACONLINOCERAS nov.

Type species. Eucalycoceras leonense Adkins, 1928, p. 240, pl. 28, fig. 1; pl. 29, fig. 3.

Diagnosis. Moderately small ammonites with narrow, high ribs that cross the venter; acanthoceratine nuclei bearing long and short ribs with umbilical bullae, conical inner ventrolateral and nodate to clavate outer ventrolateral and siphonal tubercles; inner ventrolaterals decline in middle growth, all tubercles except umbilical ones lost on later parts of body chamber where venter rounds; umbilical bullae decline and disappear at adult aperture.

Discussion. Paraconlinoceras microconchs are adult at 50–60 mm, macroconchs at 90 mm. Nuclei of *P. leonense* are identical in style and shape of ornament to slightly older *Conlinoceras tarrantense* (text-fig. 19) while sutures are identical in style (compare text-figs. 6D and 20F). *Conlinoceras tarrantense* reach maturity at 150 mm or less in microconchs, 200 mm in macroconchs. The acanthoceratine stage persists in *Conlinoceras tarrantense* to a size where *Paraconlinoceras leonense* are adult (Pl. 9, figs. 26, 27, 29, 30). If adult phragmocones are compared, *Conlinoceras tarrantense* has passed from a stage of alternately long and short ribs to one in which all ribs are long and variably bullate, have lost their inner ventrolateral and, commonly, siphonal tubercles. Ribs are broad and blunt, rather than sharp and narrow. Adult body chambers are utterly distinct.

On the basis of comparable nuclei and stratigraphic occurrence, *Paraconlinoceras leonense* is regarded as a possible derivative of *Conlinoceras*, via '*Acanthoceras*' *barcusi* Jones, 1938, which is also referred to the new genus. *Paraconlinoceras* is a homoeomorph of *Gentoniceras* Thomel, 1972. They differ in the acanthoceratine nuclei of the former which have markedly clavate outer ventrolateral and siphonal tubercles, not seen in *Gentoniceras*.

Occurrence. Middle Cenomanian *Conlinoceras tarrantense* zone of Texas, *Acanthoceras bellense* zone of Texas and Wyoming, *Conlinoceras gilberti* zone of Colorado.

Paraconlinoceras barcusi (Jones, 1938)

Pl. 8, figs. 1–7

1938	*Acanthoceras barcusi* Jones, p. 117, pl. 6, figs. 2, 3, 8, 9.
1951	*Acanthoceras barcusi* Jones; Adkins and Lozo, pl. 2, fig. 4.
1953*a*	*Acanthoceras barcusi* Jones; Stephenson, p. 203, pl. 44, figs. 9–11.

Type. Holotype is UMM 16543, the original of Jones (1938, pl. 6, fig. 2) from the 'basal Eagle Ford' of Tarrant County, Texas.

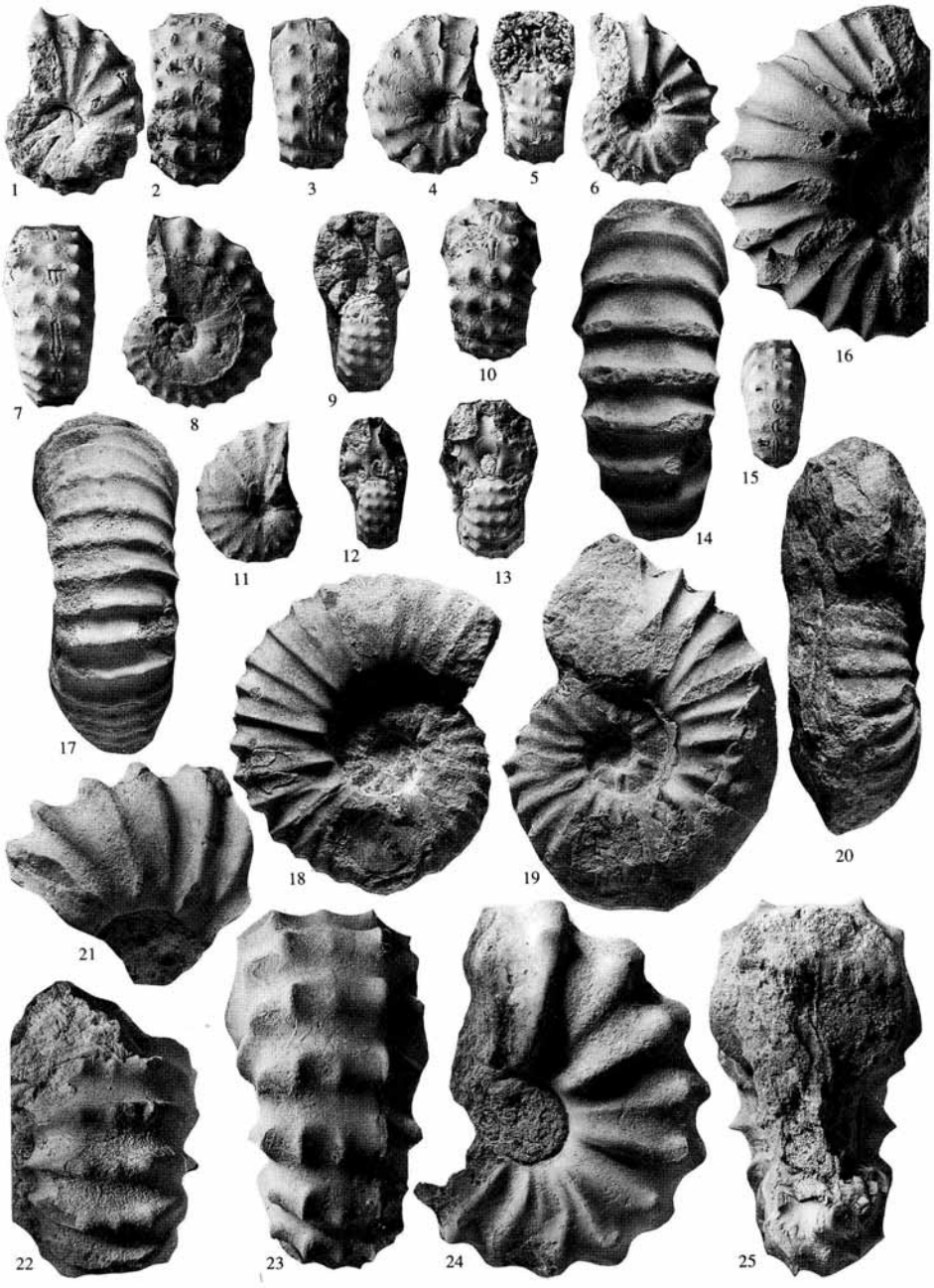
Material. USNM 420264–420267 without precise locality data; USNM 105977 from Big Bear Creek, Dallas County, all from the Tarrant Formation, middle Cenomanian *Conlinoceras tarrantense* zone.

EXPLANATION OF PLATE 7

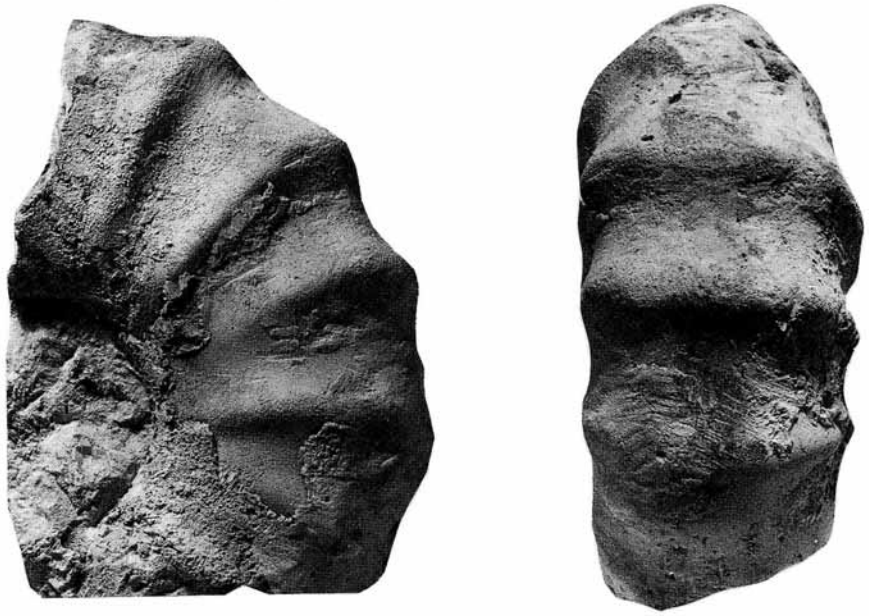
Figs. 1–13, 15, 23–25. *Conlinoceras tarrantense* (Adkins, 1928). 1 and 2, USNM 420237; 3–5, USNM 420234; 6, 10, 13, USNM 420235; 7–9, USNM 420238; 11 and 12, 15, USNM 420233; 23–25, USNM 420243, all from 2·4 km (1·5 miles) east of Euless, south bank of tributary to Big Bear Creek, Tarrant County; Tarrant Formation, *Conlinoceras tarrantense* zone.

Figs. 14, 16, 17–22. *Paraconlinoceras leonense* (Adkins, 1928). 14, 16, USNM 420257; 17 and 18, USNM 420256; 19 and 20, USNM 420262, from USGS Locality 11845; 21 and 22, USNM 420263, all from the basal shell bed of the Bluebonnet Member, Bird Creek, 6·4 (4 miles) east-north-east of Belton, Bell County. *Acanthoceras bellense* zone.

All figures are × 1.



KENNEDY and COBBAN, *Conlinoceras, Paraconlinoceras*



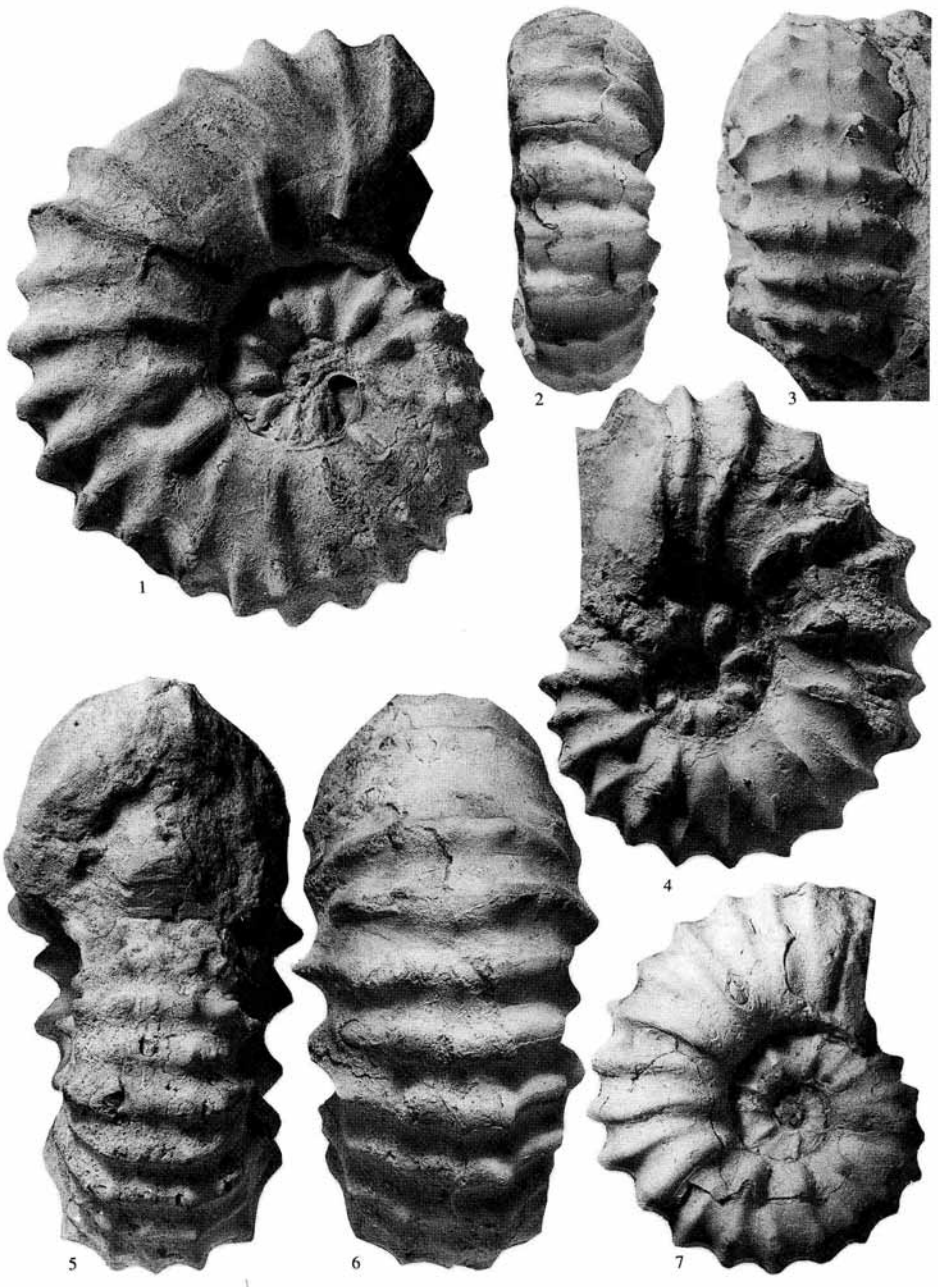
TEXT-FIG. 18. *Conlinoceras* sp. USNM 420255, from the basal shell bed of the Bluebonnet Member on Bird Creek, Bell County. Natural size.

Dimensions		D	Wb	Wh	Wb:Wh	U	
USNM 420264	c	52·0 (100)	28·9 (55·6)	21·7 (41·7)	1·33	—	(—)
	ic	48·5 (100)	22·9 (47·2)	19·0 (39·2)	1·21	—	(—)
USNM 105977	c	58·7 (100)	— (—)	22·0 (37·5)	—	19·7	(33·6)
	ic	55·5 (100)	— (—)	20·0 (36·0)	—	—	(—)
USNM 420265	c	64·2 (100)	30·4 (47·4)	25·0 (38·9)	1·2	23·2	(36·1)
	ic	60·2 (100)	26·5 (44·0)	22·3 (37·0)	1·19	—	(—)

Description. Coiling evolute with U = 33–36% of diameter, quite deep with subvertical wall in early growth becoming rounded at maturity. Umbilical shoulder broadly rounded. Costal whorl section depressed (Wb:Wh ratio 1·2–1·33), polygonal, with greatest breadth at umbilical bullae. Intercostal section depressed trapezoidal (Wb:Wh ratio 1·19–1·21) with broadly rounded inner flanks, flattened convergent outer, broadly rounded ventrolateral shoulders and somewhat flattened venter. There are 12–13 primary ribs per whorl in middle growth. These arise at the umbilical seam and develop into strong, distant coarse ribs with a strong, pointed bulla perched on the umbilical shoulder. These give rise to strong rursiradiate ribs which alternate regularly with secondary ribs that arise low on the flank. These strengthen to match the development of the primaries,

EXPLANATION OF PLATE 8

Figs. 1–7. *Paraconlinoceras barcusi* (Jones, 1938). 1, 5, 6, the holotype, UMM 16543, from the 'Basal Eagle Ford' (e.g. Tarrant Formation) of Tarrant County. 2, 7, USNM 105977, from 2·4 km (1·5 miles) east of Euless, on south bank of Big Bear Creek, Tarrant County. 3 and 4, USNM 420265, without precise locality data but from the Tarrant Formation of Tarrant County. All *Conlinoceras tarrantense* zone. All figures are × 1.



KENNEDY and COBBAN, *Paraconlinoceras*

and all ribs bear a sharp inner ventrolateral tubercle linked by a strong rib to clavate outer ventrolateral and siphonal tubercles. This ornament persists to the beginning of the adult body chamber, where there is a progressive outward migration and decline in strength of the umbilical bullae, weakening of the ventrolateral and siphonal tubercles. Specimens that we take to be adult microconchs are 59–63 mm in diameter, and show marked egression of the umbilical seam with the last few ribs before the aperture weakened and crowded, with no or very weak tubercles and an evenly rounded costal whorl section. The holotype and USNM 420265 are over 80 mm in diameter and appear to be incomplete macroconchs.

Suture (Jones 1938, pl. 6, fig. 3) with broad, bifid E/L and narrow L.

Occurrence. *Conlinoceras tarrantense* zone. Tarrant Formation of north central Texas only.

Paraconlinoceras leonense (Adkins, 1928)

Plate 6, figs. 1–6; Plate 7, figs. 14, 16–22; Plate 9, figs. 26, 27, 29, 30; text-figs. 19A–H.

1928	*Eucalycoceras leonense* Adkins, p. 240, pl. 28, fig. 1; pl. 29, fig. 3.
1928	*Metacalycoceras* ? sp. 2; Adkins, p. 242, pl. 28, fig. 2; pl. 29, fig. 2.
1942	*Eucalycoceras leonense* Adkins; Moreman, p. 207.
1969	*Eucalycoceras* (*Proeucalycoceras*) *leonense* Adkins, Thomel, p. 650.
1972	*Eucalycoceras* (*Proeucalycoceras*) *leonense* Adkins; Thomel, p. 81.
1973	*Calycoceras leonense* (Adkins); Cobban and Scott, p. 60, pl. 3, figs. 1–4.
1987*b*	*Calycoceras* (*Gentoniceras*) *leonense* (Adkins); Cobban, p. 4, pl. 1, figs. 1–17, text-fig. 2.

Holotype. TMM 34051, the original of Adkins (1928, p. 240, pl. 28, fig. 1; pl. 29, fig. 1), from the basal shell bed of the Bluebonnet Member of the Lake Waco Formation of the Eagle Ford Group near the old Belton-Temple Highway, Bell County, *Acanthoceras bellense* zone.

Material. More than 100 specimens and fragments from the same horizon as the holotype: USGS localities 11845, 13577 and 19554, J. P. Conlin and OUM collections, on Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County. Middle Cenomanian *Acanthoceras bellense* zone.

Dimensions		D	Wb	Wh	Wb:Wh	U
USNM 420256 (microconch)	c	49·7 (100)	21·5 (43·3)	18·0 (36·2)	1·2	17·5 (35·2)
USNM 420257 (juvenile)	c	53·0 (100)	22·5 (42·4)	20·8 (39·2)	1·08	15·5 (29·2)
USNM 420258 (microconch)	c	61·0 (100)	27·5 (45·1)	26·5 (43·4)	1·04	20·5 (33·6)
USNM 420259 (macroconch)	c	90·0 (100)	— (—)	30·5 (—)	—	32·8 (36·4)
	c	80·5 (100)	31·2 (38·8)	28·0 (34·8)	1·14	27·2 (33·8)

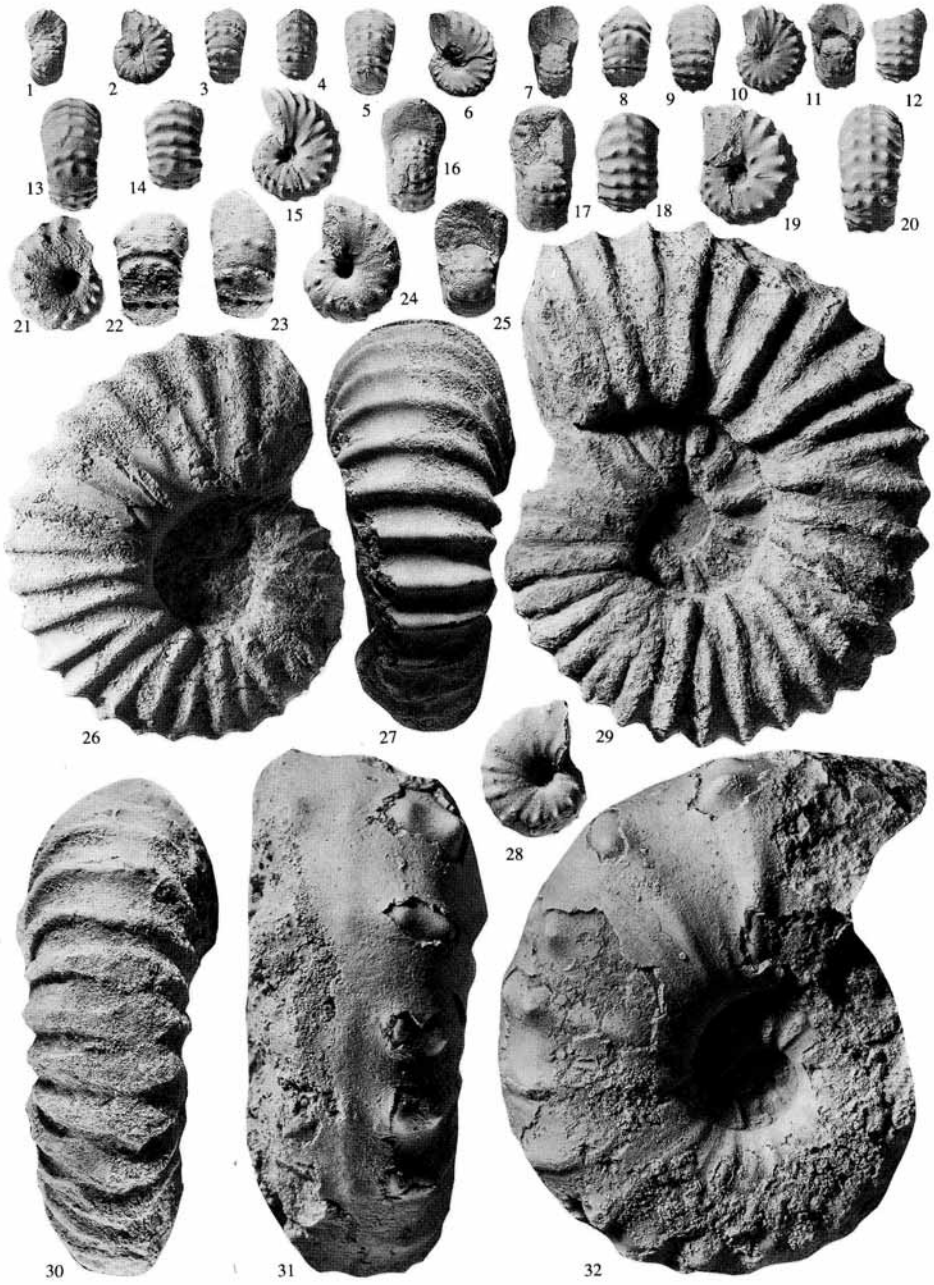
EXPLANATION OF PLATE 9

Figs. 1–25, 28. *Plesiacanthoceratoides vetula* (Cobban, 1987*b*). 1–4, USNM 420291; 5–8, USNM 420292; 10–12, USNM 420290; 13–16, USNM 420287; 17–20, USNM 420289, all from a loose concretion at USGS Mesozoic locality D12626, basal part of the Eagle Ford Group, 8·9 km (5·5 miles) north-east of Mansfield, Tarrant County. 21 and 22, paratype USNM 388194; 23–25, paratype USNM 388195; 28, paratype USNM 388197, all from USGS Mesozoic locality D5900, Belle Fourche Shale, Old Woman anticline (south-west of the Black Hills, head of Elm Creek, in W½ sec. 14, T.36N, R.62W, Niobrara County, Wyoming. All *Acanthoceras amphibolum* zone.

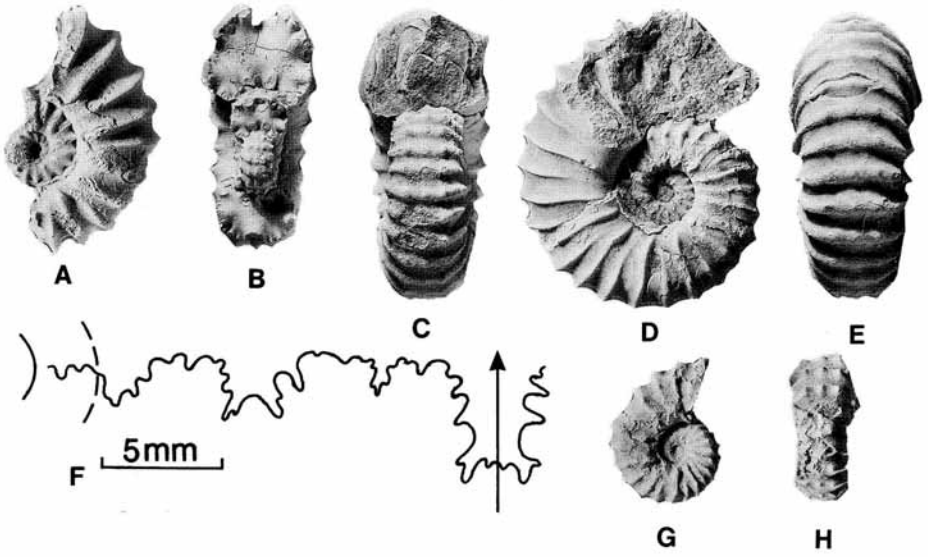
Figs. 26 and 27, 29 and 30. *Paraconlinoceras leonense* (Adkins, 1928). 26 and 27, USNM 420258; 29 and 30, USNM 420259, from USGS locality 13577, basal shell bed of Bluebonnet Member, Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County.

Figs. 31 and 32. *Acanthoceras bellense* Adkins, 1928. The holotype, TMM 3034, from the same horizon and locality as the originals of figs. 26 and 27.

Figures 21–25, 28 are ×2; the remainder are ×1.



KENNEDY and COBBAN, *Plesiacanthoceratoides, Paraconlinoceras, Acanthoceras*



TEXT-FIG. 19. *Paraconlinoceras leonense* (Adkins, 1928). A and B, USNM 388089; C–E, USNM 388087; F, external suture of USNM 388087; G and H, USNM 388088. All are from the Belle Fourche Shale at USGS Mesozoic locality D8841, west of Osage in the SW1/4 sec. 8, T. 46 N., R. 63 W., Weston County, Wyoming. A–E, G and H are natural size.

Description. The species appears to be markedly dimorphic; 2 complete microconchs are 50 and 61 mm diameter, two macroconchs 90 and 92 mm diameter. The early growth stages are not shown by the Texas material. In middle growth as far as the beginning of the adult body chamber, the coiling is evolute, with U = 27–33% of diameter, shallow, with a rounded wall. Intercostal whorl section depressed, reniform, the greatest breadth well below mid-flank. Costal section trapezoidal–polygonal. There are generally 12–14 primary ribs per whorl. They arise at the umbilical seam, strengthen into sharp bullae on the umbilical shoulder and give rise to sharp, distant, prorsiradiate primary ribs. At the smallest diameters visible these bear small inner ventrolateral tubercles that are no wider than the rib, linked by a strong rib to a clavate outer ventrolateral and a somewhat weaker siphonal tubercle. At small sizes ribs may arise in pairs from the umbilical bullae, but in general the primaries alternate regularly with secondaries inserted at or below mid-flank. The latter strengthen to equal the primaries at the ventrolateral shoulder, where they develop a full complement of tubercles. The inner ventrolateral tubercles decline around the outer whorl of the phragmocone, and the beginning of the body chamber bears outer ventrolateral and siphonal tubercles only. The umbilical seam of the mature body chamber egresses markedly, to give U = up to 37%. Umbilical bullae migrate out to the inner flank, before declining and disappearing just before the adult aperture. The outer ventrolateral and siphonals persist to the last quarter whorl before the adult aperture, thereafter they decline. The last few ribs before the aperture are weakened, and extend to the umbilical shoulder without bullae.

Suture with broad, symmetrically bifid E/L, narrow bifid L and broad L/U_2.

Discussion. The Texas material does not show the inner whorls. Study of well-preserved material from the Belle Fourche Shale at USGS Mesozoic locality D8841 in Weston County, Wyoming (text-fig. 19) shows juveniles to have strikingly *Acanthoceras*-like nuclei, with a polygonal whorl section in costal section and markedly clavate outer ventrolateral clavi. This is quite different from inner whorls of *Gentoniceras* Thomel, 1972, which the species resembles at maturity. We conclude that *P. leonense* is a homoeomorph of *Gentoniceras*, its inner whorls pointing to an origin in slightly older *Paraconlinoceras barcusi* which has comparable inner whorls (Pl. 8, figs. 1–7) and outer whorls with high, narrow ribs.

Occurrence. Middle Cenomanian *Acanthoceras bellense* zone of central Texas and eastern Wyoming. *Conlinoceras gilberti* zone of southeastern Colorado.

Genus CUNNINGTONICERAS Collignon, 1937, p. 64 (40)

(? = *Guerangericeras* Thomel, 1972)

Type species. *Ammonites cunningtoni* Sharpe, 1855 (p. 35, pl. 15, fig. 2).

Discussion. See Wright and Kennedy (1987, p. 193).

Cunningtoniceras lonsdalei (Adkins, 1928)

Plate 12, figs. 1–3, 8; text-figs. 20–22

1928 *Acanthoceras lonsdalei* Adkins, p. 244, pl. 26, fig. 5; pl. 27, fig. 3.
1942 *Acanthoceras lonsdalei* Adkins; Moreman, p. 204.
1955 *Euomphaloceras lonsdalei* (Adkins); Stephenson, p. 62 (*pars*), pl. 6, figs. 6–8, *non* 9–20.
1963 *Euomphaloceras lonsdalei* (Adkins); Wright, p. 609, pl. 87, fig. 2; pl. 88, fig. 1; pl. 89, fig. 2.
?1973 *Euomphaloceras* cf. *lonsdalei* (Adkins); Cobban and Scott, p. 71, pl. 5, figs. 1, 2, 4.
1978 *Euomphaloceras lonsdalei* (Adkins); Young and Powell, pl. 5, fig. 1 only (*non* 7, = *Acanthoceras bellense*).
1987 *Cunningtoniceras lonsdalei* (Adkins); Wright and Kennedy, p. 194, text-fig. 80.

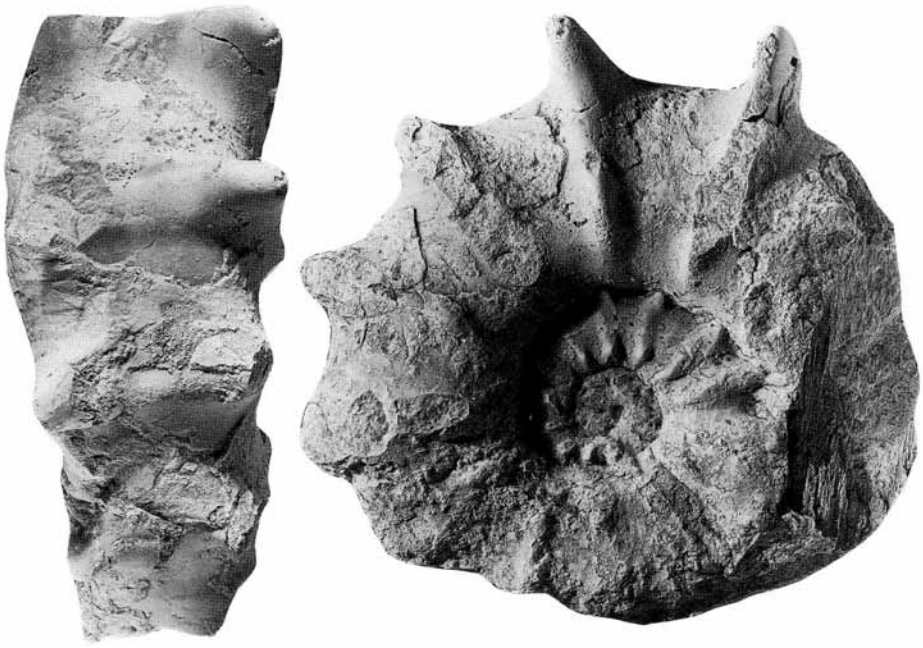
Holotype. TMM 2410, the original of Adkins (1928, p. 244, pl. 26, fig. 5, pl. 27, fig. 3) by original designation. From the Bluebonnet Member of the Lake Waco Formation of the Eagle Ford Group on the Belton-Temple road, Bell County. Middle Cenomanian *Acanthoceras bellense* zone.

Material. USNM 108831a–b (originals of Stephenson 1955, pl. 6, figs. 6–8), USNM 420268–420272, TMM 1069, WSA 12830, all from the same horizon as the holotype on Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County.

Dimensions		D	Wb	Wh	Wb:Wh	U
USNM 108831b	c	51·5 (100)	32·1 (62·3)	24·0 (46·6)	1·34	12·3 (23·9)
USNM 420269	c	52·3 (100)	28·9 (55·3)	24·0 (45·9)	1·20	12·9 (24·7)
TMM 2410	c	79·2 (100)	43·5 (54·9)	35·5 (44·8)	1·23	22·0 (27·7)
			41·0 (—)	36·1 (—)	1·14	

Description. Up to 100 mm: coiling very evolute, umbilicus comprises up to 28% of diameter. Whorl section depressed, rounded-trapezoidal in intercostal section (Wb:Wh 1·14), with greatest breadth outside umbilical shoulder. Inner flanks rounded, outer flanks flattened, convergent, ventrolateral shoulders broadly rounded, venter somewhat flattened. Costal section very depressed, polygonal, with greatest breadth at umbilical bullae. Distant primary ribs, 10 per half whorl, arise at the umbilical seam. They strengthen across the umbilical wall and develop into strong umbilical bullae perched just outside the umbilical shoulder. These give rise to broad, straight, prorsiradiate ribs, somewhat effaced on the outer flank, where they connect to a strong conical inner ventrolateral horn. A low broad rib connects to a clavate inner ventrolateral tubercle, accompanied by one or two weaker ribs connecting to generally weaker inner ventrolaterals, all ribs extending to evenly developed siphonal tubercles. There are occasional intercalated ribs with outer ventrolateral and siphonal tubercles so that the 10 or so primary ribs per half whorl correspond to 20 or more ventral ribs. An adult specimen, USNM 420271 (text-fig. 20), has inner whorls identical to those of the holotype and is mature at an estimated intercostal diameter of just over 200 mm. On the early body chamber there are distant ribs with flared umbilical bullae and a strong conical ventrolateral horn without a trace of an outer ventrolateral clavus, the horns linked across the venter by a pair of looped riblets on a broad low rib, the costal section being markedly concave. The ventral rib strengthens markedly at the end of the body chamber and is strong and bar-like, the costal profile loosing the deep ventral concavity.

Discussion. There is some variation in the ventral ribbing, as in other *Cunningtoniceras* species (Wright and Kennedy 1987). *Cunningtoniceras lonsdalei* was derived from *Acanthoceras bellense* by stabilization of multiple ventral ribbing; it is linked to *A. bellense* by a common style of flank ornament, whorl proportions, the presence of a marked siphonal ridge and distinctive bar-like rib



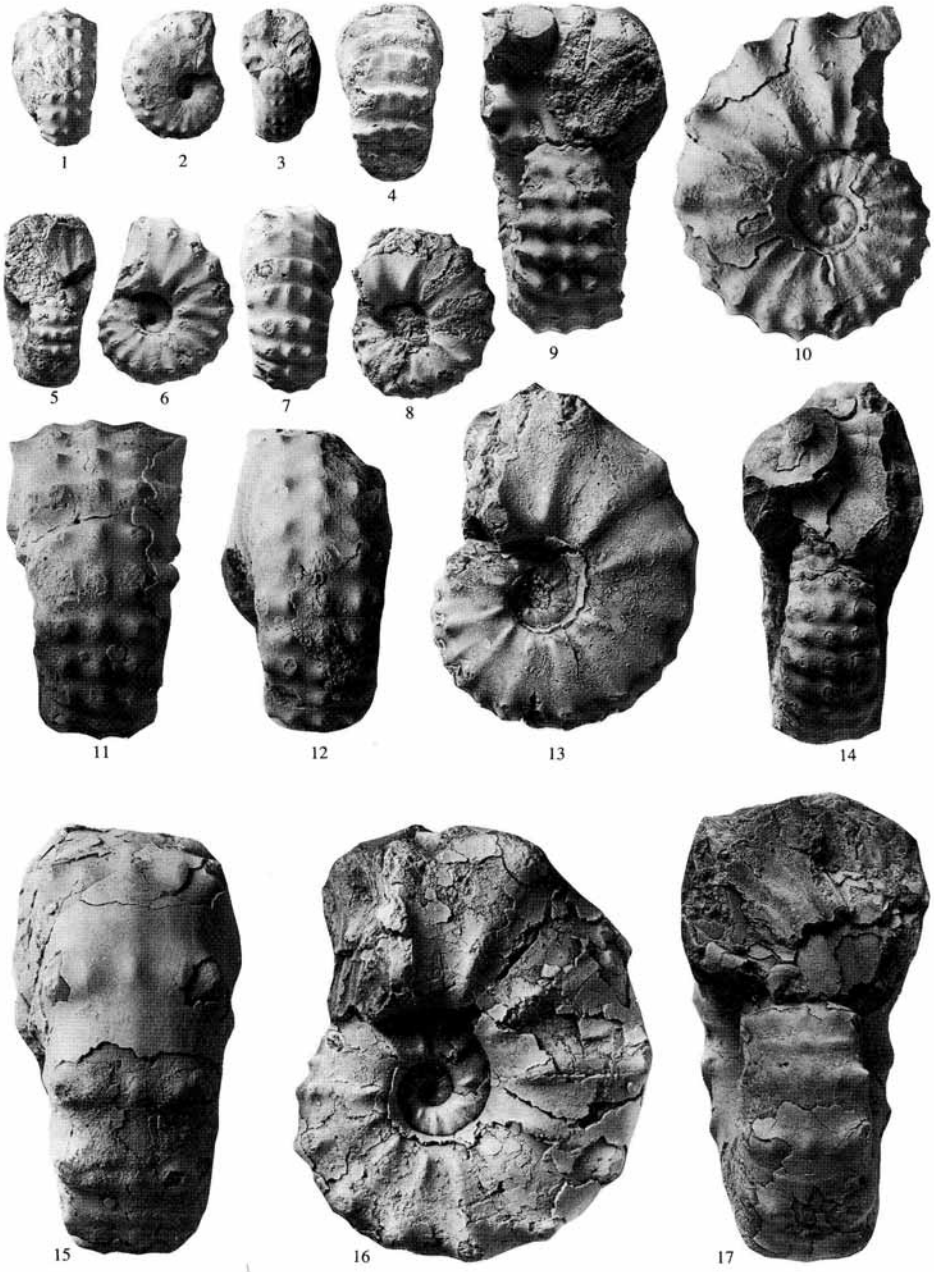
TEXT-FIG. 20. *Cunningtoniceras lonsdalei* (Adkins, 1928). USNM 420271, an adult specimen from the basal shell bed of the Bluebonnet Member on Bird Creek, Bell County. Reduced ×0·5.

at the adult aperture. Zaborski (1985) regarded *C. lonsdalei* as a subspecies of *C. cunningtoni*, but the latter is a derivative of *Acanthoceras rhotomagense*. The two species differ in that *C. cunningtoni* is much more depressed, has far fewer ribs, massive inner ventrolateral horns, obvious looping of ventral ribs and utterly different adult ornament. Stephenson (1955) confused *C. lonsdalei* and *C. johnsonanum* (Stephenson, 1955); differences are outlined below; features of other *Cunningtoniceras* species are reviewed by Wright and Kennedy (1987) and are not repeated here.

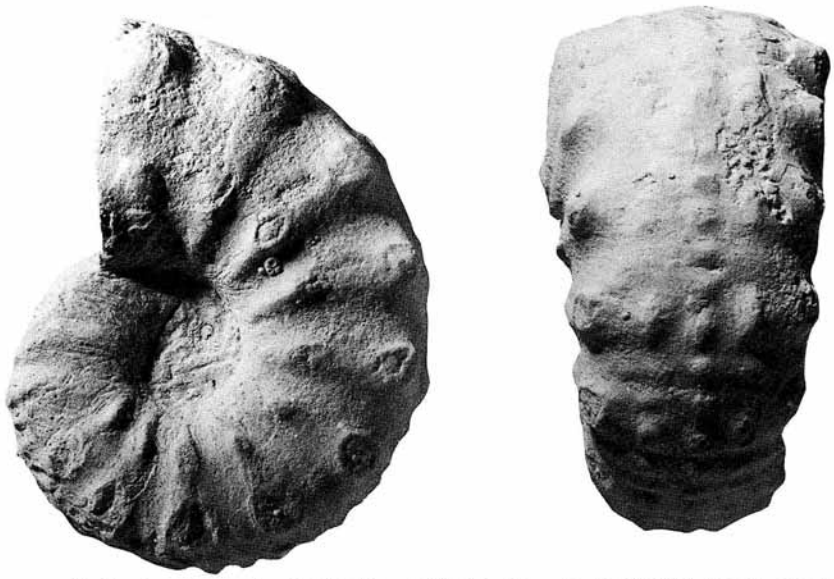
Occurrence. *Acanthoceras bellense* zone, central Texas. Middle Cenomanian of Bathurst Island, northern Australia. There is a doubtful record from the *Acanthoceras muldoonense* zone of SE Colorado.

EXPLANATION OF PLATE 10

Figs. 1–17. *Cunningtoniceras johnsonanum* (Stephenson, 1955). 1–3, USNM 420275, from east of old Alvarado–Grandview highway, 6·4 km (4 miles) south of Alvarado, Johnson County; 4, 8, USNM 420276; 5–7, USNM 420273; 15–17, USNM 420278, from concretions in cotton field 1·6 km (1 mile) north of Lillian, Johnson County; 9–11, USNM 420274; 12–14, USNM 420277, from 0·3 km (0·2 mile) south of Mountain Creek, 6·1 km (3·8 miles) north-east of the town square in Alvarado, Johnson County. All specimens from the basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone. All figures are ×1.



KENNEDY and COBBAN, *Cunningtoniceras*



TEXT-FIG. 21. *Cunningtoniceras lonsdalei* (Adkins, 1928). The holotype, TMM 2410, from the basal shell bed of the Bluebonnet Member on the Belton-Temple road, Bell County. Natural size.

Cunningtoniceras johnsonanum (Stephenson, 1955)

Plate 10, figs. 1–17; Plate 11, figs. 1 and 2.

1955 *Acanthoceras johnsonanum* Stephenson, p. 58, pl. 4, figs. 14–17.
1955 *Euomphaloceras lonsdalei* (Adkins); Stephenson, p. 62 (*pars*), pl. 6, figs. 9–20 only.

Type. The holotype is USNM 108846, from USGS locality 14583, north facing slope of Mountain Creek Valley, 4 km (2·5 miles) north-north-east of Alvarado, Johnson County. Basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone.

Material. Numerous specimens from the same horizon as the holotype at the following localities: gully in field 1·6 km (1 mile) north of Lillian, west of Lillian–Retta road; scattered concretions east of the old Alvarado–Grandview highway, 6·4 km (4 miles) south of Alvarado; hillside 0·3 km (0·2 mile) south of Mountain Creek and west of secondary road 6·1 km (3·8 miles) airline north-east of the town square in Alvarado, all in Johnson County and all *ex* Conlin Collection. USGS Mesozoic locality D12626, 8·9 km (5·5 miles) north-east of Mansfield, Tarrant County. All of the above are from concretions in the basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone.

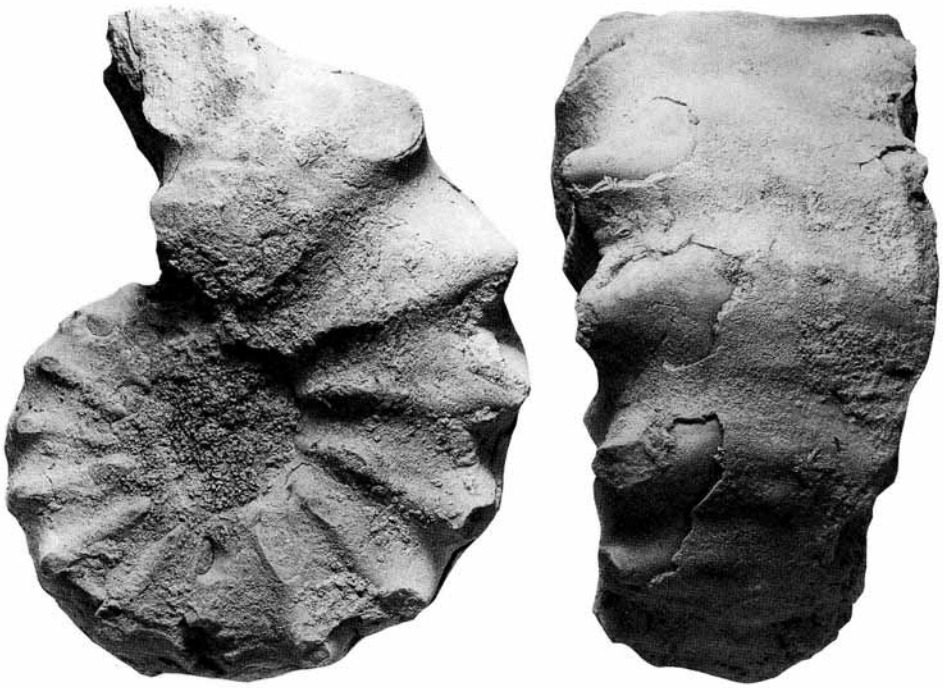
EXPLANATION OF PLATE 11

Figs. 1 and 2. *Cunningtoniceras johnsonanum* (Stephenson, 1955). The holotype, USNM 108846, from USGS locality 14583, north-facing slope on Mountain Creek Valley, 4 km (2·5 miles) north-north-east of Alvarado, Johnson County, *Acanthoceras amphibolum* zone.

Figs. 3 and 4. *Calycoceras* (*Newboldiceras*) sp. TMM 34032, from the basal shell bed of the Bluebonnet Member, Belton-Temple Highway, Bell County. *Acanthoceras bellense* zone.

All figures are × 1.

KENNEDY and COBBAN, *Cunningtoniceras, Calycoceras*



TEXT-FIG. 22. *Cunningtoniceras lonsdalei* (Adkins, 1928). TMM W. S. Adkins Collection 12830, from the basal shell bed of the Bluebonnet Member on Bird Creek, Bell County. Reduced ×0·95.

EXPLANATION OF PLATE 12

Figs. 1–3, 8. *Cunningtoniceras lonsdalei* (Adkins, 1928). 1 and 2, USNM 420268; 3, 8, USNM 420269, from the basal shell bed of the Bluebonnet Member, Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County. *Acanthoceras bellense* zone.

Figs. 4, 7. *Acanthoceras bellense* Adkins, 1928. USNM 420215, horizon and locality as for the originals of figs. 1–3, 8.

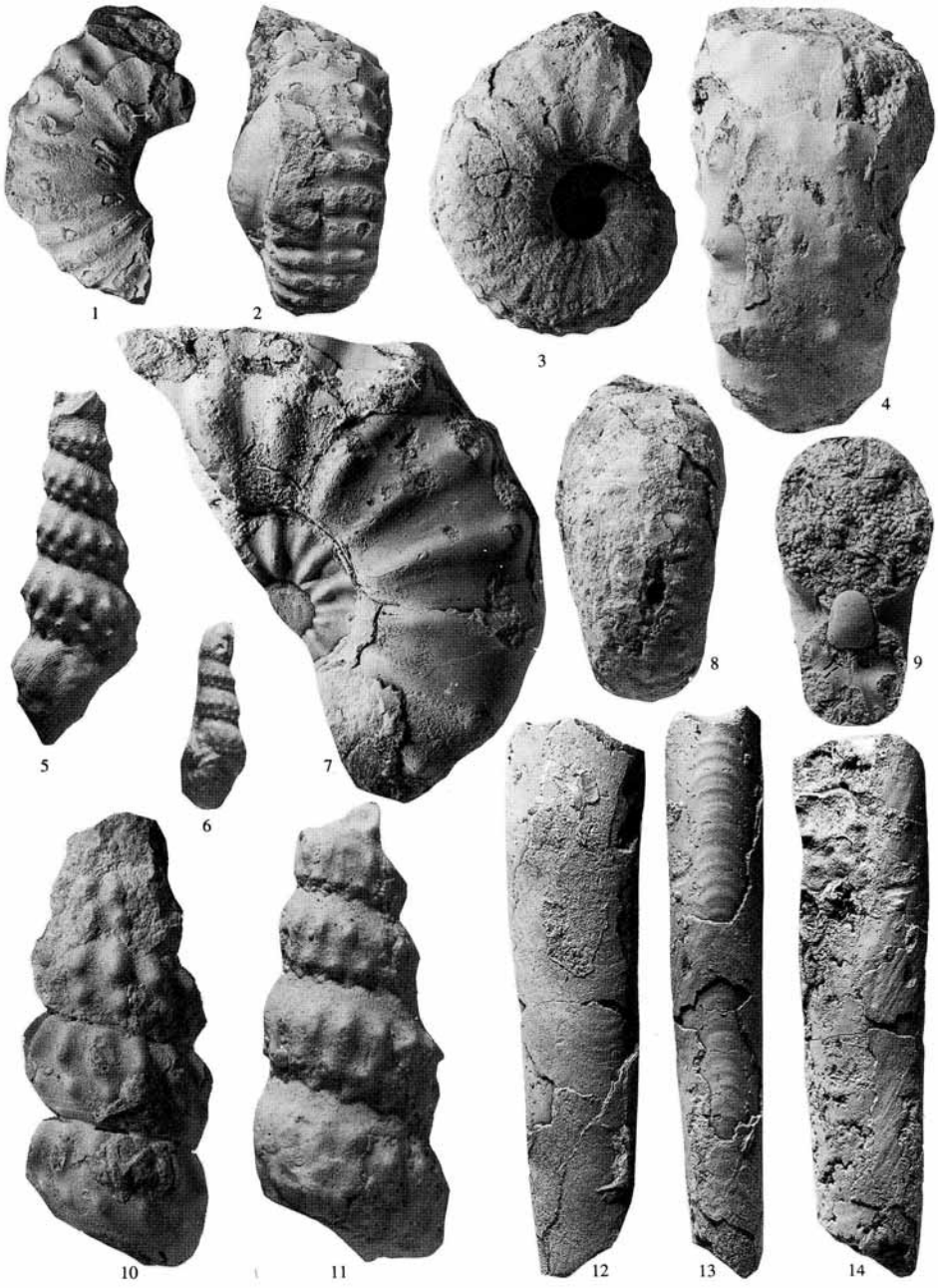
Figs. 5, 6, 11. *Turrilites* (*Turrilites*) *dearingi* Stephenson, 1953*a*. 5, USNM 420314; 6, USNM 420315, casts of specimens in the Gerry Kienzlen Collection (Dallas, Texas), from roadcut on east side of Texas Highway 360, 1·9 km (1·2 miles) south of bridge over Trinity River. 11, paratype USNM 105957, from a branch of Big Bear Creek, 2·4 km (1·5 miles) east of Euless, both in Tarrant County, Tarrant Formation, *Conlinoceras tarrantense* zone.

Fig. 9. *Plesiacanthoceras bellsanum* (Stephenson, 1953*a*). USNM 105984, from the Templeton Member of the Woodbine Formation 4·3 km (2·7 miles) north of Bells, Grayson County.

Fig. 10. *Turrilites* (*Turrilites*) *acutus* Passy, 1832. USNM 420301, from the same horizon and locality as the originals of figs. 1–3, 8.

Figs. 12–14. *Sciponoceras*? sp. TMM 2425, from the base of the Bluebonnet Member, 0·8 km (0·5 mile) south-east of Round Rock, Williamson County. *Acanthoceras bellense* zone.

Figure 9 is ×2; the remainder ×1.



KENNEDY and COBBAN, Cenomanian ammonites

Dimensions		D	Wb	Wh	Wb:Wh	U
USNM 420273	c	26·8 (100)	15·0 (56·0)	12·2 (45·5)	1·23	6·5 (24·3)
USNM 420274	c	31·0 (100)	16·5 (53·2)	13·2 (42·6)	1·25	8·0 (25·8)
USNM 420275	c	50·3 (100)	28·5 (56·7)	20·6 (40·9)	1·38	13·2 (26·2)
	ic	46·5 (100)	24·5 (52·7)	19·3 (41·5)	1·27	

Description. Coiling is moderately evolute with approximately 30% of the previous whorl covered. Umbilicus of moderate depth, comprising 24–26% of diameter, with subvertical wall. Whorls vary from very depressed (intercostal Wb:Wh ratio 1·27) to equidimensional. The intercostal whorl section is trapezoidal, the costal section polygonal, with the greatest breadth at the umbilical bulla. There are generally 12–14 primary ribs per whorl. They arise at the umbilical seam, strengthen across the umbilical wall and shoulder and develop weak to strong umbilical bullae, strength of ornament varying from weak to coarse between individuals. In robust individuals (USNM 420270, 420272, 420274) straight prorsiradiate ribs broaden and weaken somewhat as they pass across the flanks only to strengthen into a pronounced inner ventrolateral horn. A broad rib leads to strong outer ventrolateral and siphonal clavi. At small diameters, shorter ribs intercalate low on the flank and bear a full complement of tubercles, with the inner ventrolateral weaker than on the primary ribs. With increasing diameter this tubercle effaces to leave short ventral ribs with inner ventrolateral and siphonal clavi only, the short ribs sometimes linking to the inner ventrolateral horns of the primary ribs, there being twice as many ventral as flank ribs. In gracile individuals (USNM 420279), there may be up to 2 intercalated ribs with outer ventrolateral and siphonal clavi between primaries, so that there are 3 times as many ventral as flank ribs.

Most specimens are less than 70 mm in diameter, and closely resemble the holotype (Pl. 11, figs. 1 and 2). This appears to be a microconch, showing effacement of tuberculation and rounding of venter not seen in our material. The latter includes larger fragments in which inner and outer ventrolateral tubercles are differentiated to whorl heights of up to 35 mm, with multiple ventral ribs and tubercles (USNM 420274). We presume these differences to be within the limits of intraspecific variation.

Suture not seen.

Discussion. Stephenson (1955 p. 62) confused this species with the older *Cunningtoniceras lonsdalei*. Adkin's species has a rounded, rather than polygonal section, more intercalated ribs, with tubercles often much weaker than on the primaries. *C. johnsonanum* may well be descended from *C. lonsdalei*.

Co-occurring *Acanthoceras amphibolum amphibolum* variants may be superficially similar to *C. johnsonanum*. They have constricted innermost whorls, however, are compressed with distant ribs and show early loss of inner ventrolateral clavi leaving a single ventrolateral horn, with a siphonal ridge and weak siphonal clavi (Pl. 4, figs. 1–14). Adults, with striking umbilical bullae and ventrolateral horns as the only strong tuberculation are immediately distinct (text-figs. 13 and 14).

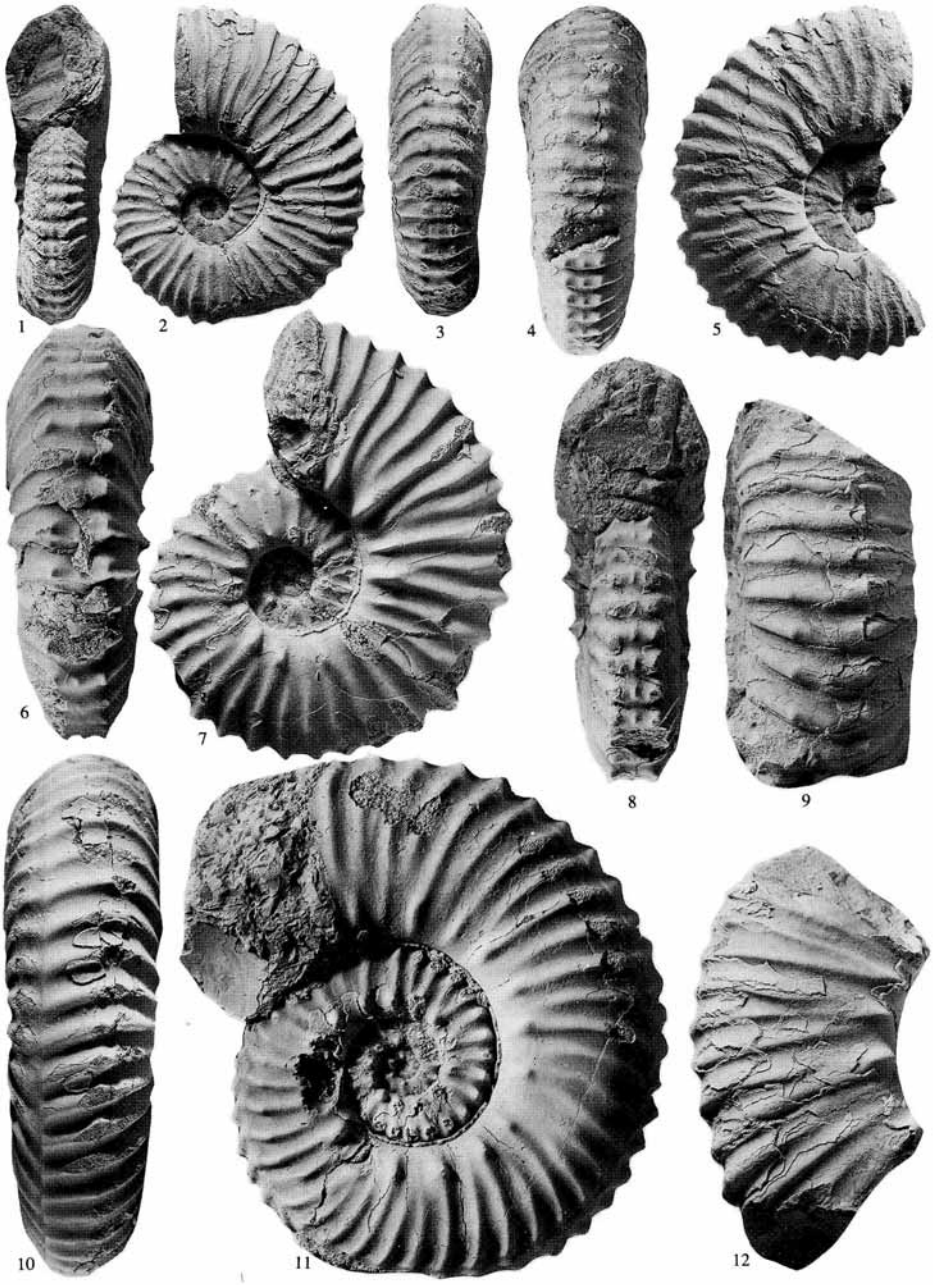
Occurrence. *Acanthoceras amphibolum* zone of central Texas only.

Cunningtoniceras inerme (Pervinquière, 1907)

1855 *Ammonites sussexiensis* Mantell; Sharpe, p. 34, pl. 15, fig. 1.
1907 *Acanthoceras cunningtoni* var. *inermis* Pervinquière, p. 277.
1953*a* *Acanthoceras*? *eulessanum* Stephenson, p. 201, pl. 47, fig. 5; pl. 48, figs. 3 and 4.
1987 *Cunningtoniceras inerme* (Pervinquière, 1907); Wright and Kennedy, p. 194, pl. 52, fig. 1; pl. 53, fig. 6; text-figs. 74 and 75, 79 (with full synonymy).

EXPLANATION OF PLATE 13

Figs. 1–12. *Tarrantoceras sellardsi* (Adkins, 1928). 1–3, USNM 400759; 4 and 5, USNM 400769; 10 and 11, USNM 400770, from concretions in cotton field 1·6 km (1 mile) north of Lillian, west of the Lillian–Retta Road, Johnson County. 6–8, USNM 400760; 9, 12, USNM 420284, from USGS Mesozoic locality D12626, 8·9 km (5·5 miles) north-east of Mansfield, Tarrant County. All specimens are from the basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone. All figures are × 1.



KENNEDY and COBBAN, *Tarrantoceras*

Discussion. Wright (1963) and Kennedy (1971) both regarded *Acanthoceras* ? *eulessanum* Stephenson, 1953*a* as a synonym of *Cunningtoniceras cunningtoni*. Wright and Kennedy (1987, p. 204) pointed out that it had strong flank ribs and compared it to *C. inerme*. It differs from specimens of the latter species (from the English Chalk) only in its lower rib density (13–14 per whorl vs. 17–20), and it is in this respect transitional to *C. cunningtoni*. We regard it as no more than a variant of *C. inerme*.

Occurrence. *Conlinoceras tarrantense* zone, Tarrant Formation of north central Texas. Where precisely dated in western Europe, it occurs at the top of the lower, *Turrilites costatus* subzone of the *Acanthoceras rhotomagense* zone in England and the German Federal Republic. It also occurs in the middle Cenomanian of France and Japan.

Genus TARRANTOCERAS Stephenson, 1955

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

Diagnosis. Small, macroconchs adult at 90–100 mm, microconchs adult at 60 mm or less. Evolute, compressed, early whorls with umbilical bullae, inner and outer ventrolateral and siphonal clavi on flexuous primary ribs separated by several secondaries; all but umbilical bullae decline or disappear at maturity. Suture simple, with broad bifid E/L and shallow bifid L.

Discussion. *Tarrantoceras* is a homoeomorph of certain *Eucalycoceras* species. The types of the two genera are distinct enough, while species such as *Eucalycoceras rowei* (Spath, 1926*b*) (see Kennedy 1971, p. 83, pl. 49, figs. 2–7; pl. 50, figs. 3–7) can be distinguished by the greater complexity of the suture with a long, narrow L, and umbilical bullae that project into the umbilicus. The inner whorls of *Tarrantoceras* have far more pronounced ventral clavi.

Cooper (1978) believed *Sumitomoceras* to be a synonym of *Tarrantoceras*; Wright and Kennedy (1981) and Kennedy (1988) regarded *Sumitomoceras* as a subgenus of *Tarrantoceras*. Subsequent work supports separation; the very early loss of siphonal tubercles in *Sumitomoceras*, presence of constrictions and suture with deep L are distinctive; the last feature suggests *Sumitomoceras* is allied to the Old World acanthoceratines, not those of the New World.

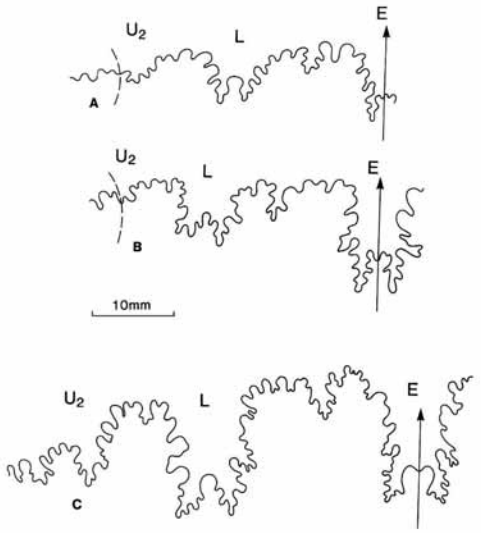
Occurrence. Middle and low upper Cenomanian of the US Western Interior and Angola.

Tarrantoceras sellardsi (Adkins, 1928)

Plate 13, figs. 1–12; Plate 14, figs. 1–16, 19, 20, 25, 29, 30; text-figs. 6A, 23A and B.

1928 *Mantelliceras sellardsi* Adkins, p. 239, pl. 25, fig. 1; pl. 26, fig. 4.
1942 *Mantelliceras sellardsi* Adkins; Moreman, p. 207.
1955 *Tarrantoceras rotatile* Stephenson, p. 59, pl. 5, figs. 1–10.
1955 *Tarrantoceras stantoni* Stephenson, p. 60, pl. 5, figs. 11–21.
1955 *Tarrantoceras lillianense* Stephenson, p. 60, pl. 5, figs. 22–27.
1971 *Eucalycoceras sellardsi* (Adkins); Kennedy, p. 84.
1973 *Tarrantoceras rotatile* Stephenson; Cobban and Scott, p. 64, pl. 10, figs. 1–11; text-fig. 25.
1977*a* *Tarantoceras rotatile* Stephenson; Cobban, p. 23, pl. 6, figs. 8–10, 28 and 29; pl. 11, figs. 7 and 8, 11–16; pl. 12, figs. 13 and 14; text-fig. 4.
1977*b* *Tarrantoceras rotatile* Stephenson; Cobban, p. 219, figs. 3N and O, 4G.
1978 *Utaturiceras* ? *sellardsi* (Adkins); Young and Powell, p. xxv, 18.
1978 *Tarrantoceras rotatile* Stephenson; Cooper, p. 92, text-fig. 20.
1984 *Tarrantoceras sellardsi* (Adkins); Cobban, p. 78.
1986 *Tarrantoceras sellardsi* (Adkins); Cobban, p. 78, figs. 3C and D.

Types. The holotype is TMM 34048, the original of Adkins (1928, pl. 25, fig. 1; pl. 26, fig. 1) from the Bluebonnet Member of the Lake Waco Formation of the Eagle Ford Group, 2·4 km (1·5 miles) south-east of



TEXT-FIG. 23. External sutures. A and B, *Tarrantoceras sellardsi* (Adkins, 1928), USNM 400772, 400760. C, *Plesiacanthoceras bellsanum* (Stephenson, 1953*a*), USNM 105983.

Round Rock, Williamson County, by original designation. The holotype of *T. rotatile* is USNM 11740, the original of Stephenson (1955, pl. 5, figs. 1–4) from Walnut Creek, 7·6 km (4·75 miles) east-north-east of Mansfield, Tarrant County. The holotype of *T. stantoni* is the original of Stephenson (1955, pl. 5, figs. 11–13); the holotype of *T. lillianense* is USNM 108841, the original of Stephenson (1955, pl. 5, figs. 22 and 23), both specimens from gully in field 1·6 km (1 mile) north of Lillian, Johnson County, both basal Eagle Ford Group. All of the above are from the *Acanthoceras amphibolum* zone.

Material. Numerous specimens from USGS Mesozoic locality 12626, roadside 8·9 km (5·5 miles) north-east of Mansfield, Tarrant County, in a loose concretion; from USGS locality 24510 from a concretion in a crop field 1·6 km (1 mile) north of Lillian, Burleston, Johnson County; from a concretion on hillside 0·3 km (0·2 miles) south of Mountain Creek, 6·1 km (3·8 miles) north-east of town square in Alvarado; from USGS locality 14591, 2·3 m (7·5 feet) above base of Cloice Member of the Lake Waco Formation, abandoned brickpit on Cloice Branch, 1·3 km (0·8 mile) east of South Bosque, McLennan County. Also numerous specimens as OUM KT40008–9, concretions from Walnut Creek, 7·6 km (4·75 miles) east of Mansfield, Tarrant County; from USGS Mesozoic locality D9502, concretions in field just east of gravel road, 0·5 km (0·3 mile) north-north-west of Lillian; from USGS Mesozoic locality D96 'Eagle Ford Shale' 6·1 m (20 feet) above base, concretion 6·7 km (4·15 miles) northeast of centre of Alvarado, Johnson County. All lower part of Eagle Ford Group, *Acanthoceras amphibolum* zone.

Dimensions		D	Wb	Wh	Wb:Wh	U
USNM 420280	c	23·0 (100)	9·0 (39·1)	9·0 (39·1)	1·0	7·6 (33·0)
USNM 420281	c	23·0 (100)	9·5 (41·3)	8·4 (36·5)	1·13	8·7 (37·8)
USNM 420282	c	29·0 (100)	11·3 (38·9)	11·1 (39·0)	1·02	11·1 (38·3)
USNM 400759	c	51·7 (100)	17·8 (34·4)	18·0 (34·8)	0·98	18·2 (35·2)
USNM 400760	c	71·0 (100)	25·0 (35·2)	26·7 (37·6)	0·94	23·3 (32·8)
USNM 400770	c	89·0 (100)	26·5 (29·8)	32·0 (36·0)	0·83	32·9 (37·0)

Description. The species is markedly dimorphic. A near-complete microconch is 57·5 mm in diameter (Pl. 13, figs. 4 and 5), complete macroconchs are 90 mm in diameter (Pl. 13, figs. 10 and 11), and a fragment (Pl. 13, figs. 9, 12) with a whorl height of 33·5 mm suggests a macroconch diameter of nearly 100 mm.

Juveniles are variable. Coiling is very evolute, with U = 33–38%, the umbilicus shallow, with a flattened umbilical wall and broadly rounded shoulder. The intercostal whorl section is compressed trapezoidal, with flattened convergent flanks, broadly rounded ventrolateral shoulders and flattened venter. The costal section varies from slightly compressed to slightly depressed, with greatest breadth at the umbilical bullae, and polygonal. There are generally 10–13 strong umbilical bullae per whorl, perched on the umbilical shoulder, and connected to the umbilical seam by a low broad rib. Additional non-bullate ribs extend to the umbilical shoulder. The ribs are strong, straight, narrow, prorsiradiate and wider than the interspaces. Single intercalated ribs arise around the middle of the flank and strengthen to match the primaries by the ventrolateral shoulder, where all bear a small, sharp inner ventrolateral tubercle that is the same width as the rib. A somewhat broadened rib extends forwards across the ventrolateral shoulder to spinose to feebly clavate inner ventrolateral clavi; a low broad transverse rib extends across the venter and bears a siphonal clavus, weaker than the outer ventrolateral. As size increases the whorls generally become more compressed and denser-ribbed, with coarsely ornamented variants with persistent tubercles having as few as 30 ribs and weakly ornamented variants having as many as 48 ribs per whorl, the inner ventrolateral tubercles weakening markedly.

On the adult body chamber of both macro- and microconchs the umbilical seam egresses and the coiling becomes progressively more evolute. The ribs flex back, becoming coarser and rectiradiate, sometimes bunching at bullae. The inner ventrolateral tubercles efface at the beginning of the body chamber, the umbilical bullae efface towards the aperture. The siphonal tubercle declines to give a flattened venter while at the adult aperture ribbing weakens and the venter rounds.

Suture simple, with broad, asymmetrically bifid E/L, narrow, little-incised L and broad L/U_2 (text-figs. 6A, 23A and B).

Discussion. Juveniles are highly variable, from hypernodose to feebly tuberculate (Pl. 14, figs. 1–11, 25, 29). This variation persists into middle growth, with the holotype of *T. stantoni* a coarsely ribbed and tuberculate individual, the holotypes of *T. sellardsi* and *T. rotatile* with subdued tuberculation and the holotype of *T. lillianense* intermediate between the two. *Tarrantoceras multicostatum* Stephenson, 1955 (p. 61, pl. 6, figs. 21–23) comes from a different locality than the types of *T. sellardsi* (and its synonyms), and is kept separate here, with no great confidence. It has an estimated 60 ribs per whorl, a rounded whorl section and early loss of tubercles. An as yet undescribed *Tarrantoceras* species is present in the *Calycoceras canitaurinum* zone in Trans-Pecos Texas,

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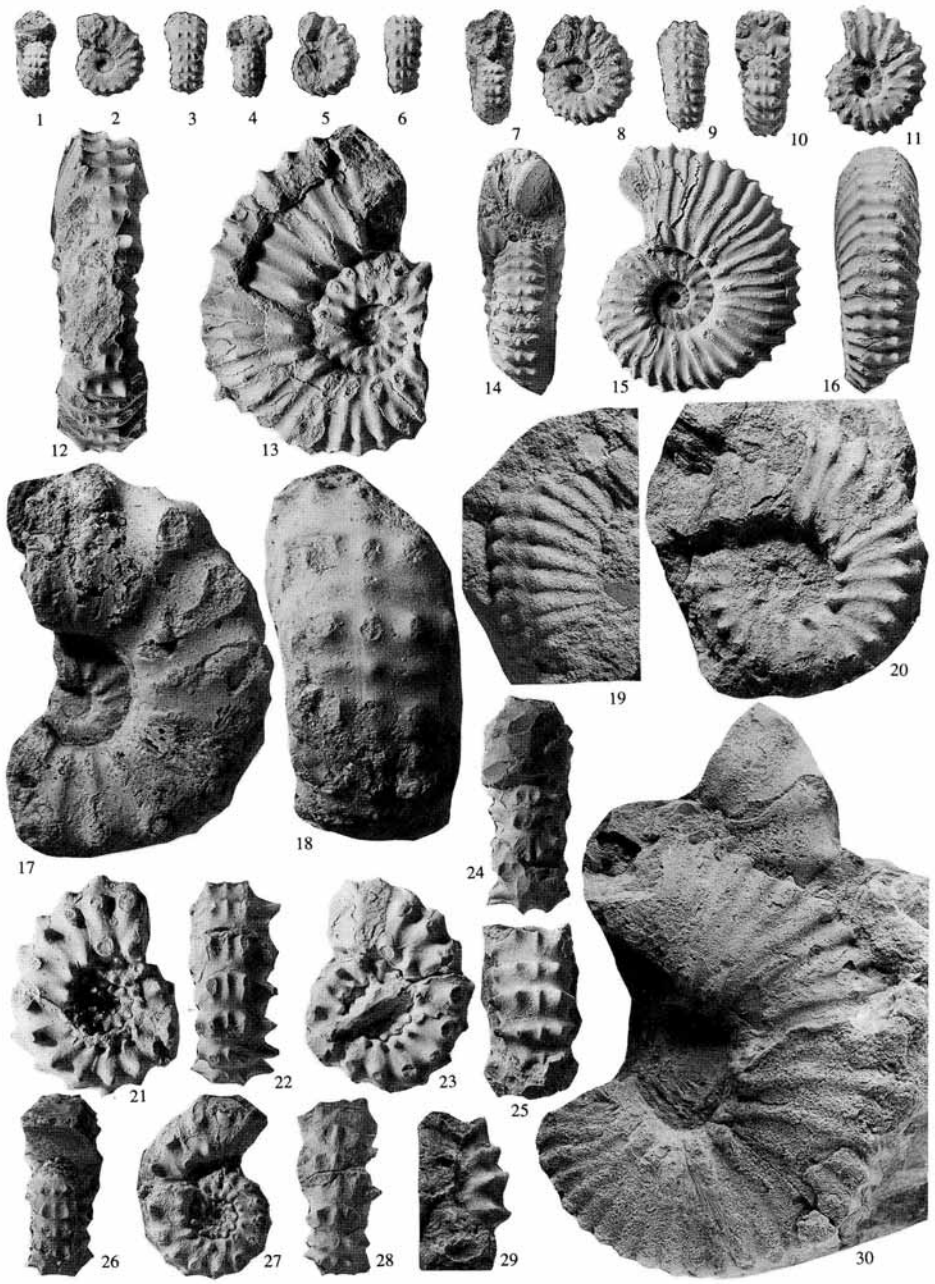
EXPLANATION OF PLATE 14

Figs. 1–16, 19, 20, 25, 29, 30. *Tarrantoceras sellardsi* (Adkins, 1928). 1–3, USNM 400762; 4–6, USNM 400767; 10 and 11, USNM 400766, from USGS Mesozoic locality D12626, 8·9 km (5·5 miles) north-east of Mansfield, Tarrant County. 7 and 8, USNM 400763, from hillside 0·3 km (0·2 mile) south of Mountain Creek, 6·1 km (3·8 miles) north-east of the town square in Alvarado, Johnson County. 12 and 13, USNM 400764, from USGS locality 11740, left bank of Walnut Creek, 7·6 km (4·75 miles) east-north-east of Mansfield, Tarrant County. 14–16, USNM 400765, from USGS locality D10113, 1·6 km (1 mile) north of Lillian, west of Lillian–Retta road, Johnson county. 25, 29, USNM 420283, from 0·3 km (0·2 mile) south of Mountain Creek, 6·1 km (3·8 miles) north-east of the town square in Alvarado, Johnson County. All specimens from the basal part of the Eagle Ford Group. 30, the holotype, TMM 34048, from the Bluebonnet Member, 2·25 km (1·5 miles) south-east of Round Rock, Williamson County. 19 is USNM 420285; 20 is USNM 420286, both from USGS Mesozoic locality 14591 at brick pit on Cloice Branch, 1·3 km (0·8 mile) east of South Bosque, McLennan County. All specimens are from the *Acanthoceras amphibolum* zone.

Figs. 21–24, 26–28. *Tarrantoceras cuspidum* (Stephenson, 1953*a*). 21–24, holotype, USNM 105974; 26–28 paratype, USNM 105975, both from USGS locality 18971, gullies south of old Sherman highway, 4·5 km (2·8 miles) east of Whitesboro, Grayson County, Templeton Member, *Plesiacanthoceras wyomingense* zone.

Figs. 17 and 18. *Cunningtoniceras lonsdalei* (Adkins, 1928). USNM 420270, from the basal shell bed of the Bluebonnet Member, 6·4 km (4 miles) east-north-east of Belton, Bell County. *Acanthoceras bellense* zone.

All figures are × 1.



KENNEDY and COBBAN, *Tarrantoceras, Cunningtoniceras*

Wyoming and western South Dakota. It differs from *T. sellardsi* in the persistent strong ventrolateral and siphonal clavi.

Tarrantoceras cuspidium (Stephenson, 1953*a*) (p. 202, pl. 50, figs. 1–4) from the *P. wyomingense* zone fauna of the Templeton Member of the Woodbine Formation is discussed further below; it is much more coarsely ribbed and tuberculate than any *T. sellardsi* seen. Of the four species of *Tarrantoceras* described (Collignon 1967) from the mid-Cenomanian of the Tarfaya Basin in Morocco, three co-occur, and represent no more than a single variable species, for which we here select the name *T. wrighti*. They are stouter than *T. sellardsi*, with coarser, blunter ribbing and tuberculation; persistent ventrolateral and siphonal tuberculation plus ribs that arise in pairs from bullae suggest they belong to some other genus. The *Tarrantoceras* cf. *rotatile* of Collingnon (1967, p. 30, pl. 16, fig. 2) is generically indeterminate from the figure and does not belong to *T. sellardsi*.

Occurrence. *Acanthoceras amphibolum* zone. Central and Trans-Pecos Texas, many localities in New Mexico, Colorado and, rarely, eastern Wyoming.

Tarrantoceras multicostatum Stephenson, 1955

1955 *Tarrantoceras multicostatum* Stephenson, p. 61, pl. 6, figs. 21–23.

Discussion. This species is carefully described and well illustrated by Stephenson (1955). None of the more than 100 specimens of *T. sellardsi* seen matches the holotype and paratype of *T. multicostatum* and they are in consequence kept separate here.

Occurrence. Basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone, 3·6 km (2·25) miles north-east of Mansfield, Tarrant County only.

Tarrantoceras cuspidum (Stephenson, 1953*a*)

Plate 14, figs. 21–24, 26–28

1953*a* *Acanthoceras cuspidum* Stephenson, p. 202, pl. 50, figs. 1–4.
1971 *Protacanthoceras cuspidum* (Stephenson); Kennedy, p. 122.
1980 '*Acanthoceras*' *cuspidum* Stephenson; Wright and Kennedy, p. 99, figs. 56, 59C.
non 1980 '*Acanthoceras*' aff. *cuspidum* Stephenson; Wright and Kennedy, p. 100, figs. 55, 59a and b.

Types. Holotype is USNM 105947, by original designation; a paratype is USNM 18971, both from gullies south of the old Sherman road, 4·5 km (2·8 miles) east of Whitesboro, Grayson County. Paratype USNM 14902 is from a bluff south of the Missouri–Kansas–Texas Railroad, 1·6 km (1 mile) north and 2·9 km (1·85 miles) east of Sadler, Grayson County. All are from the Templeton Member of the Woodbine Formation, *Plesiacanthoceras wyomingense* zone.

Discussion. This species is carefully described and well figured by Stephenson (1955). Of interest are the affinities of the species. Wright and Kennedy (1980) drew attention to the distinctive asymmetry of the ventrolateral clavi, a feature common to several North American acanthoceratines such as *Plesiacanthoceras* and *Dunveganoceras*. We have since noted remarkable similarities in this feature, as well as style of ribbing, to the most ornate variants of *T. sellardsi* (compare Pl. 14, figs. 21–24, 26–28 and Pl. 14, figs. 25, 29) such that we place *cuspidum* in *Tarrantoceras*.

Occurrence. As for types.

Genus PLESIACANTHOCERAS Haas, 1964

(= *Paracanthoceras* Haas, 1963, p. 2; *non* Furon, 1935, p. 59)

Type species. By original designation: *Metoicoceras wyomingensis* Reagan, 1924 (p. 181, pl. 19, figs. 1 and 2).

Diagnosis. Large, markedly dimorphic. Inner whorls with polygonal whorl section; bullate primaries alternate with secondaries, all ribs bearing strong conical inner and clavate outer ventrolateral and siphonal tubercles with markedly asymmetric profile; intercalated ventral ribs transiently present in some. Secondary ribs disappear after an early stage, siphonal clavi disappear at a progressively earlier ontogenetic stage in stratigraphically younger species. Inner and outer ventrolateral tubercles fuse into prominent horns in middle and late growth stages. Final rib flattened and bar-like over venter.

Suture with broad E/L and L.

Discussion. The type species, *P. wyomingense* is the last member of a Western Interior lineage that can be traced back to *Conlinoceras tarrantense* via *Plesiacanthoceras muldoonense* (Cobban and Scott, 1973). We also refer *Mammites bellsanus* Stephenson, 1953*a* to *Plesiacanthoceras*. All show variable ontogenetic development in early stages, but are linked by progressively earlier loss of siphonal tubercles, progressively earlier acquisition of primary ribs only and development of a ventrolateral horn at an early ontogenetic stage.

Plesiacanthoceras muldoonense is represented by abundant well-preserved material from the Frontier formation at USGS Mesozoic locality D9801 (south of Lone Bear Road in SW1/4 Sec. 13, T.42N., R.82 W., Johnson County, Wyoming) and USGS Mesozoic locality 23459 (near head of Fisher Draw, about 4·5 km (2·7 miles) south of Kaycee in Sec. 25, T.43 N., R. 82 W., Johnson County, Wyoming). These show inner whorls like those of *Conlinoceras gilberti* and *C. tarrantense*, with alternately long and short ribs, conical inner and clavate outer ventrolateral and siphonal tubercles to a diameter of around 25 mm (Pl. 16, figs. 1–6), beyond which the outer ventrolateral and siphonal tubercles decline, disappearing by 30–40 mm diameter. The ribbing pattern modifies so that all ribs are long, with an umbilical bulla that migrates out to an inner flank position and inner ventrolateral tubercles that strengthen into a clavate upward-directed ventrolateral horn to give a quite distinctive whorl section. Ribbing declines on the outer whorl and tubercles dominate; there may be looping of riblets between ventrolateral horns, while the adult aperture shows the development of a terminal flared ventral rib.

In *Plesiacanthoceras wyomingense* the timing of ontogenetic development of tubercles is again modified, the siphonal row disappears by 10 mm or so, secondary ribs by 10 mm (Pl. 16, figs. 7 and 8), but inner and outer ventrolateral tubercles are present and well-differentiated (Pl. 16, figs. 11–15) to a diameter of 110 mm in microconchs and 160–170 in macroconchs, beyond which the outer ventrolaterals decline and a massive inner ventrolateral horn develops, projecting outwards and above the venter. Adult *P. wyomingense* develop the same high, bar-like rib at the adult aperture as do ancestral *P. muldoonense*.

P. wyomingense is the largest species of the lineage, and retains the 'juvenile' characters of well-differentiated inner and outer ventrolateral tubercles to a diameter where all *P. muldoonense* are horned and adult. It is thus a hypermorphic giant. In spite of this, continuity of characters links the lineage into a single generic grouping in our view; resemblance to *Acanthoceras* and *Cunningtoniceras* in part reflects remote ancestry; in part evolutionary convergence. Old World *Acanthoceras* and *Cunningtoniceras* typically have a broad E/L and a narrow L. The New World taxa also have a broad E/L, but L is broad.

Occurrence. Middle and upper Cenomanian of the US Western Interior and Gulf Coast.

Plesiacanthoceras bellsanum (Stephenson, 1953*a*)

Plate 2, figs. 4–8; Plate 12, fig. 9, text-fig. 23C

1953*a* *Mammites bellsanus* Stephenson, p. 204 (*pars*), pl. 49, fig. 3; pl. 51, figs. 8–11.
1971 *Mammites* ? *bellsanus* Stephenson; Kennedy, p. 122.

Types. The holotype is USNM 105983, paratypes are USNM 105984–6, Templeton Member of the Woodbine Formation, *Plesiacanthoceras wyomingense* zone, branch of Cornelius Creek, 4·3 km (2·7 miles) north 5° east

of Bells, Grayson County. One of the paratypes, USNM 105986, is a *Metoicoceras latoventer* Stephenson, 1953*a*.

Dimensions	D	Wb	Wh	Wb:Wh	U
USNM 105983	88·7 (100)	38·6 (43·5)	42·7 (48·1)	0·9	20·0 (22·5)
USNM 105985	75·5 (100)	33·3 (44·1)	38·3 (50·7)	0·86	12·2 (16·2)

Description. USNM 105984 shows the earliest growth stage: up to a diameter of 6 mm approximately the shell is globose, smooth, non-tuberculate, bearing only low irregular folds and constrictions (Pl. 12, fig. 9). A fragment at a diameter of 27 mm shows a feeble siphonal clavus, as in *Plesiacanthoceras wyomingense* (Pl. 16, figs. 7 and 8). In middle growth coiling is fairly evolute, with 46% of the previous whorl covered. Whorl section compressed, with maximum breadth at umbilical bulla. Ornament consists of alternately long and short ribs. The former arise at elongate umbilical bullae, 11 per whorl, are rursiradiate, weakened at mid-flank but strengthened into prominent rounded inner ventrolateral tubercles, connected by a broad swelling to strongly clavate outer ventrolaterals with a markedly asymmetric profile. Most ribs are long at the smallest diameter visible; as size increases shorter ribs arise around mid-flank and strengthen into inner and outer ventrolateral tubercles that match those on the long ribs. There are no siphonal tubercles.

USNM 105985 is in a more robust shell, but has weaker umbilical bullae; USNM 105986 is a *Metoicoceras latoventer*; it is very compressed, and has very strong umbilical bullae.

Suture with broad bifid E/L and U_2, L narrower (text-fig. 23C).

Discussion. *P. bellsanum* is easily separated from *Acanthoceras amphibolum* by the very early loss of siphonal tubercles and persistence of alternately long and short ribs into middle growth plus separation of inner and outer ventrolateral tubercles to a large size. It is close to *P. wyomingense*, which has very flat sides, larger outer ventrolateral clavi in middle growth and enormous finger-like ventrolateral horns when adult (Pl. 16, figs. 7 and 8, 11–15).

Occurrence. *Plesiacanthoceras wyomingense* zone of north-central Texas only.

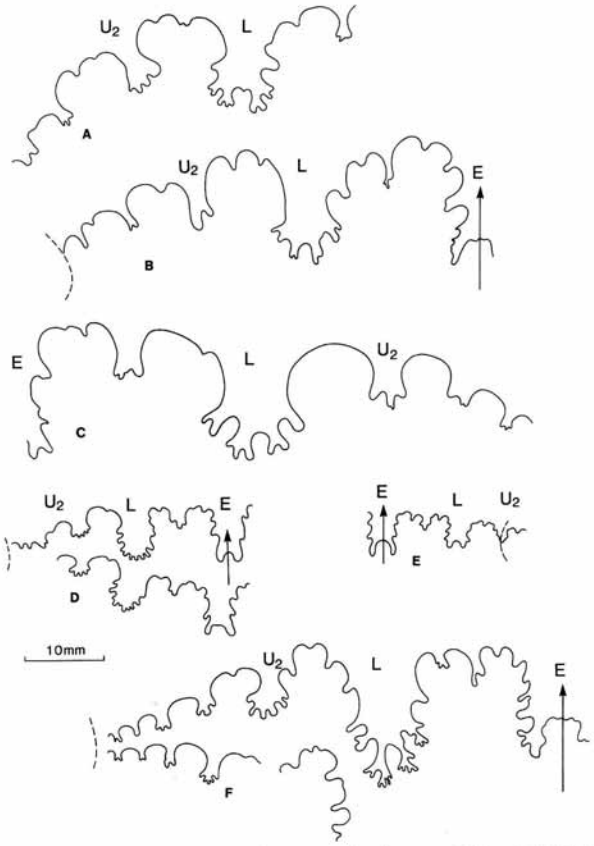
Genus PLESIACANTHOCERATOIDES nov.

Type species. *Protacanthoceras vetula* Cobban, 1987*b* (p. 21, pl. 10, figs. 1–28; text-fig. 16). Middle Cenomanian *Acanthoceras amphibolum* zone Belle Fourche Shale of the Black Hills area of eastern Wyoming and basal Eagle Ford Group of north central Texas.

Diagnosis. Progenic dwarf. Macroconchs adult at 30 mm or less diameter, microconchs about 60% of diameter of corresponding macroconchs. Whorls subquadrate, middle growth stages with primary ribs with umbilical bullae or not alternating with shorter intercalatories, all ribs with conical inner and clavate outer ventrolateral and siphonal tubercles, constrictions sometimes present. Adult body chambers show crowding and strengthening of ventral ribs and decline of ventral tubercles. Suture simple with broad, little-incised E/L, narrower L and small U_2.

Discussion. *Plesiacanthoceratoides* is a homoeomorph of *Protacanthoceras* Spath, 1923, but whereas the latter is a progenic dwarf derivative of *Acanthoceras rhotomagense*, the former is derived from *Plesiacanthoceras*. Five successive species/subspecies of *Plesiacanthoceratoides* occur in the U.S. Western Interior. The oldest species appears in association with *Plesiacanthoceras muldoonense*. *Plesiacanthoceratoides vetula* (Cobban, 1987*b*), described below, from the lower part of the *Acanthoceras amphibolum* zone is succeeded by two new subspecies of a third species in the upper part of the *A. amphibolum* zone and a fourth in the *Plesiacanthoceras wyomingense* zone.

Occurrence. Middle and low upper Cenomanian. North-central Texas, Wyoming and Montana.



TEXT-FIG. 24. External sutures. A and B, *Metoicoceras latoventer* Stephenson, 1953*a*, USNM 105998, 106000. C and D, *M. swallovi* (Shumard, 1860), USNM 105991, 105993. E, *Plesiacanthoceratoides vetula* (Cobban, 1987*b*), USNM 388189. F, *Metoicoceras geslinianum* (d'Orbigny, 1850), USNM 22938.

Plesiacanthoceratoides vetula (Cobban, 1987*b*)

Plate 9, figs. 1–25, 28; text-fig. 24E.

Types. Holotype is USNM 388189, paratypes USNM 388190–7, from the middle Cenomanian *Acanthoceras amphibolum* zone fauna of the Belle Fourche Shale at USGS Mesozoic locality D5900, on the Old Woman anticline south-west of the Black Hills, head of Elm Creek in W1/2 sec. 14, T. 36 N, R. 62 W., Niobrara County, Wyoming.

Material. Figured specimens USNM 420287 to 420292, from the concretions in the lower part of the Eagle Ford Group at USGS Mesozoic locality D12626, 8·9 km (5·2 miles) northeast of Mansfield, Tarrant County, Texas. *A. amphibolum* zone. Twelve unfigured specimens, USNM 420293, from the same locality.

Dimensions		D	Wb	Wh	Wb:Wh	U
Macroconchs						
USNM 420287	c	19·3 (100)	10·2 (52·8)	9·4 (48·7)	1·09	2·9 (15·0)
USNM 420288	c	19·0 (100)	9·6 (50·5)	8·9 (46·8)	1·08	2·6 (13·7)
USNM 420289	c	20·3 (100)	10·5 (51·7)	9·4 (46·3)	1·12	3·4 (16·7)
Microconch						
USNM 420290	c	13·8 (100)	8·0 (57·9)	6·7 (48·5)	1·19	1·6 (11·6)

Description. Markedly dimorphic, macroconchs 20 mm in diameter, microconchs two thirds diameter of macroconchs. Coiling very involute with tiny, deep umbilicus. Whorl section depressed, quadrate in intercostal section, polygonal in costal section, with greatest breadth at umbilical bullae when present and below mid-flank when not. Earliest ornamented stages bear 14 ribs per whorl, limited to the outer flank, with conical inner, clavate outer ventrolateral and siphonal tubercles. As size increases, ribs extend down the flank and are irregularly long and short, long ribs extending to the umbilical shoulder, where they may develop feeble bullae, with in adults, up to 18 ribs of which 6 or 7 are bullate. Periodic broad, deep constrictions are present on the phragmocone, flanked by ribs, while there are occasional non-tuberculate ribs in early and middle growth.

Adult body chambers show a crowding of ribs and strengthening ventrally to produce a marked ventral chevron; whereas tubercles dominate ribs on the phragmocone, the reverse is true on the last part of the body chamber. There is a marked ventral lappet at the adult aperture.

Suture line very simple with broad bifid E/L, narrow L and little incised U_2.

Discussion. Middle growth stages with constrictions are very close to those of juvenile *A. amphibolum amphibolum*. Mature body chamber ornament of *P. vetula* and disparate size immediately distinguishes the two.

Occurrence. *A. amphibolum* zone of north-central Texas and Wyoming.

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 swallovi (Shumard, 1860)

Text-fig. 24C and D.

1860 *Ammonites swallovi* Shumard, p. 591.
1953*a* *Metoicoceras swallovi* (Shumard); Stephenson, p. 207, pl. 51, figs. 1–3; pl. 52, figs. 1–5 (with full synonymy).
1953*a* *Metoicoceras swallovi macrum* Stephenson, p. 209, pl. 51, figs. 4–7.

Discussion. Stephenson described all of the surviving material of this species in detail as well as the early uncertainties surrounding it. His variety *macrum*, described as more compressed and with feebler ornament than the nominate subspecies, is regarded as a strict synonym. As already noted (p. 81) there are no longer outcrops at the type locality and the exact age of the species is unknown. All that can be said is that the suture with its little-incised elements (text-fig. 24C and D) suggests it may be from quite a high horizon in the Cenomanian, and is very distinct from that of *M. latoventer* (text-fig. 24A and B), but closer to that of *M. geslinianum* (d'Orbigny, 1850) (text-fig. 24F).

Occurrence. Templeton Member of Woodbine Formation in Lamar County (see Stephenson 1953a p. 209 for details).

Metoicoceras latoventer Stephenson, 1953*a*

Plate 17, figs. 1 and 2; text-fig. 24A and B

1953*a* *Metoicoceras latoventer* Stephenson, p. 209, pl. 53, figs. 1–9; pl. 54, figs. 9–11.
?1953*a* *Metoicoceras crassicostae* Stephenson, p. 210, pl. 58, figs. 6–8.
1953*a* *Mammites*? *bellsanus* Stephenson, p. 204 (*pars*), *non* pl. 49, fig. 3; pl. 51, figs. 8–11.

Types. The holotype of *M. latoventer* is TMM 2574, from the Templeton Member of the Woodbine Formation, 6·4 km (4 miles) east of Whitesboro; one paratype is in the same collection. Paratypes USNM 105998–105601, 106002a–j are from gullies just south of the old Sherman Highway, 4·5 km (2·8 miles) east of the centre of Whitesboro, also from the Templeton. The holotype of *Metoicoceras crassicostae* is USNM 106003 from the Templeton Member on Cornelius Creek, 4·3 km (2·7 miles) north 5° east of Bells in Grayson County. All *Plesiacanthoceras wyomingense* zone.

Material. OUM KT3926–7, 3929–3936, from the Templeton Member of the Woodbine Formation, gullies just south of old Sherman Highway, 4·5 km (2·8 miles) east by south of the centre of Whitesboro, Grayson County. *Plesiacanthoceras wyomingense* zone. USNM 105986, a paratype of *Mammites*? *bellsanus* Stephenson, 1953*a*, is from the same horizon and locality as the holotype of *Metoicoceras crassicostae* (see above).

Dimensions		D	Wb	Wh	Wb:Wh	U
USNM 105998		12·3 (100)	7·0 (56·9)	5·4 (43·9)	1·30	2·2 (17·9)
USNM 106001		24·0 (100)	13·4 (55·8)	10·9 (45·4)	1·23	4·9 (20·4)
USNM 106002	c	65·0 (100)	27·7 (42·6)	30·7 (41·2)	0·9	15·8 (24·3)
USNM 106000		76·3 (100)	31·0 (40·6)	33·4 (43·8)	0·93	18·9 (24·8)
Holotype of *M. crassicostae* USNM 100603		94·5 (100)	37·8 (40·0)	40·8 (43·2)	0·93	25·1 (26·6)

Discussion. Stephenson (1953*a*) provides a careful account of this species, and his description is not repeated here. The holotype of *M. latoventer* is an adult, as in the largest paratype figured by Stephenson (1953*a*, pl. 53, figs. 8 and 9), 113–120 mm in diameter. There are no significant differences between these specimens and the holotype (and only known specimen) of *M. crassicostae* (Pl. 17, figs. 3 and 4), a near complete adult 94·5 mm in diameter, and we suspect but cannot prove them conspecific. *M. crassicostae*, now dated as from the Texas equivalents of the US Western Interior *Plesiacanthoceras wyomingense* zone, is the oldest species of the genus. It, like *Metoicoceras praecox* Haas, 1949 (p. 15, pls. 5–7; text-figs. 5–9) of the *Calycoceras canitaurinum* zone, differs from all other species of the genus in the presence of feeble siphonal tubercles in early growth, up to a diameter of 20–25 mm in *M. latoventer* and 28–34 mm in *M. praecox*. Whereas *M. praecox* has the compressed whorl section and low broad ribs seen in later *Metoicoceras* species (including the type), *M. latoventer* has an only slightly compressed whorl even when adult, with persistent inner ventrolateral tubercles to the beginning of the outer whorl whereas these are lost at an early ontogenetic stage in later species and even lost in some variants beyond a diameter of 20 or so millimetres. This, plus the presence of a siphonal tubercle in youth suggests the origin of *latoventer*, and hence *Metoicoceras*, lay in some contemporary acanthoceratine such as *Plesiacanthoceras*, where there are parallel trends of progressively earlier loss of siphonal clavi and differentiated inner and outer ventrolateral tubercles. *Thomelites* Wright and Kennedy, 1973, suggested as a possible ancestor to *Metoicoceras* (e.g. Wright and Kennedy 1981, p. 40) may thus be no more than a convergent compressed acanthoceratine and not a close ally or ancestor.

Occurrence. As for types.

Suborder ANCYLOCERATINA Wiedmann, 1966, p. 54
Superfamily TURRILITACEAE Gill, 1871, p. 3
Family HAMITIDAE Gill, 1871, p. 3
Genus HAMITES Parkinson, 1811, p. 145

(= *Torneutoceras* Hyatt, 1900, p. 586 (objective synonym); *Stomohamites* Breistroffer, 1940 p. 85; *Hamitella* Breistroffer, 1947 p. 100 (84), *nom. nov. pro. Helicoceras* d'Orbigny, 1842 p. 611, *non* Koenig, 1825 p. 19)

Type species. *Hamites attenuatus* J. Sowerby, 1814 (p. 137, pl. 61, figs. 4 and 5) by the subsequent designation of Diener (1925, p. 88).

Hamites cimarronensis (Kauffman and Powell, 1977)

Plate 15, figs. 11, 13, 15, 17, 19–21

1953*a* *Hamites* ? sp. Stephenson, p. 197.
1977 *Stomohamites simplex cimarronensis* Kauffman and Powell, p. 97, pl. 9, figs. 1, 3 and 4; text-figs. 5 and 6.

Type. Holotype is USNM 167160, the original of Kauffman and Powell (1977, pl. 9, fig. 1) from USGS Mesozoic Locality 30235 in Cimarron County, Oklahoma. It is from the Hartland Member of the Graneros Shale, of middle Cenomanian age.

EXPLANATION OF PLATE 15

Figs. 1, 3, 5, 6, 10, 12, 16, 18, 22, 23, 25. *Turrilites* (*Turrilites*) *acutus* Passy, 1832, including transitional forms to *T.* (*T.*) *costatus* Lamarck, 1822 (figs. 10, 23). 1 is TMM 21055; 3 is USNM 420302; 6 is USNM 420305, 10 is TMM 35359; 16 is USNM 420303, 23 is USNM 420308; 25 is USNM 420304, from the basal shell bed of the Bluebonnet Member, Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County. *Acanthoceras bellense* zone. 5 is USNM 420311; 12 is USNM 420310; 18 is USNM 420312; 22 is USNM 420309, all from USGS Mesozoic locality D12626, roadside 8·9 km (5·5 miles) north-east of Mansfield, Tarrant County, basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone.

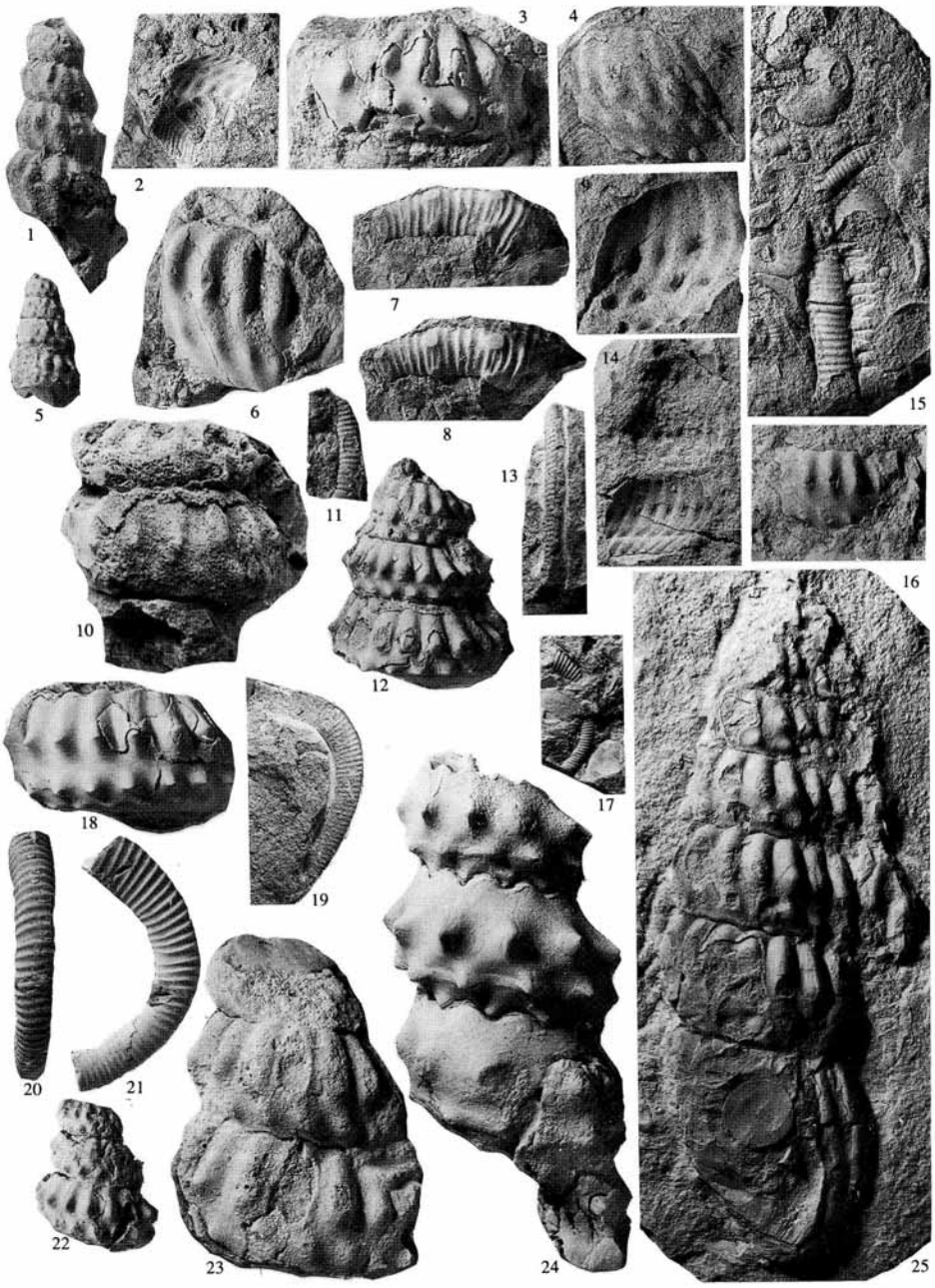
Figs. 2, 4, 9, 14. *Ostlingoceras* (*Ostlingtoceras*) *davisense* Young, 1958. Specimens are from USGS Locality 14598, temporary exposure 0·8 km (0·5 mile) east of South Bosque, near railroad, McLennan County. Pepper Shale (inferred); *Forbesiceras brundrettei* zone.

Figs. 7 and 8. *Anisoceras* cf. *plicatile* (J. Sowerby, 1819), USNM 420299, 0·3 km (0·2 mile) south of Mountain Creek, 6·1 km (3·8 miles) north-east of town square in Alvarado, Johnson County. Basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone.

Figs. 11, 13, 15, 17, 19–21. *Hamites cimarronensis* (Kauffman and Powell, 1977). 11, USNM 420297; 17, USNM 420298, from USGS Mesozoic locality D9502, concretion in field 0·5 km (0·3 mile) north-west of Lillian, Johnson County, basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone. 13, 19, USNM 424123, from USGS locality 14591, abandoned brickpit on Cloice Branch, near Waco, McLennan County. 15, USNM 420296, from the Moody Hills opposite Baggett station about 7·2 km (4·5 miles) south of McGregor, McLennan County. Both *Acanthoceras amphibolum* zone. 20 and 21, USNM 420294, from Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County. *Acanthoceras bellense* zone.

Fig. 24. *Turrilites* (*Turrilites*) *dearingi* Stephenson, 1953*a*. USNM 420316, from roadcut on east side of Texas highway 360, 1·9 km (1·2 miles) south of bridge over Trinity River, Tarrant County. Tarrant Formation, *Conlinoceras tarrantense* zone.

Figures 20 and 21 are ×2; the remainder are ×1.



KENNEDY and COBBAN, Cenomanian ammonites

Material. USNM 420294 and 420295, from the Bluebonnet Member of the Lake Waco Formation of the Eagle Ford Group, Bird Creek, Bell County; USNM 420296 from the same horizon near Waco, *Acanthoceras bellense* zone. USNM 420297 and 420298 from the basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone, USGS Mesozoic locality D9502, concretion in field 0·5 km (0·3 mile) NW of Lillian, Johnson County. A specimen from USGS Locality 14591, abandoned brickpit on Cloice Branch near Waco, McLennan County. OUM KT3937–3939 from the Templeton Member of the Woodbine Formation, *Plesiacanthoceras wyomingense* zone, gullies just south of old Sherman Highway, 4·5 km (2·8 miles) east by south of Whitesboro, Grayson County.

Discussion. Kauffman and Powell (1977) based their *Stomohamites simplex cimarronensis* on a series of crushed fragments. They differentiated it from *H. simplex* of d'Orbigny (1842, p. 550, pl. 134, figs. 12–14) (see Kennedy and Juignet 1983, p. 13, figs. 15a–d; 17a–w; 36j; 37v and w) because it had four shafts rather than three, and was larger. The complete adult form of *H. simplex* is unknown to us, whereas the reconstruction given by Kauffman and Powell (1977, text-fig. 5) shows a smaller shell than is represented by English specimens of *H. simplex* (Kennedy 1971, pl. 1, figs. 1–8). Instead, *H. cimarronensis* differs from *H. simplex* in its dense ribbing, with a rib index of up to 8 at apparent whorl heights of 11–28 mm. In *H. simplex*, the index ranges from 4·5 to 7.

Occurrence. *Acanthoceras bellense*, *Acanthoceras amphibolum* and *P. wyomingense* zones in central Texas. Similar fragments are widespread in this interval in the US Western Interior north as far as Wyoming.

Family ANISOCERATIDAE Hyatt, 1900, p. 587
(= Algeritidae Spath, 1925, 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 cf. *plicatile* (J. Sowerby, 1819)

Plate 15, figs. 7 and 8

compare:

1819 *Anisoceras plicatile* J. Sowerby, p. 281, pl. 234, fig. 1.
1983 *Anisoceras plicatile* (J. Sowerby); Kennedy and Juignet, p. 25, fig. 16a–m, p and q; 19a–e; 341, m (with synonymy).

Material. USNM 420299–420300, from the basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone, concretion on hillside 0·3 km (0·2 mile) south of Mountain Creek and west of secondary road, 6·1 km (3·8 miles) north-east of town square in Alvarado, Johnson County.

Discussion. Whorl section is slightly compressed oval with a rib index of 6. Rounded lateral tubercles are linked by groups of 2 or 3 ribs to larger, rounded ventrolateral tubercles, linked over

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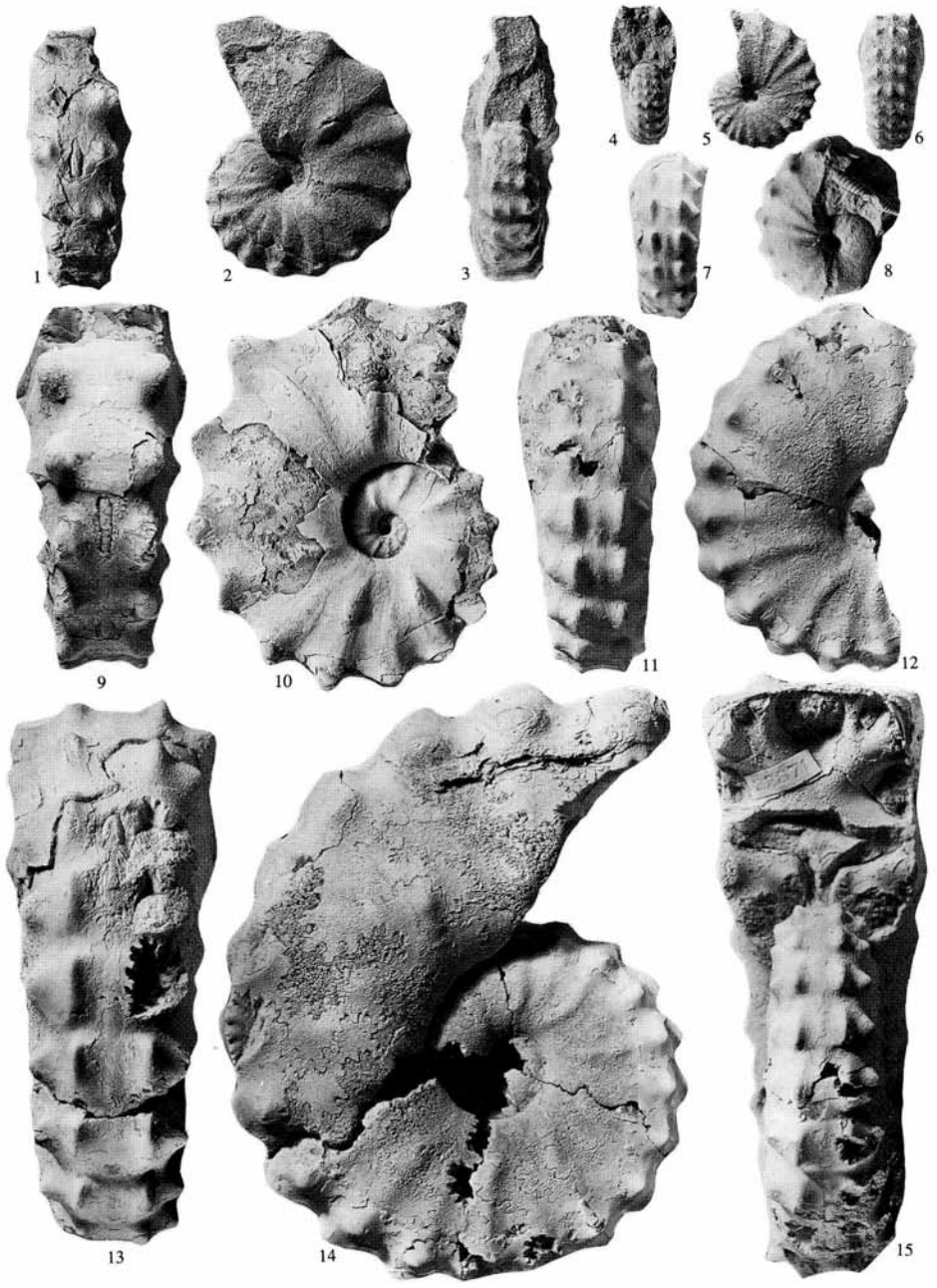
EXPLANATION OF PLATE 16

Figs. 1–6, 9, 10. *Plesiacanthoceras muldoonense* (Cobban and Scott, 1973). 1–3, USNM 388117; 4–6, USNM 388114; 9 and 10, USNM 388121, from calcareous siltstone concretions in the Frontier Formation at USGS Mesozoic locality 23459, near head of Fisher Draw about 4·5 km (2·7 miles) south of Kaycee in sec. 25, T. 43 N., R. 82 W., Johnson County, Wyoming.

Figs. 7, 8, 11–15. *Plesiacanthoceras wyomingense* (Reagan, 1924). 7 and 8, USNM 388164; 11–15, USNM 388165, all from the Belle Fourche Shale at USGS Mesozoic locality 22871, about 9·6 km (6 miles) north-east of Alzada in the $SE\frac{1}{4}$ sec. 6, T. 95 N., R. 59 E., Carter County, Montana.

All figures are × 1.



KENNEDY and COBBAN, *Plesiacanthoceras*

the venter by groups of 2–3 ribs with 2–3 intercalatories between. With such small fragments confident identification is impossible.

Occurrence. As for material.

Family BACULITIDAE Gill, 1871, p. 3
Genus SCIPONOCERAS Hyatt, 1894, p. 578

(= *Cyrtochilus* Meek, 1876, p. 392 (*non* Jakowlew, 1875, p. 252); *Cyrtochilella* Strand, 1929, p. 8).

Type species. By original designation: *Hamites baculoide* Mantell, 1822 (p. 123, pl. 23, figs. 6 and 7).

Sciponoceras? sp.

Plate 12, figs. 12–14

Material. TMM 2425, from the base of the Bluebonnet Member of the Lake Waco Formation of the Eagle Ford Group at TMM locality 245-T-24, about 0·8 km (0·5 mile) south-east of Round Rock, Williamson County. *Acanthoceras bellense* zone.

Description. Specimen is wholly septate with a maximum whorl height of 21·5 mm, and retains extensive areas of recrystallized shell. Whorl section compressed oval with whorl breadth to height ratio 0·8. Dorsum somewhat flattened, flanks very broadly rounded, venter rounded, only slightly narrower than dorsum. Shell surface ornamented by closely and evenly spaced growth lines and riblets. These are somewhat effaced on the dorsum, markedly concave on the dorsolateral area but markedly prorsiradiate and straight on the laterovental region, intersecting the line of the venter at 18°, strengthening, and crossing the venter in a linguoid peak. This same ornament is present on the internal mould. There are no constrictions visible. Imperfectly exposed sutures have rectangular, bifid elements.

Discussion. This remarkable species differs from all other described Cenomanian Baculitidae in the absence of constrictions, the presence of which differentiate *Sciponoceras* from *Baculites*. The latter is known from the Turonian onwards, and we doubt that the present specimen suffices to extend the range of the genus back for nearly half a stage. In consequence we refer it to *Sciponoceras*? sp.

Occurrence. As for material.

Family TURRILITIDAE Gill, 1871, p. 3
(= Pseudhelicoceratinae Breistroffer, 1953, p. 1350)
Genus and Subgenus OSTLINGOCERAS Hyatt, 1900, p. 587

Type species. *Turrilites puzosianus* d'Orbigny, 1842 (p. 587, pl. 123, figs. 1 and 2) by original designation.

Ostlingoceras (*Ostlingoceras*) *brandi* Young, 1958.

1958 *Ostlingoceras brandi* Young, p. 287, pl. 40, figs. 4 and 5, 7; text-fig. 1 n.
1959 *Ostlingoceras brandi* Young; Young, p. 37, pl. 8, figs. 2, 7.
1965 *Ostlingoceras* (*Ostlingoceras*) *brandi* Young; Clark; p. 37, pl. 8, figs. 2, 7.

Type. Holotype is TMM 10281 from the base of the Boquillas Formation on the NE flank of the Davis Mountains, Jeff Davis County, Texas. *Forbesiceras brundrettei* zone.

Material. One specimen from USGS locality 14592, old brickpit on Cloice Branch, 1·3 km (0·8 mile) east of South Bosque, McLennan County. Probably from the Pepper Shale; *Forbesiceras brundrettei* zone.

Discussion. Specimen is an external mould of a single whorl. It shows low, even, rounded, oblique ribs, without tubercles on the outer whorl face, weakening markedly towards the base of the whorl. The lower surface bears much finer, markedly prorsiradiate riblets and growth striae.

Occurrence. *F. brundrettei* zone. In addition to the present record it occurs at Gold Hill and Chispa Summit as well as the type locality, in Trans-Pecos Texas.

Ostlingoceras (*Ostlingoceras*) *davisense* Young, 1958

Plate 15, figs. 2, 4, 9, 14

1958 *Ostlingoceras davisense* Young, p. 289, pl. 39, figs. 29, 34.
1965 *Ostlingoceras* (*Ostlingoceras*) *davisense* Young; Clark, p. 36, pl. 8, figs. 1, 3.

Type. Holotype is TMM 10286, from the base of the Boquillas Formation on the north-east flank of the Davis Mountains, Jeff Davis County, Texas.

Material. Three specimens from USGS Locality 14598, temporary exposure 0·8 km (0·5 mile) east of South Bosque, near railroad, McLennan County. *F. brundrettei* zone, Pepper Shale (inferred).

Discussion. Specimens are external moulds only. Ornament consists of low, oblique, prorsiradiate ribs with a weak tubercle on the upper third of the outer whorl face, a second two thirds down the face and two closely spaced tubercles at the lower whorl suture, the lowermost concealed below the suture. The species is in some respects transitional to *Mariella*.

Occurrence. *F. brundrettei* zone. In addition to the present record the species occurs at Gold Hill and Chispa Summit as well as the type locality in Trans-Pecos Texas.

Genus and Subgenus TURRILITES Lamarck, 1801, p. 102

(= *Euturrilites* Breistroffer, 1953, p. 1351; *Turbinites* Dubourdieu, 1953, p. 42 *non* Martin 1809, pl. 38).

Type species. *Turrilites costatus* Lamarck, 1801 (p. 102) by original designation.

Turrilites (*Turrilites*) *acutus* Passy, 1832

Plate 12, fig. 10; Plate 15, figs. 1, 3, 5, 6, 10, 12, 16, 18, 22, 23, 25.

1832 *Turrilites acutus* Passy, p. 334, pl. 16, figs. 3 and 4.
1977*a* *Turrilites acutus* Passy, Cobban, p. 22, pl. 4, figs. 4 and 5.
1977*b* *Turrilites acutus* Passy; Cobban, figs. 2i, 2k.
1983 *Turrilites* (*Turrilites*) *acutus* Passy; Kennedy and Juignet, p. 51 (with synonymy).
1985 *Turrilites* (*Turrilites*) *acutus* Passy; Atabekian, p. 77, pl. 28, figs. 5–13; pl. 29, figs. 1–10; pl. 30, figs. 1–11 (with synonymy).

Lectotype. The original of Passy (1832, pl. 16, fig. 3) designated by Juignet and Kennedy (1976, p. 65), and from the middle Cenomanian Rouen Fossil Bed of Côte Ste Catherine, Rouen, Seine-Maritime, France. It is in the collections of the Sorbonne, now in the Université Paris VI (Pierre et Marie Curie), Paris.

Material. Numerous specimens: USNM 420309–420313, from USGS Mesozoic locality D12626, roadside 8·9 km (5·5 mile) north-east of Mansfield, Tarrant County, in a loose concretion. One specimen, USNM 420308, from USGS Mesozoic locality D9502, concretions in field just east of gravel road, 0·5 km (0·3 mile) north-north-west of Lillian, Johnson County. Six specimens USNM 420307, from concretion on hillside 0·3 km (0·2 mile) south of Mountain Creek, 6·1 km (3·8 miles) north-east of the town square in Alvarado, Johnson County. All are from the basal part of the Eagle Ford Group, *Acanthoceras amphibolum* zone. USNM 420301–420306 and OUM KT2058 are from the basal shell bed of the Bluebonnet Member of the Lake Waco Formation on Bird Creek, 6·4 km (4 miles) east-north-east of Belton, Bell County, *Acanthoceras bellense* zone.

Discussion. The specimens from the *A. amphibolum* zone are very typical representatives of this well-known species. Most of those from the *A. bellense* zone are equally unexceptional, but a few (e.g. Pl. 15, fig. 23) are transitional to *T. costatus*. Clark (1965) illustrated and described specimens from

what he spoke of as Tarrant Formation on Pepper (e.g. Bird) Creek that are actually from the basal shell bed of the Bluebonnet Member. The original of his pl. 20, figs. 1, 2 and 7 seem to be transitions from *T. acutus* to *T. costatus* (e.g. Pl. 15, figs. 1, 10, 23 herein). The same author's *T. scheuchzerianus* (1965, pl. 20, fig. 6) is no more than a worn example of this passage form, as are others cited by him on p. 54.

Occurrence. *Turrilites acutus* first appears in the middle of the middle Cenomanian, where it is widespread and common; it ranges to the lower part of the upper Cenomanian, where it is generally rare. It is known from western and eastern Europe, the USSR, North Africa, Nigeria, Angola, Zululand, Madagascar and Mozambique. In the United States there are records from California, Texas, New Mexico and Colorado; in the Western Interior and Texas it ranges from the *Acanthoceras bellense* zone to the *A. amphibolum* zone, being particularly widespread in the latter.

Turrilites (*Turrilites*) *dearingi* Stephenson, 1953*a*

Plate 12, figs. 5 and 6, 11; Plate 15, fig. 24

1953*a*	*Turrilites dearingi* Stephenson, p. 197, pl. 44, figs. 6–8.
1965	*Turrilites* (*Turrilites*) *dearingi* Stephenson; Clark, p. 55, pl. 20, fig. 4.
1971	*Turrilites dearingi* Stephenson; Kennedy, p. 31.
1976	*Turrilites dearingi* Stephenson; Juignet and Kennedy, p. 65.

Types. Holotype is USNM 105956, paratype JPC 4134 (cast is OUM KT6105 and USNM 105957), both from the Tarrant Formation at USGS locality 20788, small branch of Big Bear Creek, 2·4 km (1·5 miles) east of Euless, Tarrant County. *Conlinoceras tarrantense* zone.

Material. USNM 420136, plus casts of two specimens in the Gerry Kienzlen Collection (Dallas, Texas) (casts USNM 420314, 420315; OUM KT 6106–7), all from the same horizon as the types, roadcut on east side of Texas Highway 360, 1·9 km (1·2 miles) south of bridge over Trinity River, Tarrant County.

Description. Coiling sinistral; apical angle 21° approximately; whorls in close contact. Intercostal section shows concealed upper surface of whorls markedly concave, outer face evenly convex, lower face convex. Costal section shows outer whorl face with strikingly concave upper, middle and lower sections. There are 13–18 ribs per whorl. They arise at the crenulated upper whorl suture and are feebly prorsiradiate, strengthening into a strong pointed tubercle at the junction of upper and middle sectors of the outer whorl face. A low, broad prorsiradiate rib connects to a smaller, feebly clavate pointed tubercle at the junction of the middle and lower sections of the outer whorl face, and a further broad prorsiradiate rib connects to a slightly smaller tubercle of similar shape to those in the second row. This third row of tubercles is housed in a marked notch in the suture between the whorls, such that all three rows of tubercles are visible. The lower whorl face bears faint ribs that correspond to grooves in the upper whorl face of the succeeding whorl. Some specimens show a faint spiral ridge linking the lower two rows of tubercles.

Sutures not seen.

Discussion. Stephenson (1953*a*) compared this species only with the Lower Cenomanian *Turrilites bosquensis* Adkins, 1920 (a *Wintonia*) and Clark (1965) with *Turrilites morrisii* of Sharpe (1857) (= *carcitanensis* Matheron, 1842) (a *Neostlingoceras*). Instead, it is a close ally of *Turrilites acutus*

EXPLANATION OF PLATE 17

Figs. 1 and 2. *Metoicoceras latoventer* Stephenson, 1953*a*. TMM 21677, a paratype from the Templeton Member 4 miles east of Whitesboro, Grayson County.

Figs. 3 and 4. *Metoicoceras crassicostae* Stephenson, 1953*a*. The holotype USNM 106003, from the Templeton Member on a branch of Cornelius Creek 4·4 km (2·75 miles) north 5° east of Bells, Grayson County.

All figures are natural size.

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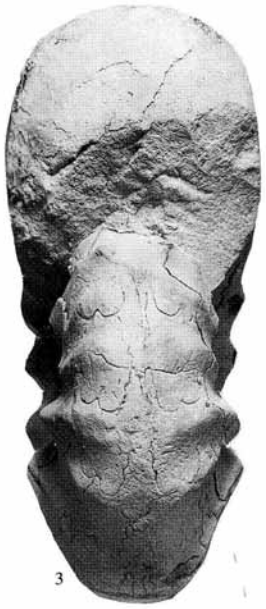

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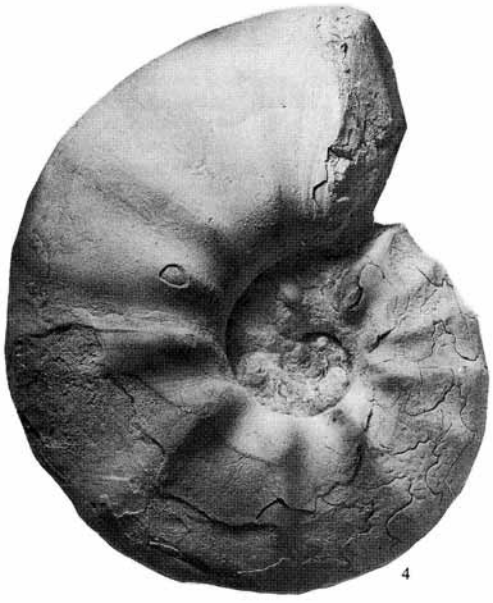

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KENNEDY and COBBAN, *Metoicoceras*

Passy, 1832 (p. 334, atlas, p. 7, pl. 16, figs. 3 and 4) from which it differs only in that the lowest row of tubercles is only slightly smaller than the second row and is much more conspicuous, not being concealed by the succeeding whorl. In the lectotype of *T. acutus* and topotypes this tubercle is far less conspicuous, although European *T. acutus* show the same range of rib density. Kennedy (1971, p. 31) thought *T. dearingi* might be an aberrant *T. acutus*, while Juignet and Kennedy (1976, p. 65) regarded it as a synonym of *T. acutus*. Of the five specimens before us, the types and the large Conlin specimen (Pl. 15, fig. 24) show the prominent lowest row of tubercles to advantage, and if this is a consistent difference, it suggests that *T. dearingi* is probably a local subspecies of *T. acutus*. It is kept separate here, but whether treated as a species or subspecies of *T. acutus* is of no importance.

Occurrence. *Conlinoceras tarrantense* zone. Tarrant Formation of north-east Texas only.

Acknowledgements. We thank J. M. Hancock and R. Parish for assistance in the field, the staff of the Geological Collections, University Museum, and the Department of Earth Sciences, Oxford, for technical assistance. One of us (WJK) gratefully acknowledges the financial assistance of the Natural Environment Research Council, Royal Society and Astor Fund (Oxford).

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Typescript received 5 August 1988
Revised typescript received 26 January 1989