Biostratigraphy of the Chispa Summit Formation at its type locality: a Cenomanian through Turonian reference section for Trans-Pecos Texas

W.J. KENNEDY, W.A. COBBAN, J.M. HANCOCK & S.C. HOOK

W.J. Kennedy, W.A. Cobban, J.M. Hancock, & S.C. Hook. 1989.11.10: Biostratigraphy of the Chispa Summit Formation at its type locality: a Cenomanian through Turonian reference section for Trans-Pecos Texas. *Bulletin of the Geological Institutions of the University of Uppsala*, N.S., Vol. 15, pp. 39–119. Uppsala ISSN 0302-2749.

A restudy of the lower Cenomanian to basal Coniacian part of the Chispa Summit Formation in Jeff Davis County in Trans-Pecos Texas shows that most of the ammonite succession farther north in the Western Interior can be recognised as far south as the Mexican Border, where typical Western Interior faunas co-occur with northwest European and Tethyan elements. The Chispa Summit Formation rests disconformably on the Buda Limestone of early Cenomanian age (zone of *Budaiceras hyatti*). The basal beds of the Chispa Summit are also of early Cenomanian age and contain *Acompsoceras*. Beds slightly higher are characterized by *Forbesiceras brundrettei* (Young, 1958) which may also be of early Cenomanian age. A little higher are beds that contain a middle Cenomanian fauna characterized by *"Eucalycoceras" leonense* Adkins, 1928.

Higher or younger middle Cenomanian ammonite faunas have not been found at Chispa Summit. A sparse *Calycoceras (Proeucalycoceras) canitaurinum* zone assemblage of earliest late Cenomanian age occurs higher, but there is no ammonite evidence of the succeeding *Metoicoceras mosbyense* zone which is so widely present in the Western Interior. The late Cenomanian zones of *Sciponoceras gracile* and *Neocardioceras juddii* contain rich ammonite assemblages, but there is no indication of the zone of *Vascoceras cauvini – V. gamai* that separates these zones in southwestern New Mexico. The Turonian is well represented by the zones of *Pseudaspidoceras flexuosum, Mammites nodosoides, Collignoniceras woollgari, Prionocyclus hyatti, P. wyomingensis* and *Scaphites whitfieldi*. Comparisons are made with sequences elsewhere in Texas, in Europe, and in Nigeria. Sixty-eight species of ammonites and 14 species of inoceramids are treated, many of them new to the region.

W.J. Kennedy, Geological Collections, University Museum, Oxford OX1 3 PW, U.K; W.A. Cobban, U.S. Geological Survey, Paleontology and Stratigraphy Branch, Box 25046, Mail Stop 919, Denver Federal Center, Denver, Colorado 80225, U.S.A; J.M. Hancock, Department of Geology, Imperial College of Science and Technology, Prince Consort Road, London SW7 2BP, U.K; S.C. Hook, Texaco Exploration and Production Technology Division, P.O. Box 770070, Texas 77215-0070, U.S.A, 15 February, 1989.

Introduction

The Chispa Summit Formation was introduced by Adkins (1933) for a sequence of what he termed . . ."clay facies, with a subordinate amount of thin platy layers and bands of septaria and concretions". . . in the Chispa Summit region of Jeff Davis County in west Texas (Figure 1). Adkins regarded it as of late Cenomanian and Turonian age on the basis of ammonites described by him in 1931. We visited this region in 1973 (WJK, JMH), 1979 (WAC, SCH) and 1980 (WAC, SCH) with two purposes in mind: to attempt correlation with Cenomanian through Turonian sequences of western Europe (WJK, JMH) and to extend the refined biozonation developed in the Western Interior of the United States south to the Mexican border (WAC, SCH). This work revealed the Chispa Summit Formation to be the thickest and most complete fossiliferous lower Cenomanian to basal Coniacian succession known in Texas and the Gulf Coast. The work further revealed the presence of a succession of previously unrecognised ammonite faunas that include co-occurring northwest European, Western Interior and Tethyan genera and species; these allow interregional correlation of the Cenomanian-Turonian stage boundary. The work further revealed a thick interval of beds between the highest undoubted Cenomanian and lowest Turonian faunas; this suggests to us that this sequence should be investigated by workers on other fossil groups, notably foraminifers, nannofossils and dinoflagella-

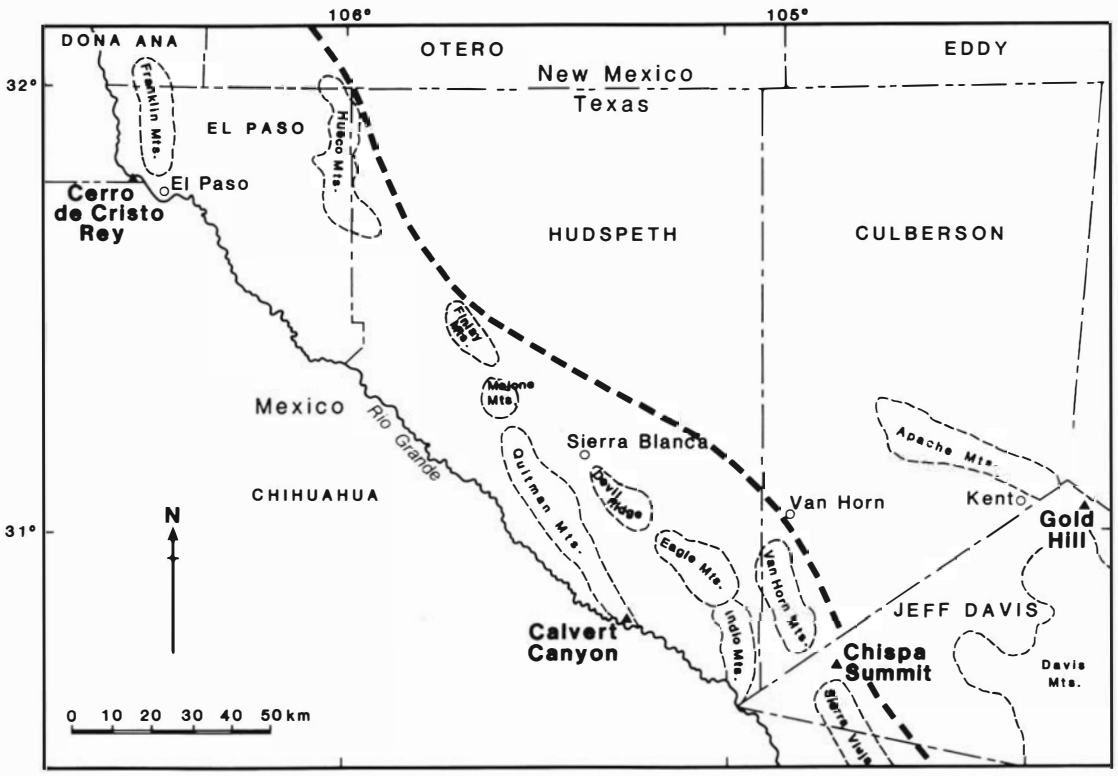


Fig. 1. Location map of part of Trans-Pecos Texas showing the position of the Chispa Summit section and other important localities mentioned in the text. The heavy broken line shows the approximate position of the boundary between the Diabolo Platform to the north-east and the Chihuahua Trough to the south-west.

tes, to determine its suitability as a potential stage boundary reference section (Hancock 1984).

Chispa Summit, which takes its name from the grade of the abandoned railway to the coal mines at San Carlos to the south lies 37 km airline south-southwest of Van Horn and is easily accessible by dirt road. The region is semi-arid and sparsely vegetated. A detailed geological map of the area is shown in Twiss (1959). The study area lies between the Van Horn Mountains to the north and the Sierra Vieja to the south, and is bounded to the east by the Mayfield fault, which separates outcropping Mesozoic and Tertiary from Quarternary deposits, and to the west by the Dieciocho fault. Southward-dipping Buda Limestone is overlain disconformably by the Chispa Summit Formation, which extends to the south for many kilometres before disappearing below the Tertiary Vieja Group. Although outcrop area is vast, the section is not without problems. Firstly, there is considerable minor tectonic disturbance which complicated thickness measurements (Adkins suggested 243 m (800 feet) in 1933, Powell measured 608 m (2 000 ft) of Cenomanian and Turonian sediments in 1965; our figure is 260–270 m (854–887 ft)); secondly, an absence of marker beds and concretions makes shale intervals difficult to subdivide and collect fossils from; thirdly, there are extensive spreads of alluvium covering the middle clay-shale interval and fourthly, intrusion of the Needle Peak pluton produced both deformation and baking of some intervals. Fortunately, none of these affects the Cenomanian-Turonian boundary interval.

Figure 2 shows the generalised lithological succession in the lower part of the sequence; Figure 3 the upper part. An unexposed interval of 65–70 m separates the two. In a general way, the succession records much of the same lithological sequence as in the southern part of the Western Interior region. Most of the lower part with its limestone units and generally higher carbonate content (Adkins, 1931, units 1 and 2) is the lithic equivalent of the Greenhorn Limestone, and the upper, more shaly part (Adkins, 1931, p. 37, units 3–8) is the lithic equivalent of the Carlile Shale.

The generalised geological setting of the area in

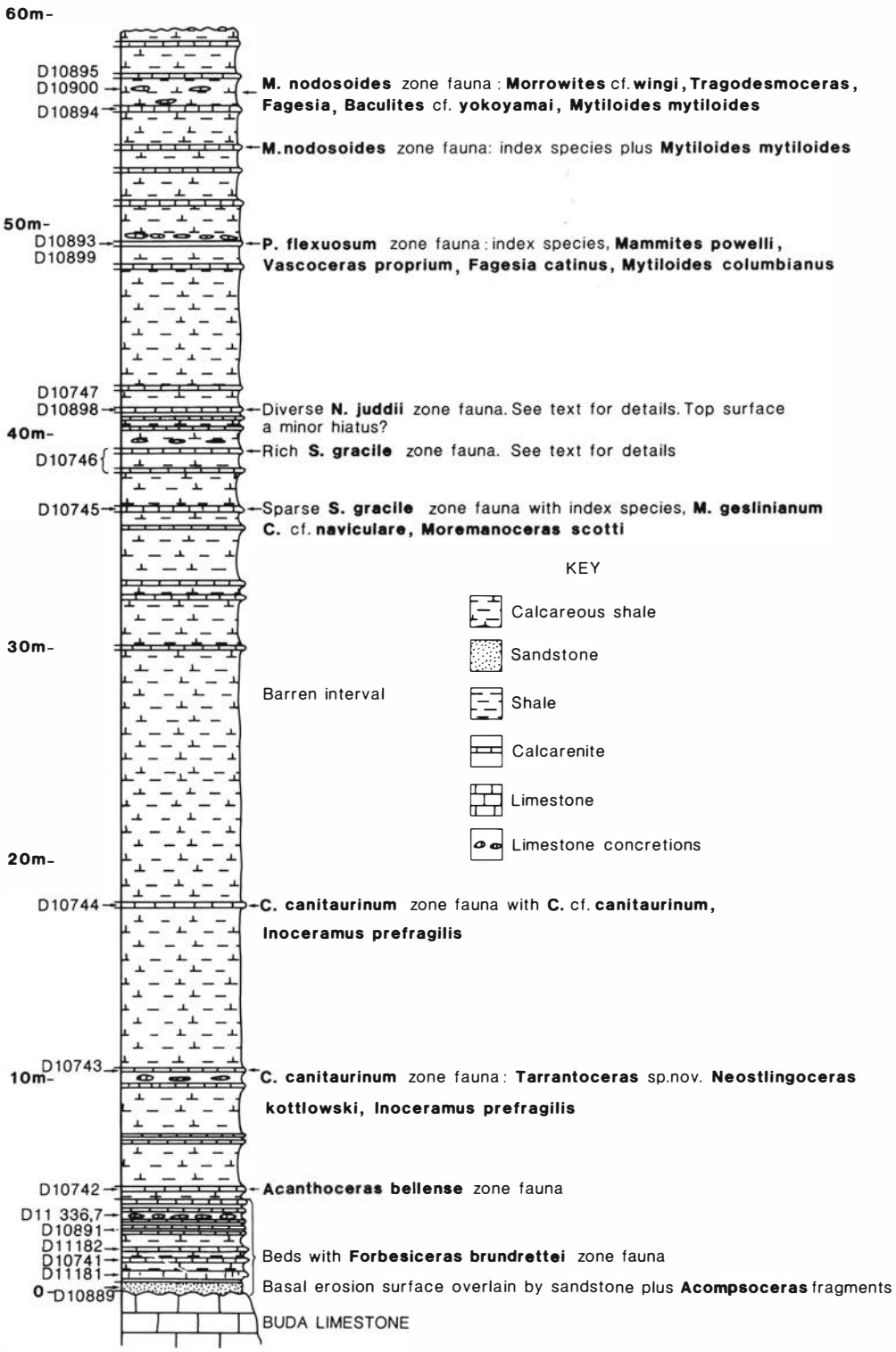


Fig. 2. Schematic section in the lower part of the Chispa Summit Formation at Chispa Summit. This interval is entirely within Unit 1 of Adkins (1931).

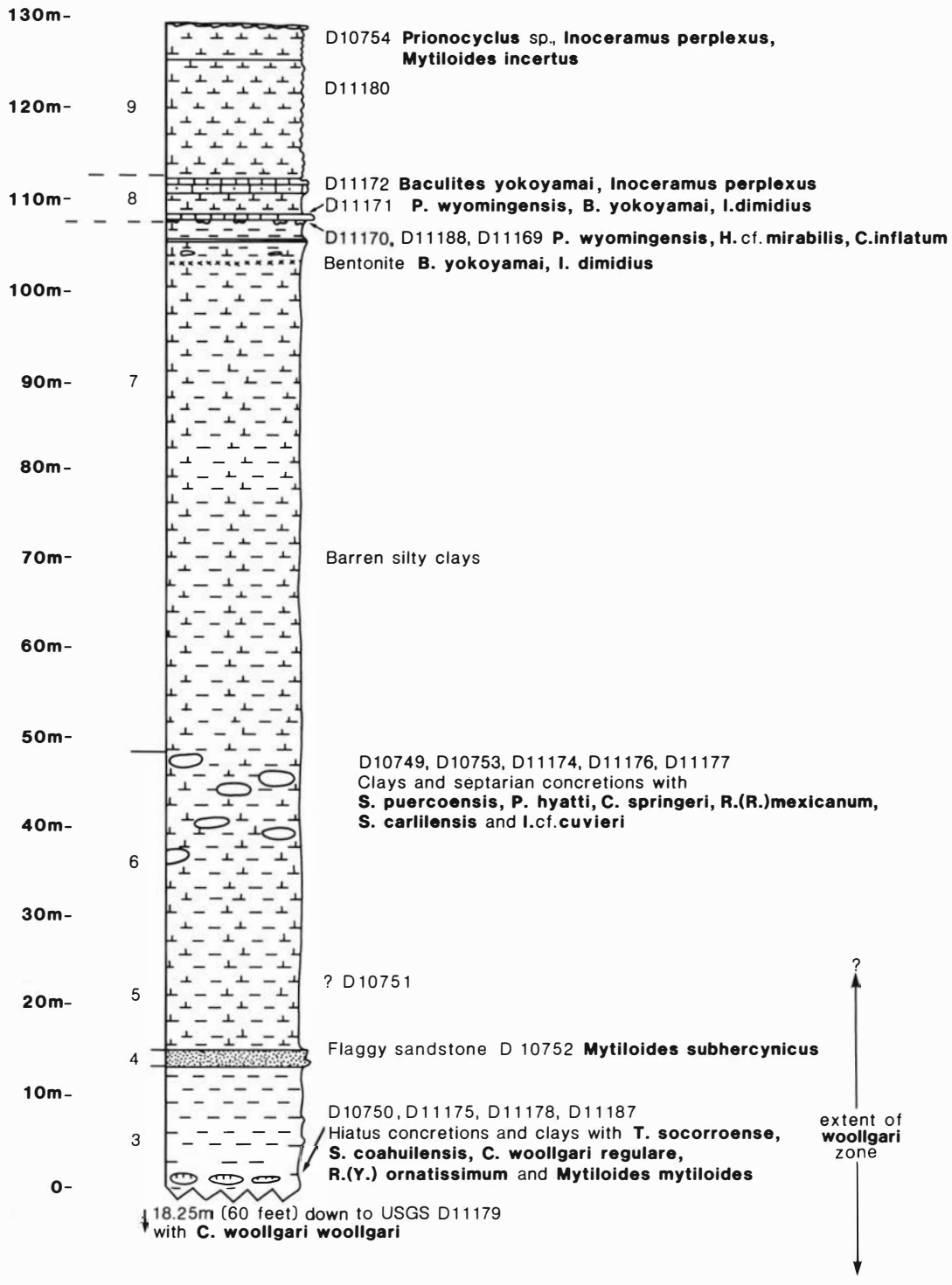


Fig. 3. Schematic section in the upper part of the Chispa Summit Formation at Chispa Summit. Approximately 130 m (460 feet) of largely barren or unexposed sediments separate this interval from that shown in Figure 2, although *Collignoniceras woollgari woollgari* occurs 18.3 m (60 feet) below the hiatus concretion bed in unit 3. The divisions recognised by Adkins are numbered 3 through 9.

Cretaceous time is shown in figure 2 in Powell (1965 and references therein). Chispa Summit thus lies in an intermediate position between the Diabolo Platform and the Chihuahua Trough (Figure 1). On the platform to the east carbonates dominate, and are termed the Boquillas Formation (Udden 1907) ranging around 147–156 m (450–475 feet) in the area of the Big Bend National Park 210 km (130 miles) to the south-east. To the west and south, the basinal facies are termed Ojinaga Formation, a predominantly clay and shale sequence more than 600 m (2 000 ft) thick in the southern Quitman Mountains on the Texas-Mexico border only 50 km from Chispa Summit.

Previous work

The first account of the Cretaceous beds and faunas of Chispa Summit is that of Adkins (1931) who divided the sequence into eight lithostratigraphical units that we retain for convenience in our account. Adkins also recognised eight successive faunal units, although no formal zonal nomenclature was proposed. A few ammonites from west Texas and northern Mexico were later described by Kummel & Decker (1954).

Powell (1963a, 1963b, 1965) described ammonites from localities in the Quitman Mountains farther west, and made passing reference to Chispa material. In 1963, Daugherty & Powell provided additional information. Powell (1965, 1970) summarised other previous work, proposed a zonation, and noted the discontinuity between the Buda Limestone and Chispa Summit Formation. Powell (1965) put forward the following zonation:

(lower Coniacian, zone of *Peroniceras* spp.)
upper Turonian
  zone of *Coilopoceras* sp. cf. *C. colleti*
  Barren zone
middle Turonian
  zone of *Coilopoceras chispaense*
  zone of *Romaniceras cumminsi*
  zone of *Spathites chispaensis*
lower Turonian
  Barren zone
  zone of *Pseudaspidoceras flexuosum*
  zone of *Kanabiceras septemseriatum*
upper (?) Cenomanian
  zone of *Pseudouhligella elgini.*

Subsequently Young & Powell (1978) proposed the following zonal scheme:

Coniacian: *Peroniceras haasi* zone
Turonian: *Prionocyclus hyatti* zone
Coilopoceras eaglefordense zone
Metoicoceras whitei zone

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
Graysonites adkinsi zone
Plesioturrilites brazosensis zone

Young & Powell also reviewed previous work on the Texas middle Cretaceous. These studies apart, we note also the micropaleontological results of Huffman (1960), Pessagno (1967, 1969), Frush & Eicher (1975) and McNulty, Neybert & Reaser (1978).

Stratigraphical results

Cenomanian through Turonian zonal sequence in west Texas

Our new collections demonstrate that the standard ammonite sequence of the southern Western Interior can be traced into West Texas as far as the Mexican border and beyond. The standard scheme is shown in Figure 4, which is taken, with minor modifications, from Cobban (1984a), where detailed evidence for the sequence and criteria for recognising zones can be found.

The faunal sequence at Chispa Summit

We have not studied the fauna of the Buda Limestone in any detail. At Chispa Summit it contains *Budaiceras hyatti* (Shattuck, 1903), index fossil of the *B. hyatti* zone, to which Young (1979 and references therein) refers all of the Buda. The Buda Limestone contains undoubted lower Cenomanian ammonites elsewhere in Texas (see Young, 1979, for faunal list).

As noted by Powell (1965, p. 515), a marked disconformity separates the Buda Limestone and Chispa Summit Formation. The basal bed of the Chispa Summit is a fine- to medium-grained thick-bedded sandstone as much as 0.9 m thick that occupies depressions on top of the Buda. The only fossil found in this sandstone (USGS locality D 10889) was part of the body chamber of a robust, ornate ammonite (USNM 419931) that suggests *Acompsoceras inconstans* (Schlüter, 1871). At a slightly dif-

STAGE		ZONE	SUBZONE
TURONIAN	UPPER	Prionocyclus quadratus	
		Scaphites whitfieldi	
		Prionocyclus wyomingensis	Scaphites ferronensis
			Scaphites warreni
		Prionocyclus macombi	Coilopoceras inflatum
			Coilopoceras colleti
	MIDDLE	Prionocyclus hyatti	Coilopoceras springeri
			Hoplitoides sandovalensis
		Prionocyclus percarinatus	
		Collignoniceras woollgari	Collignoniceras woollgari regulare
			Collignoniceras woollgari woollgari
	LOWER	Mammites nodosoides	
		Vascoceras birchbyi	
		Pseudaspidoceras flexuosum	
CENOMANIAN (PART)	UPPER	Neocardioceras juddii	
		Vascoceras cauvini	
		Sciponoceras gracile	
		Metoicoceras mosbyense	
		Calycoceras canitaurinum	
	MIDDLE	Plesiacanthoceras wyomingense	
		Acanthoceras amphibolum	
		Acanthoceras bellense	
		Conlinoceras tarrantense	

Fig. 4. The standard middle Cenomanian through upper Turonian zonal sequence recognised in the southern part of the Western Interior, modified after Cobban (1984a).

ferent locality (USGS D 11181), but near the base of the Chispa Summit Formation, fragments of two large, nearly smooth ammonites (USNM 419932, 419933) were found that may be *A. renevieri* (Sharpe, 1857).

Beds of limestone 2.1–3.9 m above the base of the Chispa Summit Formation contain a fauna that is characterized by *Forbesiceras brundrettei* (Young, 1958), the guide fossil to the zone of *Forbesiceras brundrettei* of Young and Powell (1978). USGS locality D 11182, near the base of this sequence of beds, contains *Moremanoceras elgini* (Young, 1958), *Acompsoceras* cf. *renevieri* (Sharpe, 1857), *F. brundrettei, Borissiakoceras?* sp., *Ostlingoceras davisense* Young, 1958, *Mariella* cf. *cenomanensis* (Schlüter, 1876), *Hypoturrilites youngi* Clark, 1965, *Inoceramus* aff. *arvanus* Stephenson, 1953, and *Ostrea beloiti* Logan, 1898, USGS locality D 11336, at the top of the sequence, contains the same fossils with the addition of *Ostlingoceras brandi* Young, 1958.

A thin bed of limestone 4.6 m above the base of the Chispa Summit Formation contains a different fauna that is characterized by *Acanthoceras bellense* Adkins, 1928. Other fossils in this bed at USGS locality D 10742 include *"Eucalycoceras" leonense* Adkins, 1928, *Acompsoceras?* sp., *Cunningtoniceras johnsonanum* (Stephenson, 1955), *Tarrantoceras* spp.,? *Turrilites acutus* Passy, 1832, *Inoceramus* aff. *arvanus,* and *Ostrea beloiti.* This zone, of middle Cenomanian age, will be referred to as the *Acanthoceras bellense* zone.

Another thin bed of limestone 10.4 m above the base of the Chispa Summit contains fragments of fossils including *Inoceramus prefragilis* Stephenson, 1953, which suggests an early late Cenomanian age. The collection (USGS locality D 10743) contains the ammonites *Tarrantoceras* sp. nov., *Borissiakoceras?* sp., and a bit of a turrilitid. The assemblage suggests either the zone of *Plesiacanthoceras wyomingense* or the zone of *Calycoceras canitaurinum.* A thin bed of limestone 6.4 m higher at USGS locality D 10744 definitely contains *C. canitaurinum* along with *I. prefragilis, Moremanoceras* sp. nov., and *Tarrantoceras?* sp. This bed is overlain by 18.5 m of calcareous shale from which no fossils were collected.

A conspicuous bed of limestone about 36.5 m above the base of the Chispa Summit Formation contain fossils indicative of the late Cenomanian *Sciponoceras gracile* zone. At USGS locality D 10745 this bed contained *Moremanoceras scotti* (Moreman, 1942), *C. (Calycoceras) naviculare* (Mantell, 1822), and *Metoicoceras* sp. A soft chalky bed of limestone 2 m higher yielded a more varied fauna at USGS locality D 10746. Fossils collected included a solitary coral, small echinoids, gastropods, and the ammonites *Euomphaloceras septemseriatum* (Cragin, 1893), *Pseudocalycoceras angolaense* (Spath, 1931), *Metoicoceras geslinianum* (D'Orbigny, 1850), *Borissiakoceras reesidei* Morrow, 1935, *Sciponoceras gracile* (Shumard, 1860), and *Worthoceras vermiculus* (Shumard, 1860).

A poorly preserved but very interesting fauna occurs in a soft bed of limestone about a metre above the *S. gracile* fauna. The fossils are internal molds the upper surfaces of which are corroded, thus suggesting a minor hiatus and erosion at the top of the bed. Fossils found at USGS localities D 10747 and D 10898 include *Thomelites robustus* sp. nov., *Neocardioceras juddii* (Barrois and de Guerne, 1878), *Euomphaloceras costatum* Cobban, Hook & Kennedy, 1898, *Pseudaspidoceras pseudonodosoides* (Choffat, 1898), *Nigericeras gadeni* (Chudeau, 1909), *Thomasites koulabicus* (Kler, 1908), *Thomasites* sp., *Inoceramus pictus* J. de C. Sowerby, 1829 (late forms) and *Inoceramus* sp. This represents the widely distributed *Neocardioceras juddii* zone of very late Cenomanian age.

About 8 m above the *N. juddii* fauna is a bed of concretionary limestone overlain by a bed of limestone concretions; both beds contain fossils indicative of the very early Turonian zone of *Pseudaspidoceras flexuosum.* Fossils from USGS localities D 10893 and D 10899 include *P. flexuosum, Mammites powelli* Kennedy, Wright & Hancock, 1987, *Vascoceras proprium* Reyment, 1954, *Neoptychites* cf. *cephalotus* (Courtiller, 1860), *Hamites?* sp., *Ostrea* sp., and abundant *Mytiloides columbianus* (Heinz, 1935).

Limestone beds and limestone concretions about 2.5 m above the beds with the *P. flexuosum* fauna contain fossils of the *Mammites nodosoides* zone of late early Turonian age. USGS localities D 10895 and D 10900, about 57–58.5 m above the base of the Chispa Summit Formation, contain *Tragodesmoceras bassi* Morrow, 1935, *Mammites nodosoides, Morrowites depressus* Powell, 1963b, *Baculites yokoyamai* Tokunaga & Shimizu, 1926, *Mytiloides mytiloides* (Mantell, 1822), and small smooth curved oysters that reflect attachments to *Mytiloides* and possibly the ammonite *Puebloites.*

About 26 m of shale in which fossils were not noted overlie this sequence of limestone beds and concretions. Above this shale is a concealed interval of perhaps as much as 95 m. Higher fossiliferous beds are exposed in the vicinity of Needle Peak about 2 km southwest of Chispa Summit.

The lowest collection (USGS locality D 11179) from the Needle Peak area, 32 m below a unit of flaggy sandstone contains *Collignoniceras woollgari woollgari* (Mantell, 1822), the index species of the

widely distributed *C. woollgari* zone, of early middle Turonian age. The presence of the restricted subspecies indicates the lower subzone of the *woollgari* zone.

A 2 m thick unit of shale that contains highly septarian limestone concretions as well as the bed of hiatus concretions described by Kennedy and others (1977) lies about 12 m below the flaggy sandstone. Fossils from these concretions (USGS D 10755, D 11175), include *Tragodesmoceras socorroense* Cobban & Hook, 1979, *C. woollgari regulare* (Haas 1946), *Romaniceras (Yubariceras) ornatissimum* (Stoliczka, 1864), *Spathites coahuilaensis* (Jones, 1938), *Inoceramus cuvieri* J. Sowerby, 1822, and gastropods. This fauna indicates the upper, *regulare* subzone of the *woollgari* zone. Ammonites were not found in the unit of flaggy sandstone. The only fossils (USGS D 10752) collected were inoceramids that may be *Mytiloides subhercynicus* (Seitz, 1935).

A unit of shale about 10 m thick that contains abundant fossiliferous limestone concretions lies about 20–30 m above the flaggy sandstone. *Coilopoceras* is especially common, and the unit was referred to as the *Coilopoceras* graveyard by Powell (1965). The most varied collection is at USGS locality D 10753 where the following were found: *Romaniceras (Romaniceras) mexicanum* Jones, 1938, *R. (R.)?* sp., ammonite *(incertae sedis), Spathites puercoensis* (Herrick & Johnson, 1900a), *Prionocyclus hyatti* (Stanton, 1894), *Coilopoceras springeri* Hyatt, 1903, *Scaphites carlilensis* Morrow, 1935, and *Inoceramus* sp. This represents the *Prionocyclus hyatti* zone of late middle Turonian age. In the Needle Peak area, not far from locality D 10753, W.S. Adkins and associates collected a fauna of pyritic nuclei and micromorphs, which include the following forms (identified by W.J.K.): *P. hyatti, Coilopoceras* sp. juv., *Metaptychoceras* sp. nov., *Allocrioceras* sp., and *Worthoceras* sp. nov.

A shale unit, possibly 55 m thick, that lacks concretions, overlies the unit with concretions and the *P. hyatti* fauna. A few beds of brown and grey calcarenite and calcarenitic concretions overlie the thick shale unit. These calcarenitic beds resemble those in the lower upper Turonian Juana Lopez Member of the Mancos Shale of New Mexico and contain the following fossils at USGS locality D 11170: *Prionocyclus wyomingensis* Meek, 1876, *Coilopoceras inflatum* Cobban and Hook, 1980a, *Scaphites warreni* Meek & Hayden, 1860, *Hourcquia mirabilis* Collignon, 1965a, *Baculites yokoyamai* Tokunaga & Shimizu, 1926, and abundant *Inoceramus dimidius* White, 1874. This assemblage represents the *Prionocyclus wyomingensis* zone of early late Turonian age. The concretions that contain this fauna are overlain by a bed of calcarenite that contains many of these fossils at USGS locality D 11171 as well as *Baculites undulatus* d'Orbigny, 1850, and abundant planktonic forminifers.

A thin bed of fine-grained calcareous sandstone about 17 m above D 11171 at USGS locality D 11172 contains *Inoceramus perplexus* Whitfield, 1877, and *Baculites yokoyamai.* The inoceramid suggest the late Turonian *Scaphites whitfieldi* zone.

The youngest late Turonian collection was made east of Needle Peak at USGS locality D 10754 where the following fossils were found in concretionary limestone beds: *Inoceramus parvus* Tröger, 1967, *I. perplexus, Mytiloides incertus* (Jimbo, 1894), *M. mytiloidiformis* (Tröger, 1967), *Prionocyclus* sp., and *Baculites yokoyamai.* This assemblage could be as young as the zone of *Prionocyclus quadratus.*

The youngest fauna studied came from USGS locality D 11173 some distance above D 10754. Among the fossils are *Cremnoceramus* cf. *rotundatus* (Fiege, 1930), *C.* cf. *waltersdorfensis* (Andert, 1911), *Scaphites* sp., and *Baculites* sp. The inoceramids indicate the lower part of the zone of *Cremnoceramus erectus* of very early Coniacian age. Another collection (USGS D 11180), from this zone contains *C. rotundatus* and *Forresteria* sp.

Correlation with other areas

Other sections in Trans-Pecos Texas.

Chispa Summit is the most complete faunal sequence for the lower Cenomanian to upper Turonian in Trans-Pecos Texas, but there are a number of less-complete sequences and some diverse faunas that amplify the present account.

Gold Hill and the northeast Davis Mountains. Young (1958) described an interesting silicified fauna occurring in chert at the base of the Boquillas Formation in the northeastern part of the Davis Mountains (Figure 1). Young originally regarded this fauna as early Cenomanian, but he has recently (1986, p. 1213) placed it at the base of the middle Cenomanian; this is the *Forbesiceras [Neopulchellia] brundrettei* zone at its type locality. Young initially regarded the fauna as reworked; our own colleting in the area revealed only remanié fossils scattered over a wide area with no clear contact with the Buda. The assemblage consists of *Moremanoceras elgini* (Young, 1958), *Forbesiceras brundrettei* (Young, 1958), *Ostlingoceras brandi* Young, 1958, *O. davisense* Young, 1958, *Hypoturrilites youngi* Clark, 1965, *Inoceramus* aff. *arvanus* Stephenson,

1953, *Ostrea beloiti* Logan, 1899, plus several other bivalves and gastropods. At the same locality but a little higher, unsilicified ammonites of the *Sciponoceras gracile* zone are also present. Gold Hill is in Jeff Davis County 8.8 km (5.3 mi.) south, 32° east of the common corner of Jeff Davis, Culberson and Reeves Counties (Figure 1). The same fauna as that described by Young occurs as silicified fossils resting in depressions on top of the Buda (Hook & Cobban 1983). Above, Hook & Cobban recognised only the *Acanthoceras amphibolum* and *Calycoceras canitaurinum* zones in the Cenomanian, succeeded by indications of the *Pseudaspidoceras flexuosum* and *Mammites nodosoides* zones, succeeded by the *woollgari* subzone of the *C. woollgari* zone. A marked disconformity and hardground is overlain by reworked elements of the *woollgari* subzone as well as *Prionocyclus hyatti*. The *regulare* subzone of the *woollgari* zone and the *Prionocyclus percarinatus* zones are thus missing. Perhaps this break is a development of the hiatus concretion horizon in the *regulare* subzone at Chispa Summit. Still higher elements of the zones of *Prionocyclus hyatti, P. macombi, P. wyomingensis* and *P. quadratus* are all represented.

Southern Quitman Mountains. The Buda/Ojinaga Formation boundary and succeeding strata are well exposed in Mule and Calvert Canyons close to the Texas–Mexico Border (Figure 1). Details are given by Jones & Reaser (1970, with Quadrangle Map), and Powell (1963a) described the faunas. Powell's bed A is a distinctive earthy limestone 20 cm thick, some 9.1 m above the top of the Buda. It yielded, at USGS Mesozoic locality D 10757, *Moremanoceras* aff. *elgini* (Young, 1958), *Stoliczkaia* cf. *chancellori* Wright & Kennedy, 1984, gen. nov., *Euhystrichoceras adkinsi* Powell, 1963a, *Acompsoceras sarthense* (Guéranger, 1867) (= *A. bifurcatum* Powell, 1963a), *Hypoturrilites youngi* Clark, 1965, and *Inoceramus* sp. The presence of *Acompsoceras* suggests a correlation with the basal beds of the Chispa Summit Formation at Chispa Summit. *Turrilites acutus* Passy, 1832, of middle Cenomanian age, was found about 18 m above the top of the Buda at USGS locality D 10759. The next significant fauna is that of Powell's bed B, recently revised by Kennedy, Wright & Hancock (1987). In stratigraphic isolation some 300 m above the top of the Buda, the assemblage of the *Pseudaspidoceras flexuosum* zone contains *Quitmaniceras reaseri* Powell, 1963a, *Kamerunoceras calvertense* Powell, 1963a, *Pseudaspidoceras flexuosum* Powell, 1963a, *Mammites powelli* Kennedy, Wright & Hancock, 1987, *Vascoceras proprium* Reyment, 1954, *Fagesia catinus* (Mantell, 1822), *Neoptychites* sp., *Wrightoceras munieri* (Pervinquière, 1907), *Thomasites adkinsi* (Kummel & Decker, 1954), *Allocrioceras dentonense* Moreman, 1942, *A. larvatum* (Conrad, 1855), *Sciponoceras* sp., *Worthoceras vermiculus* (Shumard, 1860) and abundant *Mytiloides columbianus* (Heinz, 1935).

El Paso

The Buda/Boquillas contact is exposed on Cerro de Cristo Rey (Cerro de Muleros) in New Mexico, some 8 km northwest of downtown El Paso (Figure 1). The hill itself is formed by an andesitic intrusive of Eocene age. The Cretaceous sequences were studied by Böse (1906, 1910) and, later by Strain (1976). Unit 11 of Böse, which he called the Eagle Ford Formation, was referred to the Boquillas Formation by Strain (1968, 1976): Böse (1910, p. 30) gave a thickness of 110 m. The basal bed yielded the following fauna in bioclastic limestones: *Moremanoceras straini* Kennedy, Cobban & Hook, 1988, *Desmoceras (Pseudouhligella)* sp., *Cunningtoniceras* cf. *johnsonanum* (Stephenson, 1955), *Paracompsoceras landisi* Cobban, 1972, *Acanthoceras amphibolum* Morrow, 1935, *Tarrantoceras sellardsi* (Adkins, 1928), *Anisoceras* sp., *Turrilites acutus* Passy, 1832, *Inoceramus* aff. *arvanus* Stephenson, 1953 and *Ostrea beloiti* Logan, 1899. This is an *A. amphibolum* zone assemblage.

Western Europe

Kennedy (1985, 1986) reviewed the standard zonation of the Cenomanian and Turonian in western Europe and compared it with that of the Western Interior of the United States. The *Sciponoceras gracile* zone is equivalent to the European *Metoicoceras geslinianum* zone, and the younger *Neocardioceras juddii* zone of the two are also equivalent. There is no trace in Texas of the poorly characterised (and as yet unnamed) fauna that occurs between the *geslinianum* and *juddii* zones in Europe. Above, the common occurrence of *Mytiloides columbianus* and *Fagesia catinus* suggests that the *Pseudaspidoceras flexuosum* and European *Watinoceras coloradoense* zones are in part or whole equivalent, as are the succeeding *Mammites nodosoides* zones. The boundary between the lower and middle Turonian corresponds to the appearance of *Collignoniceras woollgari* in both regions. The Texas occurrences show the presence of the *C. woollgari woollgari* and *C. woollgari regulare* subzones, the latter characterised by *Romaniceras (Yubariceras) ornatissimum*. In Europe this species characterises the middle part of the *C. woollgari* zone; we have now recognised that

regulare forms of *woollgari* also occur at this level in Europe. The apparent anomaly of what appeared to be typical *C. woollgari woollgari* at the top of the species range in France (Kennedy, Amédro & Colleté, 1986) is explained by the present observations that show the adults of the two forms to be indistinguishable in some cases; the anomalous French specimens we take to be adults.

Portugal

Correlation of the vascoceratid-dominated sequences in Portugal were discussed by Kennedy (1985, 1986), Kennedy, Wright & Hancock (1987) and Berthou, Chancellor & Lauverjat (1985), who reviewed the extensive earlier work of Berthou and his collaborators. The extension of *Pseudaspidoceras pseudonodosoides* to level J in Portugal shows this to be late Cenomanian as it is restricted to the *juddii* zone in the U.S. For continuing difficulties in correlation of the nearby Spanish successions at this level, see Kennedy et al. (1987).

Nigeria

Kennedy (1985, 1986) and Kennedy, Wright & Hancock (1987) recently discussed the problems associated with placement of the Cenomanian – Turonian boundary in the vascoceratid-dominated Nigerian successions on the basis of the work of Wozny & Kogbe (1984) and previous workers in the Upper Benue Basin; they conclude that the base of the Turonian lies somewhere within the *Vascoceras costatum* zone of Barber (1957), that is to say within bed 9 of the Pindiga section (Barber 1957, table 3), noting that previous reports show typical upper Cenomanian elements occurring within the *costatum* zone. Since that discussion, Popoff, Wiedmann & De Klasz (1986) have provided additional information, recognising the following zonal succession in the Pindiga sequence at and around Pindiga village:

Middle Turonian	*Choffaticeras barjonai* zone *P. (Wrightoceras) wallsi* zone *P. (Bauchioceras) nigeriensis* zone
Lower Turonian	*Paravascoceras costatum* zone
Upper Cenomanian	*Vascoceras bulbosum* zone *Vascoceras tavense* zone *Nigericeras gadeni* zone

The same zonal succession is recognised in the Gongila Formation at Ashaka Quarry, where these authors recorded more diverse faunas. *Pseudaspidoceras pseudonodosoides* occurs in the *tavense* zone, indicating the *juddii* zone of the northwest European/United States sequence. The *bulbosum* zone yields *Vascoceras evolutum* Schneegans, 1943, which is a synonym of *V. cauvini* (*fide* Schöbel 1975), again indicating the *juddii* zone. The upper part of the *nigeriensis* zone also yields *P. pseudonodosoides*, which is exclusively a *juddii* zone species elsewhere. *Vascoceras proprium*, which first appears in the basal Turonian *Pseudaspidoceras flexuosum* zone in Trans-Pecos Texas is first recorded in the *costatum* zone which thus appears to yield both upper Cenomanian and lower Turonian elements in the sense that these substages are used in the present account.

USGS Mesozoic localities in Trans-Pecos Texas

Forty-eight collections of fossils mentioned in the text were made by Hook and Cobban as well as by J.D. Powell and R.E. Burkholder, who are former members of the U.S. Geological Survey. These collections have a prefix D (for Denver, Colorado) and are stored at the Denver Federal Center in Lakewood, Colorado. Specimens from these collections that are either illustrated or mentioned in the text have been assigned USNM catalog numbers and are kept at the National Museum of Natural History, Washington, D.C.

D 10741. From 0.1–0.2 km southeast of Chispa Summit, Jeff Davis County. From a lens of calcarenite 1.5 m above base of Chispa Summit Formation.

D 10742. Same locality as D 10741. From a 2.5-cm-thick limestone bed 4.6 m above base.

D 10743. Same locality. From a shaly bed of limestone 10.4 m above base.

D 10744. Same locality. From 5-cm-thick bed of limestone 16.8 m above base.

D 10745. Same locality. From 15-cm-thick, soft, massive limestone bed about 37 m above base.

D 10746. Same locality. From 15-cm-thick, soft, massive limestone bed 2 m above D 10745.

D 10747. Same locality. From soft limestone beds 1 m above D 10746.

D 10749. From 0.9 km south-southeast of Chispa Summit. Float from thick shale unit.

D 10750. About 0.3 km southeast of Needle peak, southwest of Chispa Summit on Ninetysix

Ranch 7½ minute quadrangle. From limestone concretion below a unit of thin beds of sandstone.

D 10751. About 0.5 km west-southwest of Needle Peak. From shale unit above the sandstone beds of D 10750.

D 10752. Near head of arroyo about 1 km east of Needle Peak. Float from lower part of the sandstone unit.

D 10753. Same locality as D 10752. From limestone concretions in thick shale unit above the sandstone unit.

D 10754. Same locality. From concretionary limestone beds at top of outcrop.

D 10755. North side of service road of highway 290, 2 km east of overpass at junction with highway 80, Reeves County (Gomez Peak quadrangle). From concretionary limestone beds in Boquillas Formation.

D 10757. East side of Mule Canyon 0.8 km N 65° W of Love triangulation station of Eagle Mountains SW 7½ minute quadrangle, Hudspeth County. From soft, argillaceous 23-cm-thick limestone bed 9 m above base of Ojinaga Formation.

D 10759. Same locality as D 10757. About 18 m above base.

D 10760. Mule Canyon about 0.6 km S 73° W of Love triangulation station. From ridge-forming, platy limestone bed in Ojinaga Formation.

D 10889. Quarry just north of road and about 0.15 km west of Chispa Summit. Basal 0.6-m-thick bed of sandstone of Chispa Summit Formation.

D 10891. Same locality as D 10741. From 1.5-m-thick unit of shaly limestone beds 3–4.5 m above base of Chispa Summit Formation.

D 10893. Same locality. From ledge of concretionary limestone 50 m above base.

D 10894. A little northwest of road and about 1.7 km southwest of Chispa Summit. From 5-cm-thick bed of calcarenite 55 m above base of Chispa Summit Formation.

D 10895. Same locality as D 10894. From white limestone concretions about 57–58 m above base.

D 10898. North of road and about 1.4 km southwest of Chispa Summit. From soft, yellowish 15-cm-thick bed of limestone about 40 m above base of Chispa Summit Formation.

D 10899. A little northeast of D 10894. From unit of white and gray limestone concretions about 50 m above base.

D 10900. About 1.7 km southwest of Chispa Summit. From limestone concretions about same level as D 10895.

D 10901. About 0.1 km north of limestone quarry near southwest corner of San Martine 7½ minute quadrangle (Culberson County). Base of Boquillas Formation.

D 10902. Same locality as D 10901. About 30 cm above base.

D 10904. Same locality. From 10-cm-thick bed of gray limestone 3.3 m above base.

D 10936. Top of ridge 1.45 km N 65°E of Stone Ranch on Grayton Lake 7½ minute quadrangle, Hudspeth County. From gray concretionary limestone bed just above ridge of yellow-tan limestone in Chispa Summit Formation.

D 11169. About 2.1 km S 23° W of Needle Peak. From white-weathering limestone concretions just below base of Juana Lopez equivalent in Chispa Summit Formation.

D 11170. Same locality as D 11169. From gray concretionary limestone bed a little above D 11169.

D 11171. Same locality. From brown-weathering hard limestone bed just above D 11170.

D 11172. Same locality. From gray limestone bed higher than D 11171.

D 11173. About 3.6 km S 20°W of Needle Peak. From baked shale at dike cutting Chispa Summit Formation.

D 11174. Bottom of arroyo at breached tank 2.2 km S 31°W of Needle Peak. From white-weathering limestone concretions.

D 11175. East of Van Horn Creek and 2.5 km S 40°W of Needle Peak. From hiatus concretions below the sandy unit of the Chispa Summit Formation.

D 11176. About 1 km S 18°W of Needle Peak. From white-weathering limestone concretions.

D 11177. Arroyo 0.9 km S 22°W of Needle Peak. From white-weathering limestone concretions.

D 11178. West end of Needle Peak. From limestone concretions below the sandy unit.

D 11179. About 0.55 km S 75°W of Needle Peak. From below the sandy unit.

D 11180. About 1.4 km N 82°E of Ninetysix Ranch on Ninetysix Ranch 7½ minute quadrangle, Jeff Davis County. From soft white limestone concretions above the Juana Lopez equivalent in the Chispa Summit Formation.

D 11181. Arroyo 3 km west of Chispa Summit. From argillaceous limestone bed 1 m above base of Chispa Summit Formation.

D 11182. Same locality as D 11181. From argillaceous limestone bed 2.1 m above base.

D 11187. About 0.8 km S 81°E of Needle Peak. From white-weathering limestone concretions below the sandy unit.

D 11188. Same locality as D 11180. From concretionary limestone bed in lower part of Juana Lopez equivalent in the Chispa Summit Formation.

D 11209. About 0.1 km N 64° E of Needle Peak. From siltstone beds below hiatus concretions.

D 11319. About 0.3 km east-northeast of Gold

Hill on Gomez Peak 7½ minute quadrangle, Jeff Davis County. From base of Boquillas Formation.

D 11336. About 1.3 km S 79°W of Chispa Summit. From 3.9 m above base of Chispa Summit Formation.

D 11337. About 0.1 km south of Chispa Summit. From limestone concretions at level of D 11336.

Repositories of specimens

BMNH = British Museum (Natural History), London.
OUM = Oxford University Museum, Oxford.
TMM = Texas Memorial Museum, Austin.
UM = University of Michigan Museum of Paleontology, Ann Arbor.
USNM = National Museum of Natural History, Washington, D.C.

Plaster casts of figured specimens are deposited in the Collections of the Paleontologiska Institutionen, Uppsala.

Systematic Paleontology

Order: AMMONOIDEA Zittel, 1884

Suborder: AMMONITINA Hyatt, 1889

Superfamily: HAPLOCERATACEAE Zittel, 1884

Family: BINNEYITIDAE Reeside, 1927

Genus: BORISSIAKOCERAS Arkhanguelsky, 1916

Type species: By original designation: *Borissiakoceras mirabile* Arkhanguelsky, 1916 (p. 55, pl. 8, figs 2,3).

Borissiakoceras orbiculatum Stephenson, 1955

1955 *Borissiakoceras orbiculatum* Stephenson, p. 64, pl. 6, figs 1–4.
1988 *Borissiakoceras orbiculatum* Stephenson, 1955; Kennedy, p. 18, pl. 1, figs 23–26 (with full synonymy).

Holotype: USNM 108832 from the basal Eagle Ford Formation concretions on Walnut Creek, 4.75 mi. northeast of Mansfield, Texas; middle Cenomanian *Acanthoceras amphibolum* zone.

Material: Four specimens from USGS Mesozoic locality D 10891.

Discussion: Specimens are crushed, and range up to 35 mm in diameter. The best-preserved one shows characteristic falcoid striae, well preserved on the outer flank, where they are periodically accentuated into broad, low, distant ribs. Given differences in preservation, they agree well with material figured by Cobban (1961, p. 750, pl. 88, figs 15–44; text–figs 5a-f).

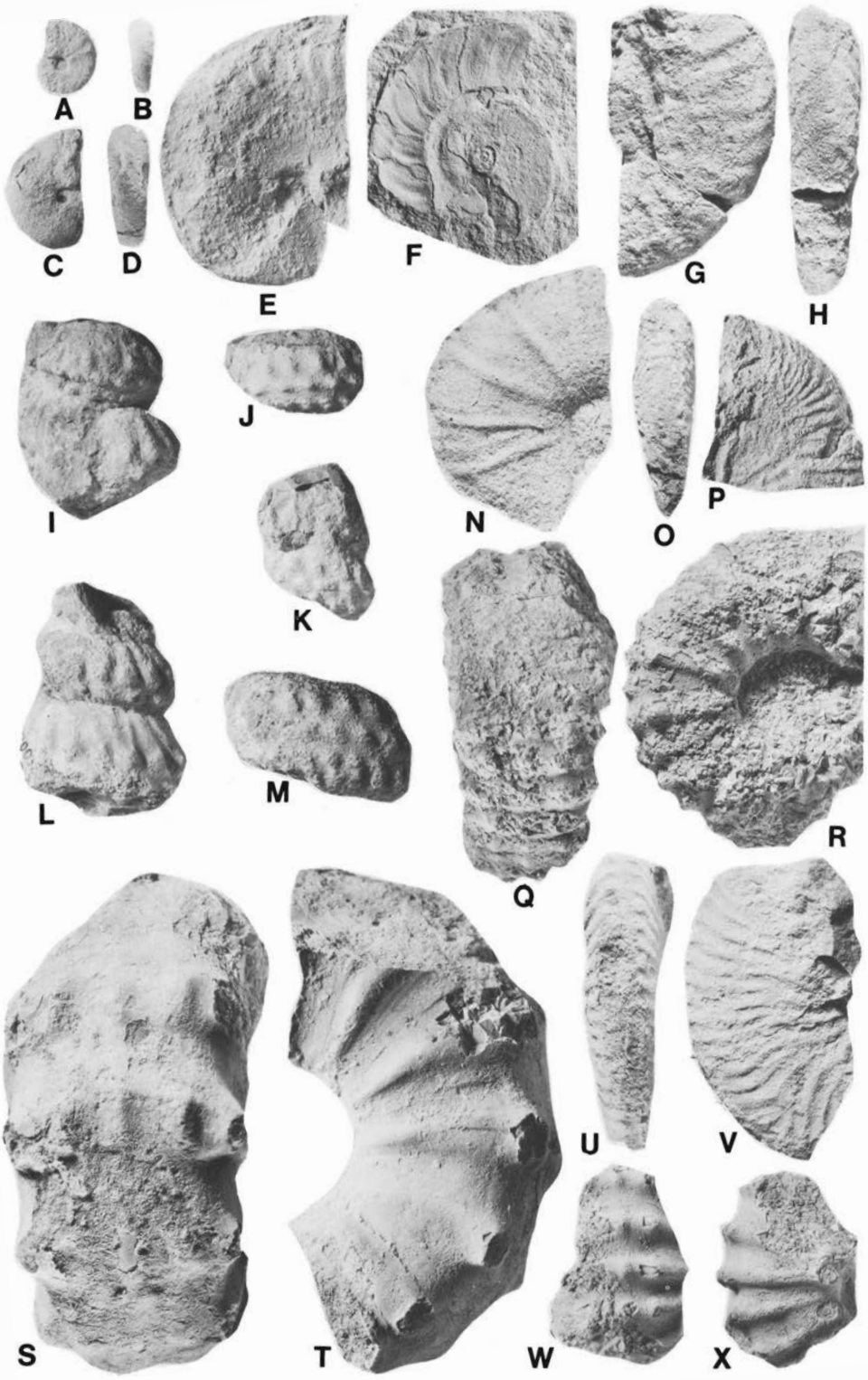
Occurrence: The species ranges from the early Cenomanian zone of *Forbesiceras brundrettei* to the late Cenomanian zone of *Sciponoceras gracile*, with records from Wyoming, Montana, Colorado, Kansas and Texas.

Borissiakoceras auriculatum Kennedy 1988

1988 *Borissiakoceras auriculatum* Kennedy, p. 19, pl. 1, figs 14–20; text–fig. 8 c.

Holotype: USNM 411430, from the Britton Formation, upper Cenomanian *Sciponoceras gracile* zone, Texcrete Quarries, Dallas County, Texas. Paratypes USNM 411431 and 411432, from the same locality.

Fig. 5. (A), (B) *Borissiakoceras reesidei* Morrow, 1935; USNM 419934, from locality D 10746, *Sciponoceras gracile* zone. (C), (D) *Moremanoceras elgini* (Young, 1958): USNM 419937, from locality D 11336, *Forbesiceras brundrettei* zone. (E) *Moremanoceras* sp. nov.: USNM 419936, from locality D 10744, *Calycoceras canitaurinum* zone. (F) *Moremanoceras elgini* (Young, 1958): USNM 419938, from locality D 10891, *Forbesiceras brundrettei* zone. (G), (H), *Tragodesmoceras* cf. *bassi* Morrow, 1935: USNM 419939, from locality D 10900, *Mammites nodosoides* zone. (I) – (M) *Mariella (Mariella)* cf. *cenomanensis* (Schlüter, 1876): (I) is USNM 420030, (J) is USNM 420033, (K), is USNM 420034, (L) is USNM 420032, (M) is USNM 420031, all from locality D 11182, *Forbesiceras brundrettei* zone. (N) *Moremanoceras scotti* (Moreman, 1942): USNM 419935, from locality D 10745, *Sciponoceras gracile* zone. (O), (P), (U), (V) *Forbesiceras brundrettei* (Young, 1958): (O), (P) are USNM 419940, (U), (V) are USNM 419941, from locality D 11336, *Forbesiceras brundrettei* zone. (Q), (R) *Cunningtoniceras johnsonanum* (Stephenson, 1955): USNM 419943, from locality D 10742, *Acanthoceras bellense* zone. (S), (T) *Acanthoceras bellense* Adkins, 1928; USNM 419942, from locality D 10742, *Acanthoceras bellense* zone. (W), (X) "*Eucalycoceras*" cf. *leonense* Adkins, 1928: USNM 419944, from locality D 10742, *Acanthoceras bellense* zone.
All figures are x 1.


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X

Discussion: Several fragments in the OUM collections from the upper Cenomanian *Sciponoceras gracile* zone fauna of Adkins (1931) Unit 1 may belong here. The species also occurs in the *S. gracile* zone of north-central Texas.

Borissiakoceras reesidei Morrow, 1935 Figs 5A, B

1935 *Borissiakoceras reesidei* Morrow, p. 463, pl. 49, fig. 7; pl. 50, fig. 5; text-fig. 8.
1961 *Borissiakoceras reesidei* Morrow; Cobban, p. 749, pl. 88, figs 1–14; text-figs 3h-k.
1965a *Borissiakoceras reesidei* Morrow; Hattin, pl. 5, figs A, B.
1978 *Borissiakoceras reesidei* Morrow; Hattin & Siemers, fig. 5.13

Holotype: By original designation: the specimen figured by Morrow (1935) as his pl. 49, fig. 7, University of Kansas Collections no. 11276, from the *Acanthoceras amphibolum* zone in the Graneros Shale, Wilson County, Kansas.

Material: USNM 419934, USGS Mesozoic locality D 10746, plus numerous poorly preserved specimens from the same horizon in the OUM Collections.

Discussion: Rounded whorls and feeble nodes, 5–6 per half whorl, characterize this species and are well seen in USNM 419934. The remaining material is rather poor or juvenille.

Occurrence: Middle Cenomanian *Acanthoceras amphibolum* to upper Cenomanian *Sciponoceras gracile* zone. There are middle Cenomanian records from Wyoming, Colorado and Kansas; the species has not been previously recorded from the *S. gracile* zone.

Superfamily: DESMOCERATACEAE Zittel, 1895

Family: DESMOCERATIDAE Zittel, 1895

Genus: MOREMANOCERAS Cobban, 1972

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

Moremanoceras scotti (Moreman, 1942)

Fig. 5 k

1927 *Pachydiscus* sp. A Moreman, p. 94, pl. 15, fig. 4.
1942 *Desmoceras scotti* Moreman, p. 208, pl. 33, fig. 8; text–fig. 2d.
1960 *Onitshoceras? scotti* (Moreman); Matsumoto, p. 46, text–figs 10A–C.
1972 *Desmoceras (Moremanoceras) scotti* Moreman; Cobban, p. 6, pl. 2, figs 1–23, text–figs 3–5.
1977 *Desmoceras (Moremanoceras) scotti* Moreman; Kauffman, p. 251, pl. 16, figs 1, 2.
1986 *Moremanoceras scotti* (Moreman); Cobban, fig. 3A, B.
1988 *Desmoceras (Moremanoceras) scotti* Moreman; Kennedy, p. 22, pl. 1, figs 1–13.

Holotype: By monotypy: TMM 19807 from the Britton Formation on Hackberry Creek, 0.5 mile north of Somers-Coppel Road, north of Somers, Texas. Upper Cenomanian, *Sciponoceras gracile* zone.

Material: USNM 419935 and a second specimen from USGS Mesozoic locality D 10745.

Discussion: See Cobban (1972) and Kennedy (1988) for recent accounts of this species; the former provides an extensive discussion; the latter reillustrates the holotype. Both of the present specimens are crushed, but show the characteristic globose involute shell form and distant bar-like flared ribs so typical of the species.

Occurrence: Upper Cenomanian *Sciponoceras gracile* zone of Trans-Pecos and north-central Texas, New Mexico (Cooke Range), Arizona and Colorado. See Cobban (1972) for details.

Moremanoceras sp. nov.

Fig. 5E

Material: USNM 419936, from USGS Mesozoic locality D 10744, upper Cenomanian *Calycoceras canitaurinum* zone.

Discussion: The specimen is crushed, with a maximum diameter of 40 mm. Coiling very involute, with tiny umbilicus. Inner and middle flanks smooth, outer flanks developing concave, distant ribs that extend onto the ventrolateral shoulder. It appears to be a *Moremanoceras*, and a representative of an unnamed species. Similar forms occur in the *Calycoceras canitaurinum* zone of Grant County, New Mexico.

Moremanoceras elgini (Young, 1958)

Fig. 5C, D, F

1958 *Desmoceras (Pseudouhlighella) elgini* Young, p. 292, pl. 39, figs 4–20, 24, 25, 30, 31; text-figs 1a–e.
1959 *Pseudouhlighella elgini* Young; Young, p. 80, pl. 2, figs 1–7.

non
1963a *Desmoceras (Pseudouhlighella) elgini* Young; Powell, p. 314, pl. 31, figs 13–16.
1978 *Pseudouhlighella elgini* Young; Young & Powell, pl. 3, figs 3–5, 7, 8, 15.

Type: The holotype is TMM 10782A; it and numerous paratypes are from the base of the Boquillas Formation on the northeast flank of the Davis Mountains in Trans-Pecos Texas.

Material: Numerous specimens from USGS Mesozoic localities D 11336, D 11337, D 10891, D 10901 and D 11182 plus abundant juveniles in the OUM collections.

Discussion: Kennedy, Cobban & Hook (1988) discuss the basis for referring this species to *Moremanoceras* rather than *Pseudouhlighella*. *Moremanoceras elgini* most closely resembles *M. straini* Kennedy, Cobban & Hook 1988, from which it differs in being more compressed with very flat sides and developing coarse, distant lateral and ventrolateral ribs at a diameter when *straini* is still smooth; adults are smaller, and never develop a siphonal keel or ridge.

Occurrence: This species is present in large numbers in the basal Chispa Summit, Ojinaga, and Boquillas Formations in Trans-Pecos Texas; it also occurs at the same horizon in Kinney County, Texas. It is a good indicator for the *Forbesiceras brundrettei* zone.

Family MUNIERICERATIDAE Wright, 1952

Genus TRAGODESMOCERAS Spath, 1922

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

Tragodesmoceras socorroense Cobban & Hook, 1979

1979 *Tragodesmoceras socorroense* Cobban & Hook, p. 13, pl. 5, figs 9, 10; pls 6, 7; pl. 11, fig. 10; text–fig. 4.
1983a *Tragodesmoceras socorroense* Cobban & Hook; Cobban & Hook, p. 7, pl. 2, figs 10–14.
1986 *Tragodesmoceras socorroense* Cobban & Hook; Cobban, p. 81, fig. 7G, H.

Types: Holotype is USNM 252806, the original of Cobban & Hook, 1979, pl. 6, figs 1, 2; text–fig. 4. Paratypes are USNM 252807, 252808, 255608, from the middle Turonian *Collignoniceras woollgari* subzone fauna of the Mancos Shale of north-central New Mexico.

Material: Two large fragments from USGS Mesozoic locality D 10750; OUM KT905 from the hiatus concretion bed in that unit.

Discussion: OUM KT905 is a large, wholly septate disc 260 mm in diameter, that agrees closely with the holotype and other specimens from the Turonian Tres Hermanos Formation of New Mexico.

Occurrence: Middle Turonian *Collignoniceras woollgari* zone of Trans-Pecos Texas and New Mexico.

Tragodesmoceras cf. *bassi* Morrow, 1935
Fig. 5G, H

compare
1935 *Tragodesmoceras bassi* Morrow, 1935, p. 468, pl. 52, figs 1a–c; pl. 53, figs 3–5; text–figs 1, 3.
1972 *Tragodesmoceras bassi* Morrow; Cobban & Scott, p. 58, pl. 38, figs 2, 3, 5–13; pl. 39.

Material: One specimen, USNM 419939, from USGS Mesozoic locality D 10900. Lower Turonian, *Mammites nodosoides* zone.

Discussion: The specimen has a maximum preserved whorl height of 23 mm. Primary ribs are straight on the inner flank, concave on the outer, sweeping forwards to form a marked ventral chevron. Intercalatories arise high and low on the flank and strengthen to match the primaries on the outermost flank and ventrolateral shoulders.

Superfamily ACANTHOCERATACEAE de Grossouvre, 1894

Family LYELLICERATIDAE Spath, 1921

Subfamily STOLICZKAIINAE Breistroffer, 1953

Genus BUDAICERAS Böse, 1928

Type species: Budaiceras mexicanum Böse, 1928, p. 259, pl. 10, figs 1–3; pl. 9, figs 16, 17; by original designation = *Budaiceras hyatti* Shattuck, 1903, p. 36, pl. 25, figs 2, 3.

Budaiceras hyatti (Shattuck, 1903)
Fig. 7L, M

1903 *Budaiceras hyatti* Shattuck, p. 36, pl. 25, figs 2, 3
1979 *Budaiceras hyatti* (Shattuck, 1903); Young, p. 63, pl. 7, figs 1–4, 6–10, 12–14 (With full synonymy).

Holotype: By monotypy, USNM 30243 the original of Shattuck, 1903, pl. 25, figs 2, 3, from the lower Cenomanian Buda Limestone of Shoal Creek, Travis County, Texas.

Material: OUM KT907, collected loose from Buda Limestone float at Chispa Summit.

Discussion: The specimen consists of just under half a whorl of a partially septate specimen 62 mm in diameter. There are nine strong, broad, distant flexuous ribs on the flank. The venter is acute with small siphonal clavi that are twice as numerous as the ribs. The fragment finds an exact match in specimens described and figured by Young (1979), who discussed differences from other species.

Occurrence: Lower Cenomanian *Budaiceras hyatti* zone of Texas and northern Mexico.

Family FORBESICERATIDAE Wright, 1952

Genus FORBESICERAS Kossmat, 1897

Types species: Ammonites largilliertianus d'Orbigny, 1841, p. 320, pl. 95; by subsequent designation by Diener, 1925, p. 180.

Forbesiceras brundrettei (Young, 1958)

Figs 50, P, U, V; Fig. 71

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 brundretti* Young; Young, pl. 1, figs 4, 7, 8; pl. 3, fig. 4.
1978 *Forbesiceras brundrettei* (Young); Young & Powell, pp. 15–24, pl. 3, figs 1, 2, 6.
1983 *Forbesiceras brundrettei* (Young); Hook & Cobban, p. 52.

Holotype: TMM 10734, the original of Young, 1958, pl. 39, figs 35–37, from the base of the Boquillas Formation on the northeast flank of the Davis Mountains in Trans–Pecos Texas.

Material: Seven specimens from USGS Mesozoic locality D 11336; 1 from locality D 11337; 3 from locality D 10902. Lower Cenomanian, *Forbesiceras brundrettei* zone.

Discussion: The Chispa material is poor. This species is characterised by its crowded, bidichotomous falcoid flank ribs in middle growth, terminating in sharp ventral clavi, and lack of siphonal ornament. It is closest to *Forbesiceras chevillei* (Pictet & Renevier, 1866) (*fide* Wright & Kennedy, 1984, p. 93, pl. 13, fig. 2; pl. 15, figs 1, 2; text–fig. 17) which differs in several respects, notably the presence of multiple ventral ribs between clavi and mid-lateral tubercles. *Forbesiceras conlini* Stephenson, 1953 (p. 205, pl. 56, fig. 1; pl. 57, figs 1, 2) of the middle Cenomanian *Conlinoceras tarrantense* zone in north-central Texas may be differentiated from *F. brundrettei* on the same criteria.

Occurrence: Forbesiceras brundrettei is the index species of the *Forbesiceras brundrettei* zone. In west Texas the species occurs at USGS Mesozoic locality D 10902 in Culberson County along with *Moremanoceras elgini* as well as at USGS Mesozoic locality D 11319 at Gold Hill in Jeff Davis County (Hook & Cobban, 1983) and at the type locality (Young, 1958). The species also occurs on Cloice Branch in Mc Lennan County, Texas, presumably in the Pepper Shale.

Family ACANTHOCERATIDAE de Grossouvre, 1894

Subfamily ACANTHOCERATINAE de Grossouvre, 1894

Genus ACOMPSOCERAS Hyatt, 1903

(=*Pseudacompsoceras* Spath, 1925, p. 197)

Type species: Ammonites bochumensis Schlüter, 1871, p. 1, pl. 1, figs 1–4 by original designation (=*Ammonites renevieri* Sharpe, 1857, p. 44, pl. 20, fig. 2).

Acompsoceras spp.

Material: Three poorly preserved fragments from the basal part of the Chispa Summit Formation at USGS Mesozoic localities D 10889 and D 11181.

Discussion: All three specimens are internal molds of sandstone that represent parts of body chambers of large ammonites. The oldest specimen, USNM 419931, from the base of the Chispa Summit Formation at USGS Mesozoic locality D 10889, is a fragment 194 mm in length that represents about two-thirds of a whorl of a robust ammonite. The whorl is a little higher than wide with broadly rounded flanks and flattened venter. Four widely spaced, rounded, rectiradiate ribs of equal lengths

are present; these arise from umbilical bullae and end in ventrolateral clavi. Whether other tubercles were present cannot be determined because of the poor condition of the specimen. The specimen may represent the adult of some ornamented species of *Acompsoceras* such as *A. renevieri* (Sharpe, 1857) (e.g. *Ammonites sarthensis* Guéranger, 1867, p. 5, pl. 4, fig. 1; pl. 8, fig. 2; a synonym) or *A. inconstans* (Schlüter, 1871, p. 7, pl. 3, figs 1–5).

The other two specimens (USNM 419932, 419933) are parts of large whorls from 1 m above the base of the Chispa Summit Formation at USGS locality D 11181. Only one side of each is preserved, but they indicate whorls higher than wide with broadly rounded flanks and flattened venters. One (USNM 419933) has a whorl height of 132 mm and ornament of low, broad ribs that begin from low umbilical bullae and fade out on the upper part of the flank. The other (USNM 419932) is a fragment 233 mm long of a little more than half a whorl of a smooth specimen that has a whorl height of 101 mm. Its dorsum shows the presence of ventrolateral clavi and a low siphonal ridge on the penultimate whorl. The specimen probably represents the body chamber of a weakly ornamented variant such as *A. renevieri* (Sharpe, 1857, p. 44, pl. 2, fig. 2).

Occurrence: As under material. *Acompsoceras* is generally a good marker for the high lower Cenomanian.

Genus ACANTHOCERAS Neumayr, 1875

Type species: Ammonites rhotomagensis Brongniart *in* Cuvier & Brongniart, 1822, p. 391, pl. N, figs 2a, b, by subsequent designation of de Grossouvre (1894).

Acanthoceras bellense Adkins, 1928

Fig. 5S, T

1928 *Acanthoceras bellense* Adkins, p. 245, pl. 30, figs 1, 2.
1928 *Acanthoceras stephensoni* Adkins, p. 246, pl. 31, figs 1, 2.
1928 *Acanthoceras* n. sp. 6 aff. *Cunningtoni* var. *cornutum* Kossmat, 1895; Adkins, p. 247, pl. 5, fig. 1.
?1928 *Acanthoceras* n. sp. 7, Adkins, p. 247.
1942 *Acanthoceras* aff. *rhotomagense* (Defrance); Moreman, p. 201.
1942 *Acanthoceras* aff. *turneri* White; Moreman, p. 202.
1942 *Acanthoceras* aff. *hunteri* Kossmat; Moreman, p. 203.
1942 *Acanthoceras validum* Moreman, p. 203, pl. 32, fig. 1; text-fig. 2 j.
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 & Kennedy, p. 190, text-fig. 66a.
1987 *Acanthoceras bellense* Adkins; Cobban, p. 5, pl. 1, figs 18, 19; pl. 2, fig. 2; text-fig. 5.

Material: Four fragments from USGS Mesozoic locality D 10742.

Discussion: Each specimen consists of less than half a whorl that has a robust quadrangular whorl section a little broader than high. Straight, rectiradiate primary ribs begin on the rounded umbilical wall and may or may not rise into low umbilical bullae on the shoulder. The ribs cross the flattened flanks, where they weaken and broaden on the outer part and then rise into prominent nodate inner ventrolateral tubercles and terminate in smaller outer ventrolateral clavi. These are matched by low siphonal tubercles on the flattened venter. Ribs and tubercles are rather sparse and number about 8 per half whorl.

Occurrence: Middle Cenomanian *Acanthoceras bellense* zone in east-central and Trans-Pecos Texas, southern New Mexico, and eastern Wyoming.

Genus CUNNINGTONICERAS Collignon, 1937

Type species: Ammonites cunningtoni Sharpe, 1855, p. 35, pl. 15, fig. 2; by original designation.

Cunningtoniceras johnsonanum (Stephenson, 1955)

Fig. 5O, R

1955 *Acanthoceras johnsonanum* Stephenson, p. 58, pl. 4, fig 14–17.
1955 *Euomphaloceras lonsdalei* (Adkins); Stephenson, p. 62 (*pars*), pl. 6, figs 9–20 only.
1988 *Cunningtoniceras* cf. *johnsonanum* (Stephenson, 1955); Kennedy, Cobban & Hook, p. 38, fig. 20 p.

Type: Holotype is USNM 108846, the original of Stephenson, 1955, pl. 4, figs 14–17, by monotypy, from the *Acanthoceras amphibolum* zone fauna of the basal Eagle Ford Group in Johnson County, Texas.

Material: Two well-preserved specimens and 6 fragments from USGS Mesozoic locality D 10742; a doubtful fragment from D 11336.

Discussion: The holotype is well illustrated and described by Stephenson (1955, p. 58, pl. 4, figs 14–17). Additional material in the J.P. Conlin Collection (Federal Center, Denver, Colorado), from various localities in Johnson County, Texas, include specimens with intercalated ventral ribs such that there are more outer ventrolateral and siphonal than inner ventrolateral tubercles, suggesting the species to be a *Cunningtoniceras.* USNM 419943 (Fig. 4(q)) shows this feature.

Occurrence: Middle Cenomanian *Acanthoceras amphibolum* zone in north-central Texas. *Acanthoceras bellense* zone in Trans-Pecos Texas.

Genus uncertain

"Eucalycoceras" cf. *leonense* Adkins, 1928

Fig. 5W, X

compare:

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

Material: One specimen (USNM 419944) from USGS Mesozoic locality D 10742.

Discussion: The specimen is a fragment preserving only part of 4 ribs with weak inner and strong clavate outer ventrolateral and siphonal tubercles. Whorl section' style and strength of ribbing match that of better-preserved topotypes in the USGS and OUM collections although poor preservation precludes firm identification.

Occurrence: Middle Cenomanian *Acanthoceras bellense* zone in east-central and Trans-Pecos Texas and eastern Wyoming.

Genus CALYCOCERAS Hyatt, 1900

Subgenus CALYCOCERAS Hyatt, 1900

(ICZN Generic Name no. 1352)

Type species: By designation under the Plenary Powers (ICZN Opinion no. 557)

Ammonites navicularis Mantell, 1822, p. 198, pl. 22, fig. 5 (ICZN Specific Name No.1633).

Calycoceras (Calycoceras) naviculare (Mantell, 1822)

Fig. 6A, B

1822 *Ammonites navicularis* Mantell, p. 198, pl. 22, fig. 5 (in error in explanation of plate: *Ammonites catinus*).
1981 *Calycoceras (Calycoceras) naviculare* (Mantell, 1822); Wright and Kennedy, p. 34, pl. 4, fig. 5; pl. 5, figs 1–3; text-figs 13, 14c–e (with synonymy).
1986 *Calycoceras naviculare* (Mantell); Kennedy, pl. 8, fig. 6.
1988 *Calycoceras (Calycoceras) naviculare* (Mantell, 1822); Kennedy, p. 39, pl. 4, fig. 10.

Holotype: By monotypy: BMNH 5681, the original of Mantell, 1822, pl. 22, fig. 5, from the upper Cenomanian *Metoicoceras geslinianum* zone Plenus Marl of "Offham", Sussex (see Wright & Kennedy, 1981, p. 35).

Material: Three specimens from USGS Mesozoic Locality D 10745.

Discussion: The material is crushed. The largest specimen had a diameter in excess of 200 mm. Its ornament consists of coarse bullate straight recti- to feebly rursiradiate primaries and single shorter intercalatories that alternate regularly. The ventral region is poorly preserved but shows a ventrolateral angulation to have been present. See Cobban (1972) for a full description of the North American material of the species, which these specimens match closely.

Occurence: Calycoceras (C.) naviculare first occurs in the *Calycoceras guerangeri* zone and its correlatives in England and France and possibly in the *Metoicoceras mosbyense* zone of the Cooke Range in southern New Mexico. The species is much more widespread in the *Sciponoceras gracile* zone and its correlatives in Texas, New Mexico, Colorado, Kansas and California in the United States, and in England, France, Germany, Spain, Portugal, North Africa, Angola, Madagascar, the near East, Iran, south India and Japan.

Subgenus PROEUCALYCOCERAS Thomel, 1972

Type species: Calycoceras (Eucalycoceras) besairiei Collignon, 1937, p.. 37(13), pl. 3, figs 1–4; pl. 8, fig. 5; by original designation.

Fig. 6. (A), (B) *Calycoceras (Calycoceras) naviculare* (Mantell, 1822): USNM 419945, from locality D 10745, *S. gracile* zone.
Both figures are x 1.

Calycoceras (Proeucalycoceras) cf. *canitaurinum* (Haas, 1949)

compare:

1949 *Mantelliceras canitaurinum* Haas, p. 9, pls 1–3; pl. 4, figs 1, 2, 4; text-figs 1–4.

Material: Two fragments from USGS Mesozoic locality D 10744.

Discussion: These two large fragments have a whorl height of up to 100 mm. They show the characteristic and distinctive ribbing of adults of the species (Haas, 1949, pls 1–3; pl. 4, figs 1, 2), quite unlike that of any other described North American species.

Occurrence: Widespread in the upper Cenomanian *Calycoceras canitaurinum* zone from north-central

Montana south to New Mexico. Also recorded from Gold Hill, Jeff Davis Country, Texas (Hook & Cobban, 1983); unknown east of the Pecos River.

Genus PSEUDOCALYCOCERAS Thomel, 1969

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

Pseudocalycoceras angolaense (Spath, 1931)

Figs 7A, B, J

1931 *Protacanthoceras angolaense* Spath, p. 316.
1978 *Pseudocalycoceras angolaense* (Spath); Cooper, p. 96, text-figs 4A–C, H–K; 61, J; 10F, G; 14A; 18E, F; 19A–B; 23–25; 26F–K (with synonymy).
1988 *Pseudocalycoceras angolaense* (Spath, 1931); Kennedy, p. 42, pl. 4, figs 1, 2, 6–9, 11, 12; pl. 5, figs 1–12; pl. 8, figs 7, 8; text-figs 10h, 11b, e.

Lectotype: By the subsequent designation of Kennedy, 1988, p. 42: the original of Douvillé, 1931, p. 17, pl. 1, fig. 1, from the upper Cenomanian of Salinas, Angola.

Material: Numerous specimens from USGS Mesozoic locality D 10746. The holotype of *Eucalycoceras underwoodi* Powell, 1963a (p. 315, pl. 31, fig. 17; text-figs 3e, g); TMM 31086. Several specimens in the Adkins Collection (TMM) and OUM KT 1047-55, 1108 and 1110.

Discussion: See Cobban & Scott (1972), Wright & Kennedy (1981) and Kennedy (1988) for descriptions of this species. *Eucalycoceras underwoodi* Powell, 1963a is an obvious synonym; other material varies widely in strength of ribbing and tuberculation, as in previously described material.

Occurrence: Upper Cenomanian *Sciponoceras gracile* zone and correlatives in north-central and Trans-Pecos Texas, New Mexico, Arizona, Colorado, Kansas and Utah in the United States, and in southern England, France, Angola and Japan.

Genus TARRANTOCERAS Stephenson, 1955

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

Tarrantoceras sp. nov.

Fig. 7C, K

Material: Numerous crushed specimens from USGS Mesozoic locality D 10743.

Discussion: This species, to be described fully elsewhere, differs from *T. sellardsi* in that it has more compressed whorls with denser ribbing and retention of ventrolateral and siphonal clavi to a large diameter.

Occurrence: Upper Cenomanian *Calycoceras canitaurinum* zone in Trans-Pecos Texas, also in the basal part of the Cody Shale of northwestern Wyoming and possibly in the base of the Greenhorn Formation in the Black Hills area of western South Dakota.

Genus SUMITOMOCERAS Matsumoto, 1969

Type species: Sumitomoceras faustum Matsumoto & Muramoto, 1969, p. 283, pl. 38, figs 1–4; text-fig. 8.

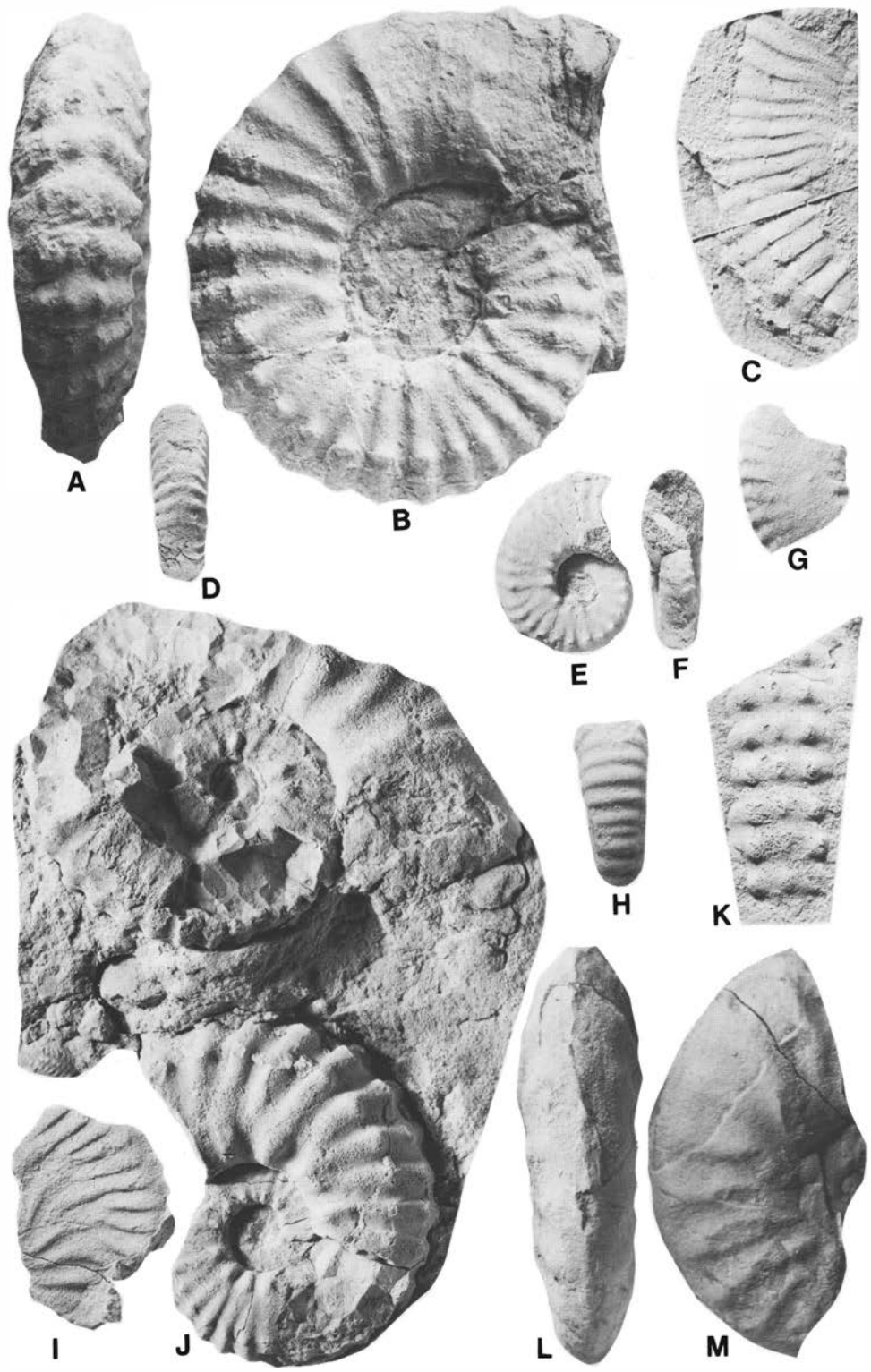
Sumitomoceras conlini (Wright & Kennedy, 1981)

Fig. 7D–F

1981 *Tarrantoceras (Sumitomoceras) conlini* Wright & Kennedy, p. 39, text-fig. 16A.
1988 *Tarrantoceras (Sumitomoceras) conlini* Wright & Kennedy, 1981; Kennedy, p. 44, pl. 6, figs 1–5, 8–13, 16, 17; text-fig. 10b.

Holotype: By monotypy, USNM 400803, from the Britton Formation, upper Cenomanian *Sciponoceras gracile* zone, east bank of creek 1/2 mile west of old Britton-Midlothian road, 2 1/2 miles south of Britton, Ellis Country, Texas.

Fig. 7. (A), (B), (J) *Pseudocalycoceras angolaense* (Spath, 1931): (A), (B) are the holotype of *Eucalycoceras underwoodi* Powell, 1963, TMM 31085, (J) is USNM 419948, from locality D 10746; both *Sciponoceras gracile* zone. (C), (K) *Tarrantoceras* sp. nov. (C) is USNM 419949, (K) is USNM 419950, both from locality D 10743, *Calycoceras canitaurinum* zone. (D), (E), (F) *Sumitomoceras conlini* (Wright & Kennedy, 1981): USNM 419951, from locality D 10746, *S. gracile* zone. (G), (H) *Sumitomoceras* sp: TMM 34028, the original of the *Metacalycoceras* (?) sp. of Adkins, 1931, pl. 2, figs. 13, 14: *S. gracile* zone presumed. (I) *Forbesiceras brundrettei* (Young, 1958): USNM 419952, from locality D 11336, *F. brundrettei* zone. (L), (M) *Budaiceras hyatti* (Shattuck, 1903): OUM KT907, *B. hyatti* zone.
All figures are natural size.


A
B
C
D
E
F
G
H
K
I
J
L
M

Material: Two specimens from the J.D. Powell Collection, by their preservation from USGS Mesozoic locality D 10746.

Discussion: The larger specimen (Fig. 7d–f) is beautifully preserved with the following dimensions: 16.8(100) 9.5(35.4) 11.2(41.8) 12.0(44.8). It matches perefectly with material from north central Texas described by Kennedy (1988) and well preserved specimens from New Mexico in the USGS collections.

Occurrence: Upper Cenomanian *Sciponoceras gracile* zone of north-central and southern Texas; also occurs in New Mexico and southeastern Colorado.

Sumitomoceras sp.

Fig. 7G, H

1931 *Metacalycoceras* (?) sp. Adkins, p. 45, pl. 2, figs 13–14.

Material: TMM 34028, Adkins original specimen, from his Unit 1.

Discussion: This fragment is very worn on the flanks but whorl section, umbilical bullae and ventral rib pattern all suggest a *Sumitomoceras,* rather coarser ribbed than typical *S. conlini* of the same size.

Genus THOMELITES Wright & Kennedy, 1973

Type species: Jeanrogericeras sornayi Thomel, 1966, p. 431, pl. 11, figs 1–3; by original designation.

Thomelites robustus sp. nov.

Fig. 8A–F, J, K

Types: Holotype is USNM 419953, paratype USNM 419954–419957, from locality D 10747. Upper Cenomanian, *Neocardioceras juddii* zone.

Description: Medium-sized, largest known specimen is 90 mm in diameter. Coiling evolute, umbilicus deep, broad for genus (35 % of diameter), with rounded, outward-inclined wall. Whorl section depressed, with costal wb:wh ratio 1.13, intercostal ratio 1.11; trapezoidal, greatest breadth low on flank or at umbilical bulla. Inner flanks strongly rounded, outer flanks flattened, convergent, concave costally. Venter broadly rounded, flattened both costally and intercostally. Inner whorls poorly preserved; septate parts of outer whorl and older part of body chamber with massive umbilical bullae, 4 or 5 per half whorl. Each gives rise to a low, broad, straight, rectiradiate rib or pair of ribs, one of which is more tenuously connected to the umbilical bulla than the other. Short intercalated ribs also present. All ribs bear weak to strong rounded inner ventrolateral tubercles and a strong, outward-directed pinched outer ventrolateral clavus. A subdued rib connects the clavi across the venter, and bears a large, rounded clavate siphonal tubercle.

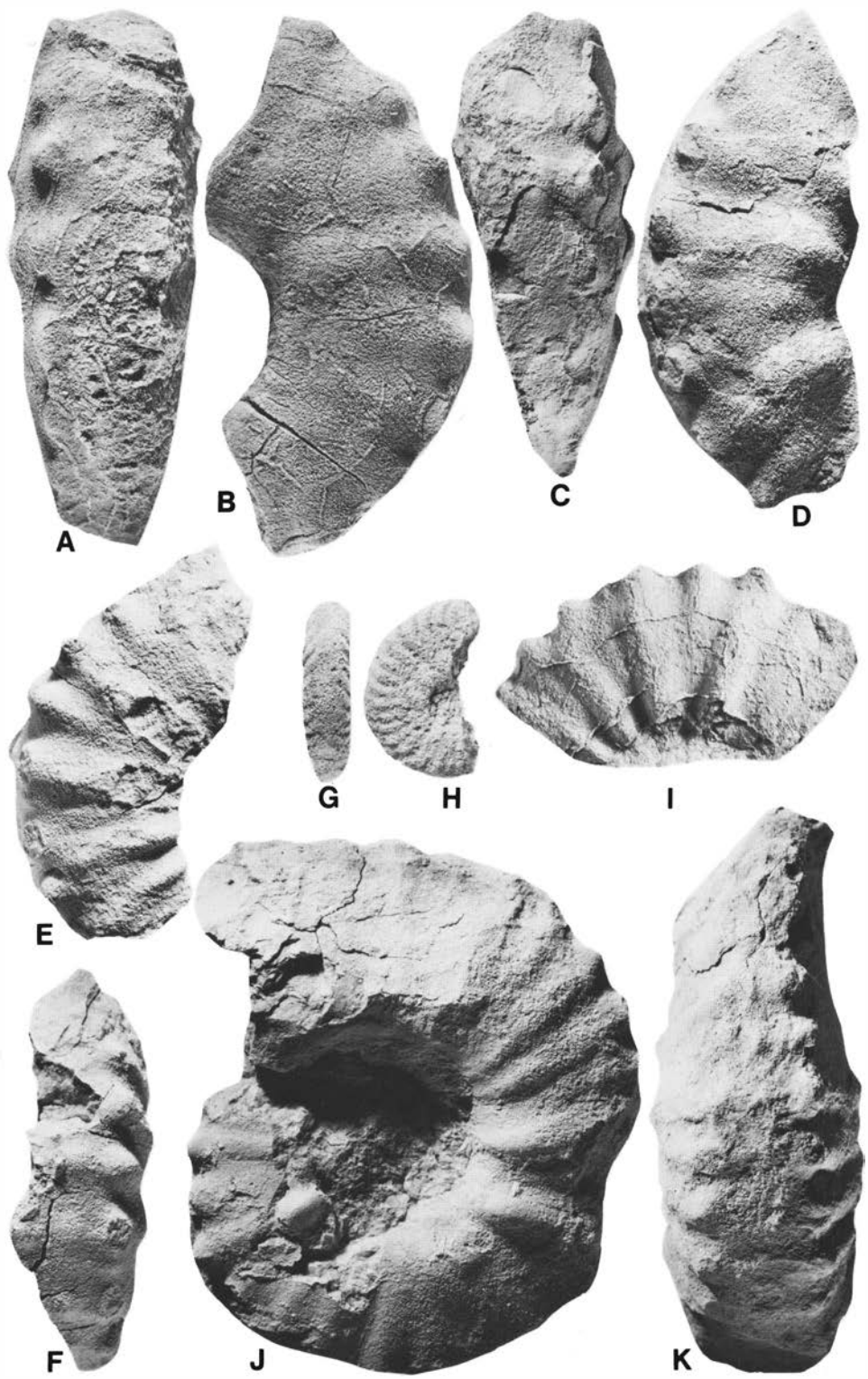
On later parts of the (mature?) body chamber umbilical bullae decline and ribs crowd, most extending to the umbilicus, with or without a feeble bulla. The venter becomes tabulate, with somewhat weakened to effaced inner ventrolateral tubercles although the outer ventrolaterals persist.

Sutures not seen.

Discussion: Thomelites robustus sp. nov. differs from contemporaneous *T. serotinus* Wright & Kennedy, 1981 (p. 40, pl. 8, figs 7, 9–16; pl. 10, fig. 19; text-figs 19M, O, R), which has parallel flanks, much finer and denser ornament with smaller umbilical bullae, and narrower, weaker and more numerous ribs that total 30–42 per whorl in middle growth. The older *Thomelites sornayi* (Thomel, 1969) (p. 431, pl. 11, figs 1–3; see Wright & Kennedy, 1973, 1981 for synonymy and illustrations of variants) is much more variable with compressed variants easily separable from the present species; depressed ones have comparable coarse ornament to *T. robustus* but umbilical bullae are stronger and spinate, and inner and outer ventrolateral tubercles are strong, particularly the inner. *Thomelites hancocki* Juignet & Kennedy, 1976 (p. 124, pl. 34, fig. 2) is more densely ribbed than both of the above species.

Occurrence: Upper Cenomanian *Neocardioceras juddii* zone in Trans-Pecos Texas.

Fig. 8. (A) – (F), (J), (K) *Thomelites robustus* sp. nov.: (A), (B) paratype USNM 419954, from locality D 10898 (C), (D) paratype USNM 419955, (E), (F) paratype USNM 419956, (I) paratype USNM 419957, (J), (K) holotype USNM 419953, all from locality D 10747, *Neocardioceras juddii* zone. (G), (H) *Hourcquia mirabilis* Collignon, 1965; USNM 414519, from locality D 11170, *Prionocyclus wyomingensis* zone, *Scaphites warreni* subzone.
All figures are x 1.


A
B
C
D
E
G
H
I
F
J
K

Genus NEOCARDIOCERAS Spath, 1926

Type species: Ammonites juddii Barrois & de Guerne, 1878, p. 46, pl. 1, figs 1, 2, by original designation.

Discussion: Neocardioceras was first described from western Europe where the type species is taken as zonal index for the uppermost named zone of the Cenomanian. It occurs at the same horizon in Texas, New Mexico, Arizona, Wyoming and Montana. The *Plesiacanthoceras wyomingense* and *Dunveganoceras pondi* zones of the Black Hills contain uncrushed specimens of a series of undescribed species of the genus; crushed specimens in shale also occur more widely in the northern part of the Western Interior. The material shows a number of common features with *"Acanthoceras" cuspidum* Stephenson, 1953 (p. 202, pl. 50, figs 1–4) such as to suggest this *wyomingense* zone species, which we believe to be a *Tarrantoceras,* is a possible ancestor. There remains, however, a gap in the record with *Neocardioceras* unknown in the *gracile* zone.

Neocardioceras juddii (Barrois & de Guerne, 1878)

Fig. 8A–F

1878 *Ammonites juddii* Barrois & de Guerne, p. 46, pl. 1, figs 1, 2.
1981 *Neocardioceras juddii juddii* (Barrois & Guerne, 1878); Wright and Kennedy, p. 49, pl. 8, fig. 1; pl. 9, figs 1–20; text-fig. 17, 1, 2; text-fig. 19, figs H, L (with full synonymy).
1981 *Neocardioceras juddii* Barrois & Guerne; Hook & Cobban, pl. 1, figs 5–8.
1986 *Neocardioceras juddii juddii* (Barrois & Guerne); Kennedy, pl. 8, figs 1–3.

Types: The original syntypes of Barrois & de Guerne (1878 pl. 1, figs 1, 2) have not been traced. They were said to be from the "Marne à *Belemnites plenus*" of Novy-Chevrières, Ardennes, France.

Material: Ten specimens from Adkins unit 1, bed 15 at locality D 10898. Upper Cenomanian *Neocardioceras juddii* zone.

Discussion: The specimens include 3 finely ribbed individuals identical to European specimens referred to the species, 2 with coarser ornament and 2 with very coarse decoration not seen in European material. Comparison with large collections of well-preserved material from New Mexico convinces us that but a single species is represented.

Occurrence: Widespread in New Mexico (Cooke Range, Big Burro Mountains, Little Burro Mountains), Black Mesa, Arizona; Tropic Shale of Utah, Frontier Formation of south-central Montana and north-central Wyoming. Also known from southern England, northern France, the German Federal Republic and Czechoslovakia.

Genus NIGERICERAS Schneegans, 1943

Type species: Nigericeras gignouxi Schneegans, 1943, p. 119, pl. 5, figs 10–15; by subsequent designation by Reyment, 1955, p. 62.

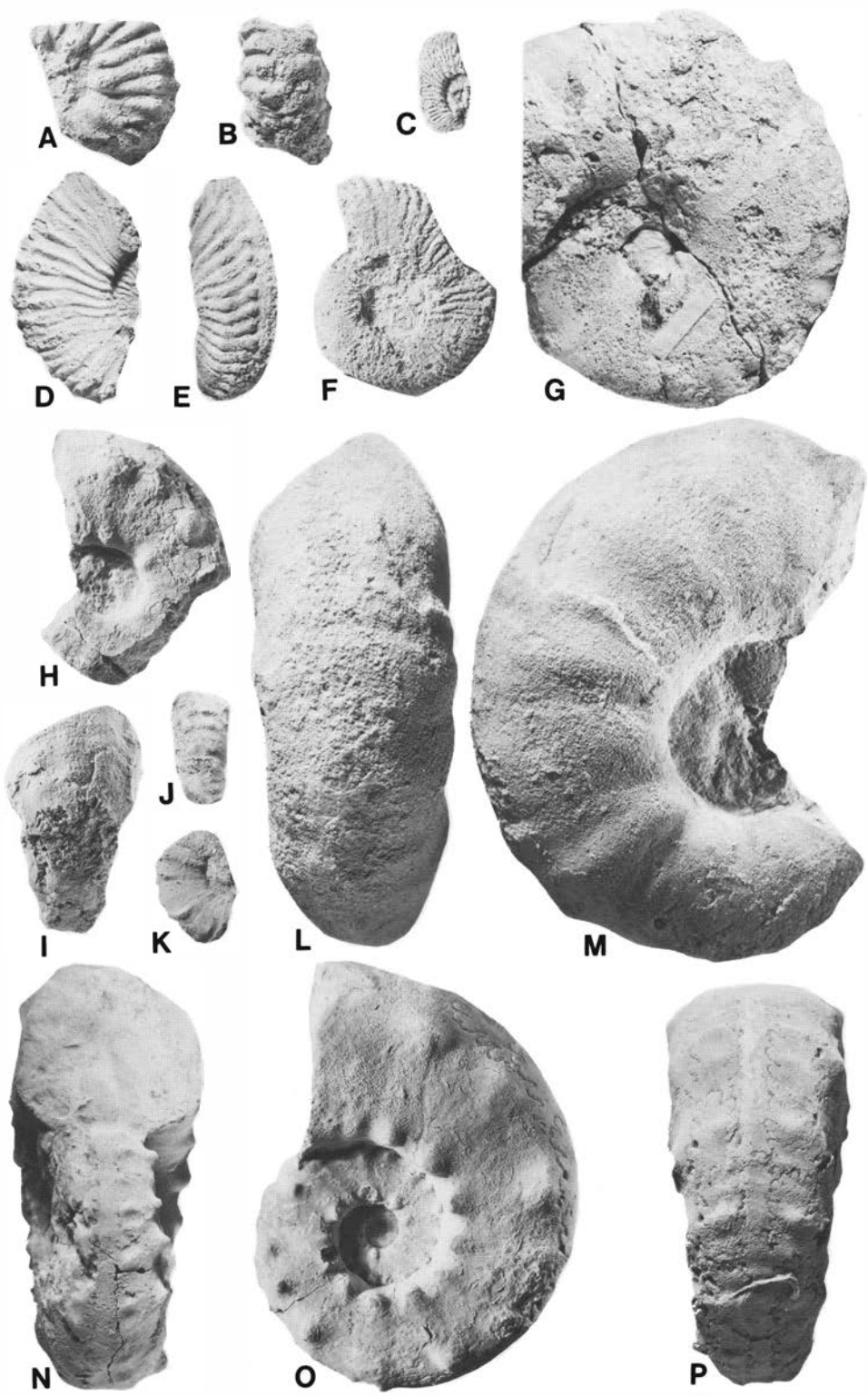
Discussion: Wright & Kennedy (1981 p. 85) followed Wright (1957) and others in referring *Nigericeras* to Vascoceratidae. We now know that *Vascoceras* occurs in the *Sciponoceras gracile* zone of both the Western Interior and northwest Europe and at the top of the *Metoicoceras mosbyense* zone in New Mexico. These occurrences pre-date the first appearance of *Nigericeras,* and the *Vascoceras* species concerned have already lost the multiply tuberculate and typically acanthoceratine inner whorls of the former genus, of which they are thus not the ancestor. We regard *Nigericeras* as Acanthoceratinae in which the loss of ornament in adults is homoeomorphous with Vascoceratinae and not an indicator of close affinity.

Nigericeras gadeni (Chudeau, 1909)

Fig. 9L, M; Fig. 11O, P

1909 *Acanthoceras? gadeni* Chudeau, p. 71, pl. 3, fig. 6.
1921 *Acanthoceras gadeni* Chudeau; Chudeau, p. 468, fig. 4.
1925 *Acanthoceras gadeni* Chudeau; Diener, p. 161.

Fig. 9. (A) – (F) *Neocardioceras juddii* (Barrois & de Guerne, 1878): (A), (B) is USNM 419958, (C) is USNM 419959, (D), is USNM 419960, (E) is USNM 419961, (F) is USNM 419962, all from loccality D 10898, *Neocardioceras juddi* zone. (G) *Vascoceras cauvini* Chudeau, 1909, USNM 419999, from locality D 10747, *Neocardioceras juddii* zone. (H) – (K), (N) – (P) *Pseudaspidoceras pseudonodosoides* (Choffat, 1898): (H), (I) are USNM 419975, from locality D 10747; (J), (K) are USNM 419976, from locality D 10898, (N) – (P) USNM 337428, from locality D 10114 in the Cooke Range, southwest New Mexico, *Neocardioceras juddii* zone. (L), (M) *Nigericeras gadeni* (Chudeau, 1909): USNM 419963, from locality D 10747, *Neocardioceras juddii* zone.
All figures are x 1.


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P

1943 *Nigericeras gignouxi* Schneegans, p. 119, pl. 5, figs 10–15; text-figs 1, 2.
1943 *Nigericeras lamberti* Schneegans, p. 21, pl. 6, figs 1–5, 7; text-figs 3–4.
1943 *Nigericeras gadeni* (Chudeau); Schneegans, p. 123, pl. 7, figs 3, 4; text-fig. 5.
1943 *Nigericeras* sp. 1 Schneegans, p. 124, pl. 6, fig. 6; text-fig. 6.
1943 *Nigericeras jacqueti* Schneegans, p. 125, pl. 6, fig. 8; text-fig. 7 *non* pl. 7, fig. 1 (= *Vascoceras cauvini* Chudeau; *fide* Schöbel, 1975).
1943 *Nigericeras* sp. 2 Schneegans, p. 126, pl. 7, fig. 2; text-fig. 8.
1975 *Nigericeras gadeni* (Chudeau); Schöbel, p. 117, pl. 6, figs 1–3 (with additional synonymy).
1981 *Nigericeras* cf. *gignouxi* Schneegans, 1943; Wright & Kennedy, p. 85, pl. 15, fig. 6.

Holotype: By monotypy, the original of Chudeau 1909, p. 71, pl. 3, fig. 6, from Damergou, Niger.

Material: One specimen (Fig. 9L, M) from locality D 10747. A second imprecisely localised specimen in the Adkins Collection, TMM 12754 also belongs here.

Description: USNM 419963 is a near-complete specimen 83 mm in diameter: Coiling moderately evolute, with 34 % of previous whorl covered. umbilicus comprises 33 % of diameter, is of moderate depth, with a rounded wall. Whorl section depressed, subreniform, with broadly rounded inner and flattened, convergent outer flanks and broadly rounded venter. Six large, blunt, low umbilical bullae of variable strength and development are present on the last half whorl. They give rise to one or a pair of low, broad, straight, prorsiradiate ribs that decline in strength as they cross the flanks and are very subdued – mere low undulations – over the venter.

Adkin's specimen (Fig. 11O, P) lacks bullae and has ribs that are weak on the inner flank but strengthen on the outer flank before weakening again over the venter. It seems to be a body chamber fragment.

Discussion: Schöbel (1975) analysed a large population of *Nigericeras* from Damergou (Niger) and concluded that *N. gignouxi, lamberti, jacqueti,* species 1 and species 2 of Schneegans (1943) were all synonyms of *gadeni.* USNM 419963 closely resembles the holotype of the species, whereas the Adkins' specimen finds a match in adult specimens such as that illustrated by Schneegans (1943, pl. 7, fig. 4).

Occurrence: Upper Cenomanian, *Neocardioceras juddii* zone of Trans-Pecos Texas. Specimens from Niger and adjacent areas are presumably of the same date. The English specimen is from a slightly lower horizon, between *juddii* and *geslinianum* zones of the English sequence.

Subfamily EUOMPHALOCERATINAE Cooper, 1978

Genus EUOMPHALOCERAS Spath, 1923

Type species: Ammonites euomphalus Sharpe, 1855, p. 31, pl. 13, fig. 4; by monotypy.

Euomphaloceras septemseriatum (Cragin, 1893)

Fig. 10A–J; Fig. 11D–I

1893 *Scaphites septem-seriatus* Cragin, p. 240.
1981 *Euomphaloceras septemseriatum* (Cragin, 1893); Wright & Kennedy, p. 55, pl. 12, figs 1–8; pl. 13, figs 1–6; pl. 14, figs 5–9 (with synonymy).
1988 *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy, p. 53; pl. 8, figs 1–6; pl. 9, figs 1–3, 5–7, 9–12; pl. 22, fig. 3; text-figs 10c, 11d (with synonymy).

Holotype: TMM 21085, from the Britton Formation, upper Cenomanian *Sciponoceras gracile* zone, Keenan's Crossing on the Trinity River, Dallas County, Texas.

Material: Numerous specimens from locality D 10746; TMM Adkins Collection and OUM KT 1044, all from the same horizon.

Discussion: Cobban & Scott (1972), Wright & Kennedy (1981) and Kennedy (1988) describe this species at length. The Chispa Summit material shows the wide intraspecific variation documented previously, and includes beautifully preserved juveniles (Fig. 10A–J) as well as larger specimens in middle growth (Fig. 11D–I).

Occurence: Upper Cenomanian *Sciponoceras gracile* zone and correlatives in Trans-Pecos and north-central Texas, New Mexico, Arizona, Colorado, Kansas, Montana, Utah and California; northern Mexico, Brazil, southern England, northern France and the German Federal Republic, Angola, Nigeria and Japan.

Euomphaloceras costatum Cobban, Hook & Kennedy, 1989

Fig. 11A–C, J–N; Fig. 12 A–H; Fig. 13A, B

1981 *Kamerunoceras* aff. *puebloense* (Cobban & Scott, 1972); Wright & Kennedy, p. 56, pl. 14, figs 3, 11.
1981 *Euomphaloceras septemseriatum* (Cragin, 1893); Wright & Kennedy, p. 55 (*pars.*), pl. 14, figs 7–9.
1989 *Euomphaloceras costatum* Cobban, Hook & Kennedy, p. 37, figs 37, 77S–EE, 78A–H.

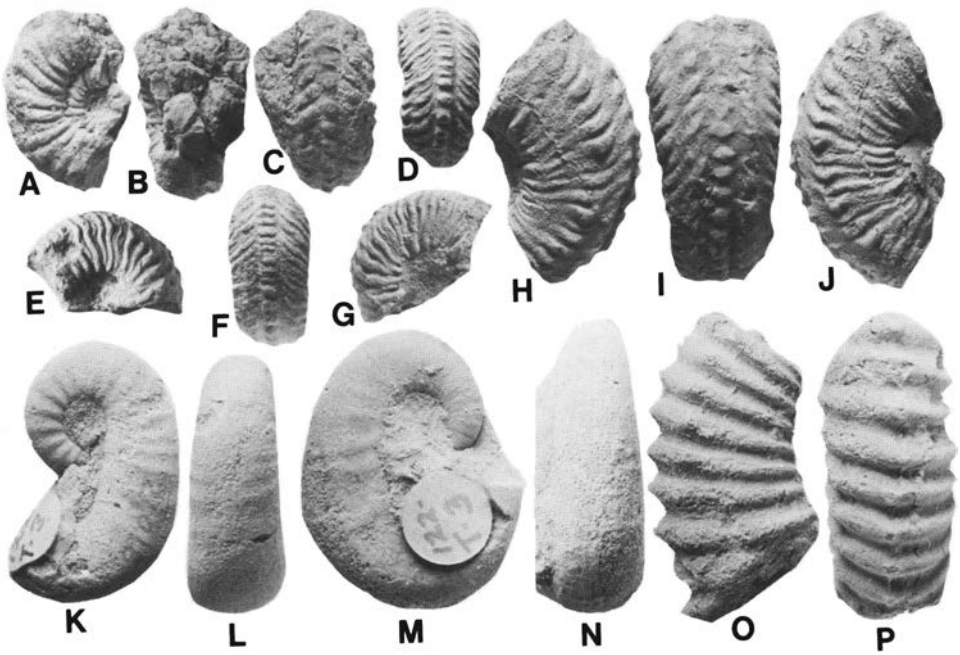


Fig. 10. (A) – (J) *Euomphaloceras septemseriatum* (Cragin, 1893): TMM, Adkins Collection, from Chispa Summit; *Sciponoceras gracile* zone inferred. (K) – (N) *Worthoceras vermiculus* (Shumard, 1860): (K), (L) are TMM 21018, a macroconch, the original of Adkins, 1931, pl. 2, fig. 11; (M), (N) are TMM 21019, also a macroconch, the original of Adkins, 1931, pl. 2, fig. 12; both from Chispa Summit, *Sciponoceras gracile* zone inferred. (O), (P) *Allocrioceras annulatum* (Shumard, 1860): TMM 35367, the original of Adkins 1931, pl. 2, fig. 8; from Chispa Summit, *Sciponoceras gracile* zone inferred.
All figures are x 2.

Types: Holotype is USNM 419966, from USGS Mesozoic locality D 10114 on the west side of the Cooke Range, Luna County, New Mexico. Paratype USNM 419967 is from the same horizon and locality. Paratypes USNM 419969 and 419974 are from USGS Mesozoic locality D 10527, Redrock Canyon, Grant County, New Mexico; paratype USNM 419971 is from USGS Mesozoic locality D 11526, Slate Creek, Grant County, New Mexico; paratypes USNM 419968, 419970, and 419972 are from USGS Mesozoic locality D 11752, Clyde Creek, Grant County, New Mexico; paratype USNM 419973 is from USGS Mesozoic locality D 10995, Slate Creek, Grant County, New Mexico. All upper Cenomanian, *Neocardioceras juddii* zone.

Material: Numerous topotypes. Fourteen specimens from Adkins' unit 1, bed 15 at Chispa Summit. All upper Cenomanian *Neocardioceras juddii* zone.

Dimensions:

	D	*Wb*	*Wh*	*Wb:Wh*	*U*
Holotype USNM 419966	44.3(100)	–(–)	16.7(37.7)	–	15.0(33.9)
Paratype USNM 419969	c 49.8(100)	20.0)40.1)	19.0(38.2)	1.05	17.2(34.5)
Paratype USNM 419971	c 93.0(100)	37.0(39.8)	37.0(39.8)	1.0	32.2(34.6)

Description: Coiling evolute with shallow dorsal impressed zone. Whorls expand slowly. Umbilicus broad, moderately deep, with subvertical wall in early growth, rounding and inclining outwards later. Whorl section varies from depressed to equidimensional in intercostal section with broadly rounded inner flanks, flattened, convergent mid- and outer flanks and a broadly rounded venter. Degree of flattening variable.

Ornament to a diameter of up to 17 mm consists of dense, crowded flexuous lirae, concave over the umbilical wall and shoulder, sweeping forwards and convex across the middle of the flanks, then sweeping forwards to cross the venter in a narrow convexity; very feeble strengthenings of ribs on the ventrolateral shoulders and over the siphonal region are incipient tubercles. In some specimens lirae strengthen to form collars to feeble constrictions, as in the holotype. As size increases lirae differentiate into dense, crowded, flexuous ribs as in USNM 419968, with development of weak inner and outer ventrolateral and siphonal tubercles. Thereafter ribbing differentiates into stronger primaries, 20–23 per whorl at a diameter of 45–50 mm, with a weak bulla just outside the umbilical shoulder from which the ribs are straight, narrow and prorsiradiate across the flank, developing a strong conical inner ventrolateral tubercle. Short ribs arise on the ventrolateral shoulder, or not, and there are numerous outer ventrolateral tubercles, 2–3 times as numerous (or more) than the inner ventrolaterals. There is a marked siphonal ridge bearing numerous small tubercles. As size increases beyond 50 mm, primary ribs differentiate into weak and strong ones with bullae of variable strength, and the inner ventrolateral tubercles develop spines that interfere with later growth. Outer ventrolateral tubercles corresponding to primary ribs become stronger than those between primaries and are opposite the inner ventrolaterals. Maturity is indicated by a decline of tubercles and crowding of ribs; specimens attain a diameter of over 150 mm.

Suture with broad bifid L (Fig. 13A, B).

Discussion: This species is abundant at Chispa Summit and is a good indicator for the topmost Cenomanian. All specimens are very poor, and for this reason we illustrate well-preserved material from New Mexico for comparison. We have debated the generic attribution of this species between ourselves at some length. The early constricted stages, coiling, whorl section and large size suggest assignment to *Kamerunoceras* Reyment, 1954, whereas the pattern of ribbing and tuberculation with outer ventrolateral and siphonal tubercles more numerous than inner, presence of inner ventrolateral spines and suture with broad L (whereas it is narrower than the E/L saddle in all later *Kamerunoceras* including the type species) ally it to *Euomphaloceras septemseriatum*. On balance we refer it to the latter genus.

Euomphaloceras costatum is easily differentiated from *E. septemseriatum* by its more evolute coiling, larger size, distinctive inner whorls and distant regular ribbing at maturity.

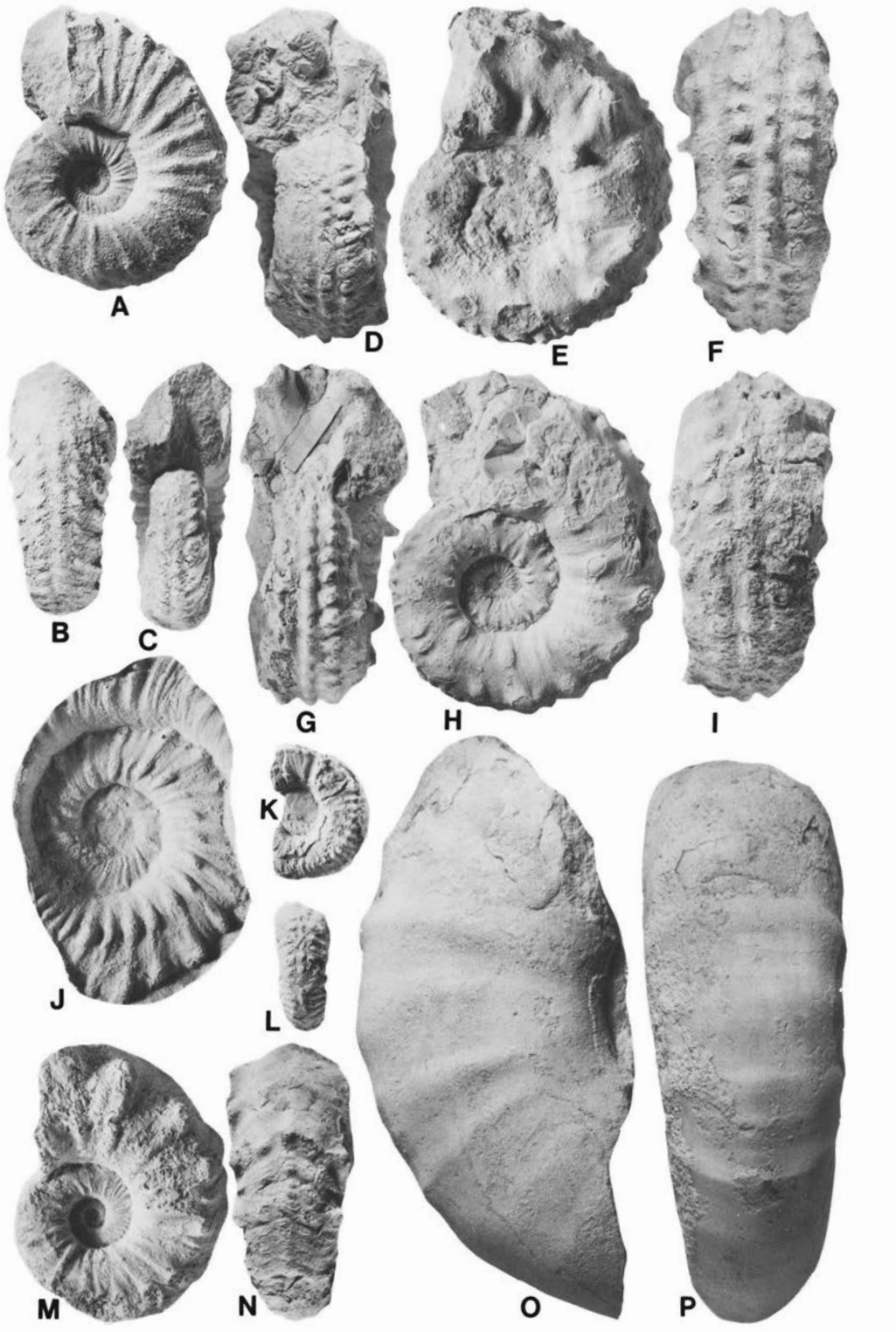
Occurrence: Upper Cenomanian *Neocardioceras juddii* zone of the Western Interior. Uppermost Cenomanian of southern England.

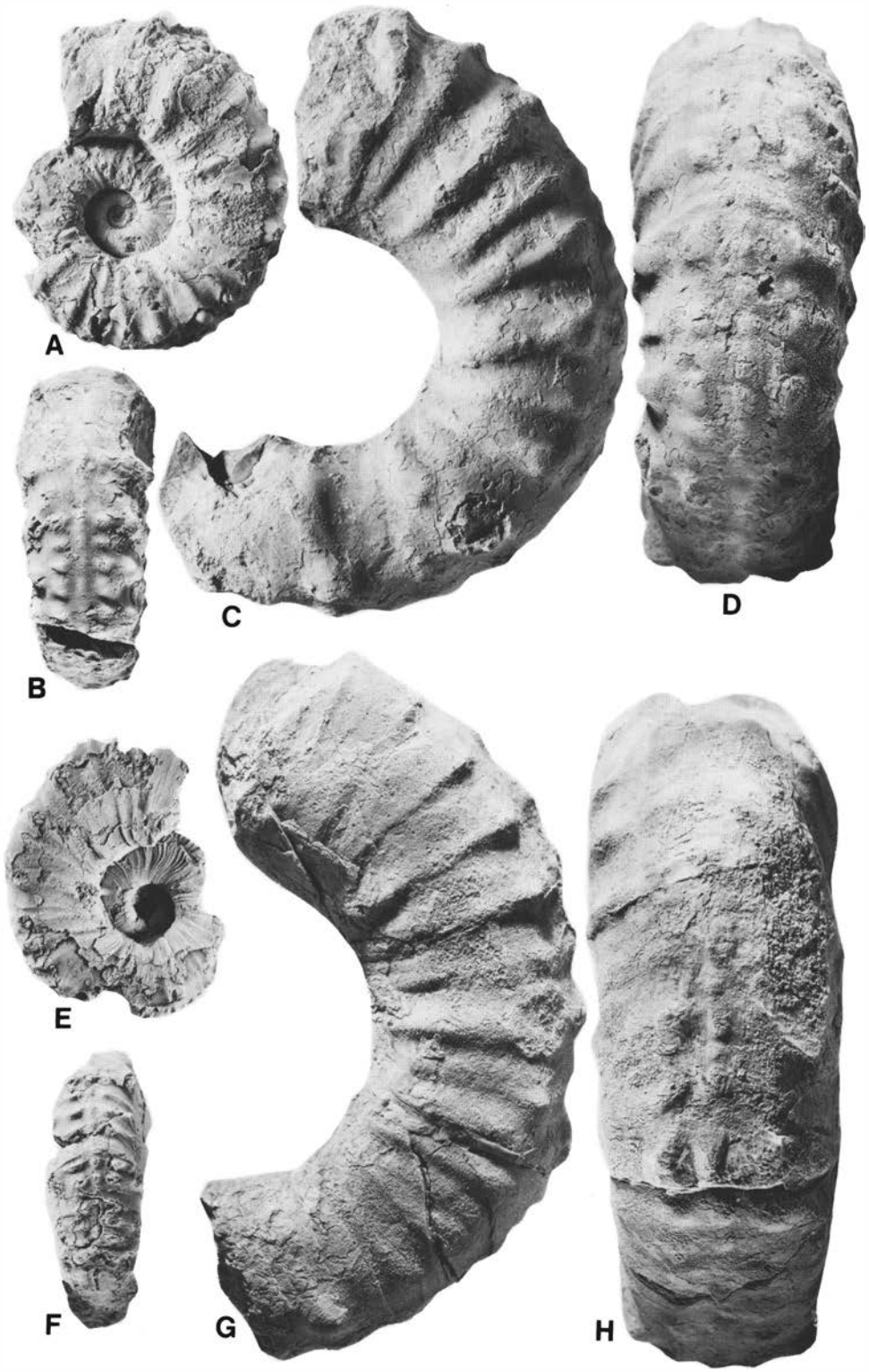
Genus PSEUDASPIDOCERAS Hyatt, 1903

Type species: Ammonites footeanus Stoliczka, 1864, p. 101, pl. 52, figs 1, 2; by original designation.

Discussion: The subfamilial assignation of the type species of *Pseudaspidoceras* presents certain problems, as discussed by Wright & Kennedy (1981, p. 82). The outer whorls of the lectotype (Stoliczka 1864, pl. 52, figs 1, 1a) and the paralectotype (pl. 52, fig. 2, 2a) resemble *Pseudaspidoceras pseudonodosoides* (Choffat, 1898) and *P. flexuosum* Powell, 1963a closely, whereas the suture of the holotype (Stoliczka, 1864, pl. 52, fig. 1c) has a very broad L. All suggest that *Pseudaspidoceras* is Euomphaloceratinae. Yet what purport to be the inner whorls of the holotype (Stoliczka, 1864, pl. 52, fig. 1b) appear typically mammitine. The last point led Kennedy, Wright & Hancock (1980c, text-fig. 9) and Wright & Kennedy (1981, p. 81) to derive *Pseudaspidoceras* from *Mammites*. We now know that the former precedes the latter, first appearing in the *juddii* zone versus the *flexuosum* zone for the first

Fig. 11. (A) – (C), (J) – (N) *Euomphaloceras costatum* sp. nov.: (A) – (C) holotype USNM 419966, from locality D 10114; (J) paratype USNM 419967, from locality D 10114 (K), (L) paratype USNM 419968; from locality D 11752; (M), (N) paratype USNM 419969, from locality D 10527. All specimens from the *Neocardioceras juddii* zone of the Cooke Range and Big Burro Mountains in southwest New Mexico. (D) – (F), (G) – (I) *Euomphaloceras septemseriatum* (Cragin, 1893): (D) – (F) are USNM 419964; (G) – (I) are USNM 419965, both from locality D 10746, *Sciponoceras gracile* zone. (O), (P) *Nigericeras gadeni* (Chudeau, 1909): TMM, W. S. Adkins Collection 12754, from Chispa Summit. All figures are x 1.


A
D
E
F
B
C
G
H
I
K
J
L
M
N
O
P


A
B
C
D
E
F
G
H

Mammites, and there are passage forms between *Kamerunoceras* and *Pseudaspidoceras pseudonodosoides* in New Mexico (USGS collections, Denver).

The weight of evidence thus suggests that *Pseudaspidoceras* is Euomphaloceratinae rather than Mammitinae. We place it in the former at this time for as Wright & Kennedy (1981, p. 82) note the apparently anomalous inner whorls of the lectotype that suggest otherwise remain to be restudied.

Pseudaspidoceras pseudonodosoides (Choffat, 1898)

Fig. 9H–K, N–P

1898 *Acanthoceras (?) pseudonodosoides* Choffat, p. 65, pl. 16, figs 5–8; pl. 22, figs 32, 33.
1912 *Mammites pseudonodosoides* Choffat; Roman, p. 12, pl. 2, fig. 2; pl. 3, fig. 2.
1969 *Pseudaspidoceras* cf. *P. pseudonodosoides* (Choffat); Freund & Raab, p. 14, pl. 1, figs 10, 11; text-figs 4j–k.
1981 *Pseudaspidoceras* n. sp. Hook & Cobban, pl. 1, figs 1–4; 9–11; pl. 2, figs 6–11; pl. 3, figs 1–4.
1983b *Pseudaspidoceras pseudonodosoides* (Choffat); Cobban & Hook, p. 37, figs 2, 3.

Lectotype: Here designated: the original of Choffat 1898 pl. 16, fig. 5; pl. 22, fig. 32, from the niveau du *Vascoceras douvillei,* Costa-d'Arnes, Portugal.

Material: Two well-preserved specimens and 13 fragments from localities D 10747 and D 10898; OUM KT 1103 from the same horizon close by.

Description: The smallest fragment (Fig. 9J, K) available has a whorl height of 8.5 mm and shows distant non-bullate primaries with prominent bullate inner ventrolateral nodes. Between are 2–3 irregularly developed secondaries, with feeble inner ventrolateral tubercles or not, all ribs having feeble outer ventrolateral clavi close to the siphonal line, where there are pronounced ventral constrictions. The smallest complete specimen before us is 40 mm diameter. Coiling is evolute, with shallow dorsal impressed zone. Umbilicus of moderate size, 29 % of diameter and quite deep. Whorls massive, with depressed, rectangular whorl section (Wb:Wh is 1.21), the greatest breadth at the inner ventrolateral tubercle in costal section and at the ventrolateral shoulder intercostally. Inner whorl flanks flattened,

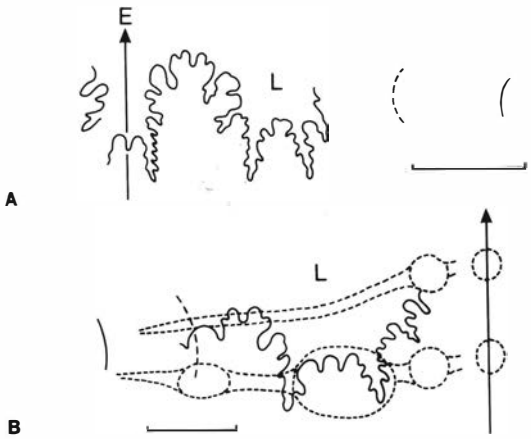


Fig. 13. (A), (B) External sutures of *Euomphaloceras costatum* sp. nov.: (A) paraptype USNM 419974; (B) paratype USNM 419973. Bar scale is 5 mm.

diverging outwards. Ventrolateral shoulders narrowly rounded, the venter broad and flattened. There are five weak, variably developed umbilical bullae per half whorl. These give rise to low, broad, straight, prorsiradiate ribs, almost effaced at midflank, while non-bullate ribs are also present between the primaries, extending low on the flank as mere striae that may reach the umbilicus. All ribs bear inner ventrolateral tubercles, borne on the ventrolateral shoulder; they are generally weak on the secondaries but strong on the primaries. Venter ill-preserved, but with a weak rib projected forwards to a small rounded ventral tubercle lying close to the siphonal line.

OUM K 1103 shows development to 60 mm. The umbilical bullae remain distant, as do the primary ribs. The inner ventrolateral tubercles are the strongest, but the venter is now broad and flat, without obvious ribs and no trace of outer ventrolateral tubercles. The primary ribs seem, in some cases, to be subdivided and to loop between tubercles; there are strong growth lirae, some approaching riblets, and irregular ventral constrictions in the interspaces. The remaining material is rather poor, but suggests the species may have attained a diameter of more than 150 mm.

Fig. 12. (A) – (H) *Euomphaloceras costatum* sp. nov.: (A), (B) paratype USNM 419970, from locality D11752; (C), (D) paratype USNM 419971, from lowerlase D 11526; (E), (F) paratype USNM 419972, from locality D 11752: (G), (H) paraptype USNM 419973, from locality D 10995. All are from the *Neocardioceras juddii* zone of the Big Burro Mountains in southwest New Mexico.
All figures are x 1.

Discussion: OUM KT 1103 is very close indeed to the lectotype (Choffat, 1898, pl. 16, fig. 5; pl. 22, fig. 32); and also resembles both the rather poor material from Israel described by Freund & Raab (1969, pl. 1, figs 10–11) and better preserved juveniles from New Mexico (Fig. 9N–P). Freund & Raab referred to *P. pseudonodosoides* a specimen from Egypt that Greco (1915, p. 208, pl. 17, fig. 5) had considered as *Mammites (Pseudaspidoceras) footeanus* (?) Stol. sp., but it shows persistent inner and outer ventrolateral tubercles to a large size, thus differing from the present species. Collignon (1965b p. 176) has renamed it *P. footei* var *grecoi.*

The early loss of all but umbilical and a single ventral tubercle, linked by distant, bar-like ribs (well-illustrated by Hook & Cobban, 1981, pl. 3, fig. 2) plus massive quadrate whorls are a highly distinctive feature of this species. The innermost whorls (Fig. 9J, K) are, however, very similar to those of *Pseudaspidoceras flexuosum* Powell, 1963a (e.g., Kennedy, Wright & Hancock, 1987, pl. 2, figs 1–4) and reference to *Pseudaspidoceras* is beyond doubt. Abundant and well-preserved material from New Mexico before us shows that middle growth stages are commonly characterised by outer ventrolateral tubercles that are more numerous than inner ventrolateral and umbilical ones, with the outer ventrolaterals on the bullate primaries stronger than those on the secondary ribs (Fig. 9N–P). Ventral ribs and constrictions are feeble. These characters show *Ammonites conciliatus* Stoliczka, 1864 (p. 99, pl. 50, fig. 4; pl. 51, fig. 1) to be a close ally, as may be *Mammites hourcqi* Collignon, 1939 (p. 82, pl. 7, figs 1, 2; text-fig. F).

Occurrence: Upper Cenomanian *Neocardioceras juddii* zone and correlatives. Widespread in New Mexico, Arizona, and Trans-Pecos Texas; also occurs in Portugal, Tunisia and Israel.

Pseudaspidoceras flexuosum Powell, 1963a

1963a *Pseudaspidoceras flexuosum* Powell, p. 318, pl. 32, figs 1, 9, 10; text-figs 2a–c, f, g.
1986 *Pseudaspidoceras flexuosum* Powell; Kennedy, pl. 11, figs 10–13.
1986 *Pseudaspidoceras flexuosum* Powell; Cobban, p. 81, fig. 9(J).
1987 *Pseudaspidoceras flexuosum* Powell, 1963; Kennedy, Wright & Hancock, p. 34. pl. 2, figs 1–4, 8–13, 16, 17; text-figs 3A–C, 5, 6C, D, 7A–C (with synonymy).

Holotype: TMM 30842, the original of Powell, 1963a, pl. 32, figs 1, 9, from the lower Turonian *Pseudaspidoceras flexuosum* zone of Dos Alamos, Chihuahua, Mexico.

Material: Numerous specimens from localities D 10899, D 10936; also OUM collections.

Discussion: The material mostly consists of large, rather badly worn body chambers of this distinctive species, revised by Kennedy, Wright & Hancock (1987).

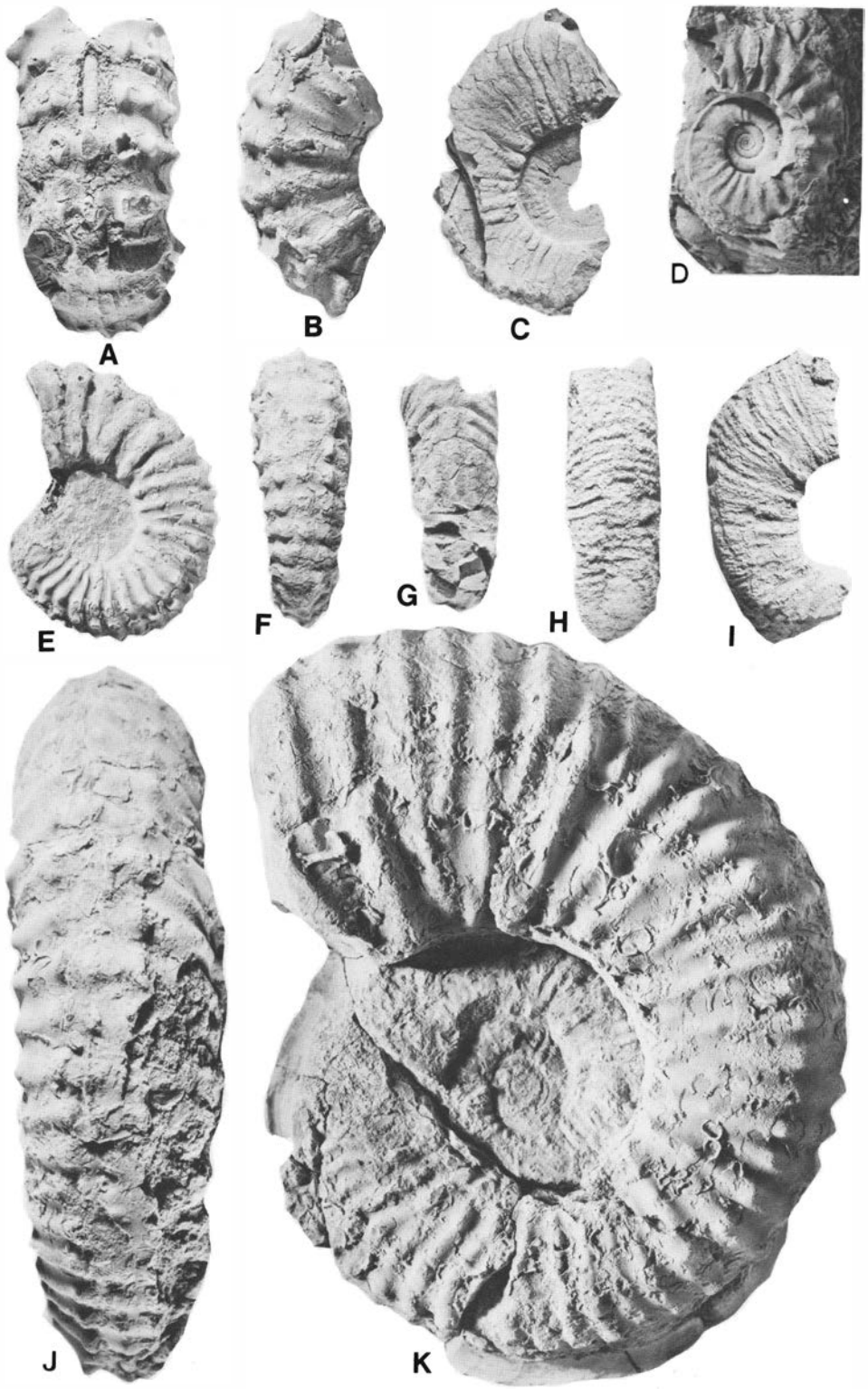
Occurrence: Lower Turonian *Pseudaspidoceras flexuosum* zone, Calvert Canyon and Grayton Lake Quadrangle, Hudspeth County, and Chispa Summit, Jeff Davis County, Texas, southwestern New Mexico, Arizona – New Mexico boundary area; northern Chihuahua. Also recorded from the lower Turonian of Czechoslovakia and Nigeria.

Genus MORROWITES Cobban & Hook, 1983a

Type species: Mammites wingi Morrow, 1935 p. 467, pl. 51, fig. 2; pl. 52, fig. 2; text-fig. 2.

Discussion: Morrowites closely resembles *Mammites* Laube & Bruder, 1887 in middle and late growth. The very early whorls are, however, highly distinctive, being smooth with periodic constructions (Cobban & Hook, 1983a, pl. 4, figs 1–3), and the suture line has a very broad bifid L rather than the very narrow L of *Mammites.* This suture style is typical of *Euomphaloceras* of Euomphaloceratinae. *Kamerunoceras* and *Romaniceras* of the Euomphaloceratinae have constricted inner whorls with tuberculate collar-ribs as in *Morrowites.* We conclude that *Morrowites* is a euomphaloceratine homoeomorph of *Mammites,* and transfer it to that subfamily.

Fig. 14. (A), (B) *Romaniceras (Yubariceras) ornatissimum* (Stoliczka, 1864): USNM 419981, from locality D 11187 *regulare* subzone of *Collignoniceras woollgari* zone. (C), (G) *Romaniceras (Romaniceras)* sp.? USNM 419979, from locality D 10753, *Prionocyclus hyatti* zone, *Coilopoceras springeri* subzone. (D), (E), (F), (J), (K) *Romaniceras (Romaniceras) mexicanum* Jones, 1938: (D) is OUM KT875: (E), (F) are USNM 419977, from locality D 10753; (J), (K) are USNM 419978, from locality D 11177, all *Prionocyclus hyatti* zone, *Coilopoceras springeri subzone.* (H), (I) *incertae sedis:* USNM 419980, from locality D 10753, *P. hyatti* zone, *C. springeri* subzone.
All figures are x 1.


A
B
C
D
E
F
G
H
I
J
K

Morrowites depressus (Powell, 1963b)

1963b *Mammites ? depressus* Powell, p. 1228, pl. 168, figs 1–3; pl. 170, figs 4, 5; pl. 171, fig. 1; text-figs 5e, 6f–h.
1983a *Morrowites depressus* (Powell); Cobban & Hook, p. 11, pl. 6, figs 1, 2; text-fig. 5 (with synonymy).
1986 *Morrowites depressus* (Powell); Cobban, p. 81, fig. 10.

Holotype: TMM 30953, the original of Powell 1963b, pl. 168, figs 2, 3, from the middle Turonian *Collignoniceras woollgari* zone fauna of Cannonball Hill, Chihuahua, Mexico.

Material: Fragments of several large individuals from locality D 10895; OUM 847–850, from the same horizon.

Discussion: This species has been fully revised by Cobban & Hook (1983a). The present material consists of fragmentary adults with whorl heights of up to 100 mm and diameters in excess of 300 mm. Massive quadrate depressed whorls readily separate it from both *Morrowites wingi* (Morrow, 1935) (see below) and *M. subdepressus* Cobban & Hook, 1983a, (p. 11, pl. 1, figs 8–13; pl. 3, figs 19, 20; pl. 4, figs 1–3, 12–16; pl. 7, text-figs 6–7).

Occurrence: Lower Turonian *Mammites nodosoides* zone of New Mexico, Gold Hill in Jeff Davis Country, and Chispa Summit. Middle Turonian *Collignoniceras woollgari* zone, *woollgari* subzone of Chihuahua, Mexico and New Mexico, Greenhorn Limestone near Pueblo, Colorado, Tropic Shale of southern Utah; and Froniter Formation near Buffalo, Wyoming.

Morrowites cf. *wingi* (Morrow, 1935)

compare:

1935 *Mammites wingi* Morrow, p. 467, pl. 51, fig. 2; pl. 52, fig. 2; text-fig. 2.
1983a *Morrowites wingi* (Morrow); Cobban and Hook, p. 9, text-figs 3, 4 (with synonymy).

Holotype: The original of Morrow 1935 pl. 52, fig. 2, from the lower Turonian *Mammites nodosoides* zone of Kansas.

Material: Several fragments from locality D 10900.

Discussion: The material is poor, but resembles specimens described by Cobban & Scott (1972, p. 79, pl. 26, figs 1–4 only; pl. 32; text-fig. 38; *non* pl. 33). *Morrowites depressus* is much larger with very depressed whorls and strong outward-directed horns, and develops looped ventral riblets at maturity. *M. subdepressus* Cobban & Hook, 1983a (p. 12, pl. 1, figs 8–13; pl. 3, figs 19, 20; pl. 4, figs 1–3, 12–16; pl. 7; text-figs 6, 7) is also depressed rather than compressed as in *Morrowites wingi.*

Occurrence: Lower Turonian *Mammites nodosoides* zone of the South Dakota, (Black Hills), southern Colorado, Kansas and New Mexico.

Genus ROMANICERAS Spath, 1923

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

Subgenus ROMANICERAS Spath, 1923

Romaniceras (Romaniceras) mexicanum Jones, 1938

Fig. 14D–F, J, K

1938 *Romaniceras mexicanum* Jones, p. 121, pl. 7, figs 1, 6.
1938 *Romaniceras adkinsi* Jones, p. 120, pl. 8, figs 4, 5.
1938 *Romaniceras santaanaense* Jones, p. 121, pl. 8, figs 1, 6.
1938 *Romaniceras toribioense* Jones, p. 122, pl. 7, figs 7, 8.
1959 *Romaniceras pseudodeverianum* (Jimbo); Matsumoto, p. 93 (*pars*).
1980a *Shuparoceras* sp. nov. Kennedy, Wright & Hancock, p. 329, text-fig. 2.
1980a *Romaniceras (Romaniceras) kallesi* (Zázvorka, 1958); Kennedy, Wright & Hancock, p. 342 (*pars*), text-fig. 6 only.
1988 *Romaniceras (Romaniceras) mexicanum* Jones, 1938; Kennedy & Cobban, p. 25, figs 2, 3, 5, 6a–d, g, 7–10.
1988 *Romaniceras (Romaniceras) mexicanum* Jones, 1938; Kennedy, p. 54, pl. 10, figs 1–4; 14–17; text-fig. 24g.

Holotype: By original designation University of Michigan Museum of Paleontology no. 16928, the original of Jones, 1938, p. 121, pl. 7, figs 1, 6, from the Turonian Indidura Formation of Coahuila, Mexico.

Material: Two specimens from localities D 10753 and D 11177; also OUM KT814, 871-876 from the same horizon.

Discussion: Kennedy & Cobban (1988) described and illustrated this species, as well as its variability and synonymy. The present material consists of two rather coarsely ribbed juveniles (Fig. 14D, E, F),

Fig. 15. Romaniceras (Yubariceras) ornatissimum (Stoliczka, 1864): TMM 35441, the holotype of *Romaniceras cumminsi* Adkins, 1931, pl. 3, figs. 5, 6, from Chispa Summit; *regulare* subzone of *Collignoniceras woollgari* zone inferred.
Reduced x 0.4, the original is 330 mm in diameter.

one of which shows the early, constricted stage (Fig. 14D) and a somewhat distorted closely ribbed specimen 115 mm (Fig. 14J, K) in diameter. Differences from other species are discussed by Kennedy & Cobban (1988).

Occurrence: Middle Turonian *Prionocyclus hyatti* zone, *Coilopoceras springeri* subzone of New Mexico and Trans-Pecos Texas; condensed zone in the Eagle Ford Group of the Austin area. The types are from Coahuila, Mexico.

Romaniceras (Romaniceras) sp.?

Fig. 14C, G

Material: One specimen, USNM 419979 from locality D 11177.

Description: Maximum preserved diameter 46 mm, part of which is body chamber. Coiling moderately evolute, with umbilicus comprising 55 % of diameter, of moderate depth, the umbilical wall flattened and subvertical. Whorl section slightly compressed (whorl breadth to height ratio 0.88), subquadrate, with parallel flanks and broadly rounded ventrolateral shoulders. Venter somewhat flattened. Ornament consisted of crowded round, flexuous, prorsiradiate ribs, broader than the interspaces. They arise from closely spaced umbilical bullae, singly or in pairs, and are accompanied by non-bullate ribs that extend to the umbilical shoulder as mere striae, and shorter intercalatories. The ribs sweep forwards from the umbilical shoulder, are feebly convex at mid-flank, and concave on the outer flank, where they sweep forwards over the ventrolateral shoulders to cross the venter in a broad convexity. All ribs bear small bullate inner and weakly clavate outer ventrolateral and siphonal tubercles.

Sutures not seen.

Discussion: This fragment, with dense, crowded flexuous ribs and no detectable lateral tubercles differs from all described Turonian Euomphaloceratinae. It most closely resembles inner whorls of *R. (R.) mexicanum* Jones, 1938, described above, and we presume it to be either an oddity in which development of lateral tubercles is supressed or delayed, or a new taxon.

Occurrence: Middle Turonian *Prionocyclus hyatti* zone of Trans-Pecos Texas.

Incertae sedis

Fig. 14H, I

Material: One specimen, USNM 419980 from locality D 10753.

Description: The specimen is crushed and distorted and some 45 mm in diameter. Coiling is moderately evolute, with umbilicus of moderate depth. Whorls expand slowly, and their original section was probably as wide as high, with flattened flanks, narrowly rounded ventrolateral shoulders and broad, flattened venter. Weak, elongate umbilical bullae give rise to strong, straight, prorsiradiate ribs, singly or in pairs. These are separated by up to four non-bullae ribs that either arise at the umbilical shoulders as mere striae or are inserted low on the flank, where a few of the primary ribs may branch. The ribs pass straight across the venter without a trace of tubercles.

Discussion: So close is this specimen to certain Jurassic and Cretaceous Perisphinctaceae that we were inclined to dismiss it as an exotic specimen brought in by a previous geological visitor to the area. Yet the preservation is identical to that of other material in the *springeri* subzone concretions at Chispa and we must presume it to be genuinely indigenous. The ribbing style shows some resemblance to *Romaniceras (Romaniceras)* sp.? described above; it may be a further new euomphaloceratine, but no more can be said without additional specimens.

Occurrence: Middle Turonian *Prionocyclus hyatti* zone of Trans-Pecos Texas.

Subgenus YUBARICERAS Matsumoto, Saito & Fukada, 1957

Type species: By original designation: *Yubariceras yubarense* Matsumoto, Saito & Fukada, 1957, p. 27, pl. 8, fig. 1; pl. 10, fig. 1; pl. 11, fig. 1; pl. 13, fig. 1; pl. 15, fig. 1; text-figs 8, 9; = *Ammonites ornatissimus* Stoliczka, 1864, p. 75, pl. 40.

Romaniceras (Yubariceras) ornatissimum (Stoliczka, 1864)

Figs 14A, B; 15A, B; 16A, B

1864 *Ammonites ornatissimus* Stoliczka, p. 75, pl. 40.
1981 *Romaniceras (Yubariceras) ornatissimum* (Stoliczka, 1864); Wright & Kennedy, p. 60, pl. 15, figs 1, 2, 4 (with synonymy).
1986 *Romaniceras (Yubariceras) ornatissimum* (Stoliczka); Kennedy, pl. 15.

Fig. 16. (A), (B) *Romaniceras (Yubariceras) ornatissimum* (Stoliczka, 1864): USNM 419982, from locality D 11177, *Prionocyclus hyatti* zone. (C), (D) *Mammites powelli* Kennedy, Wright & Hancock, 1987: USNM 419988, an adult body chamber from locality D 11183, Calvert Canyon, 6.8 km south of north line and 1.8 km east of west line of Eagle Mountains SW quadrangle, Hudspeth County, *Pseudaspidoceras flexuosum* zone.
All figures are x 1.


A
B
C
D

Fig. 17. Metoicoceras geslinianum (d'Orbigny, 1850): TMM ex. W. S. Adkins Collection 2319, the phragmocone of an adult macroconch from Chispa Summit; *Sciponoceras gracile* zone. Both figures are slightly reduced; the original is 150 mm in diameter.

Holotype: By monotypy, Geological Survey of India Collections, no. 174, the original of Stoliczka 1864, pl. 40, from the Uttatur Group of Odium, south India.

Material: Numerous specimens from the prominent hiatus concretion bed (Fig. 3), but the species ranges higher: localities D 10750, D 10751, D 10759, D 11177, D 11187; also the holotypes of *Romaniceras loboense* Adkins 1931 (p. 44, pl. 2, figs 1, 21; pl. 23, fig. 5) and *R. cumminsi* Adkins, 1931 (p. 43, pl. 3, fig. 6) and other TMM and OUM specimens.

Discussion: Kennedy, Wright & Hancock (1980a, p. 348, pl. 39, figs 1–6; pl. 40, figs 1, 3, 5; pl. 45, fig. 1; pl. 48, figs 1–4; pl. 49, figs 1–8; pl. 50, figs 1–4; text-figs 3E, 7, 8) review this species, its variation and synonyms at length. The abundant Chispa material is rather fragmentary but typical, ranging from nuclei (Fig. 14A, B), to the large near-adult holotype of *Romaniceras cumminsi,* over 330 mm in diameter (Fig. 15). Adkins (1931) recorded this species (as *R. cumminsi*) from his units 3 and 5. All our material comes from the equivalent of his unit 3; specimens he recorded from unit 5 are specimens of

R. (R.) mexicanum, described above. The holotype of *cumminsi* was referred to unit 5 by Adkins, but it is in fact from an unknown horizon and was not collected by him.

Occurrence: Middle Turonian, upper part of *Collignoniceras woollgari* zone where precisely dated in southern England, France, Czechoslovakia, Lebanon, Israel, Tunisia, Madagascar, southern India, Japan, northern Mexico, Trans-Pecos Texas and California, also low *Prionocyclus hyatti* zone at Chispa Summit.

Subfamily MAMMITINAE Hyatt, 1903

Genus METOICOCERAS Hyatt, 1903

Type species: Metoicoceras swallovi Shumard, 1860, p. 591; by subsequent designation by Shimer & Shrock 1944 p. 591.

Metoicoceras geslinianum (d'Orbigny, 1850)

Figs 17A, B; 18A–C

1841 *Ammonites catillus* d'Orbigny, p. 325, pl. 97, figs 1, 2.
1850 *Ammonites geslinianus* d'Orbigny, p. 146.
1958 *Metoicoceras* sp. Young, p. 291, pl. 40, figs 3, 8.
1981 *Metoicoceras geslinianum* (d'Orbigny, 1850); Wright & Kennedy, p. 62, pl. 17, fig. 2; pl. 18, figs 1, 2; pl. 19, figs 1, 2; pl. 20, figs 1–3; pl. 21, figs 1, 2; text-figs 19C–E; 20; 21A–D (with synonymy).
1986 *Metoicoceras geslinianum* (d'Orbigny); Kennedy, pl. 10.
1986 *Metoicoceras geslinianum* (d'Orbigny); Cobban, p. 81, fig. 3 (J) and (K).
1988 *Metoicoceras geslinianum* (d'Orbigny, 1850); Kennedy, p. 58, pl. 7, fig. 8; pl. 8, figs 25–27; pl. 10, figs 16, 17; text-figs 20–23 (with synonymy).

Lectotype: MNHP 6110, the original of d'Orbigny 1841, pl. 97, figs 1, 2, from the upper Cenomanian of northern France.

Material: Numerous specimens from locality D 10746; also TMM W.S. Adkins Collection and OUM collections. One specimen from locality D 10745.

Discussion: Early and middle growth stages are described by Cobban & Scott (1972) and Wright & Kennedy (1981). Kennedy (1988) described and illustrated the striking dimorphism shown by north-central Texan material. The present abundant material is mostly fragmentary, but includes two large macroconchs (Adkins Collection, TMM 11430, 2319) (Fig. 17A, B).

Occurrence: Upper Cenomanian *Sciponoceras gracile* zone and correlatives. Texas, New Mexico, Arizona, Colorado, Kansas, Utah and elsewhere in the Western Interior; northern Mexico, southern England, France, Spain, Germany, Czechoslovakia, Iran (?), Angola, Nigeria, and possibly, Morocco.

Genus SPATHITES Kummel & Decker, 1954

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

Spathites (Spathites) coahuilaensis (Jones, 1938)

Fig. 18D–M

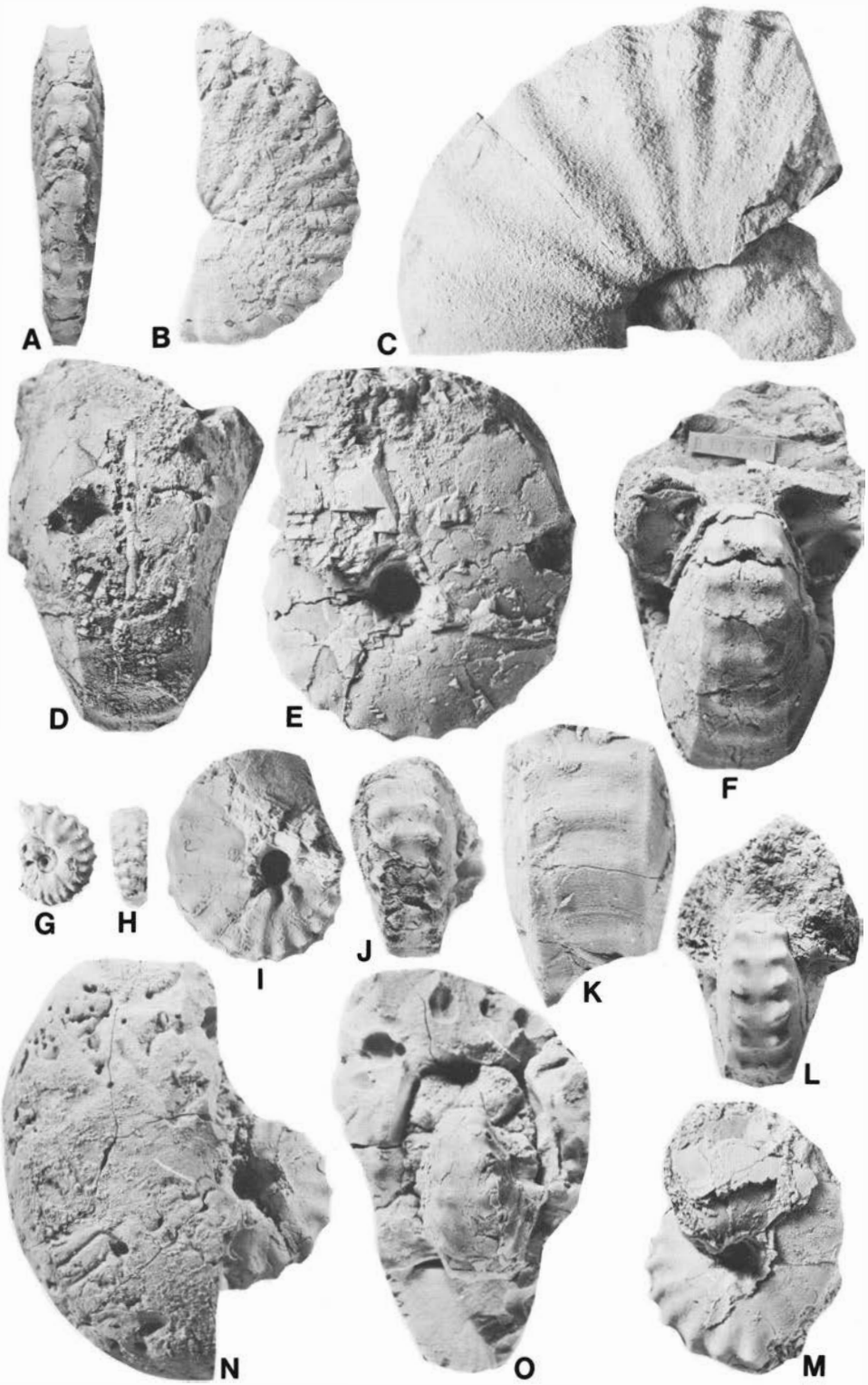
1931 *Pseudotissotia* (?) n. sp. Adkins, p. 58, pl. 2, fig. 5; pl. 4, figs 3, 6.
1938 *Pseudotissotia (?) coahuilaensis* Jones, p. 123, pl. 9, figs 1, 3, 8.
1938 *Pseudotissotia (?) kellyi* Jones, p. 124, pl. 9, figs 2, 7; pl. 10, fig. 9; *non* pl. 8, fig. 3 (= *Wrightoceras* sp.).
1954 *Spathites coahuilaensis* (Jones); Kummel & Decker, pp. 311, 312.
1954 *Spathites chispaensis* Kummel & Decker, p. 311, pl. 30, figs 1, 2; pl. 31, figs 1–15; text-fig. 1.
1954 *Spathites kellyi* (Jones); Kummel & Decker, pp. 311, 312.
1957 *Spathites chispaensis* Kummel & Decker; Wright, p. L419, text-fig. 539, 1.
1980c *Spathites chispaensis* Kummel & Decker; Kennedy, Wright & Hancock, p. 822, text-figs 1, 8b.
1988 *Spathites coahuilensis* (Jones); Cobban, p. 8, figs. 2a–n; 3p–y; 4.

Types: Holotype in UMMP 16822, the original of Jones, 1938, pl. 9, figs 1, 3, 8, from an unknown horizon in Coahuila, Mexico.

Material: Numerous specimens from locality D 10750. Also OUM KT 859, 895-6, 943.

Discussion: Kummel & Decker (1954) described and illustrated this species at length; we have examined their type series and numerous topotypes which convince us that their *chispaensis, coahuilaensis* of Jones, 1938 and *kellyi* of Jones, 1938 are conspecific. As first revising author Cobban (1988) selected *coahuilaensis* as the name for the species. The Chispa material includes both juveniles and adults, agreeing perfectly with previously described material.

Occurrence: Middle Turonian, *Collignoniceras woollgari* zone, Trans-Pecos Texas, and New Mexico; Coahuila and Chihuahua, Mexico.


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O

Spathites (Spathites) puercoensis (Herrick & Johnson, 1900a)

1900a *Buchiceras swallovi* Shumard; Herrick & Johnson, p. 39, pl. 1, figs 1, 2.
1900a *Buchiceras swallovi* Shumard var. *puercoensis* Herrick & Johnson, p. 39, pl. 1, figs 3, 4.
1900b *Buchiceras swallovi* Shumard; Herrick & Johnson, p. 213, pl. 27, figs 1, 2.
1900b *Buchiceras swallovi* Shumard var. *puercoensis* Herrick & Johnson, p. 213, pl. 27, figs 3, 4.
1968 *Spathites puercoensis* (Herrick & Johnson); Dane, Kauffman, & Cobban, p. F7.
1980c *Spathites (Spathites) puercoensis* (Herrick & Johnson); Kennedy, Wright & Hancock, p. 834, pl. 104, figs 1–5; pl. 106, fig. 3; text-fig. 8c.
1988 *Spathites puercoensis* (Herrick & Johnson); Cobban, p. 15, figs 3a–l, 9a–c, g–m; 10a–l, 11a–f, 14.
1988 *Spathites puercoensis* (Herrick & Johnson, 1900a); Kennedy, p. 70, pl. 2, fig. 15; pl. 12, figs 4–8; text-figs 24b, c; 31a.

Types: Destroyed in a fire of 1910. A neotype will be designated by Cobban when the Rio Puerco fauna that yielded the type material is revised.

Material: One specimen OUM KT 821.

Discussion: Spathites (Spathites) puercoensis is a highly distinctive species. The present specimen although poor shows the characteristic pseudoceratitic suture; the lobes are minutely denticulate, E/L bifid with few incisions, the saddles on the umbilical lobe entire in some cases.

Occurrence: Upper Turonian, *Prionocyclus hyatti* zone, *Coilopoceras springeri* subzone, Trans-Pecos Texas and New Mexico.

Genus MAMMITES Laube & Bruder, 1887

Type species: Ammonites nodosoides Schlüter, 1871, p. 19, pl. 8, figs 1–4. By monotypy.

Mammites powelli Kennedy, Wright & Hancock, 1987

Fig. 16C, D

1963a *Mammites nodosoides* (Schlotheim); Powell, p. 316, pl. 33, figs 1, 3, 4, 6, 10, 11; text-fig. 3m–o, t, u.
1978 *Mammites nodosoides* (Schlotheim); Young & Powell, pl. 2, fig. 2.
1982 *Mammites* cf. *mutabilis* Reyment; Chancellor, p. 90, figs 22, 23.
1987 *Mammites powelli* Kennedy, Wright & Hancock, p. 42, pl. 3, figs 1–14; pl. 4, figs 16, 17; text-fig. 2F, G.

Holotype: OUM KT404, the original of Kennedy et al 1987, pl. 3, figs 13 and 14; by original designation, from the lower Turonian *Pseudaspidoceras flexuosum* zone fauna of Calvert Canyon, Hudspeth County, Texas.

Material: Several specimens from locality D 10899; also from locality D 10936, in the Grayton Lake quadrangle, Hudspeth County, Texas.

Discussion: Kennedy et al (1987) had only juveniles of this species, showing the mammitine early stages. Specimens from locality D 10936 and new topotypes show the features of the adult (Fig. 16C, D). These are mature at 100–130 mm diameter. Coiling is very evolute, with U = 42.7 % with a very shallow umbilicus, the wall low and outward-inclined. The whorl section is depressed trapezoidal in intercostal section, with broadly rounded inner flank, flattened convergent outer flank, broadly rounded ventrolateral shoulder and broad flattened venter. Four strong distant umbilical bullae per half whorl are present on the last part of the adult phragmocone. These bullae give rise to broad, straight, prorsiradiate primary ribs that efface at mid-flank before strengthening once more, or not; the latter simply terminate at mid-flank. There are up to two shorter ribs between the primaries. These and the persistent primaries strengthen into conical inner ventrolateral tubercles connected by a prorsiradiate high, bar-like rib to a strong, feebly clavate outer ventrolateral tubercle. As size increases these merge progressively into a bar-like node with a smooth ventral zone between. Umbilical bullae and primary ribs end abruptly on the later part of the body chamber leaving a third of a whorl without umbilical or flank ornament: there are only feeble riblets and folds. Ribs reappear on the outer flank and strengthen into strong, conical inner ventrolateral tubercles linked to broad, bar-like prorsiradiate ribs that terminate at a feeble outer ventrolateral clavus. As the

Fig. 18. (A), (B), (C) *Metoicoceras geslinianum* (d'Orbigny, 1850): (A), (B) are USNM 419983 (C) is USNM 419984, both from locality D 10746, *Sciponoceras gracile* zone. (D) – (O) *Spathites (Spathites) coahuilensis* (Jones, 1938): (D) – (F) are USNM 419985 from locality D 10750, (G), (H) are USNM 419986 from locality D 10750, (I), (J) are USNM 419987, from locality D 10750, (K) is USNM 404339 from locality D 10751, (L), (M) are USNM 404341 from locality D 10750, (N), (O) are USNM 404336 from locality D 10751, all from the *regulare* subzone of *Collignoniceras woollgari* zone.
All figures are x 1.

adult aperture is approached, these disappear leaving a tubular terminal portion. The wide interspaces between these very distant ribs bears a weak ornament of convex growth lines and striae.

These adult features show *Mammites powelli* to be a close ally of *Mammites mohovanensis* Böse, 1920 (p. 206, pl. 12, figs 6, 8; text-fig. 4), recently revised by Chancellor (1982, p. 86, figs 2E, 8–10, 14, 16–21). The latter is a much more massive involute shell, although this might be no more than the limits of intraspecific variation. Differences from the other species are discussed by Kennedy, Wright & Hancock (1987, p. 42).

The present species is quite unlike *Mammites nodosoides* (the type species of the genus) at maturity, although inner whorls of the two are of identical style and ornament (compare Kennedy et al., 1987, pl. 3, figs 1–12 with Cobban & Hook, 1983a, pl. 4, figs 4–9, 17, 18). These similarities suggest that *Mammites nodosoides* may be a hypermorphic giant derivative of *M. powelli* and its allies on one hand, rather than being derived from *Spathites* as suggested by Kennedy, Wright & Hancock (1980c, p. 822, 833; text-fig. 9).

On the other hand, the small size and distinctive middle and late ornament of *M. powelli* and *M. mohovanensis* is so different from that of *Mammites nodosoides* that generic or subgeneric separation may be appropriate.

Occurrence: Lower Turonian, *Pseudaspidoceras flexuosum* zone of Trans-Pecos Texas; also known from northern Chihuahua, Mexico, and Novo Redondo, Angola.

Family VASCOCERATIDAE H. Douvillé, 1912

Subfamily VASCOCERATINAE H. Douvillé, 1912

Genus VASCOCERAS Choffat, 1898

Subgenus VASCOCERAS Choffat, 1898

Type species: Vascoceras gamai Choffat, 1898, p. 54, pl. 7, figs 1–4; pl. 8, fig. 1; pl. 10, fig. 2; pl. 21, figs 1–3; by original designation.

Discussion: Paravascoceras Furon, 1935, *Pachyvascoceras* Furon, 1935, *Paracanthoceras* Furon, 1935, *Broggiiceras* Benavides-Cáceres, 1956, *Discovascoceras* Collignon, 1957 and *Provascoceras* Cooper, 1979, are all regarded as synonyms of *Vascoceras.* Wright & Kennedy (1980, 1987) have recently described a series of species and subspecies of *Protacanthoceras* from a pre-*gracile* zone upper Cenomanian that are the immediate ancestors of the earliest *Vascoceras, V. (V.) diartianum* (d'Orbigny, 1850). Recent collections from the Colorado Formation of Luna County, New Mexico, extend the range of *V. diartianum.* It occurs 3 m below the base of the *gracile* zone, associated with *Eucalycoceras pentagonum* (Jukes-Browne, 1896) and *Euomphaloceras euomphalum* (Sharpe, 1855) indicating a horizon equivalent to the northwest European *Calycoceras guerangeri* zone.

Vascoceras (Vascoceras) proprium (Reyment, 1954)

Fig. 20A, B

1954 *Pachyvascoceras proprium* Reyment, p. 258, pl. 5, fig. 1; text-fig. 3d.
1986 *Vascoceras proprium* (Reyment); Kennedy, figs 10–12.
1987 *Vascoceras proprium* (Reyment); Kennedy, Wright & Hancock, p. 46, pl. 4, figs 1–15, 18, 19; pls 5–6; text-figs 8A–C, 9. (with full synonymy)

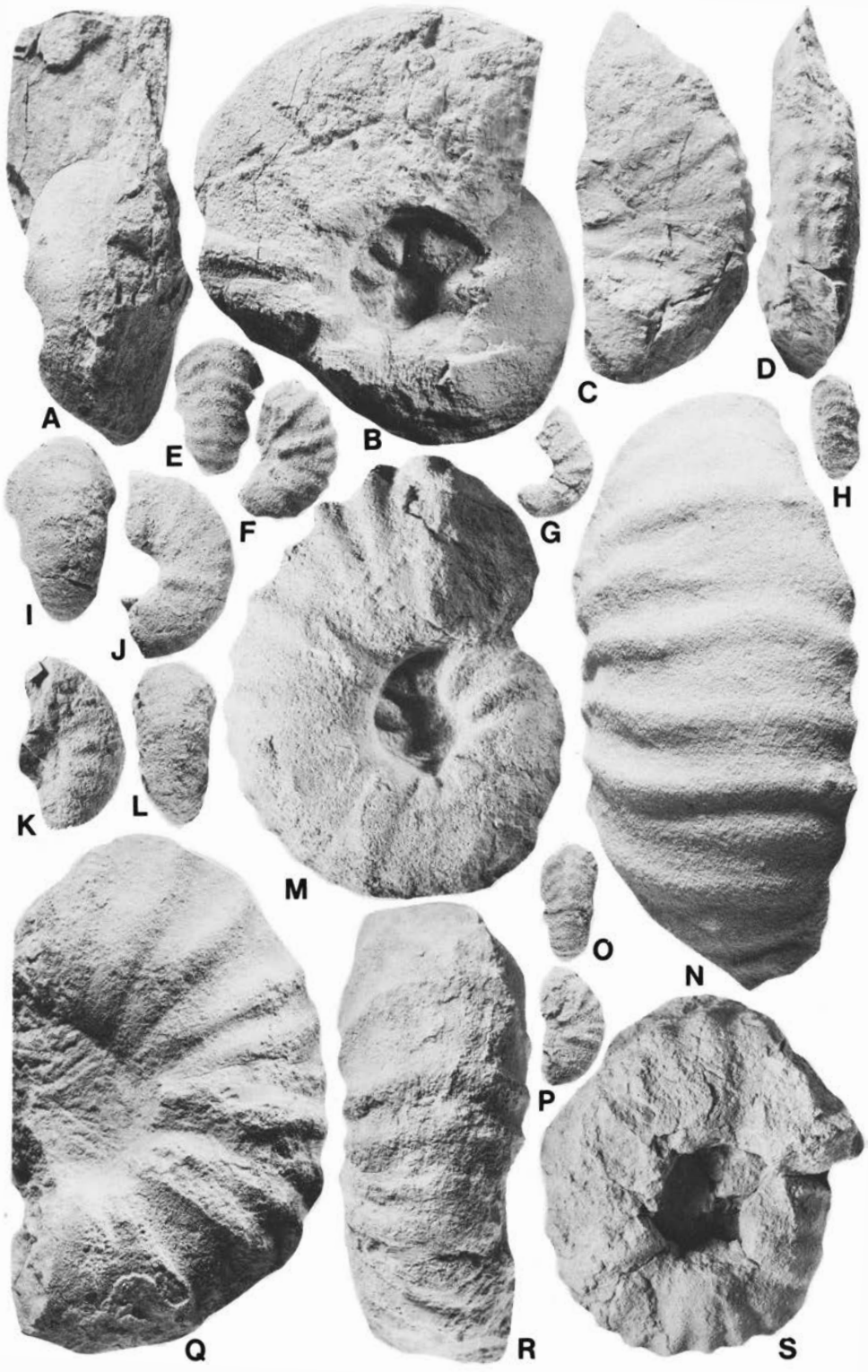
Holoptype: BMNH C47302, the original of Reyment, 1954, p. 258, pl. 5, fig. 1; text-fig. 3d; by original designation. From the lower Turonian of northern Nigeria.

Material: Numerous specimens from localities D 10893 and D 10899 and the same horizon in the Grayton Lake quadrangle, Hudspeth County, Texas.

Discussion: Kennedy, Wright & Hancock (1987) describe and discuss the variation in this species at length. The present material is typical, including both juvenile and adult specimens.

Occurrence: Lower Turonian *Pseudaspidoceras flexuosum* zone in Trans-Pecos Texas; also recorded from Chihuahua, northern Mexico and Nigeria.

Fig. 19. (A), (B), (E), – (L), (O), (P) *Vascoceras (Vascoceras) silvanense* Choffat, 1898: (A), (B) are USNM 419990; possible juveniles (E), (F) are USNM 419991, (G), (H) are USNM 419992, (I), (J) are USNM 419993, (K), (L) are USNM 419994, (O), (P) are USNM 419995, all from locality D 10747, *Neocardioceras juddii* zone. (C), (D) *Thomasites* sp: USNM 420005, from locality D 10747, *N. juddii* zone. (M), (N), (Q), (R), (S) *Thomasites koulabicus* (Kler, 1908): (M) is USNM 420001, (N) is USNM 420002, (Q), (R) are USNM 420003, (S) is USNM 420004, all from locality D 10747, *N. juddiii* zone.
All figures are x 1.


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S

Vascoceras (Vascoceras) silvanense Choffat, 1898

Fig. 19A, B, E–L, O, P

1898 *Vascoceras silvanensis* Choffat, p. 57, pl. 8, fig. 5; pl. 21, fig. 9.
1956 *Vascoceras* cf. *V. silvanense* Choffat; Benavides-Cáceres, p. 471, pl. 56, fig. 7.

Holotype: The original of Choffat, 1898, pl. 8, fig. 5; pl. 21, fig. 9; by monotypy; it is from an imprecise horizon at Silvan, west of Pampilhosa, Portugal.

Material: Eight specimens from locality D 10747. Upper Cenomanian *Neocardioceras juddii* zone.

Description: Specimens that may be juveniles of this species are 17–20 mm in diameter and very *Fagesia*-like, in that they have depressed, reniform whorl sections, with swollen inner sides converging to a broadly rounded venter. Strong to massive umbilical bullae, 4–5 per half whorl, give rise to strong, narrow, rounded prorsiradiate primary ribs that pass straight across the inner flanks and then project forwards and cross the venter in a broad convexity. One or two shorter, weaker secondaries are present between the primaries, arising high or low on the flank. Shallow constrictions follow some of the primaries.

The larger specimens have a maximum preserved diameter of 68 mm. Coiling is involute with a deep umbilicus. Because of crushing, the whorl section cannot be accurately determined; it appears to have been depressed and reniform, with the greatest breadth at the massive umbilical bullae. Seven massive conical umbilical bullae per whorl are present on the inner whorls and first half of the outer whorl. These give rise to strong lateral bulges that extend out across the flanks and decline at the ventrolateral shoulders to leave a broad, smooth, rounded venter. On the last half whorl, which appears in part to be body chamber, the bullae weaken and low ribs develop. The preservation of the best specimen is, however, imperfect at this point.

Discussion: Of described *Vascoceras* species, only *V. silvanense* has the massive whorls and massive umbilical bulges of our form. *Vascoceras bulbosum* (Reyment, 1954) (p. 263, pl. 4, fig. 2; text-figs 3g, 9; Barber 1957, pl. 6, figs 6, 8; pl. 27, figs 1–6) also has strong lateral bulges, but is a less massive shell.

Occurrence: Upper Cenomanian *Neocardioceras juddii* zone of Trans-Pecos Texas; Portugal.

Vascoceras (Vascoceras) cauvini Chudeau, 1909

Figs 9G, 20C–G

1909 *Vascoceras cauvini* Chudeau, p. 68, pl. 1, figs 1, 2; pl. 2, figs 1–3; pl. 3, figs 1, 2, 4.
1975 *Paravascoceras cauvini* (Chudeau) 1909; Schöbel, p. 119, pl. 4, figs 1–3; pl. 5, figs 1–4 (with synonymy).
1986 *Paravascoceras cauvini* (Chudeau); Zaborski, p. 727, figs 1–4.

Types: Lectotype, here designated, is the original of Chudeau, 1909, p. 68, pl. 1, fig. 1; pl. 3, fig. 1. Paratypes are the originals of Chudeau, 1909, p. 68, pl. 1, fig. 2; pl. 2, fig. 2; pl. 3, figs 1, 2, 4; all are preserved in the collections of the Muséum National d'Histoire Naturelle, Paris.

Material: Seven specimens from locality D 10747 and two from locality D 10898.

Description: The material consists of poorly preserved internal moulds that show considerable variation. The largest specimen (USNM 419999) has a diameter of 67.5 mm with an umbilical ratio of 0.28. Inner flanks are smooth and umbilical bullae are absent. low, rounded ribs arise on the outer part of the flanks and cross the venter transversely; these number 25 per whorl. A second specimen is involute with U = 18 %; its umbilicus is of moderate depth with an outward-inclined umbilical wall. The whorl section is compressed, with a whorl breadth to height ratio of 0.7. The inner flanks are flattened and the outer flanks converge to a narrowly arched venter. Inner and middle flanks are smooth; outer flank and venter are crossed by low, broad, coarse, rounded ribs. A third is even more compressed and entirely smooth.

Discussion: Comparison with a large suite of specimens from Israel (OUM collections) and the excellent account of Schöbel (1975) show these specimens to be *Vascoceras cauvini.* They particularly resemble the specimens figured by Schneegans (1943, pl. 7, fig. 1, as *Nigericeras jacqueti*) and Schöbel (1975, pl. 5, figs 1a–c to 3a–c).

Occurrence: Vascoceras cauvini is a long-ranging species; it can be dated as occurring in the equivalents of the *Sciponoceras gracile* zone in Israel by virtue of its co-occurrence there with *Metoicoceras geslinianum* (Lewy, Kennedy & Chancellor 1984, fig. 4, I) and as extending to the *Neocardioceras juddii* zone on the basis of the present occurrences. It characterises a *cauvini* zone in Israel that is equivalent to the *juddii* zone herein; it occurs in the Sinai Peninsula and the Algerian Sahara; elsewhere

Fig. 20. (A), (B) *Vascoceras (Vascoceras) proprium* (Reyment, 1954): USNM 419989, from locality D 10899. *Pseudaspidoceras flexuosum* zone. (C) – (G) *Vascoceras (Vascoceras) cauvini* (Chudeau, 1909): (C) and (D) are USNM 419996. (E) is USNM 419997. (F) and (G) are USNM 419998, all from locality D 10747. *Neocardioceras juddii* zone.
All figures are x 1.

in Africa it occurs in the southern Sudan, Niger and Nigeria. There are also records from Peru (as *Broggiiceras* species). In southwestern New Mexico *Vascoceras cauvini* characterises a zone between the *gracile* and *juddii* zones; occurrences in the last named zone are restricted to Chispa Summit, however.

Genus FAGESIA Pervinquière, 1907

Type species: Olcostephanus superstes Kossmat, 1897, p. 26, pl. 6, fig. 1; by original designation.

Discussion: Fagesia has generally been regarded as exclusively Turonian, first appearing in the *Pseudaspidoceras flexuosum* zone and extending to the *Collignoniceras woollgari* zone; note, however, that poor fragments of *Fagesia* occur in the upper Cenomanian *Neocardioceras juddii* zone in Luna County, New Mexico (Hook & Cobban, 1981, pl. 2, figs 1, 2, 5).

Fagesia catinus (Mantell, 1822)

1822 *Ammonites catinus* Mantell, p. 198, pl. 22, fig. 10 (*non* fig. 5, attributed in error; = *Ammonites navicularis*).
1986 *Fagesia catinus* (Mantell); Kennedy, pl. 12, figs 1, 2, 8, 9.
1987 *Fagesia catinus* (Mantell, 1982); Kennedy, Wright & Hancock, p. 51, pl. 7, figs 1–13; pl. 8, figs 1–4, 6–9; text-figs 2J, K, M, N, 10 (with synonymy).

Holotype: By monotypy, BMNH C3379, the original of Mantell, 1822, pl. 22, fig. 10. From the lower Turonian Middle Chalk near Lewes, Sussex.

Material: Several specimens from Adkins' unit 1 at localities D 10893 and D 10899 and the same horizon at D 10936 in the Grayton Lake Quadrangle, Hudspeth County.

Discussion: The *flexuosum* zone material corresponds to that described by Kennedy, Wright & Hancock (1987). Material from the *nodosoides* zone that is poorly preserved and indicates adult diameters in excess of 300 mm may also belong here.

Occurrence: Lower Turonian of Trans-Pecos Texas, Montana and California; northern Mexico, southern England, France and Venezuela. The upper Cenomanian *Neocardioceras juddii* zone material from New Mexico seems to belong here.

Genus NEOPTYCHITES Kossmat, 1895

Type species: Ammonites telinga Stoliczka, 1865, p. 124, pl. 61, figs 1, 2; by original designation = *Ammonites cephalotus* Courtiller, 1860 p. 248, pl. 2, figs 1–4.

Neoptychites cf. *cephalotus* (Courtiller, 1860)

compare

1860 *Ammonites cephalotus* Courtiller, p. 248, pl. 2, figs 1–4.
1979 *Ammonites cephalotus* (Courtiller); Kennedy & Wright, p. 670, pl. 82, figs 3–5; pl. 83, figs 1–3; pl. 84, fig. 3; pl. 85, figs 1–5; pl. 86, figs 5–6; text-fig. 2 (with synonymy).
1983a *Neoptychites cephalotus* (Courtiller); Cobban & Hook, p. 14, pl. 3, figs 9–11; pls 9–12; text-fig. 11.

Lectotype: The original of Courtiller, 1860, pl. 2, figs 1, 2, is in the collections of the Château de Saumur, Maine-et-Loire, France. Designated by Kennedy & Wright, 1979, p. 674, the type is from the middle Turonian of the environs of Saumur, France.

Material: One specimen from locality D 10899. Lower Turonian *Pseudaspidoceras flexuosum* zone.

Discussion: The specimen (USNM 420000) consists of a quarter of a whorl that has a compressed, oval section at a whorl height of 35 mm. The shell surface is smooth except for broad constrictions flanked by collar ribs. The specimen closely resembles the variant of *N. cephalotus* figured by Cobban & Hook (1983a, pl. 3, fig. 10), although poor preservation precludes firm reference to the species.

Subfamily PSEUDOTISSOTINAE Hyatt, 1903

Genus THOMASITES Pervinquière, 1907

Type species: Pachydiscus rollandi Peron, 1889, p. 25, pl. 27, figs 1–3; by original designation.

Thomasites koulabicus (Kler, 1908)

Fig. 19M, N, Q–S

1908 *Pseudotissotia koulabica* Kler, p. 157, pls 6, 7; pl. 8, fig. 1.
1954 *Gombeoceras koulabicum* Kler; Reyment, p. 69.
1958 *Thomasites koulabicus* (Kler); Luppov & Drushchhits, p. 124, pl. 61, figs 3a, 3b; text-fig. 99b.
1969 *Gombeoceras (Ferganites) koulabicum* (Kler); Stankevich & Pojarkova, p. 94, pl. 2, fig. 3; pl. 3, fig. 1.

1983 *Thomasites koulabicus* (Kler); Yan Heng-Ren et al., pl. 1, figs 4–6.
1987 *Thomasites koulabicus* (Kler, 1909); Zaborski, p. 48, figs 33a–c.

Holotype: The original of Kler, 1908, pl. 1, fig. 2, from the so-called "lower Turonian" of Turkestan in the USSR.

Material: Eight specimens from locality D 10747 and D 110898.

Description: Coiling moderately involute with U = 18 % in middle growth. Whorl section depressed with greatest breadth at umbilical bullae or low on flank. Whorl sides strongly inflated and venter broadly rounded. There are five massive umbilical bullae per half whorl at 50–60 mm diameter. These give rise to groups of 2 or 3 coarse, blunt, straight prorsiradiate ribs, while 1 or 2 shorter intercalatories arise around mid-flank. All ribs show a marked angulation and blunt ventrolateral tubercles from which the ribs pass straight across the venter which is fastigiate in costal section with a blunt siphonal node. The massive bullae generally decline in strength from 70 mm onwards, with bullate and non-bullate primary ribs and shorter intercalatories. With increasing diameter, the relative proportions modify, the coiling becoming more evolute and the whorls only slightly broader than high. The largest specimen (Fig. 19N) shows strengthening of ventral ribbing with a rounding of the venter, a trace of a ventrolateral node, but loss of the siphonal one.

Discussion: These specimens, although poor show a comparable ornament, coiling and ontogeny to the type material of *Pseudotissotia koulabica.* Small specimens compare well with the holotype (Kler 1908, pl. 6, fig. 2; Stankevich & Pojarkova, 1969, pl. 2, fig. 3), and our larger specimens agree with the larger paratype (Kler, 1908, pl. 7, fig. 1). The relationship between *T. koulabicus* and other species is discussed by Reyment (1954) and Wright & Kennedy (1981). Ornament is in general significantly coarser than in Nigerian species of the genus. *Gombeoceras (Ferganites) kanicum* Stankevich & Pojarkova, 1969 (p. 95, pl. 3, fig. 2) and *G. (F.) kleri* Luppov *in* Stankevich & Pojarkova, 1969 (p. 96, pl. 4, figs 1–3) may well be no more that variants of this species, a view supported by Zaborski (1987).

Apart from the cited specimens numerous other fragments from the same horizon at Chispa Summit may belong here.

Occurrence: Upper Cenomanian *Neocardioceras juddii* zone in Trans-Pecos Texas. The types are from what we presume to be the same horizon in Turkestan, and Yan Heng-Ren et al. (1983) illustrated a specimen from the upper member of the Kukebai Formation in the Western Tarim Basin, south Xinjiang, China. The single Nigerian specimen (Zaborski, 1987) is from either the Upper Cenomanian or Lower Turonian.

Thomasites sp.

Fig. 19C, D

Material: One specimen (USNM 420005) from Adkins' unit 1 at locality D 10747. Upper Cenomanian, *Neocardioceras juddii* zone.

Discussion: This crushed fragment appears to have come from a rather involute species. The flanks are ornamented by feeble umbilical bullae and irregular low, broad, crowded ribs, both primaries and secondaries. The venter is narrow and flattened, with a blunt lateral keel on each side bearing low clavi that correspond to the ends of the ribs. A shallow groove separates these from a siphonal ridge that also bears blunt clavi. The specimen is specifically indeterminate but of interest as a second instance of co-occurring *Neocardioceras* and *Thomasites,* previously noted in southern England (Wright & Kennedy, 1981, pp. 99 et seq.).

Thomasites sp.?

Material: Five poorly preserved specimens from locality D 10747.

Discussion: Coiling is evolute, with broad, depressed rounded-trapezoidal whorl section. Ornament consists of coarse, distant bullate primary ribs alternating with weaker, shorter intercalated ribs. There are variably developed weak oblique ventral tubercles on either side of the flattened venter, across which they are linked by a weak rib that may bear a weak siphonal tubercle.

Occurrence: Upper Cenomanian, *Neocardioceras juddii* zone.

Subfamily HOURCQUIINAE Renz, 1982

Genus HOURCQUIA Collignon, 1965a

Type species: Hourcquia mirabilis Collignon, 1965a, p. 77, pl. 411, fig. 1703; pl. 413, fig. 1709.

Hourcquia mirabilis Collignon, 1965a

Fig. 8G, H

compare:

1965a *Hourcquia mirabilis* Collignon, p. 77, pl. 411, fig. 1703; pl. 413, fig. 1709.
1965a *Hourcquia ingens* Collignon, p. 80, pl. 412, figs 1704–1706; pl. 463, fig. 1708.
1965a *Hourcquia ingens* var. *antsakoazatensis* Collignon, p. 82, pl. 413, fig. 1710.
1981 *Horcquia* cf. *ingens* Collignon; Obata *et al.*, pl. 2, fig. 2.
1982 *Hourcquia ingens* Collignon, 1965; Matsumoto & Obata, p. 79, pl. 4, fig. 2.

Material: A single fragment (USNM 414519) from locality D 11170, and an impression (USNM 414520) in calcarenite from the same stratigraphic position at a nearby locality (D 11188).

Discussion: One specimen (Fig. 8G, H) is a poorly-preserved composite internal mould 28 mm in diameter. Coiling is involute, the small umbilicus comprising 25 % of the diameter. The whorl section is compressed, with a whorl breadth to height ratio of 0.67. The sides are flattened, the ventrolateral shoulders are rounded, and the venter is fastigiate-carinate. Umblical bullae give rise to groups of low, broad, falcoid ribs, and there are occasional shorter intercalatories. All ribs sweep forward across the ventrolateral shoulder and terminate in blunt clavi on either side of the rounded siphonal ridge.

The specimen compares closely with the compressed *Hourcquia ingens* Collignon, 1965a (p. 80, pl. 412, figs 1704–1706) from Antsakoazato (Belo-sur-Tsiribihina), Madagascar. This co-occurs with the type species, *H. mirabilis* (Collignon, 1965a, p. 77, pl. 411, fig. 1703; pl. 413, fig. 1709) of which it is no more than a variant, as is *H. ingens antsakoazatensis* Collignon, 1965a (p. 81, pl. 413, figs 1707, 1710).

Occurrence: In the United States *Hourcquia* is known from the present specimens and six others from the upper Turonian zones of *Prionocyclus macombi* and *P. wyomingensis* at various localities in New Mexico and at two localities in Trans-Pecos Texas. The types are from Madagascar.

Family COLLIGNONICERATIDAE Wright & Wright, 1951

Subfamily COLLIGNONICERATINAE Wright & Wright, 1951

Genus COLLIGNONICERAS Breistroffer, 1947

Type species: Ammonites woollgari Mantell, 1822, p. 197, pl. 21, fig. 16; pl. 22, fig. 7; by original designation by Meek, 1876, p. 453 as type species of

Prionotropis Meek, 1876 (non Fieber, 1853) for which Breistroffer (1947, unpaged) proposed *Collignoniceras* as *nomen novum.*

Collignoniceras woollgari woollgari (Mantell, 1822)

Figs 24A–C, H–L

1822 *Ammonites woollgari* Mantell, p. 197, pl. 21, fig. 16; pl. 22, fig. 7.
1979 *Collignoniceras woollgari woollgari* (Mantell); Cobban & Hook, p. 21, pl. 1, figs 1–11; pl. 2, figs 5–22; pl. 4, figs 11, 12; pl. 5, figs 13–16; pl. 12, figs 1, 2 (with synonymy).

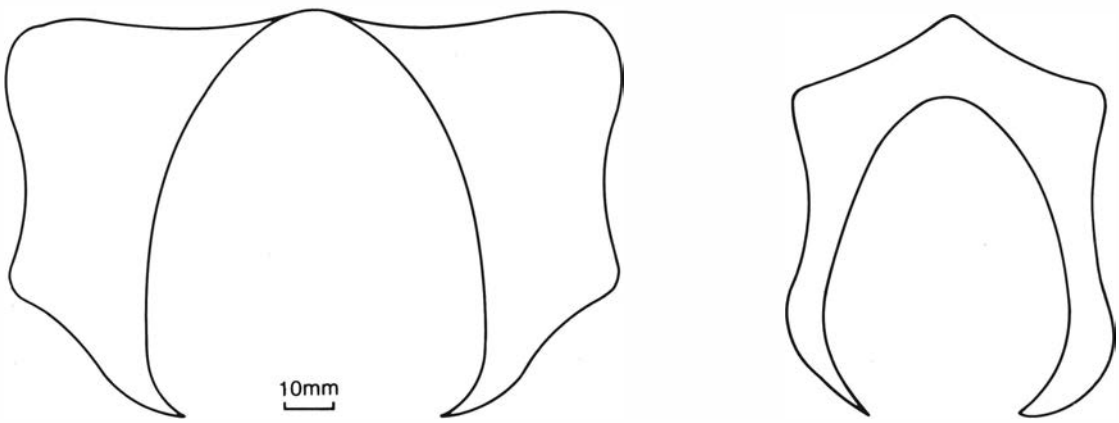


Fig. 21. Adult apertural sections of (A) macroconch (USNM 420012) and (B) microconch (OUM KT 951) of *Collignoniceras woollgari* (Mantell, 1822) *regulare* Haas, 1946.
Bar scale is 10 mm.

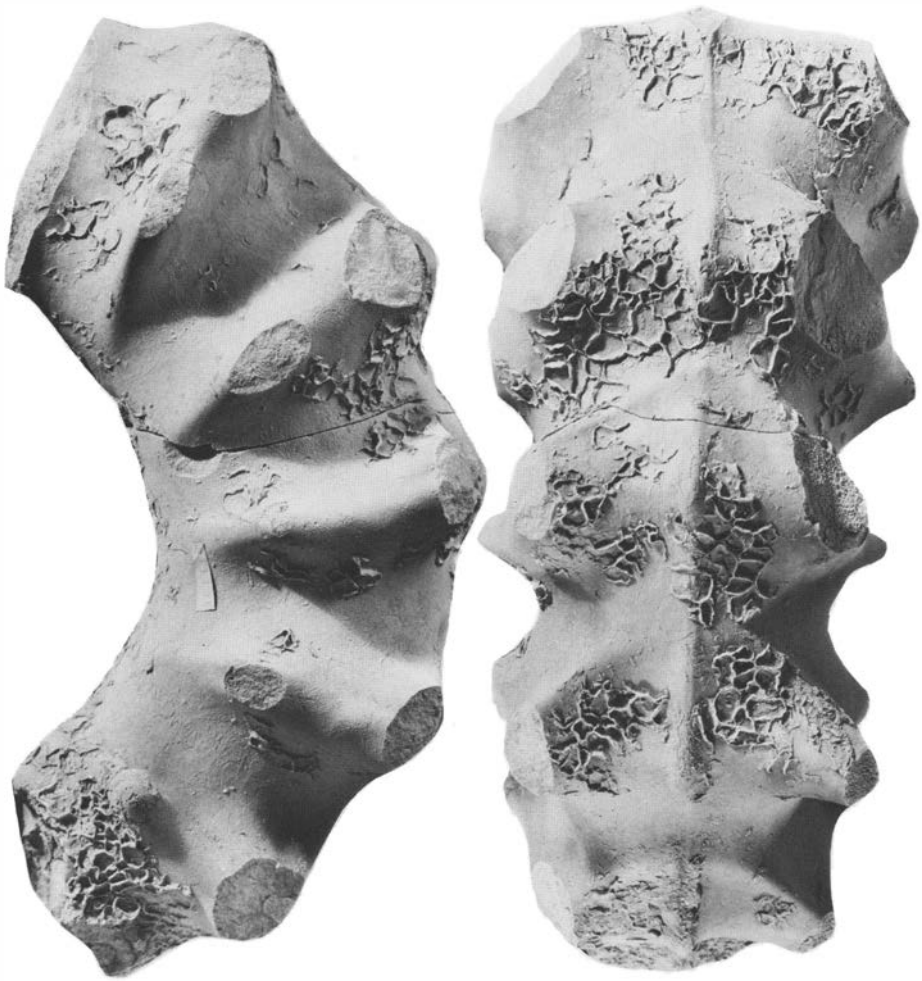


Fig. 22. Collignoniceras woollgari (Mantell, 1822 *regulare* Haas, 1946: USNM 420012, from locality D 11186, *regulare* subzone of *C. woollgari* zone. Reduced x 0.75.

1980b *Collignoniceras woollgari* (Mantell); Kennedy, Wright & Hancock, p. 560 (*pars*), pls 62, 63, figs 1–4, 7–9, 11, 12 *non* 5–6; pl. 64; pl. 65, figs 1–3; *non* 4–8; *non* pls 66, 67; *non* pl. 69, figs. 3, 4; *non* pl. 71, figs. 1–3; *non* text-fig. 1A; text-fig. 2; ? 3; 4C–D *non* A–B.

1981 *Collignoniceras woollgari* (Mantell, 1822); Wright & Kennedy, p. 103, pl. 28, fig. 3; *non* 1, 2; pl. 29, fig. 5; *non* 1–4, 6, 7; pl. 30, fig. 1.

1986 *Collignoniceras woollgari woollgari* (Mantell); Cobban, p. 81, figs 6J, K, 7K, L.

1986 *Collignoniceras woollgari* (Mantell); Kennedy, pl. 13, figs 1–3; pl. 16, figs 1, 2.

Types: Lectotype, by the subsequent designation of Wright & Wright, 1951, p. 35, is BMNH 5682, the original of Mantell, 1822, pl. 21, fig. 16. There are also two presumed paralectotypes, BMNH C5742a and b. All are from the middle Turonian Middle Chalk of Lewes, Sussex.

Material: One specimen (Figure 24L) from Adkins' unit 2 at locality D 11209, 18.25 m (60 feet) below the hiatus concretion bed in unit 3. We have also examined numerous specimens from Cannonball Hill, Chihuahua, Mexico in connection with this study (OUM and J. D. Powell Collections).

Discussion: The present material confirms the presence of both early *C. woollgari woollgari* and late *C. woollgari regulare* Haas, 1946 in trans-Pecos Texas. The former have middle and late growth stages characterised by secondary ribs, more siphonal tubercles than ventral ones and looped ribs connect-

Fig. 23. Collignoniceras woollgari (Mantell, 1822) *regulare* (Haas, 1946): OUM KT951, from the *regulare* subzone of the *C. woollgari woollgari* zone.
Reduced x 0.7. the original is 180 mm long.

ing ventrolateral horns, a feature well seen in the Mexican material (examples are shown as Fig. 24A–C, H–K). In contrast, subspecies *regulare* generally lacks these features in middle growth. Adult body chambers of the two subspecies are, however, near inseparable in some cases.

Occurrence: Middle Turonian, lower subzone of *C. woollgari* zone. Widespread in the United States from the Mexican border to Wyoming; California, northern Mexico, Europe, the USSR west to Transcaspia, Japan and northern Australia.

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

Figs 21, 22, 23, 24D

1946 *Prionotropis woollgari* var. *regularis* Haas, p. 154, pl. 16, figs 1–17; text-figs 10–12, 59–74, 78, 80, 81, 83.
1979 *Collignoniceras woollgari regulare* Haas; Cobban and Hook, p. 22, pl. 3, figs 1–14; pl. 12, fig. 3.

Holotype: By original designation: the original of Haas, 1946, p. 154, pl. 16, figs 14, 16; text-figs 80, 81, South Dakota School of Mines Collection no. 1470. "Probably from the Carlile Formation, Black Hills area" (*fide* Haas).

Material: Numerous specimens from the level of the hiatus concretion bed or collected loose: USGS Mesozoic localities D 10750, D 11178, D 11175, D 11187; also OUM collections. The holotype of *Pseudaspidoceras chispaense* Adkins, 1931, TMM 34088 and *Pseudaspidoceras* (?) n. sp. A of Adkins (1931, p. 3, pl. 3, figs 3, 4) also belong here.

Discussion: C. woollgari regulare differs from the nominate subspecies, discussed above, in the absence of secondary ribs and in having siphonal and ventrolateral tubercles that are equal in number in middle growth. In addition, ribs are higher and sparser on *C. w. regulare.* This is well shown by excellent specimens from the Black Hills figured by Cobban & Hook (1979, pl. 3, figs 1–14 and pl. 12, fig. 3), who show these ribs extending onto the body chamber of an individual 140 mm in diameter. The Chispa material extends to a much greater size and includes adult body chambers that are up to 360 mm in diameter such as the giant fragments figured by Adkins (1931). Two forms of adult occur. The smaller (Fig. 23) have a distinctly compressed whorl section, oval intercostally (Fig. 21B). Strong distant primary ribs have flared umbilical bullae that migrate out at maturity and ventrolateral horns that may retain a trace of the outer ventrolateral clavus linked by a high, flared, prorsiradiate rib to an angular culmination with a pronounced clavus, the clavi commonly linked by a siphonal ridge. These we take to be microconchs. The larger (Fig. 22) have a much more robust oval whorl section, as wide as high at the beginning of the body chamber but becoming compressed at the adult aperture (Fig. 21A); we take them to be macroconchs. The distant ribs are coarser and lower than in the microconch, although they also migrate out to a mid-lateral position at maturity. The ventrolateral horns point out at the beginning of the adult body chamber with a persistent outer ventrolateral clavus that merges towards the adult aperture to give a costal whorl section much broader than high with a broad, flattened venter. Ventral ornament consists of a siphonal ridge that strengthens opposite the horns with one or sometimes two distinct clavi. Low broad ribs extend from the adapertural and adapical limits of the horns and loop to these clavi (Adkins, 1931, pl. 3, fig. 2).

Both micro- and macroconchs have a short tubular terminal part to the body chamber, without major ribs or tubercles.

Discussion: Medium-sized specimens of *C. w. woollgari* and *C. w. regulare* are utterly distinct. At maturity there is the same type of dimorphism, but some *regulare* adult body chambers that we have seen have a siphonal ridge, siphonal tubercles more numerous than ventrolateral ones and looped ventral ribs such that these body chambers are inseparable from *C. woollgari woollgari.*

Occurrence: Middle Turonian *C. woollgari* zone, *regulare* subzone. Widespread in the Western Interior from Wyoming to the Mexican border. The subspecies also occurs in western Europe.

Genus *PRIONOCYCLUS* Meek, 1871

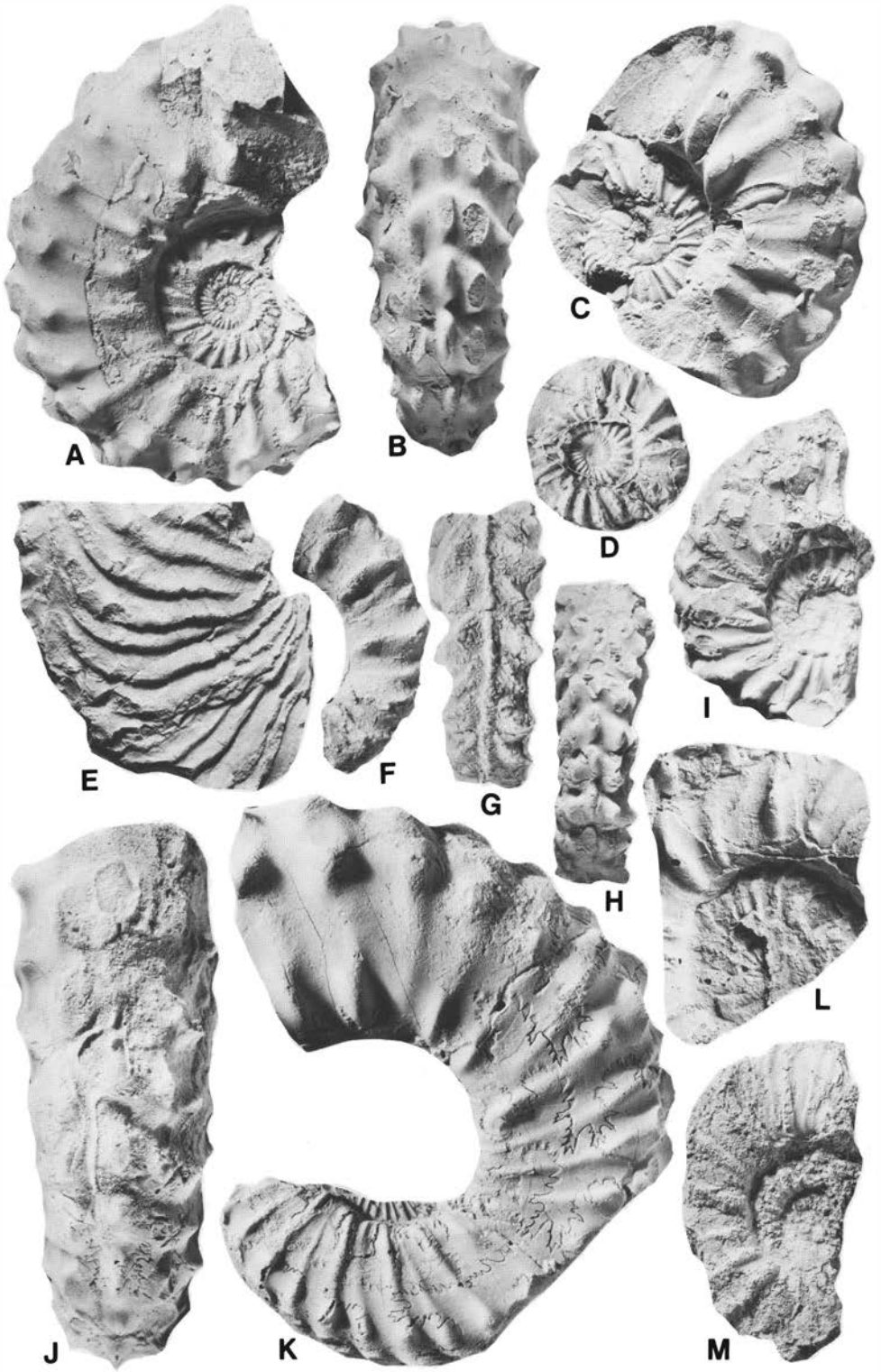
Type species: Prionocyclus serratocarinatus Meek, 1871 p. 298 (*non* Stoliczka 1865 p. 57, pl. 32, fig. 3) = *Prionocyclus wyomingensis* Meek, 1876, p. 452.

Prionocyclus hyatti (Stanton, 1894)

Figs 24F, G, M; 25, 26A, B, 27A–J, S–W

1894 *Prionotropis hyatti* Stanton, p. 176, pl. 42, figs 5–8.
1899 *Prionotropis hyatti* Stanton; Logan, p. 468, pl. 102, figs 5–8.
1910 *Prionotropis hyatti* Stanton; Grabau & Shimer, p. 228, fig. 1509 (e–g).
1925 *Prionotropis hyatti* Stanton; Diener, p. 156.
1928 *Prionotropis* aff. *P. hyatti* Stanton; Adkins, p. 250.
1928 *Prionotropis eaglensis* Adkins, p. 250, pl. 32, figs 1, 2.
1931 *Pseudaspidoceras eaglense* (Adkins); Adkins, p. 53.
1951 *Collignoniceras hyatti* (Stanton); Cobban, pp. 2191, 2192, fig. 2.
1952 *Collignoniceras hyatti* (Stanton); Cobban & Reeside, p. 1019.
1962 *Collignoniceras hyatti* (Stanton); Hattin, p. 79, pl. 24, figs A–E.
1963b *Prionocyclus hyatti* (Stanton); Powell, p. 1220, pl. 166, figs 1, 8–12; text-figs 5(a), (c), (d), (f–h).
1965b *Collignoniceras hyatti* (Stanton); Hattin, fig. 4 (4).
1976 *Prionocyclus hyatti* (Stanton); Cobban, p. 122, pl. 1, fig. 1.
1976 *Prionocyclus hyatti* (Stanton); Kennedy & Cobban, pl. 8, fig. 3.
1977 *Prionocyclus hyatti* (Stanton); Kauffman, p. 260, pl. 22, fig. 1; pl. 26, fig. 7.
1977 *Prionocyclus hyatti* (Stanton); Hattin, p. 189, figs 8 (9), (11).
1978 *Prionocyclus hyatti* (Stanton); Hattin & Siemers, figs 10 (9), (11).
1978 *Prionocyclus hyatti* (Stanton); Young & Powell, pl. 1, figs 1–3, 7, 8.
1979 *Prionocyclus hyatti* (Stanton); Merewether, Cobban, & Cavanaugh, pl. 3, figs 1, 2.
1986 *Prionocyclus hyatti* (Stanton); Cobban, fig. 3q.
1988 *Prionocyclus hyatti* (Stanton, 1894); Kennedy, p. 75, pl. 15, figs 1–24; pl. 16, figs 1–20; pl. 17, figs 1–7; text; figs 24D, E, F, 25–27, 31B.

Types: Lectotype, by the subsequent designation of Matsumoto, 1965, p. 19 is USNM 2291, the original of Stanton, 1894, pl. 42, figs 5, 6; figured paralecto-


A
B
C
D
E
F
G
H
I
J
K
L
M

type is the original of Stanton's pl. 22, figs 7, 8, with the same registration number. they are from the middle Turonian Codell Sandstone (*Pugnellus* Sandstone) Member of the Carlile Shale of Huerfano Park, Colorado.

Material: Numerous fragmentary moulds from USGS Mesozoic localities D 10749, D 10753, D 11177 and OUM collections. Several hundred pyritic nuclei in the TMM, W. S. Adkins collections from Adkins (1931) localities 11377, 2612, 2627 and 2642.

Discussion: The Chispa material includes abundant pyritic nuclei (Fig. 27A–J, S–W) that continue the ontogeny down to 2–3 mm diameter. These include evolute coarsely ribbed individuals (Fig. 27A–E) as well as more compressed ones (Fig. 27G–J), both with and without differentiation of ribbing at these early stages.

A medium-sized individual of the robust form is shown in Figure 26. The holotype of *Prionotropis eaglensis* Adkins, 1928 (p. 250, pl. 32, figs. 1–2) is a fragment of a larger individual. An adult specimen before us (USNM 420015) (Fig. 25) has a whorl height of 100 mm corresponding to an estimated diameter of 250–300 mm; its intercostal section is nearly circular. Distant primary ribs that have feeble umbilical bullae, link to massive ventrolateral horns that are directed outwards and upwards. Low, broad ribs extend from the adaptertural and adapical edges of the horn and cross the venter in a diamond-shaped pattern, linking to a coarse, blunt undulating siphonal ridge. Such as remains of the body chamber is too crushed for description.

Occurrence: Widespread in the middle Turonian *Prionocyclus hyatti* zone from northern Mexico to the Canadian border.

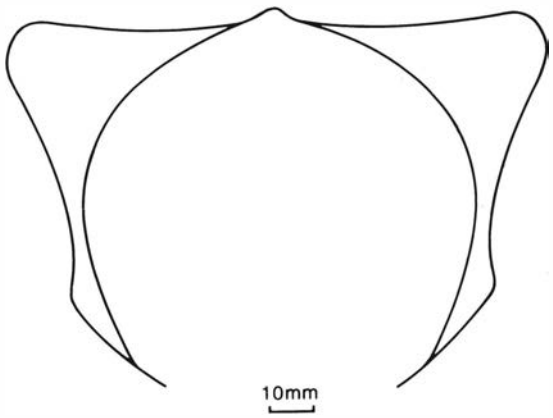


Fig. 25. Whorl section of an adult *Prionocyclus hyatti* (Stanton, 1894), based on USNM 420015, from locality D 10753.
Bar scale is 10 mm.

Prionocyclus wyomingensis Meek, 1876

Fig. 24E

1870 *Ammonites serrato-carinatus* Meek, p. 429.
1871 *Ammonites (Pleuroceras) serrato-carinatus* Meek; Meek, p. 298.
1876 *Prionocyclus wyomingensis* Meek, p. 452, footnote.
1880 *Prionocyclus wyomingensis* Meek; Whitfield, p. 440, pl. 14, figs 1–3.
1883 *Prionocyclus wyomingensis* Meek; White, p. 35, pl. 15, figs 1a–e.
1894 *Prionocyclus wyomingensis* Meek; Stanton, p. 171, pl. 40, figs 1–4.
1896 *Prionocyclus wyomingensis* Meek; Gilbert, p. 565, pl. 58, figs 1–3.
1898 *Prionocyclus wyomingensis* Meek; Logan, p. 463, pl. 106, figs 1–4.
1903 *Prionocyclus wyomingensis* Meek; Barbour, pl. 5, figs 4, 5.
1910 *Prionocyclus wyomingensis* Meek; Grabau & Shimer, p. 228, fig. 1510a–d.
1921 *Prionocyclus wyomingensis* Meek; Grabau, fig. 1697 (e)–(h).
1925 *Prionocyclus wyomingensis* Meek; Diener, p. 155.
?1932 *Prionocyclus reesidei* Sidwell, p. 318 (*pars.*) pl. 49, figs 10, 11.
1938 *Prionocyclus wyomingensis* Meek; Roman, p. 457, pl. 46, fig. 435.
1944 *Prionocyclus wyomingensis* (Meek); Shimer & Shrock, p. 593, pl. 247, figs 3, 4.
1946 *Prionocyclus wyomingensis* Meek, and variety *robusta* Haas, p. 200, *non* var. *elegans* p. 210 (= *P. novimexicanus*); pl. 20, figs 1–3, 5–7; *non* pl. 20, fig. 4 (= *P. novimexicanus*); pl. 21, figs 4, 6; *non* plate. 21, figs 1–3, 5 (= *P. novimexicanus*); pl. 22, figs 3–5; *non* pl. 22, figs 1, 2 (= *P. novimexicanus*) pl. 23, figs 1, 3 (in part); pl.

Fig. 24. (A) – (C), (H), (I), (J), (K), (L) *Collignoniceras woollgari woollgari (Mantell, 1822) (A), (B)* are USNM 420006, (C) is USNM 420007, (H), (I) are USNM 420009, (J), (K) are USNM 420010, all from Cannonball Hill, Chihuahua, Mexico, (L) is USNM 420011 from locality D 11209. (D) *Collignoniceras woollgari regulare* (Haas, 1946), USNM 420008, from locality D 11179. (E) *Prionocyclus wyomingensis* Meek, 1876: USNM 420017, from locality D 11171, *P. wyomingensis* zone, *Scaphites warreni* subzone. (F), (G), (M) *Prionocyclus hyatti* (Stanton, 1894): (F), (G) are USNM 420013, from locality D 10753; (M) is USNM 420014, from locality D 10753, *Prionocyclus hyatti* zone, *Coilopoceras springeri* subzone.
All figures are x 1.

Fig. 26. Prionocyclus hyatti (Stanton, 1894): USNM 420016, from USGS Mesozoic locality D 11177, *P. hyatti* zone, *Coilopoceras springeri* subzone.
Reduced x 0.7, the original is 190 mm in diameter.

24, figs 2, 3; text-figs 93–97, 105–108; *non* 98–104 (= *P. novimexicanus*).

1957 *Prionocyclus wyomingensis* Meek; Wright, p. 426, fig. 547(6).

1960 *Prionocyclus wyomingensis* Meek; Termier & Termier, fig. 2418.

1965 *Prionocyclus wyomingensis* Meek; Matsumoto, p. 18, pl. 16, fig. 1; pl. 17, fig. 2; pl. 19, fig. 1.

1971 *Prionocyclus wyomingensis* Meek; Matsumoto, p. 132, pl. 21, fig. 2; pl. 22, fig. 1; text-fig. 2.

1975 *Prionocyclus wyomingensis* Meek; Hattin, pl. 2, fig. 11.

*non*1976 *Prionocyclus wyomingensis* Meek; Kennedy & Cobban, pl. 11, fig. 4 (= *P. novimexicanus*).

*non*1977 *Prionocyclus wyomingensis* Meek; Kauffman, p. 266, pl. 26, figs 2, 3 (= *P. novimexicanus*).

*non*1978 *Prionocyclus wyomingensis elegans* Haas; Kauffman, Cobban & Eicher, pl. 5, fig. 14 (= *P. novimexicanus*).

*non*1982 *Prionocyclus wyomingensis* Meek; Case, fig. 12(63) (= *P. novimexicanus*).

1986 *Prionocyclus wyomingensis* Meek, 1876a; Kennedy, p. 88, pl. 14, fig. 8.

Types: Lectotype, by the subsequent designation of Matsumoto, 1965, p. 18 is USNM 7728, the original of Stanton, 1894, pl. 40, fig. 3; 2 paralectotypes have the same number and are the originals of Stanton, 1894, pl. 40, figs 1, 2. All are from what is now known as the Wall Creek Sandstone Member of the Frontier Formation in the Medicine Bow River valley of southeastern Wyoming (Cobban 1984a, p. 86).

Material: Fragmentary specimens and moulds from localities D 11170 and D 11171.

Discussion: Although fragmentary this material clearly belongs to *P. wyomingensis*. This species differs from *P. hyatti* in combining conspicuous ribbing with a relatively slender whorl. Ribs are always differentiated into strong primary ones and weaker pri-

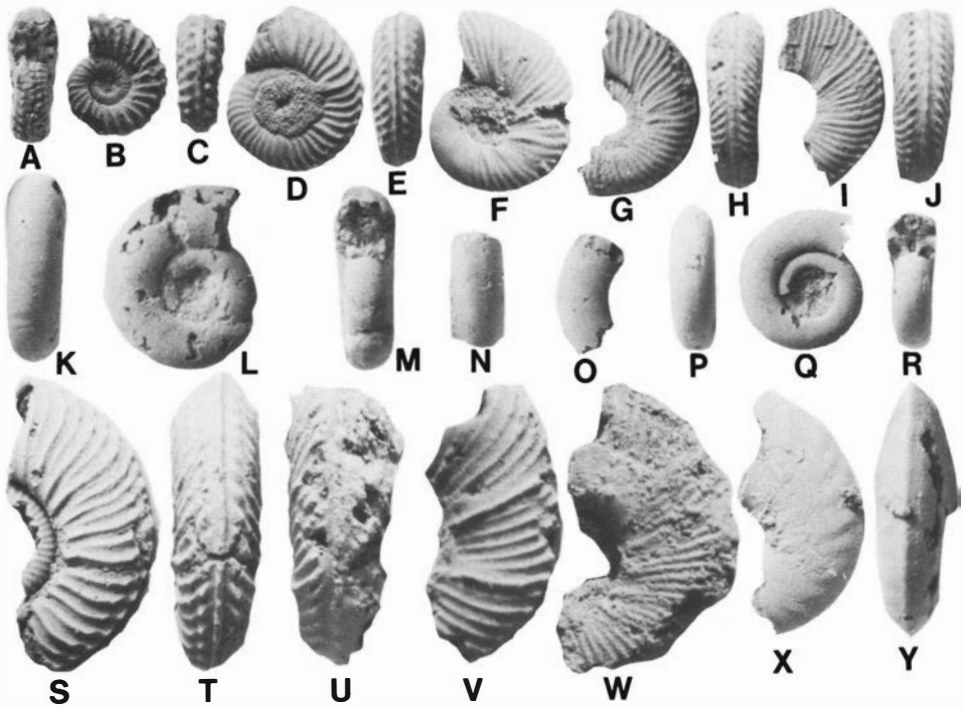


Fig. 27. (A) – (J), (S) – (W) *Prionocyclus hyatti* (Stanton, 1894): (A)– (C), (U) – (W) are from Adkins (1931) Locality 2612, clay beds 200 yards southest of Needle Peak; (D) – (J), (S), (T) are from TMM Adkins Collection 11377, "E of Willoughby Ranch, 1/4 mile south of Needle Peak". (K) – (R) *Worthoceras* cf. *minor* Kennedy, 1988 all from Adkins Collection 11377, as above. (X), (Y) *Coilopoceras springeri* Hyatt, 1903, from Adkins Collection 11377, as above.
All figures are magnified x 4.

mary and secondary ones; the stronger ribs support umbilical tubercles and inner and outer ventrolateral ones. Ribs sometimes arise in groups from bullae and may develop a lateral tubercle and in some cases, even a finger-like septate inner ventrolateral horn.

Prionocyclus novimexicanus (Marcou, 1858, p. 35, pl. 1, fig. 2; see Hook & Cobban, 1979, p. 35, figs 3E–L), of which *P. wyomingensis elegans* Haas, 1946 (p. 200, pl. 19, figs 1–7, 11–14; pl. 20, fig. 4; pl. 21, figs 1–3, 5; pl. 22, figs 1, 2; text-figs 98–104) is a synonym, is easily differentiated from *P. hyatti* by the loss of the outer ventrolateral tubercle early in ontogeny.

Occurrence: Upper Turonian *Prionocyclus wyomingensis* zone. Rare in Trans-Pecos and north-central Texas (McNulty, 1966). The species is found from south-central New Mexico northward through Colorado, Wyoming, and Montana and eastward to southwestern South Dakota and southwestern Kansas. A single specimen has been recorded from Japan (Matsumoto, 1971, p. 132, pl. 21, fig. 2; pl. 22, fig. 1; text fig. 2).

Prionocyclus novimexicanus (Marcou, 1858)

1858 *Ammonites Novi-Mexicani* Marcou, p. 35, pl. 1, fig. 2.
1925 *Ammonites novi-mexicanus* Marcou; Diener, p. 31.
?1942 *Prionocyclus novimexicanus* (Marcou); Moreman, p. 214.
1946 *Prionocyclus wyomingensis* (Meek) var. *elegans* Haas, p. 211, pl. 19, figs 1–7, 11–14; pl. 20, fig. 4; pl. 21, figs 1–3, 5; pl. 22, figs 1, 2; text-figs 98–104.
1965 *Ammonites novi-mexicanus* Marcou; Matsumoto, p. 20.
1970 *Prionocyclus (Prionocyclus) wyomingensis* Meek var. *elegans* Haas; Jeletzky, pl. 26, fig. 8.
1972 *Prionocyclus wyomingensis elegans* Haas; Merewether & Cobban, table 1.
1976 *Prionocyclus wyomingensis* Meek; Kennedy & Cobban, pl. 11, fig. 4.
1977 *Prionocyclus wyomingensis* Meek; Kauffman, p. 266, pl. 26, figs 2, 3.

1978 *Prionocyclus wyomingensis elegans* Haas; Kauffman, Cobban & Eicher, pl. 5, fig. 14.
1979 *Prionocyclus novimexicanus* (Marcou); Hook & Cobban, p. 35, fig. 3E–L.
1982 *Prionocyclus wyomingensis* Meek; Case, fig. 12 (63).

Holotype: BMNH C49764, from an uncertain locality in New Mexico (*fide* Hook & Cobban 1979).

Material: Two impressions in siltstone from locality D 10754. Upper Turonian *Scaphites whitfieldi* zone.

Discussion: Prionocyclus novimexicanus most closely resembles *P. wyomingensis* Meek, 1876, from which it may be differentiated by the loss of the outer ventrolateral tubercle early in ontogeny in *novimexicanus,* which also has a low ridge bordering a smooth ventral groove on either side of the siphonal ridge, features not seen in *wyomingensis.*

Occurrence: Upper Turonian *Scaphites whitfieldi* zone; widespread in the Western Interior from the Canadian to Mexican borders. See Hook & Cobban (1979, p. 40, fig. 4) for details.

Family COILOPOCERATIDAE Hyatt, 1903

Genus COILOPOCERAS Hyatt, 1903

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

Coilopoceras springeri Hyatt, 1903

Fig. 27X, Y; 28–30, 31M, N, W, X

1903 *Coilopoceras springeri* Hyatt, p. 96, pl. 12, figs 1–3.
1931 *Coilopoceras eaglefordense* Adkins, p. 46, pl. 4, figs 4, 8; pl. 5, fig. 1.
1931 *Coilopoceras chispaense* Adkins, p. 48, pl. 4, figs 5, 7; pl. 5, fig. 2.
1931 *Coilopoceras* sp. aff. *C. springeri* Hyatt; Adkins, p. 51, pl. 5, fig. 3.
1978 *Glebsoceras* (sic) *chispaense* (Adkins); Young & Powell, pl. 4, fig. 2; pl. 5, fig. 6.
1978 *Coilopoceras eaglefordense* Adkins; Young and Powell, pl. 5, figs 4, 5.
1980a *Coilopoceras springeri* Hyatt; Cobban and Hook, p. 16, pl. 1, figs 5, 6; pl. 3, figs 9–11; pl. 6, figs 9, 10; pl. 10; pl. 18, figs 7–10; pl. 19, figs 1–9; text-figs 11–13.
1988 *Coilopoceras springeri* Hyatt, 1903; Kennedy, p. 92, pl. 13, figs 4–7; text-figs 24H, I, 33, 34.

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

Material: Numerous specimens from localities D 10749, D 10753, D 11174, D 11176, D 11177; TMM Collections including the holotypes of *Coilopoceras chispaense* Adkins, 1931 and *C. eaglefordense* Adkins, 1931; also pyritic nuclei from Adkins (1931) localities 2612, 2627 and 11377, and OUM KT796–803, 805–820, and 822–825.

Discussion: This species occurs in vast numbers at Chispa Summit in what Powell (1965) termed the *Coilopoceras* graveyard level. The species is fully described by Cobban & Hook (1980a) who studied Chispa Summit material. Both smooth (*eaglefordense*) and ribbed (*chispaense*) variants occur, the latter referred to *Glebsoceras [Glebosoceras]* Reyment, 1954 by Young & Powell (1978). The species attains a large size with phragmocones up to 600 mm diameter; it proved impossible to collect and measure enough adult specimens to determine whether the smooth and ribbed forms correspond to size dimorphs.

Coilopoceras springeri is a descendant of *Hoplitoides sandovalensis* Cobban & Hook, 1980a (p. 8, pl. 2; pl. 3, figs 6–8; 12–16; pl. 4; pl. 11, fig. 1; pl. 18, figs 4–6; text-figs 6, 7) which characterises the lower subzone of the *hyatti* zone. The two are indistinguishable when mature but easily separated if the early stages are known. *Coilopoceras sandovalensis* has a tabulate venter in early growth stages, whereas it is acute in the early growth stages in *springeri* (Fig. 27X, Y).

Occurrence: Middle Turonian *Prionocyclus hyatti* zone, *Coilopoceras springeri* subzone in Trans-Pecos and north-central Texas and New Mexico.

Coilopoceras inflatum Cobban & Hook, 1980a

1980a *Coilopoceras inflatum* Cobban & Hook, p. 19, pl. 1, figs 9–11; pl. 11, fig. 2; pls 12–17; pl. 18, figs 1–3; 11–13; pls 20, 21; text-figs 14, 15.
1986 *Coilopoceras inflatum* Cobban & Hook; Cobban, p. 81, fig. 7A–C.
1988 *Coilopoceras inflatum* Cobban & Hook, 1980a; Kennedy, p. 96.

Holotype: USNM 275920, the original of Cobban & Hook, 1980a, p. 19, pl. 11, fig. 2, from the upper Turonian *Prionocyclus wyomingensis* zone in Valencia County, New Mexico.

Material: Fragments of two large phragmocones from locality D 11170.

Discussion: These internal molds have only one side preserved, but they show the stout whorl section

Fig. 28. Coilopoceras springeri Hyatt, 1903: TMM Collections, the holotype of *Coilopoceras chispaense* Adkins, 1931.
Reduced x 0.9, the original is 361 mm in diameter.

and bold ornament typical of this species. Whorl heights are 144 mm (USNM 420022) and 167 mm (USNM 420023). See Cobban & Hook (1980a) for differences from other species.

Occurrence: Known only from the upper Turonian *Prionocyclus wyomingensis* zone of New Mexico and Chispa Summit.

Suborder ANCYLOCERATINA Wiedmann, 1966

Superfamily TURRILITACEAE Gill, 1871

Family HAMITIDAE Gill, 1871

Genus *Metaptychoceras* Spath, 1926

Type species: Ptychoceras smithi Woods, 1896, p. 74, pl. 2, figs 1, 2; by original designation.

Fig. 29. Coilopoceras springeri Hyatt, 1903: USNM 420018, from locality D 11177, *Prionocyclus hyatti* zone, *C. springeri* subzone.
Reduced x 0.8, the original is 165 mm in diameter.

Metaptychoceras cf. *crassum* Kennedy, 1988

1931 *Metaptychoceras* n. sp. aff. *M. smithi* (H. Woods); Adkins, p. 64.
1951 *Metaptychoceras* Adkins & Lozo, p. 155.
1988 *Metaptychoceras crassum* Kennedy, p. 98, pl. 21, figs 11, 12, 16–18, 21–24.

Discussion: Fragments of a minute *Metaptychoceras* characterised by very coarse ribbing on the last two shafts occur in the pyritic faunas from the *Prionocyclus hyatti* zone at Adkins localities 2621 and 2627. A comparable form, *M. crassum,* occurs in the upper part of the Eagle Ford Group in north-central Texas and is described by Kennedy (1988).

Genus HAMITES Parkinson, 1811

Type species: Hamites attenuatus J. Sowerby, 1814, p. 137, pl. 61, figs 4, 5; by subsequent designation by Diener 1925 (p. 65).

Hamites? sp.

Fig. 31A–C

Material: Two specimens from locality D 10899. Lower Turonian *Pseudaspidoceras flexuosum* zone.

Discussion: Whorl section appears to have been oval, with blunt, feebly oblique ribs as wide as the

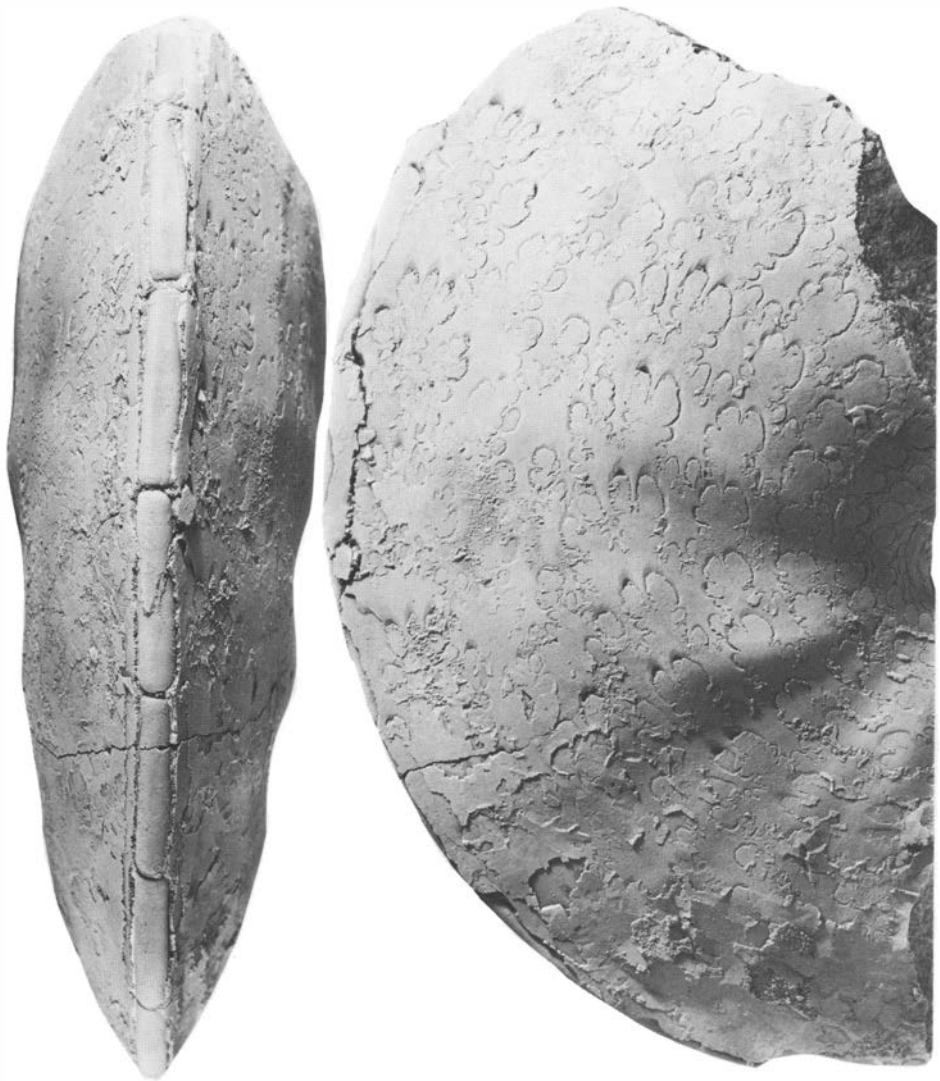


Fig. 30. Coilopoceras springeri Hyatt, 1903: USNM 420019, from locality D 11177, *Prionocyclus hyatti* zone, *C. springeri* subzone.
Reduced x 0.7, thee original is 190 mm in diameter.

interspaces. If correctly identified these fragments extend the range of the genus from upper Cenomanian *Sciponoceras gracile* zone into the Turonian.

Family ANISOCERATIDAE Hyatt, 1900

Genus ALLOCRIOCERAS Spath, 1926

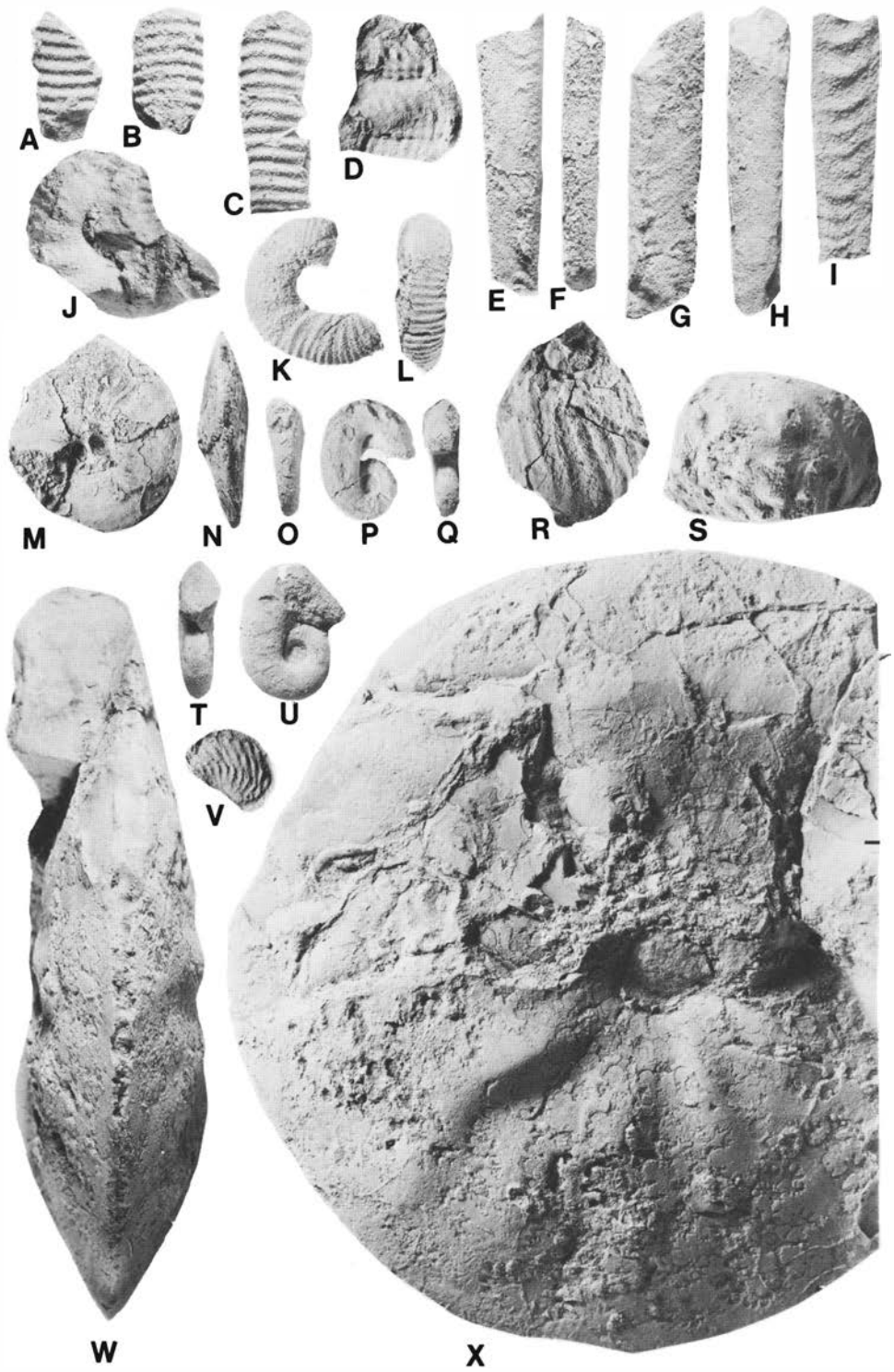
Type species: Crioceras ellipticum Woods, 1896, p. 84 (*non* Mantell), renamed *Allocrioceras woodsi* Spath, 1939, p. 598 = *Hamites angustus* J. de C. Sowerby, 1850, p. 346, pl. 29, fig. 12.

Allocrioceras annulatum Shumard, 1860

Fig. 10, O, P

1860 *Ancyloceras annulatus* Shumard, p. 595.
1931 *Allocrioceras* n. sp. Adkins, p. 63, pl. 2, figs 6, 8.
1981 *Allocrioceras annulatum* (Shumard, 1860); Wright & Kennedy, p. 111, pl. 32, figs 3–7 (with synonymy).
1988 *Allocrioceras annulatum* (Shumard, 1860); Kennedy, p. 104, pl. 19, figs 3–12, 14; pl. 22, figs 1, 2; pl. 24, fig. 2; text-fig. 36.

Types: Lost. From the Britton Formation, upper Cenomanian *Sciponoceras gracile* zone of Shawnee Creek, Grayson County, Texas.


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X

Material: TMM 21017, the original of Adkins, 1931, p. 63, pl. 2, figs 6, 8. By its preservation from USGS Mesozoic locality D 10746.

Discussion: Kennedy (1988) described well-preserved material from north-central Texas, where the species is abundant. In contrast, but a single specimen is known from Chispa Summit, and that somewhat malformed, with one row of tubercles much weaker than the other.

Occurrence: Upper Cenomanian *Sciponoceras gracile* zone and correlatives in north-central and Trans-Pecos Texas, New Mexico, Arizona, Colorado, Kansas, Utah and Wyoming; northern Mexico, southern England and Haute Normandie in France.

Allocrioceras spp.

Discussion: A poorly preserved fragment from the *Pseudaspidoceras flexuosum* zone at locality D 10899 is probably *A. larvatum* (Conrad, 1855), a species abundant elsewhere in Trans-Pecos Texas (Kennedy, Wright & Hancock 1987, p.63, pl. 10, figs 1–8). Two small pyritic specimens from the *Prionocyclus hyatti* zone, *Coilopoceras springeri* subzone in the TMM Collections from W. S. Adkins (1931) locality 2627 represent another species.

Family TURRILITIDAE Gill, 1871

Genus OSTLINGOCERAS Hyatt, 1900

Type species: Turrilites puzosianus d'Orbigny, 1842a, p. 587, pl. 123, figs 1, 2; by original designation.

Ostlingoceras brandi Young, 1958

Fig. 31R

1958 *Ostlingoceras brandi* Young, p. 287, pl. 40, figs 4, 5, 7; text-fig. 1n.
1959 *Ostlingoceras brandi* Young; Young, pl. 1, figs 5, 6, 9.
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 northeast flank of the Davis Mountains, Jeff Davis County, Texas.

Material: Several specimens from localities D 11336, and D 11337, also OUM 10900-4. Lower Cenomanian *Forbesiceras brundrettei* zone.

Discussion: The Chispa Summit material closely matches abundant topotypes in the OUM Collections. There are generally 20 low, oblique ribs per whorl, with a feeble tubercle just above the lower whorl suture. This species most closely resembles *O. davisense* Young, 1958 (p. 289, pl. 39, figs 29, 34) with which it co-occurs; *davisense* has, however, up to 4 rows of tubercles on the ribs, one close to mid-flank, one just above the lower whorl suture, and two closely spaced tubercles on the lower whorl face. Whether *brandi* and *davisense* are separate species or mere intraspecific variants of a single species cannot be determined from the present material.

Occurrence: Lower Cenomanian *Forbesiceras brundrettei* zone of Gold Hill (Hook & Cobban, 1983, p. 51) as well as the type locality in Jeff Davis county. Localities D 10901 and D 10902 in Culberson County; both in Trans-Pecos Texas. Cloice Branch in McLennan County, Texas, presumed to be from the Pepper Shale Member of the Woodbine Formation.

Fig. 31. (A) – (C) *Hamites* ? sp. (A), (B) are USNM 420024, (C) is USNM 420025, both from locality D 10899, *Presudaspidoceras flexuosum* zone. (D), (V) *Ostlingoceras davisense* Young, 1958: (D) is USNM 420027, (V) is USNM 420028, both from locality D 10902, *Forbesiceras brundrettei* zone. (E) – (H) *Baculites* cf. *yokoyamai* Tokunaga & Shimizu, 1926: (E), (F) are USNM 420035, (G), (H) are USNM 420036, both from locality D 11170, *Prionocyclus wyomingensis* zone. (I) *Baculites undulatus* d'Orbigny, 1850: USNM 420037, from locality D 11171, *P. wyomingensis* zone. (J) *Scaphites carlilensis* Morrow, 1935: USNM 420038, from locality D 10753, *Prionocyclus hyatti* zone, *Coilopoceras springeri* subzone. (K), (L) *Scaphites warreni* Meek & Hayden, 1860: USNM 420039, from locality D 11170, *P. wyomingensis* zone, *S. warreni* subzone. (M), (N), (W), (X) *Coilopoceras springeri* Hyatt, 1903. (M), (N) are USNM 420020, (W), (X) are USNM 420021, from locality D 11177, *P. hyatti* zone, *C. springeri* subzone. (O), (P), (Q), (T), (U) *Worthoceras vermiculus* (Shumard, 1860): (O), (P), (Q) are USNM 420040, (T), (U) are USNM 420041, both from locality D 10746, *Sciponoceras gracile* zone. (R) *Ostlingoceras brandi* Young, 1958: USNM 420026, from locality D 11336, *Forbesiceras brundrettei* zone. (S) *Hypoturrilites youngi* Clark, 1965: USNM 420029, from locality D 11182, *F. brundrettei* zone.
All figures are x 1.

Ostlingoceras davisense Young, 1958

Fig. 31D, V

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 northeast flank of the Davis Mountains, Jeff Davis County, Texas.

Material: Two specimens from locality D 11336. These speciemens are poorly preserved; better specimens from the type area are shown in Fig. 31D, V.

Discussion: Differences from *O. brandi* are noted above. The generic position of this species is of some interest; it resembles *Mariella* in several respects and might be better referred to that genus.

Occurrence: Lower Cenomanian *Forbesiceras brundrettei* zone of Gold Hill as well as Chispa Summit and the type locality in Jeff Davis County. Localities D 10901 and D 10902 in Culberson County and D 11336 in Jeff Davis County, all in Trans-Pecos Texas. Cloice Branch in McLennan County, Texas, presumed to be from the Pepper Shale Member of the Woodbine.

Genus and Subgenus: MARIELLA Nowak, 1916

Type species: Turrilites bergeri Brongniart, 1822, by original designation.

Mariella (Mariella) sp. cf. *cenomanensis* (Schlüter, 1876)

Fig. 5I–M

Material: Seven specimens from the basal part of the Chispa Summit Formation at locality D 11182.

Description: These small specimens, which consist of 1 or 2 whorls, differ from other species of turrilitids from this level in that the basal row of tubercles consists of double tubercles. Each of these tubercles is clavate and has a notch parallel to its long axis. Tubercles in the next higher row are also clavate and about the same size as those below. Tubercles of the third row are located a little above the middle of the flanks; they are nodate and larger than those of the other rows. An oblique rib extends from each of the upper tubercles to the top of the whorl. Tubercles in all three rows are equal in numbers.

Discussion: These specimens are poorly preserved, but comparable to *Mariella (Mariella) cenomanensis* (Schlüter, 1876) (p. 131, pl. 37, figs 6–8).

Occurrence: Lower Cenomanian *Forbesiceras brundrettei* zone at locality D 11182.

Genus HYPOTURRILITES Dubourdieu, 1953

Types species: Turrilites gravesianus d'Orbigny, 1842a, p. 596, pl. 144, figs 3–5; by original designation.

Hypoturrilites youngi Clark, 1965

Fig. 31S

1958 *Hypoturrilites* n. sp. Young, p. 287, pl. 39, fig. 32; text-fig. 1g.
1965 *Hypoturrilites youngi* Clark, p. 52, pl. 19, fig. 6.

Type: TMM 10285, the original of Clark, 1965, pl. 19, fig. 6; holotype by monotypy. From the base of the Boquillas Formation on the northeast flank of the Davis Mountains, Jeff Davis County, Texas.

Material: Two specimens from locality D 11337, and one from D 11182.

Discussion: At both Chispa Summit and the type locality, small specimens like the holotype occur with very large, generally poorly preserved fragments with whorl heights of up to 60 mm. *Hypoturrilites youngi* thus matches some of the largest species known, such as *H. komatoi* (Yabe, 1904) (p. 7, pl. 1, fig. 1; pl. 2, fig. 1) and *H. gravesianus* (d'Orbigny, 1842a) (p. 596, pl. 144, figs 3–5), the latter as represented by specimens in the British Museum (Natural History).

Occurrence: Lower Cenomanian, *Forbesiceras brundrettei* zone at the type locality of *H. youngi* and at Chispa Summit and Gold Hill, Trans-Pecos Texas.

Genus NEOSTLINGOCERAS Klinger & Kennedy, 1978

Type species: Turrilites carcitanensis Matheron, 1842, p. 267, pl. 12, fig. 4; by original designation.

Neostlingoceras kottlowski Cobban & Hook, 1981

1981 *Neostlingoceras kottlowski* Cobban & Hook, p. 26, pl. 4, figs 1–28.
1984a *Neostlingoceras kottlowski* Cobban & Hook; Cobban, p. 17, pl. 4, fig. 9.

Type: Holotype, by original designation is USNM 306777, the original of Cobban & Hook, 1981, pl. 4, figs 14–16.

Material: One specimen from locality D 10743.

Discussion: The single specimen is a bit of a whorl that appears to represent *N. kottlowski.* Numerous crushed specimens were found farther south at USGS Mesozoic locality D 10760.

Occurrence: The species is best known from the upper Cenomanian *Calycoceras canitaurinum* zone but may appear in the underlying *Plesiacanthoceras wyomingense* zone. The geographic distribution extends from Montana south to the present occurrences on the Texas-Mexico border (see Cobban & Hook, 1981, fig. 8).

Family BACULITIDAE Gill, 1871

Genus SCIPONOCERAS Hyatt, 1894

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

Sciponoceras gracile (Shumard, 1860)

1860 *Baculites gracilis* Shumard, p. 596.
1981 *Sciponoceras gracile* (Shumard, 1860); Wright and Kennedy, p. 112, pl. 31, figs. 1–3; pl. 32, figs. 8, 11; text-figs. 38A–Q (with full synonymy).
1983 *Sciponoceras gracile* (Shumard); Kennedy and Juignet, p. 22, figs. 18a–d, 32i–p (with additional synonymy).
1984 *Sciponoceras gracile* (Shumard, 1860); Kennedy, Amédro, Badillet, Hancock and Wright, p. 41, figs. 2a–d.
1988 *Sciponoceras gracile* (Shumard, 1860); Kennedy, p. 108, pl. 20, figs 1–14, 17–20; text-fig. 38.

Types: Shumard's types are lost, but are presumed to be from the upper Cenomanian *Sciponoceras gracile* zone fauna of the Britton Formation of the Eagle Ford Group. The locality given by Shumard is Grayson County, Texas.

Material: Numerous fragmentary specimens from locality D 10746.

Discussion: Variation and dimorphism in the abundant and well-preserved north-central Texas material is described by Kennedy (1988) to whom reference should be made. The Chispa Summit material is rather fragmentary and the species far less abundant than elsewhere in both Texas and the Western Interior.

Occurrence: Upper Cenomanian *Sciponoceras gracile* zone and correlatives. Abundant in north-central Texas, Arizona, New Mexico, Colorado, Kansas, Wyoming, Montana, Utah and California; northern Mexico, southern England, northern France, southern Germany, and possibly, Angola. Rare, poorly-preserved *Sciponoceras* from the *juddii* zone of Grant County in New Mexico may be late survivors of this species.

Genus BACULITES Lamarck, 1799

Type species: Baculites vertebralis Lamarck, 1801, p. 103; by subsequent designation by Meek 1876 p. 391.

Baculites yokoyamai Tokunaga & Shimizu, 1926

Fig. 31E–H

compare

1926 *Baculites (Lechites) yokoyamai* Tokunaga & Shimizu, p. 195, pl. 22, fig. 5; pl. 26, fig. 11.
1979 *Baculites yokoyamai* Tokunaga & Shimizu; Cobban & Hook, p. 13, pl. 4, figs 9, 10 (with synonymy).
1986 *Baculites yokoyamai* Tokunaga & Shimizu; Cobban, p. 81, fig. 3E–I.
1988 *Baculites yokoyamai* Tokunaga & Shimizu, 1926; Kennedy, p. 110, pl. 23, figs 8–10; text-fig. 29C.

Discussion: Poorly-preserved smooth to feebly ornamented *Baculites* first appear in the upper part of the lower Turonian at locality D 10900 and range upward through the upper Turonian at locality D 10754. Some show delicate ventral ribbing and are comparable to other examples of *B. yokoyamai,* which ranges throughout the whole of the Turonian in the Western Interior (Cobban & Hook, 1979, p. 13).

Baculites undulatus d'Orbigny, 1850

Fig. 31I

1850 *Baculites undulatus* d'Orbigny, p. 190.
1979 *Baculites undulatus* d'Orbigny; Wright, p. 287, pl. 1, figs 6–8; pl. 7, fig. 11 (with synonymy).
1985 *Baculites undulatus* d'Orbigny, 1850; Breton & Bavent, p. 102, figs 1–3.
1986 *Baculites undulatus* d'Orbigny; Cobban, p. 81.

Type: Holotype, by monotypy is d'Orbigny's original specimen (1850, p. 190) figured by Roman & Mazeran (1913, pl. 4, fig. 6) and Sornay (1955), Muséum National d'Histoire Naturelle, d'Orbigny Collection, no. 6796, from the upper Turonian of Uchaux, Vaucluse, France.

Material: A single specimen from locality D 11171. OUM KT931–2, 935–6; slabs with numerous specimens, from the same horizon.

Discussion: Fragmentary *Baculites* from the *Prionocyclus wyomingensis* zone differ from those referred to *B. yokoyamai* above in having strong crescentic flank ribs in addition to fine ventral intercalatories. These closely resemble both English (Wright, 1979, p. 287, pl. 1, figs 6–8; pl. 7, fig. 11) and Japanese examples (Matsumoto & Obata, 1963, p. 28, pl. 8, fig. 4; pl. 9, figs 1–5; pl. 11, figs 2, 3; text-figs 62–71).

Occurrence: Upper Turonian, *Prionocyclus macombi* and *P. wyomingensis* zones, Trans-Pecos Texas and New Mexico. Upper Turonian of Japan, southern England, France and, possibly, Czechoslovakia.

Superfamily SCAPHITACEAE Gill, 1871

Family SCAPHITIDAE Gill, 1871

Subfamily SCAPHITINAE Gill, 1871

Genus SCAPHITES Parkinson, 1811

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

Scaphites carlilensis Morrow, 1935

Fig. 31J

1935 *Scaphites carlilensis* Morrow, p. 466, pl. 50, fig. 4.

Holotype: The original of Morrow, 1935, pl. 50, fig. 4, from the *Prionocyclus hyatti* zone of Kansas.

Material: One specimen from locality D 10753.

Discussion: This fragmentary but typical specimen agrees closely with contemporaneous specimens from north-central Texas to be revised elsewhere, when a full synonymy will be given (Kennedy, 1988). *Scaphites carlilensis* is based on a macroconch, of which *Scaphites pygmaeus* Morrow, 1935 (p. 465, pl. 50, fig. 2, renamed *morrowi* Jeletzky, 1949 because of prior usage by Holzapfel (1888)) is the microconch. *Scaphites arcadiensis* Moreman, 1942 (p. 216, pl. 34, fig. 3) is a synonym and a macroconch. All the *Scaphites* from the Carlile Shale of Kansas described by Crick (1978) may be no more than variable dimorphic *S. carlilensis* in our view, in spite of Crick's detailed numerical analysis which led him to divide 46 body chambers from a single horizon into five species.

Occurrence: Middle Turonian *Prionocyclus hyatti* zone; known from Trans-Pecos and north-central Texas; rare in New Mexico, but common in Kansas and extending to northwestern Montana.

Scaphites warreni Meek & Hayden, 1860

Fig. 31K, L

1860 *Scaphites warreni* Meek & Hayden, p. 177.
1952 *Scaphites warreni* Meek & Hayden; Cobban, p. 21, pl. 3, figs 8–21 (with synonymy).
1952 *Scaphites warreni* Meek & Hayden var. *ubiquitosus* Cobban, p. 23, pl. 3, figs 26, 27; pl. 4, figs 1–15.
1960 *Scaphites warreni* Meek & Hayden; Easton, text-figs II. 28–2a–b.
1975 *Scaphites warreni* var. *ubiquitosus* Cobban; Hattin, pl. 2, figs 8–10.
1976 *Scaphites warreni* Meek & Hayden; Cobban, p. 122, pl. 1, fig. 3.
1977 *Scaphites warreni* Meek & Hayden; Kauffman, p. 259, pl. 22, figs 11, 12; pl. 23, figs 5, 6.
1979 *Scaphites warreni* Meek & Hayden; Merewether, Cobban & Cavanaugh, pl. 2, figs 6–9.

Holotype: USNM 225, from the Carlile Shale of the southern edge of the Black Hills, South Dakota; by monotypy.

Material: Two specimens from locality D 11170. Upper Turonian *Prionocyclus wyomingensis* zone, *Scaphites warreni* subzone.

Discussion: Scaphites warreni is based upon a stout form, the macroconch (Cobban, 1952, pl. 3, figs 8–21). The microconch is the generally smaller, slender evolute form named *S. warreni ubiquitosus* Cobban, 1952 (pl. 3, figs 26, 27; pl. 4, figs 1–15). The Chispa Summit specimens are both rather typical microconchs. Variety *haydeni* of Cobban (1952 p. 23, pl. 3, figs 22, 25) is a rare form with very strong primary ribs, based on a macroconch.

Occurrence: This species is the index of the lower subzone of the upper Turonian *Prionocyclus wyomingensis* zone and is known from southeastern Montana, western South Dakota, southwestern Kansas, Colorado, Utah, New Mexico and, herein, Trans-Pecos Texas.

Subfamily OTSCAPHITINAE Wright, 1953

Genus WORTHOCERAS Adkins, 1928

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

Worthoceras vermiculus (Shumard, 1860)

Fig. 10K–N; 31O–Q, T, U

1860 *Scaphites vermiculus* Shumard, p. 419.
1931 *Scaphites* sp. aff. *africanus* Pervinquière; Adkins, p. 63, pl. 2, figs 11, 12.
1988 *Worthoceras vermiculus* (Shumard, 1860); Kennedy, p. 114, pl. 22, figs 5, 10–15; pl. 24, figs 22–23; text-fig. 39.

Neotype: TMM 19827, designated by Moreman (1942, p. 214) from the upper Cenomanian Britton Formation 0.8 km east of the Britton-Midlothian road, Ellis County, Texas.

Material: Abundant specimens from USGS Mesozoic locality D 10746 plus numerous OUM specimens from the same horizon.

Discussion: This species is reviewed at length by Kennedy (1988) to whom reference should be made. The neotype of *Worthoceras vermiculus* is a microconch; the corresponding macroconch is *Worthoceras gibbosum* Moreman, 1942 (p. 215, pl. 34, figs 12, 13; text-fig. 2p). *Scaphites* sp. aff. *africanus* Pervinquière of Adkins (1931, p. 63, pl. 2, figs. 11, 12) are macroconchs of this species (Fig. 10K–N). Macroconchs are much commoner than microconchs in the Chispa Summit material, as indeed they are in north-central Texas.

Occurrence: Upper Cenomanian *Sciponoceras gracile* zone, north central and Trans-Pecos Texas, New Mexico, Colorado, Kansas and Wyoming; the German Federal Republic, Eastbourne, Sussex, England; southeast France.

Worthoceras cf. *minor* Kennedy, 1988

Fig. 27K–R

1951 *Worthoceras* Adkins and Lozo, p. 155.
1988 *Worthoceras minor* Kennedy, p. 116, pl. 21, figs 1–10, 13, 14, 25.

Discussion: The pyritic fauna of minute ammonites and nuclei from the *Prionocyclus hyatti* zone, *Coilopoceras springeri* subzone at Adkins (1931) localities 2612, 2627 and 11377 include spires of *Worthoceras* up to 6 mm in diameter. they are closely comparable to *W. minor,* a minute species with adult body chambers only 15 mm in maximum length that is common in the upper part of the Eagle Ford Group in north-central Texas.

Class BIVALVIA Linnaeus, 1758

Subclass PTERIOMORPHIA Beurlen, 1944

Order PTERIOIDA Newell, 1965

Superfamily PTERIACEA Gray, 1847

Family INOCERAMIDAE Giebel, 1852

Genus INOCERAMUS J. Sowerby, 1814

Type species: Inoceramus cuvierii J. Sowerby, 1814, p. 448 (ICZN Opinion 743, 1957).

Inoceramus aff. *arvanus* Stephenson, 1953

Fig. 32A–C, E, F

Material: Numerous specimens from localities D 10742, D 11181, D 11182, D 11336 and D 11337 at Chispa Summit.

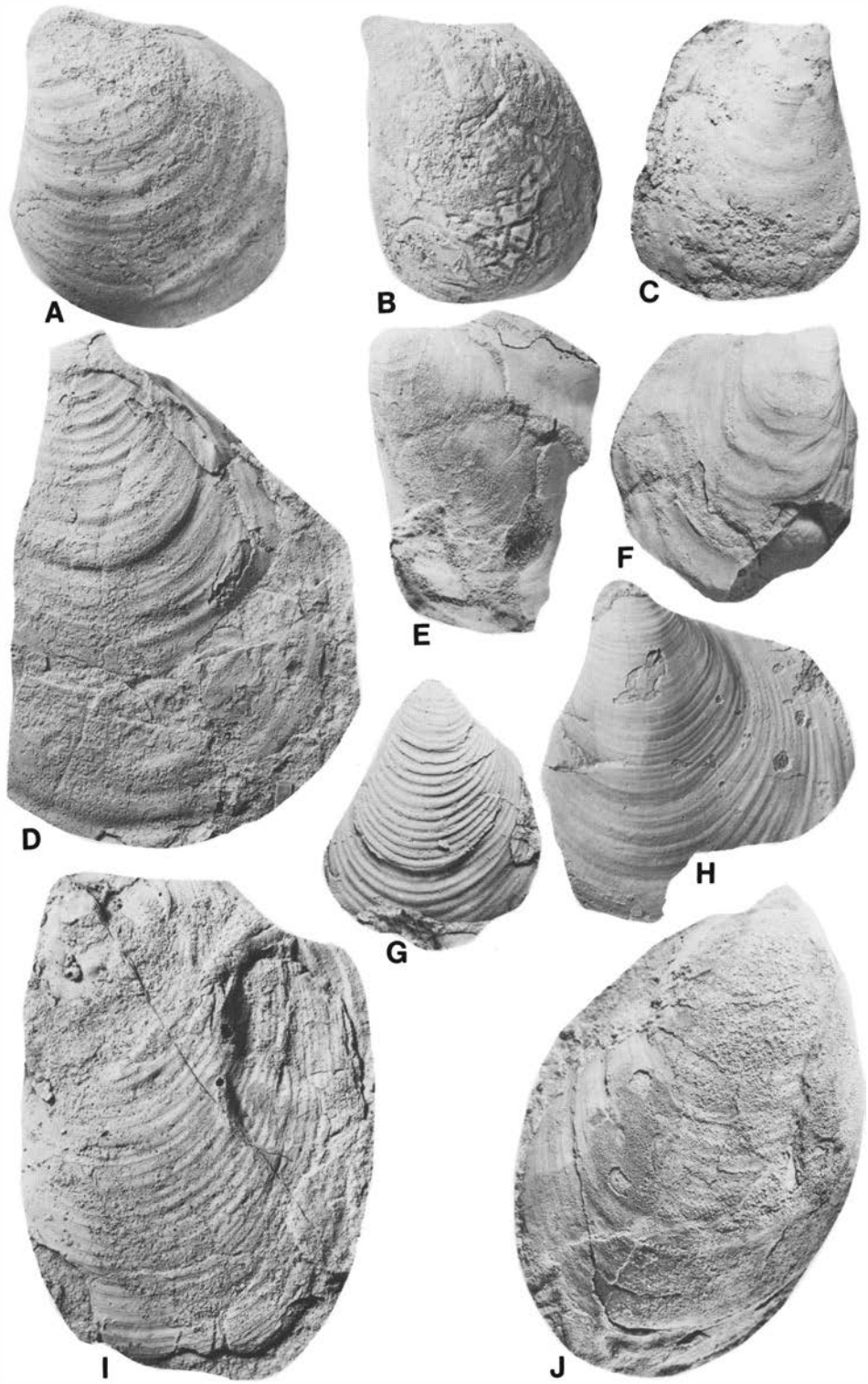
Discussion: Moderately convex inoceramids that have a subquadrate to nearly square shell outline with a posterior auricle and ornament of weak, irregular growth lines and rugae resemble *I. arvanus* Stephenson, 1953 (p. 65, pl. 12, figs 6–9) in these features but differ in lacking a posterior sulcus. Other specimens are considerably higher than wide with a slightly concave anterior margin. Some of the more weakly ornamented specimens resemble *I. tenuistriatus* Nagao & Matsumoto, 1939 (p. 272, pl. 24, fig. 8; pl. 26, figs 1–4). Although more than one species are probably included in the forms illustrated in Figure 32 and listed from the localities above, most of the specimens seem to represent some generalized form that gave rise to *I. arvanus.*

Occurrence: Rare in the *Forbesiceras brundrettei* zone and abundant in the *Acanthoceras bellense* zone in Trans-Pecos Texas.

Inoceramus prefragilis Stephenson, 1953

Fig. 32D, G–I

1953 *Inoceramus prefragilis* Stephenson, p. 64, pl. 12, figs 10–12; pl. 13, figs 1, 2.
1975 *Inoceramus prefragilis* Stephenson; Hattin, p. 209, pl. 3, figs H–N; pl. 5, figs L, M.
1977 *Inoceramus prefragilis* Stephenson; Cobban, p. 15, pl. 19, figs 1, 2, 4.


A
B
C
D
E
F
G
H
I
J

1977 *Inoceramus prefragilis prefragilis* Stephenson; Kauffman & Powell, p. 60, pl. 1, figs 5, 6; pl. 2, figs 7, 9.
1977 *Inoceramus prefragilis stephensoni* Kauffman & Powell, p. 62, pl. 2, figs 1, 3, 6, 8, 10.
1977 *Inoceramus prefragilis* Stephenson; Kauffman, p. 232, pl. 4, figs 10, 11.
1977 *Inoceramus prefragilis* Stephenson; Hattin & Siemers, text-fig. 6.6, 6.9.
1978 *Inoceramus prefragilis* Stephenson; Hattin, p. 185, figs 5.6, 5.9.
1983 *Inoceramus prefragilis stephensoni* Kauffman & Powell; Cobban, p. 4, pl. 2, figs 19, 20; pl. 3.
1984a *Inoceramus prefragilis* Stephenson, Cobban, p. 12, pl. 4, figs 10, 11; pl. 5, fig. 6.
1986 *Inoceramus prefragilis* Stephenson; Cobban, fig. 8B.

Holotype: USNM 105151, the original of Stephenson, 1953, p. 64, pl. 12, fig. 10, from the middle Cenomanian Lewisville Member of the Woodbine Formation in Grayson County, Texas.

Material: Numerous fragments from localities D 10743 and D 10744.

Discussion: This distinctive species is characterised by closely spaced growth lines that make it recognisable even in fragments. Stephenson (1953) and Kauffman & Powell (1977) described the species thoroughly. The subspecies *stephensoni* differs from the nominate species in having a broader and flatter shell without a shallow posteroventral sulcus and with regular ornament persisting to a very large size.

Occurrence: Aside from northeastern Texas, *I. prefragilis* is found from Trans-Pecos Texas northward through the Western Interior to southern Montana. The species is chiefly found in the upper Cenomanian *Calycoceras canitaurinum* zone, but specimens have been found sparingly in the underlying *Plesiacanthoceras wyomingense* zone. Kauffman & Powell (1977) attribute a longer range, down as far as the *Conlinoceras tarrantense* zone. Wiedmann & Kauffman (1978, pl. 4, fig. 15; reproduced in Wiedmann, 1980, pl. 1, fig. 15) recorded *Inoceramus* aff. *prefragilis* from the middle Cenomanian of northern Spain.

Inoceramus pictus J. de C. Sowerby, 1829

Fig. 32J; Fig. 33A, D, F, G, L

1829 *Inoceramus pictus* J. de C. Sowerby, p. 215, pl. 604, fig. 1.
1911 *Inoceramus pictus* J. de C. Sowerby; Woods, p. 279, text-fig. 36 only (with full synonymy)
1965b *Inoceramus pictus* Sowerby; Hattin, fig. 3.7.
1967 *Inoceramus pictus pictus* J. de C. Sowerby; Tröger, p. 36, pl. 3, figs 1–6; text-figs 6, 7.
1977 *Inoceramus pictus pictus* Sowerby; Kauffman & Powell, p. 55, pl. 1, fig. 1.
1977 *Inoceramus pictus* Sowerby; Kauffman, p. 232, pl. 4, fig. 12; pl. 5, fig. 3.
1978b *Inoceramus pictus pictus* Sowerby; Kauffman, pl. 4, figs 2, 11.
1984a *Inoceramus pictus pictus* J. de C. Sowerby; Cobban, p. 11, pl. 3, figs 5–7.

Type: BMNH 43272, from the Lower Chalk of Guildford, Surrey, England; by monotypy.

Material: Fragmentary specimens from localities D 10745 and D 10746; upper Cenomanian *Sciponoceras gracile* zone. Several specimens from USGS Mesozoic localities D 10747 and D 10898; upper Cenomanian *Neocardioceras juddii* zone.

Discussion: Inoceramus pictus has been divided into a number of subspecies by authors, yet no account of the British material is available to allow comparison of these with variation in material contemporary with the holotype, which is from the 'Chalk Marl' of Guildford, Surrey, England (see illustration in Kauffman & Powell, 1977, pl. 1, fig. 1). Material from the *S. gracile* zone at Chispa Summit shows a combination of even growth lines and rugae that resemble those of the holotype. Specimens from the succeeding *N. juddii* zone also agree with the holotype (Figure 33 (f)); others show closely spaced growth lines (Fig. 33G).

Occurrence: Widespread in the upper Cenomanian of the Western Interior and northern Mexico, ranging from the *Calycoceras canitaurinum* zone to the *Neocardioceras juddii* zone. Occurs widely in the middle and upper Cenomanian of eastern and western Europe, the USSR, Greenland and elsewhere.

Fig. 32. (A) – (C), (E), (F) *Inoceramus* aff. *arvanus* Stephenson, 1953: (A) is USNM 420042, (B) is USNM 420043, both from locality D 10742; (C) is USNM 420044, (E) is USNM 420045, (F) is USNM 420046, all from locality D 11336, *Forbesiceras brundrettei* zone. (D), (G) – (I) *Inoceramus prefragilis* Stephenson, 1953: (D) is USNM 420047, (G) is USNM 420048, (H) is USNM 420049, (I) is USNM 420050, all from locality D 10743, *Calycoceras canitaurinum* zone. (J) *Inoceramus pictus* J. de C. Sowerby, 1829: USNM 420051, from locality D 10898, *Neocardioceras juddii* zone. All figures are x 1.

Inoceramus cf. *cuvieri* Brongniart, 1822

compare

1822 *Inoceramus cuvieri* Brongniart, p. 386, pl. 4, figs 10A, E–I.

Material: Several fragments from USGS Mesozoic locality D 11177.

Discussion and Occurrence: Thick-shelled fragments of a very large *Inoceramus* show the characteristic growth line ornament of *I. cuvieri* as illustrated by Woods (e.g. 1912, text-fig. 73). This species, which occurs widely in the Western Interior from southeastern Montana to New Mexico and in western Europe and elsewhere, is most abundant in the middle Turonian zones of *Collignoniceras woollgari* and *Prionocyclus hyatti.* Excellent specimens are illustrated by Hattin (1962, pl. 15).

Inoceramus dimidius White, 1874

Fig. 33B–C, E, H–J

1874 *Inoceramus dimidius* White, p. 174.
1877 *Inoceramus dimidius* White; White, p. 181, pl. 16, fig. 2.
1894 *Inoceramus dimidius* White; Stanton, p. 78, pl. 10, figs 5, 6.
1898 *Inoceramus dimidius* White; Logan, p. 452, pl. 98, figs 5, 6.
1903 *Inoceramus dimidius* White; Johnson, p. 116, pl. 2, fig. 18.
1909 *Inoceramus dimidius* White, Grabau & Shimer p. 441, fig. 579.
1942 *Inoceramus dimidius* White; Moreman, p. 200, pl. 31, figs 2, 6.
1944 *Inoceramus dimidius* White; Shimer & Shrock, p. 389, pl. 151, figs 3, 4.
1975 *Inoceramus dimidius* White; Hattin, pl. 2, figs 6, 7.
1977 *Inoceramus? dimidius dimidius* White; Kauffman, p. 238, pl. 8, figs 7, 12, 13.
1980 *Inoceramus dimidius* White; Hook & Cobban, p. 44, fig. 7.
1986 *Inoceramus dimidius* White; Cobban, fig. 5C, D.

Types: Kauffman (1977 p. 238) designated USNM 8623a, one of White's original specimens, as the lectoholotype and USNM 8623b as a lectoparatype. These terms have no meaning under the *Rules of Zoological Nomenclature* (3rd Edition, 1985) and cannot be construed as valid designations of types of whatever category. We here designate USNM 86232a, the original of White, 1874, p. 26, illustrated by White, 1877, pl. 16, fig. 2b, as the lectotype. The type is from the Pescado Tongue of the Mancos Shale of the Pescado area, 21 km (13 mil) east of Zuni Pueblo, New Mexico, not from the Juana Lopez Member equivalent of the Mancos Shale on the east bank of the Rio Puerco 6 miles below Caza Salazar, New Mexico as stated by Kauffman, (1977, p. 238) (note that other designations of lectoholotypes by Kauffman, 1977, are also incorrect).

Material: Numerous specimens from localities D 11169, D 11170, 11171 and 11172.

Discussion: This is a highly variable species and no two specimens are alike. A distinctive feature of many individuals is the well-ornamented early growth stage followed by a marked geniculation in the shell profile, beyond which ornament is irregular or absent.

Occurrence: Upper Turonian *Prionocyclus wyomingensis* zone. Widespread from Texas to the southern Montana.

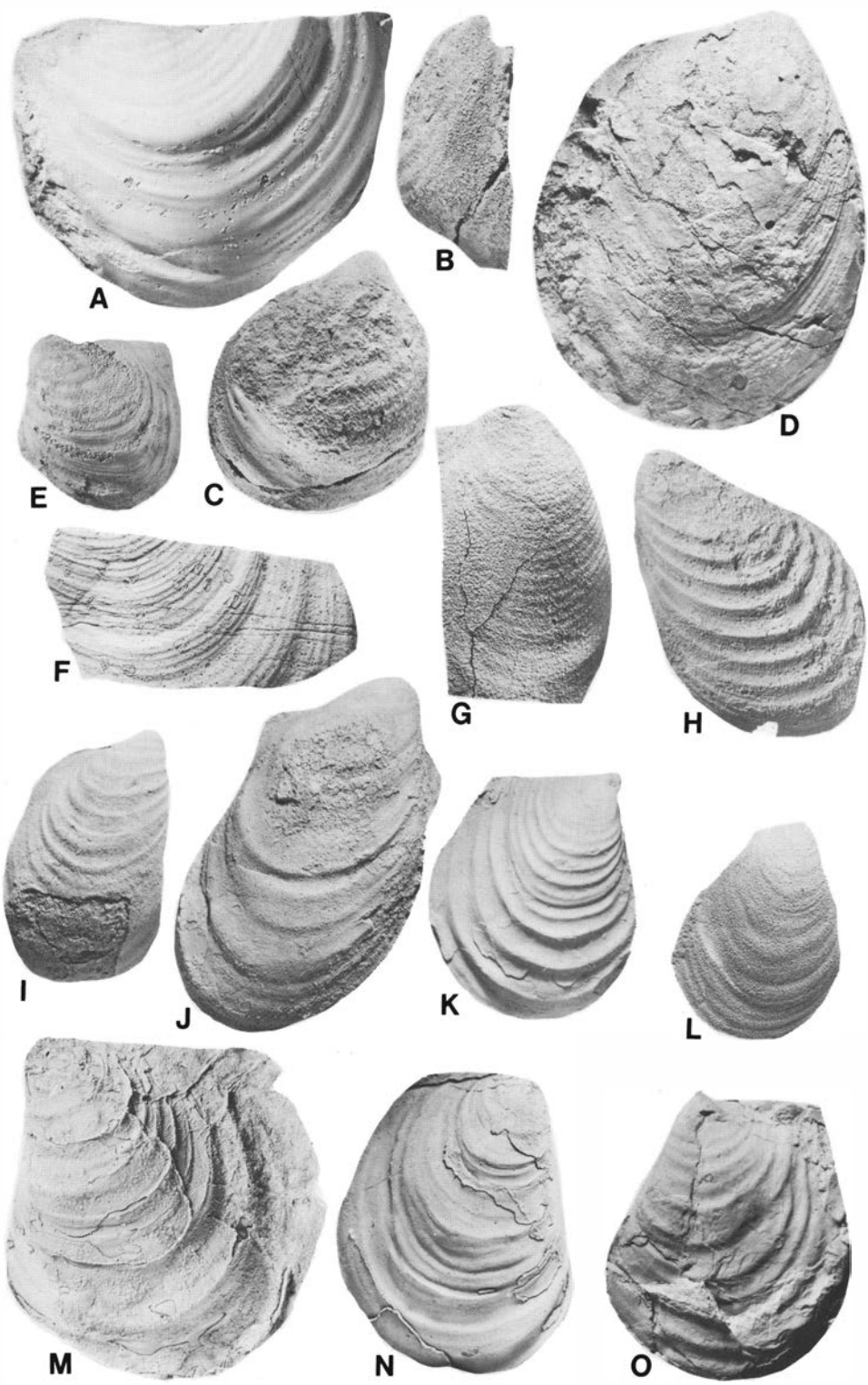
Inoceramus perplexus Whitfield, 1877

Fig. 33K, M–O; 34F

1877 *Inoceramus perplexus* Whitfield, p. 31.
1880 *Inoceramus perplexus* Whitfield, p. 392, pl. 8, fig. 3; pl. 10, figs 4, 5.
1898 *Inoceramus perplexus* Whitfield; Logan, p. 450, pl. 87, fig. 1.
1977 *Inoceramus (Inoceramus) perplexus* Whitfield; Kauffman, p. 238, pl. 8, figs 6, 14, 15.
1984b *Inoceramus perplexus* Whitfield; Cobban, p. 11, pl. 2, figs 1–3.

Lectotype: Here designated: USNM 12274, the original of Whitfield, 1880, p. 392, pl. 8, fig. 3; pl. 10, fig. 5. (Figure 33(k).)

Fig. 33. (A), (D), (F), (G), (L) *Inoceramus pictus* J. de C. Sowerby, 1829: (A) is USNM 420052, from locality D 10747, *Neocardioceras juddii* zone; (D) is USNM 420053, from locality D 10898, *N. juddii* zone; (F) is USNM 420054, from locality D 10746, *Sciponoceras gracile* zone; (G) is USNM 420055, (L) is USNM 420056, both from the same horizon and locality as (A). (B), (C), (E), (H), (I), (J) *Inoceramus dimidius* White, 1874: (B), (C) are USNM 420057, (E) is USNM 420058, (H) is USNM 420059, (I) is USNM 420060, (J) is USNM 420061, all from locality D 11170, *Prionocyclus wyomingensis* zone. (K), (M), (N), (O) *Inoceramus perplexus* Whitfield, 1877: (K) is the lectotype, USNM 12274, from the Carlile Shale, Belle Fourche River 10 miles west of Crow Peak, Black Hills region, (M) is USNM 420062, (N) is USNM 420063, both from locality D 10754, *P. wyomingensis* zone. (O), paralectotype USNM 12263, from the same horizon and locality as (K).
All figures are x 1.


A
B
D
E
C
F
G
H
I
J
K
L
M
N
O

Material: Numerous specimens from locality D 10754.

Discussion: This small species is a descendant of *Inoceramus dimidius.* The hinge is long, well-defined, with a sharp terminal umbo and a prominent posterior wing. There are strong, rounded concentric rugae of variable strength and spacing. The species differs from ancestral *dimidius* in its lack of geniculation and subsequent feebly ornamented stage.

Occurrence: Upper Turonian *Scaphites whitfieldi* and *Prionocyclus quadratus* zones, widespread and abundant in the Western Interior from central Montana south to New Mexico. Not previously recorded from west Texas.

Inoceramus sp.

Fig. 34A

Material: Fragmentary specimens from localities D 10747 and D 10898. Upper Cenomanian *Neocardioceras juddii* zone.

Discussion: The present material is poor, but seems to be a species transitional from *Inoceramus* to *Mytiloides.* Specimens are somewhat elongate and have weak growth lines and irregular rugae.

Genus MYTILOIDES Brongniart, 1822

Type species: Ostracites labiatus Schlotheim, 1813, p. 93; by monotypy.

Mytiloides columbianus (Heinz, 1935)

Fig. 34C–E, G, H

1894 *Inoceramus labiatus* Schlotheim; Stanton, pl. 14, fig. 2.
1898 *Inoceramus labiatus* Schlotheim; Logan, pl. 92, fig. 4.
1900b *Inoceramus labiatus labiatus* Schlotheim; Herrick & Johnson, pl. 37, fig. 2.
1901 *Inoceramus labiatus* (Schlotheim); Hill, pl. 40, fig. 1 only.
1908 *Inoceramus labiatus* Schlotheim; Grabau & Shimer, p. 443, fig. 583.
1920 *Inoceramus labiatus* Schlotheim; Böse, p. 229, pl. 20, fig. 5.
1921 *Inoceramus labiatus* Schlotheim; Grabau, fig. 1696b.
1923 *Inoceramus labiatus* (Schlotheim); Reeside, p. 31, pl. 14, fig. 5.
1928 *Inoceramus plicatus* (d'Orbigny); Heinz, p. 63, pl. 4, fig. 4.
1935 *Orpheoceramus columbianus* Heinz, p. 304.
1955 *Inoceramus labiatus* (Schlotheim); Cobban, p. 204, pl. 2, fig. 11.
1977 *Mytiloides* sp. aff. *M. duplicostatus* (Anderson); Kauffman & Powell, p. 81, pl. 6, fig. 5; pl. 7, figs 2, 6.
1977 *Mytiloides* sp. aff. *M. duplicostatus* (Anderson); Kauffman, pl. 6, fig. 11.
1977 *Mytiloides mytiloides* (Mantell); Kauffman, pl. 6, fig. 12.
1978 *Mytiloides* sp. aff. *M. duplicostatus* (Anderson); Kauffman, Cobban, & Eicher, p. xxiii.9, pl. 10, fig. 11.
1978 *Mytiloides mytiloides* (Mantell); Kauffman, Cobban & Eicher, p. xxiii.9, pl. 10, fig. 12.
1978 *Mytiloides mytiloides* (Mantell); Wiedmann & Kauffman, pl. 2, fig. 3.
1978 *Mytiloides opalensis elongata* (Seitz); Wiedmann & Kauffman, pl. 2, figs 5, 11.
1980 *Mytiloides mytiloides* (Mantell); Wiedmann, pl. 2, fig. 3.
1980 *Mytiloides opalensis elongata* (Seitz); Wiedmann, pl. 2, figs 5, 11.
1986 *Mytiloides plicatus* (d'Orbigny); Cobban, fig. 8F.
1987 *Mytiloides columbianus* (Heinz); Kennedy, Wright & Hancock, text-fig. 12A; C.

Type: Holotype is the original of Heinz, 1928, p. 63, pl. 4, fig. 4, from Cachira, Colombia.

Material: Numerous specimens from localities D 10893, and D 10899.

Discussion: This highly distinctive species is characterised by its moderate elongation, flattened form, with umbo anterior and a fairly short hinge line. Ornament consists of rugae, commonly doubled (or bearing a pair or riblets) with unpaired riblets between. Occasional specimens may lack the doubling or have rugae bearing several riblets; we believe these to be no more than intraspecific variants.

The holotype of this species is a well preserved specimen from 2 km south of Cachira, Colombia. Heinz (1928, p. 63, pl. 4, fig. 4) originally referred the specimen to *Inoceramus plicatus* d'Orbigny, 1842b (p. 56, pl. 3, fig. 9). Dr. F. Etayo-Serna (letter of 30 January 1987) tells us that d'Orbigny's original of *plicatus* was probably collected from beds of Turonian to Cenomanian age, but the surviving syntypes (Kennedy, Wright and Hancock, 1987, text-fig. 12D) bear no resemblance to the figure and we regard *plicatus* as a *nomen dubium.* Dr. Etayo-Serna also indicates that the type specimen of *Inoceramus columbianus* is from near the Cachira river mouth (Porto Wilches, not Porto Nilches as Heinz wrote) and that it is Late Cretaceous (Turonian or younger). Subsequent authors have ignored Heinz's name, referring to this species as *Mytiloides opalensis* (Böse, 1923) or as *Mytiloides* aff. *M. duplicostatus* (Anderson, 1958). The lectotype of *M. opalensis,* the original of Böse's pl. 13, figs 2, 3, appears to be a middle Turonian species with a much more

circular form to the growth lines and rugae. Badillet & Sornay (1980) have drawn attention to the fact that use of the name *opalensis* for very low Turonian *Mytiloides* by some authors is unacceptable; we agree. *Mytiloides duplicostatus* is an upper Turonian species from California; the holotype was associated with *Oregoniceras jilsoni* Anderson, 1958, which is a *Subprionocyclus neptuni* (Geinitz, 1850). *Mytiloides duplicostatus* is much more elongate than the present species, although showing the same doubling of riblets.

Occurrence: Lower Turonian *Pseudaspidoceras flexuosum* zone. Widespread in the Western Interior from Montana south to New Mexico and west Texas. Widespread at the same horizon in western Europe and Colombia.

Mytiloides mytiloides (Mantell, 1822)

Fig. 34B

1822 *Inoceramus mytiloides* Mantell, p. 215, pl. 28, fig. 2.
1977 *Mytiloides mytiloides* (Mantell); Kauffman & Powell, p. 74, pl. 6, figs 11–16 (with synonymy).
1978b *Mytiloides mytiloides mytiloides* (Mantell) *sensu* Seitz 1934; Kauffman, pl. 1, figs 4, 12.
1978 *Mytiloides mytiloides* (Mantell); Kauffman, Cobban & Eicher, pl. 10, fig. 8 only.
1978 *Mytiloides mytiloides* (Mantell); Hattin, fig. 6.3.
1983 *Mytiloides mytiloides* (Mantell) s.1.; Cobban, p. 6, pl. 1, fig. 1; pl. 8, figs 8, 9.
1984b *Mytiloides mytiloides* (Mantell); Cobban, p. 9, pl. 2, figs 14, 15.

Type: BMNH 5859, the original of Mantell, 1822, pl. 28, fig. 2, is referred to as the type by several authors; it is a syntype, as Mantell refers to more than one specimen. The specimen is from the Middle Chalk of Plumpton, Sussex, England.

Material: Numerous specimens from localities D 10895 and D 10900. Lower Turonian, *Mammites nodosoides* zone. OUM Collections: from middle Turonian *Collignoniceras woollgari* zone, *regulare* subzone.

Discussion: This species is described in detail by Kauffman & Powell (1977). The species is the *Inoceramus labiatus* of most authors, and is the most abundant inoceramid in the Turonian of the Western Interior. *Mytiloides mytiloides* differs from *M. submytiloides* (Seitz, 1935) most obviously in having stronger sculpture and a much more elongate form, and differs from *Mytiloides columbianus* in its greater elongation and less uniform ornament.

Occurrence: Mytiloidus mytiloides ranges from the lower Turonian *Mammites nodosoides* zone into the middle Turonian *Collignoniceras woollgari* zone. The inoceramid occurs throughout the Western Interior, it is widespread in western and eastern Europe, the USSR, and elsewhere.

Mytiloides cf. *subhercynicus* (Seitz, 1935)

Fig. 34I

compare:

1935 *Mytiloides labiatus* n. var. *subhercynica* Seitz, p. 465, pl. 40, figs 1–5; text-figs 17, 18.
1935 *Mytiloides labiatus* var. *hercynica* forma *transiens* Seitz, p. 468, pl. 40, figs. 3, 4.

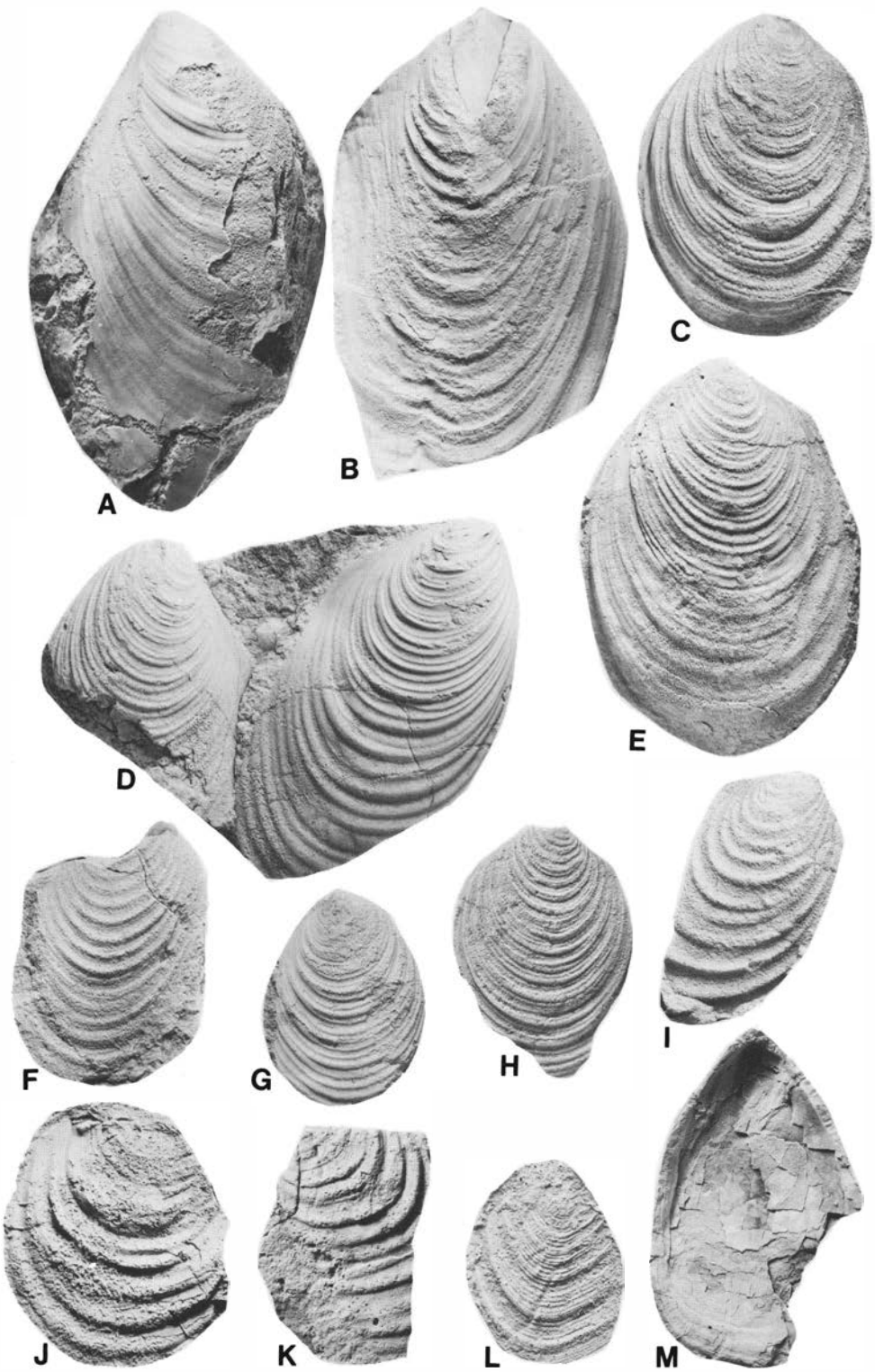
Holotype: The original of Seitz, 1935, pl. 40, fig. 1, destroyed during World War II according to Badillet & Sornay (1980). It was from the Turonian of Lengerich, Germany.

Material: Two specimens from locality D 10894; four specimens from locality D 10752.

Discussion: The early stages are circular to subcircular in many specimens, followed by an elongate mytiliform adult stage. Ornament consists of evenly spaced sharp rugae at first, thereafter becoming irregular and widely spaced.

Badillet & Sornay (1980) discussed the variation and nomenclature of this species. They point out that *Inoceramus labiatus subhercynica* Seitz, 1935 (p. 465, pl. 40, figs 1–5; text-figs 17,18) is the early stage and *Inoceramus labiatus subhercynica* var. *transiens* the adult of the same species. These authors conserve the name *transiens* as a subspecies of their *Inoceramus goppelnensis,* introduced as *nomen novum* for *Inoceramus opalensis* Seitz *non* Böse *elongatus* Seitz *non* Etheridge, abandoning the name *subhercynicus* because of subsequent usage by Egoian (1955). This is nomenclaturally invalid. Seitz's *subhercynica* was introduced as a variety and under the *Rules* use of either of the terms "variety" or "form" prior to 1961 is not to be interpreted as an express statement of either subspecific or infrasubspecific rank. However, a form of a variety must in logic be of infrasubspecific rank so that *elongatus* is not available.

Occurrence: Lower Turonian *Mammites nodosoides* zone and middle Turonian *Collignoniceras woollgari* zone. Widespread in the Western Interior from Wyoming to New Mexico and west Texas. Widespread in western Europe, Mexico and elsewhere.


A
B
C
D
E
F
G
H
I
J
K
L
M

Mytiloides incertus (Jimbo, 1894)

1894 *Mytiloides incertus* Jimbo, p. 189 (43), pl. 24(8), fig. 7.
1984 *Mytiloides incertus* (Jimbo); Noda, p. 498, pl. 84, pl. 85, pl. 86, figs 1–8 (with synonymy).

Lectotype: By subsequent designation of Matsumoto & Noda, 1983, p. 111, University of Tokyo Collections no. UMUT MM7535, from a float concretion in the bed of the Pombets, Hokkaido, Japan.

Material: Five specimens from locality D 10754, upper Turonian *Scaphites whitfieldi* zone.

Discussion: Matsumoto & Noda (1983)and Noda (1984) discussed this species at length and clarified its age and relationships. The characteristic ornament is of regular concentric rugae with very even fine riblets between. Complete shells have a distinctive quadrangular appearance. The European *Inoceramus fiegei fiegei* Tröger, 1967 (p. 105, pl. 11, fig. 3; pl. 13, figs 14, 15, 17, 20) is a synonym.

Occurrence: Upper Turonian *Prionocyclus quadratus* zone from Montana south to southern New Mexico. The present material is from the underlying *Scaphites whitfieldi* zone. The species has a wide distribution in the upper Turonian of central Europe, Afghanistan, and possibly, Brazil.

Genus CREMNOCERAMUS Cox, 1969

Type species: Inoceramus inconstans Woods, 1912, p. 285, text-fig. 43, by original designation.

Cremnoceramus cf. *rotundatus* (Fiege, 1930)

Fig. 34J, K

compare:

1930 *Inoceramus inconstans rotundatus* em. Fiege, p. 42, pl. 7, fig. 32; pl. 8, fig. 31, *non* fig. 33.
1967 *Inoceramus rotundatus* Fiege; Tröger, p. 110, pl. 13, figs 5, 6; pl. 13, figs 10-13 (with synonymy).
1979 *Cremnoceramus ? rotundatus* (Fiege); Kauffman *in* Herm, Kauffman & Wiedmann, p. 68, pl. 9, figs A, C (with synonymy).
1984b *Cremnoceramus ? rotundatus* (Fiege); Cobban, p. 9, pl. 1, figs 2, 3.

Material: Three specimens from locality D 11173.

Discussion: Cremnoceramus rotundatus has been regarded as upper Turonian in Europe, but Kauffman (1975, 1977, 1978a–b; Kauffman, Cobban & Eicher, 1978) have established a very early Coniacian *rotundatus* zone and claim European occurrences to be of this age. The geographic distribution extends from the Western Interior to the Caribbean, western Europe and the USSR.

Cremnoceramus cf. *waltersdorfensis* (Andert, 1911)

Fig. 34L

compare

1911 *Inoceramus waltersdorfensis* Andert, p. 53, pl. 5, figs 2, 5.
1977 *Inoceramus waltersdorfensis* Andert; Kauffman, p. 243, pl. 10, fig. 8.
1977 *Inoceramus waltersdorfensis waltersdorfensis* Andert; Kauffman, p. 241, pl. 9, figs 22, 26.
1984b *Cremnoceramus? waltersdorfensis* (Andert); Cobban, p. 8, pl. 1, fig. 1.

Material: Two specimens from locality D 11173, lower Coniacian.

Discussion and Occurrence: This form occurs in the *Prionocyclus quadratus* and *Scaphites preventricosus* zones, thus spanning the Turonian-Coniacian boundary in the Western Interior. The V-shaped ribbing is distinctive, even on fragments. The species ranges from northern Montana to central New Mexico and Trans-Pecos Texas, and is also present in the Austin Chalk in central Texas. Widespread in eastern and western Europe.

Fig. 34. (A) *Inoceramus* sp.: USNM 420065, from locality D 10747. *Neocardioceras juddii* zone. (B) *Mytiloides mytiloides* (Mantell, 1822): USNM 420071, from locality D 10900, *Mammites nodosoides* zone. (C) – (E), (G), (H) *Mytiloides columbianus* (Heinz, 1935): (C) is USNM 420066, (D) is USNM 420067, (E) is USNM 420068, (G) is USNM 420069, (H) is USNM 420070, all from locality D 10899, *Pseudaspidoceras flexuosum* zone. (F) *Inoceramus perplexus* Whitfield, 1877, USNM 420064, from locality D 10754, *Prionocyclus wyomingensis* zone. (I) *Mytiloides* cf. *subhercynicus* (Seitz, 1935), USNM 420072, from locality D 10894, *Mammites nodosoides* zone. (J), (K) *Cremnoceramus* cf. *rotundatus* Fiege, 1930, (J) is USNM 420073, (K) is USNM 420074, both from locality D 11173, lower Coniacian. (L) *Cremnoceramus* ? cf. *waltersdorfensis* Andert, 1911, USNM 419946, from locality D 11173, lower Coniacian. (M) *Ostrea beloiti* Logan, 1899, USNM 419947, from locality D 10741, *Forbesiceras brundrettei* zone.
All figures are x 1.

Suborder OSTREINA Férussac, 1822

Superfamily OSTREACEA Rafinesque, 1815

Family OSTREIDAE Rafinesque, 1815

Subfamily OSTREINAE Rafinesque, 1815

Genus OSTREA Linnaeus, 1758

Type species: Ostrea edulis Linnaeus, 1758, p. 696 (ICZN Opinion 94, 1958).

Ostrea beloiti Logan, 1899

Fig. 34M

1876 *Ostrea elegantula* Newberry, p. 33 (*nomen oblitum*).
1884 *Ostrea elegantula* Newberry; White, p. 295, pl. 36, figs 5–7.
1899 *Ostrea beloiti* Logan, p. 214, pl. 25, figs 7, 8.
1965a *Ostrea beloiti* Logan; Hattin, p. 50, pl. 4, figs A, B, G, I.
1977 *Ostrea beloiti* Logan; Kauffman & Powell, p. 92, pl. 8, figs 9, 10.
1977 *Ostrea beloiti* Logan; Hattin, fig. 4.14.
1980b *Ostrea beloiti* Logan; Cobban & Hook, p. 169, fig. 2A, B.
1984a *Ostrea beloiti* Logan; Cobban, p. 13, pl. 5, fig. 11.
1986 *Ostrea beloiti* Logan; Cobban, fig. 5, I, b.
1988 *Ostrea beloiti* Logan; Kennedy, Cobban & Hook, p. 42, figs. 2f, g, m, r.

Type: Lectotype, here designated, the original of Logan, 1899, pl. 25, figs 7, 8, from the Cenomanian of north-central Kansas.

Material: Numerous specimens from localities D 10741, D 10742, D 11182, D 11336 and D 11337.

Discussion: Kauffman & Powell (1977, p. 92, pl. 8, figs 9, 10) described *O. beloiti* in detail and outline differences between it and other Western Interior middle Cretaceous species. Hook & Cobban (1980, p. 42) noted that *Ostrea elegantula* Newberry, 1876 (p. 33), first illustrated by White (1884) which has the same types as *O. beloiti* is a prior name, but correctly relegated it to the status of a *nomen oblitum.* Cobban & Hook (1980b, fig. 1) show the distribution of *O. beloiti* in New Mexico and the Western Interior.

Occurrence: The species ranges from the middle Cenomanian *Conlinoceras tarrantense* zone, where it is rare in southern Colorado to the upper Cenomanian *Dunveganoceras pondi* zone, where it is rare in the Great Plains areas and in New Mexico. *Ostrea beloiti* is abundant and sometimes a rock former in the middle Cenomanian *Acanthoceras amphibolum* zone, ranging from Manitoba (McNeil & Caldwell, 1974) to west and north central Texas.

Acknowledgements. – We thank the staff of the Geological Collections, University Museum, and Department of Earth Sciences, Oxford and the U.S. Geological Survey Paleontology and Stratigraphy Branch, Denver, for their technical assistance, in particular R. E. Burkholder, who prepared and photographed most of the material studied. Kennedy and Hancock acknowledge with thanks the financial support of the Natural Environment Research Council, the Royal Society and the Lindemann Trust.

REFERENCES

Adkins, W. S. 1928. Handbook of Texas Cretaceous Fossils. *Bull. Univ. Tex.*, 2838, 385 pp.
Adkins, W. S. 1931. Some Upper Cretaceous ammonites in western Texas. *Bull. Univ. Tex.*, 3103, 35–72.
Adkins, W. S. 1933. The Mesozoic Systems in Texas. *Bull. Univ. Tex.*, 3232, 239–518 (1932 imprint).
Adkins, W. S. & Lozo, F. E. 1951. Stratigraphy of the Woodbine and Eagle Ford, Waco area, Texas. *Fondren Sci. Ser.* 43, 101–169.
Anderson, F. M. 1958. Upper Cretaceous of the Pacific Coast. *Mem. Geol. Soc. Am.* 71, 378 + xi pp.
Andert, H. 1911. Die Inoceramen des Kreibitz-Zittauer Sandsteingebirge. *Festschrift Humboldtvereins, Feifer 50 Jahr Bestehens*, 33–64. Max Wegner, Leipzig.
Arkhanguelsky, A. D. 1916. [The Upper Cretaceous Molluscs of Turkestan. Part 1.] *Trudy Geol. kom.* 151, 1–57 [In Russian].
Badillet, G. & Sornay, J. 1980. Sur quelques formes du groupe d'*Inoceramus labiatus* décrites par O. Seitz. Impossibilité d'utiliser ce groupe pour une datation stratigraphique du Turonien inférieur du Saumurois (France). *C.r. hebd. Acad. Sci., Paris, Série D* 290, 323–325.
Barber, W. 1957. Lower Turonian ammonites from north-eastern Nigeria. *Bull. Geol. Surv. Nigeria* 26, 86 pp.
Barbour, E. H. 1903. Report of the State geologist. *Nebraska Geol. Surv.* 1, 258 pp.
Barrois, C. & Guerne, J. de. 1878. Description de quelques espèces nouvelles de la Craie de l'Est du Bassin de Paris. *Annls. Soc. Géol. Nord* 5, 42–64.
Benavides-Cáceres, V. E. 1956. Cretaceous system in northern Peru. *Bull. Am. Mus. Nat. Hist.* 108, 353–494.
Berthou, P. Y., Chancellor, G. R. & Lauverjat, J. 1985. Revision of the Cenomanian-Turonian ammonite *Vascoceras* Choffat, 1898, from Portugal. *Comucões Serv. Geol. Portugal* 71, 55–79.
Beurlen, K. 1944. Beiträge zur Stammesgeschichte der Muscheln. *Sber. bayer. Akad. Wiss.* 1944 (1, 2), 133–145.
Böse, E. 1906. Excursion au Cerro de Muleros. *Int. Geol. Cong.* 10, Guidebook for Excurison 20, 24 pp.
Böse, E. 1910. Monographía geológica y paleontológica del Cerro de Muleros cerca de Ciudad Juaŕez, Estado de Chihuahua, y descripción de la fauna cretácea de La Encantada, Placer de Guadalupe, Estado de Chihuahua. *Bolen Inst. geol. México* 25, 193 pp.
Böse, E. 1920. On a new ammonite fauna from the Lower Turonian of Mexico. *Bull. Univ. Tex.* 1856, 173–257 (1918 imprint).
Böse, E. 1923. Algunas faunas Cretácicas de Zacatecas, Durango y Guerrero. *Bolen Inst. geol. México* 42, 219 + iv pp.

Böse, E. 1928. Cretaceous ammonites from Texas and northern Mexico. *Bull. Univ. Tex.* 2748, 143–357 [1927 imprint].

Breistroffer, M. 1947. Notes de nomenclature paleózoologiques. *Proc. verb. mens. Soc. Sci. Dauphiné* Année 26, no. 195, 5 pp. (unpaginated).

Breistroffer, M. 1953. Commentaires taxonomiques. *in* Breistroffer, M. & Villoutreys, O. de. Les ammonites albiennes de Peille (Alpes-Maritimes). *Trav. Lab. Géol. Univ. Grenoble* 30, 69–74 (for 1952).

Breton, G. & Bavent, M. 1985. *Baculites undulatus* d'Orbigny, 1850 du Turonien d' Eletôt près Fécamp (Seine-Maritime). *Bull. trimestr. soc. géol. Normandie amis Mus. Havre* 72, pp. 101–102.

Brongniart, A. 1822. Sur quelques terrains de Craie hors du Bassin de Paris. Pp. 80–101 *In* Cuvier, G. & Brongniart, A. *Description geólogique des environs de Paris.* 3rd Edn. 428 pp. chez G. Dufour et E. d' Ocagne, Librairies, Paris.

Case, G. R. 1982. *A pictorial guide to fossils.* 515 pp., Van Nostrand Reinhold Company, New York.

Chancellor, G. R. 1982. Cenomanian-Turonian ammonites from Coahuila, Mexico. *Bull. geol. Instn. Univ. Uppsala* New Series 9, 77–129.

Choffat, P. 1898. Recueil d'études paléontologiques sur la faune crétacique du Portugal. 1, espèces nouvelles ou peu connues. Deuxième série, Les Ammonées du Bellasien, des couches à Neolobites Vibrayeanus, du Turonien et du Senónien. *Trav. géol. Portugal* (1898), 41–86.

Chudeau, R. 1909. Ammonites du Damergou (Sahara méridional): *Bull. Soc. géol. France* (4) 9, 67–71.

Chudeau, R. 1921. Ammonites turoniennes du Soudan. *Bull. Mus. Hist. Nat., Paris* 27, 463–470.

Clark, D. L. 1965. Heteromorph ammonites from the Albian and Cenomanian of Texas and adjacent areas. *Mem. geol. Soc. Am.* 95, 99 + viii pp.

Cobban, W. A. 1951. Colorado shale of central and northwestern Montana and equivalent rocks of Black Hills. *Bull. Am. Ass. Petrol. Geol.* 35 (10), 2170–2198.

Cobban, W. A. 1952. Scaphitoid cephalopods of the Colorado group. *Prof. Pap. U.S. geol. Surv.* 239, 42 pp. [1951 imprint].

Cobban, W. A. 1953. A new species of *Prionocyclus* from Upper Cretaceous Carlile shale. *J. Paleont.* 27 (3), 353–355.

Cobban, W. A. 1955. Some guide fossils from the Colorado shale and Telegraph Creek formation, northwestern Montana, *in Billings Geological Society Guidebook Sixth Annual Field Conference, Sweetgrass arch-Disturbed belt, Montana,* 198–207.

Cobban, W. A. 1961. The ammonite family Binneyitidae Reeside in the Western Interior of the United States. *J. Paleont.* 35, 737–758.

Cobban, W. A. 1972. New and little known ammonites from the Upper Cretaceous (Cenomanian and Turonian) of the Western Interior of the United States. *Prof. Pap. U.S. geol. Surv.* 699, 24 pp. (1971 imprint).

Cobban, W. A. 1976. Ammonite record from the Mancos Shale of the Castle Valley-Woodside area, east-central Utah. *Geology Stud. Brigham Young Univ.* 22, 1117–126.

Cobban, W. A. 1977. Characteristic marine molluscan fossils from the Dakota Sandstone and intertongued Mancos Shale, west-central New Mexico. *Prof. Pap. U.S. geol. Surv.* 1009, 30 pp.

Cobban, W. A. 1983. Molluscan fossil record from the northeastern part of the Upper Cretaceous seaway, western interior. *Prof. Pap. U.S. geol. Surv.* 1253, 1–25.

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

Cobban, W. A. 1984b. Molluscan record from a mid-Cretaceous borehole in Weston County, Wyoming. *Prof. Pap. U.S. geol. Surv.* 1271, 24 pp.

Cobban, W. A. 1986. Upper Cretaceous molluscan record from Lincoln County, New Mexico. *Southwestern Section of AAPG Transactions and Guidebook of 1986 Convention* 77–89. New Mexico Bureau of Mines & Mineral Resources: Socorro.

Cobban, W. A. 1987. Some middle Cenomanian (Upper Cretaceous' acanthoceratid ammonites from the Western Interior of the United States. *Prof. Pap. U.S. geol. Surv.* 1445, 28 pp.

Cobban, W. A. 1988. The late Cretaceous ammonite *Spathites* Kummel & Decker in New Mexico. *Bull. New Mex. Bur. Min. Miner. Res.* 114, 5–22.

Cobban, W. A. & Hook, S. C. 1979. *Collignoniceras woollgari woollgari* (Mantell) ammonite fauna from the Upper Cretaceous of western interior, United States. *Mem. New Mex. Bur. Min. Miner. Res.* 37, 51 pp.

Cobban, W. A. & Hook, S. C. 1980a. The upper Cretaceous (Turonian) ammonite family Coilopoceratidae Hyatt in the western interior of the United States. *Prof. Pap. U.S. geol. Surv.* 1192, 28 pp.

Cobban, W. A. & Hook, S. C. 1980b. Occcurrence of *Ostrea beloiti* Logan in Cenomanian rocks of Transpecos Texas. *New Mexico Geological Society Guidebook, 31st Field Conference, Trans-Pecos Region, 1980* 169–172. New Mexico Bureau of Mines & Mineral Resources: Socorro.

Cobban, W. A. & Hook, S. C. 1981. New turrilitid ammonite from mid-Cretaceous (Cenomanian) of southwest New Mexico. *Circ. New Mex. Bur. Min. Miner. Res.* 130, 22–29.

Cobban, W. A. & Hook, S. C. 1983a. Mid-Cretaceous (Turonian) ammonite fauna from Fence Lake area of west-central New Mexico. *Mem. New Mex. Bur. Min. Miner. Res.* 41, 50 pp.

Cobban, W. A. & Hook, S. C. 1983b. *Pseudaspidoceras pseudonodosoides* – common Upper Cretaceous guide fossil in southwest New Mexico. *Ann. Rep. New Mex. Bur. Min. Miner. res.* 1982, 37–40.

Cobban, W. A., Hook, S. C. &Kennedy, W. J. 1989. Upper Cretaceous rocks and ammonite faunas of southwestern New Mexico. *Mem. New Mex. Bur. Min. Miner. Res.* 45. 139 pp.

Cobban, W. A. & Reeside, J. B. Jr. 1952. Correlation of the Cretaceous formations of the Western Interior of the United States. *Bull. geol. Soc. Am.* 63 (10), 1011–1043.

Cobban, W. A. & Scott, G. R. 1972. Stratigraphy and ammonite fauna of Graneros Shale and Greenhorn Limestone near Pueblo, Colorado. *Prof. Pap. U.S. geol. Surv.* 645, 108 pp.

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

Collignon, M. 1939. Fossiles Cénomaniens et Turoniens du Menabe (Madagascar). *Annls géol. Serv. Min. Madagascar* 8, 29–72.

Collignon, M. 1957. Céphalopodes néocrétacées du Tinhret (Fezzan). *Annls. Paléont.* 43, 113–136.

Collignon, M. 1965a. *Atlas des fossiles caractéristiques de Madagascar (Ammonites)* XII *Turonien.* 82 + iv pp. Tananarive: Service Géologique.

Collignon, M. 1965b. Nouvelles ammonites néocretacées sahariennes. *Annls. Paléont.* 51, 163–202 (1–40).

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

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

Cooper, M. R. 1979. Ammonite evolution and its bearing on the Cenomanian – Turonian boundary problem. *Paläont. Zeitschr.* 53, 120–128.

Courtiller [A.]. 1860. Description de trois nouvelles espèces d'ammonites du terrain crétacé des environs de Saumur (étage turonien), et des ammonites *Carolinus* et *Fleuriausianus,* à l' état adulte. *Mém. Soc. imp. Agr. Sci. Arts Angers* 3, 246–252.

Cox, L. R. 1969. *Treatise on Invertebrate Paleontology. Part N, Mollusca 6, Bivalvia,* volumes 1 and 2, 952 pp. Geological Society of America and University of Kansas Press, New York & Lawrence.

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

Crick, R. 1978. Morphological variation in the ammonite *Scaphites* of the Blue Hill Member, Carlile Shale, upper Cretaceous, Kansas. *Paleont. Contr. Univ. Kansas* 88, 28 pp.

Cuvier, G., & Brongniart, A. 1822. Description géologique des couches des environs de Paris. . . , *in* Cuvier, G. *Recherches sur les Ossemens Fossiles* 2, 239–648.

Dane, C. H., Kauffman, E. G., & Cobban, W. A. 1968. Semilla Sandstone, a new member of the Mancos Shale in the southeastern part of the San Juan Basin, New Mexico. *Bull. U.S. geol. Surv.* 1254-F, 21 pp.

Daugerty, F. W. & Powell, J. D. 1963. Late Cretaceous stratigraphy in northern Coahuila, Mexico. *Bull. Am. Ass. Petrol. Geol.* 47, 2059–2064.

Diener, C. 1925. Ammonoidea Neocretacea. *Fossilium Catalogus (1: Animalia)* 29, 244 pp.

Douvillé, H. 1912. Évolution et classification des Pulchelliidés. *Bull. Soc. géol. Fr.* (4) 11 (for 1911), 285–320.

Douville, H. 1931. Les ammonites de Salinas, *in* Contribution à la géologie de l'Angola. *Bolm. Mus. Lab. miner. géol. Univ. Lisb.* (1), 1, 17-46.

Dubourdieu, G. 1953. Ammonites nouvelles des Monts du Mellègue. *Bull. Serv. Carte géol. Algér., Ie sér., Paléontologie* 16, 76 pp.

Easton, W. H. 1960. *Invertebrate Paleontology* xii + 701 pp. Harper, New York.

Egoian, V. L. 1955. *[The Upper Cretaceous deposits of the southwestern part of the Armenian SSR.]* 270 pp. Erevan: Academy of Sciences of the Armenian SSR [In Armenian].

Férussac, A. E. de. 1822. *Tableaux systèmatique des animaux mollusques.* 111 pp. Paris & London.

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

Fiege, K. 1930. Über die Inoceramen des Oberturon mit besonderer Berüchsichtigung der in Rheinland und Westfalen Vorkommenden Formen. *Palaeontographica* 73, 31–47.

Freund, R. & Raab, M. 1969. Lower Turonian ammonites from Israel. *Spec. Pap. Palaeont.* 4, 83 + v pp.

Frush, M. P. & Eicher, D. L. 1975. Cenomanian and Turonian Foraminifera and palaeoenvironemnts in the Big Bend region of Texas and Mexico. *Spec. Pap. geol. Ass. Can.* 31, 277–301.

Furon, R. 1935. Le Crétacé et le Tertiaire du Sahara Soudanais (Soudan, Niger, Tchad). *Archs. Mus. natn. Hist. nat. Paris* (6) 13, 1–96.

Geinitz, H. B. 1850. *Das Quadersandsteingebirge oder Kreidegebirge in Deutschland.* 292 pp., Craz & Gerlach, Freiberg.

Giebel, C. G. 1852. *Deutschlands Petrefacten. Ein systematisches Verzeichniss aller in Deutschland und der angrenzenden Ländern vorkommenden Petrefacten nebst Angabe der Synonyme und Fundorte.* 329–441. Leipzig.

Gilbert, G. K. 1896. The underground water of the Arkansas Valley in eastern Colorado. *U.S. geol. Surv. 17th Ann. Rep. part 2* 551–601.

Gill, T. 1871. Arrangement of the families of mollusks. *Smithsonian Miscellaneous Collections* 227, 49 + vi pp.

Grabau, A. W. 1921. *A Textbook of Geology, pt 2, Historical Geology.* 976 pp., D. C. Heath and Co., New York.

Grabau, A. W. & Shimer, H. W. 1909–1910. *North American Index Fossils; Invertebrates.* 1, 853 + viii pp. (1909); 2, 909 + xv pp. (1910). A. G. Seiler & Company, New York.

Gray, J. E. 1847. A list of the genera of recent Mollusca, their synonyms and types. *Proc. Zoo. Soc.* 15, 129–219.

Greco, B. 1915. Fauna cretacea dell' Eggito raccolta dal Figari Bey. *Palaeontogr. Ital.* 29, 189–231 (1–43).

Grossouvre, A. de 1894. Recherches sur la craie supérieure. 2: Paléontologie – Les ammonites de la craie supérieure. *Mém. Serv. Carte géol. dét. Fr.* 1013 + vii pp.

Guefanger, E. 1867. *Album paléontologique du department de la Sarthe.* 20 pp., Beauvais & Vallienne, Le Mans.

Haas, O. 1946. Intraspecific variation in, and ontogeny of, *Prionotropis woollgari* and *Prionocyclus wyomingensis. Bull Am. Mus. Nat. Hist.* 86, 141–224.

Haas, O. 1949. Acanthoceratid Ammonoidea from near Greybull, Wyoming. *Bull. Am. Mus. Nat. Hist.* 93, 1–39.

Haas, O. 1963. *Paracanthoceras wyomingense* (Reagan) from the Western Interior of the United States and from Alberta (Ammonoidea). *Amer. Mus. Novit.* 2151, 19 pp.

Haas, O. 1964. *Plesiacanthoceras,* new name for *Paracanthoceras* Haas, 1963, *non* Furon, 1935. *J. Paleont.* 38, 610.

Hancock, J. M. 1984. Some possible boundary stratotypes for the base of the Cenomanian and Turonian stages. *Bull. geol. Soc. Denmark* 33, 123–128.

Hattin, D. E. 1962. Stratigraphy of the Carlile Shale (Upper Cretaceous) in Kansas. *Bull. Kansas Univ. geol. Surv.* 156, 155 pp. 27 pls.

Hattin, D. E. 1965a. Stratigraphy of the Graneros Shale (Upper Cretaceous) in Central Kansas. *Bull. Kansas Univ. geol. Surv.* 178, 83 pp.

Hattin, D. E. 1965b. Upper Cretaceous stratigraphy, paleontology, and paleoecology of western Kansas, with a section on Pierre Shale, by W. A. Cobban. *Geological Society of America Field Conference Guidebook, 78th Annual Meetings,* 69 pp.

Hattin, D. E. 1975. Stratigraphic study of the Carlile-Niobrara (Upper Cretaceous) unconformity in Kansas and northeastern Nebraska. *Spec. Pap. geol. Ass. Can.* 13, 195–210.

Hattin, D. E. 1977. Upper Cretaceous stratigraphy, paleontology and paleoecology of western Kansas. *Mount. Geologist* 14, 175–218.

Hattin, D. E. & Siemers, C. 1978. *Guidebook. Upper Cretaceous stratigraphy and depositional environments of western Kansas.* 102 pp. Kansas Geological Survey, Lawrence, Kansas.

Heinz, R. 1928. Über die Oberkreide-Inoceramen Süd-Amerikas. *Mitt. geol. St. Inst. Hamburg* 10, 41–97.

Heinz, R. 1935. Unterkreide – Inoceramen von der Kapverden – Insel Maio. *Neues Jb. Miner. Geol. Paläont. Beil Bd.* 73, 302–311.

Herm, D., Kauffman, E. G. & Wiedmann, J. 1979. The age and depositional environment of the "Gosau"-Group (Coniacian-Santonian), Brandenberg/Tirol, Austria. *Mitt. geol. St. Inst. Hamburg*, 19, 27–92.

Herrick, C. L. & Johnson, D. W. 1900a. The geology of the Albuquerque sheet. *Bull. New Mex. Univ.* 2, 1–67.

Herrick, C. L. & Johnson, D. W. 1900b. The Geology of the Albuquerque Sheet. *Bull. Denison Univ. Sci. Labs.* 11, article 9, 175–239.

Hill, R. T. 1901. Geography and geology of the Black and Grand Prairies, Texas, with detailed descriptions of the Cretaceous formations and special reference to artesian waters. *U.S. Geol. Surv., 21st Ann. Rep.* 7, 666 pp.

Holzapfel, E. 1887–1888. Die Mollusken der Aachener Kreide. *Palaeontographica* 34, 29–180.

Hook, S. C. & Cobban, W. A. 1979. *Prionocyclus novimexicanus* (Marcou) – – common Upper Cretaceous guide fossil in New Mexico. *Ann. Rep. New Mex. Bur. Min. Miner. Res.* 1977–1978, 34–42.

Hook, S. C. & Cobban, W. A. 1980. Some guide fossils in Upper Cretaceous Juana Lopez Member of Mancos and Carlile Shales, New Mexico. *Ann. Rep. New Mex. Bur. Min. Miner. Res.* 1978–1979, 38–49.

Hook, S. C. & Cobban, W. A. 1981. Late Greenhorn (mid-Cretaceous) discontinuity surfaces, southwest New Mexico. *Circ. New Mex. Bur. Min. Miner. Res.* 180, 5–21.

Hook, S. C. & Cobban, W. A. 1983. Mid-Cretaceous molluscan sequence at Gold Hill, Jeff Davis County, Texas, with comparison to New Mexico. *Circ. New Mex. Bur. Min. Miner. Res.* 185, 48–54.

Huffman, M. E. 1960. *Micropaleontology of lower portion of Boquillas Formation near Hot Springs, Big Bend National Park, Brewster County, Texas.* Unpublished Master's Thesis, Texas Technological College.

Hyatt, A. 1889. Genesis of the Arietidae. *Smithson. Contr. Knowl.* 673, 238 + xi pp.

Hyatt, A. 1894. Phylogeny of an acquired characteristic. *Proc. Am. phil. Soc.* 32, 349–647.

Hyatt, A. 1900. *Cephalopoda.* Pp. 502–604 in Zittel, K. A. 1896–1900. *Textbook of Palaeontology* translated by C. R. Eastman. Macmillan, London.

Hyatt, A. 1903. Pseudoceratites of the Cretaceous. *Monogr. U.S. Geol. Surv.* 44, 351 pp.

Jeletzky, J. A. 1949. *Scaphites morrowi,* new name for *Scaphites pygmaeus* Morrow, 1935, *non* Holzapfel, 1888. *J. Paleont* 23, p. 330.

Jeletzky, J. A. 1970. Cretaceous macrofaunas. Pp. 649–662. *In* Douglas, R. J. W. (Ed.) Geology and economic minerals of Canada. *Economic Geology Report* 1 (5th Edn). 838 pp.

Jimbo, K. 1894. Beiträge zur Kenntniss der Fauna der Kreideformation von Hokkaido. *Palaönt.-Abh.* 2, 147–194.

Johnson, D. W. 1903. The geology of the Cerrillos Hills, New Mexico; Part 2, palaeontology. *School of Mines Quarterly* 24, 101–174.

Jones, T. S. 1938. Geology of Sierra la Pena and paleontology of the Indidura Formation, Coahuila, Mexico. *Bull. geol. Soc. Am.* 49, 69–150.

Jones, B. R. & Reaser, D. F. 1970. Geology of southern Quitman Mountains, Hudspeth County. 24 pp. *In* Guidebook. Geology of the southern Quitman Mountains area, Trans-Pecos Texas. *Permian Basin Section of the Society of Economic Geologists and Paleontologists* Guidebook 70–12.

Juignet, P. & Kennedy, W. J. 1979. Faunes d' Ammonites et biostratigraphie comparée du Cénomanien du Nord-Ouest de la France (Normandie) et du sud de l' Angleterre. *Bull. Trimestr. Soc. géol. Normandie amis Mus. Havre* 63, 193 pp.

Jukes-Browne, A. J. 1896. *in* Jukes-Browne, A. J. & Hill, W. A delimitation of the Cenomanian: – being a comparison of the corresponding beds in south-western England and western France. *Q. Jl. geol. Soc. Lond.* 52, 99–178.

Kauffman, E. G. 1975. Dispersal and biotic potential of benthonic Bivalvia in the Western Interior. *Spec. Pap. geol. Ass. Canada* 13, 143–194.

Kauffman, E. G. 1977. Illustrated guide to biostratigraphically important macrofossils, western interior basin, U. S.A. *Mount. Geologist* 14, 225–274.

Kauffman, E. G. 1978a. British Middle Cretaceous inoceramid biostratigraphy. *Ann. Mus. Hist. Nat. Nice* 4, iv. 1 – iv. 12 (1976 imprint).

Kauffman, E. G. 1978b. An outline of the Middle Cretaceous marine history and inoceramid biostratigraphy of the Bohemian Basin, Czechoslovakia. *Ann. Mus. Hist Nat. Nice* 4, xiii. 1 – xiii. 12. (1976 imprint).

Kauffman, E. G., Cobban, W. A. & Eicher, D. 1978. Albian through Lower Coniacian strata, biostratigraphy and principal events, Western Interior United States. *Ann. Mus. Hist. Nat. Nice* 4, xxiii. 1 – xxiii. 52. (1976 imprint).

Kauffman, E. G. & Powell, J. D. 1977. Palaeontology. Pp. 47-114 *In* Kauffman, E. G., Hattin, D. E. & Powell, J. D. Stratigraphic, paleontologic, and paleoenvironmental analysis of the Upper Cretaceous rocks of Cimarron County, northwestern Oklahoma. *Mem. geol. Soc. Am.* 149, 149 pp.

Kennedy, W. J. 1985. Integrated macrobiostratigraphy of the Albian to basal Santonian. *Publications from the Paleontological Institution of the University of Uppsala Special Volume* 5, 91–108.

Kennedy, W. J. 1986. Appendix 1: Ammonite biostratigraphy of the Albian to basal Santonian, pp. 129–182 *in* Events of the mid-Cretaceous. Final report on results obtained by IGCP Project No. 58, 1974–1985, Reyment R. A. & Bengtson, P., compilers. *Physics and Chemistry of the Earth* 16.

Kennedy, W. J. 1988. Late Cenomanian and Turonian ammonite faunas from north-east and central Texas. *Spec. Pap. Palaeont.* 39, 131 pp.

Kennedy, W. J., Amédro, F., Badillet, G., Hancock, J. M. & Wright, C. W. 1984. Notes on late Cenomanian and Turonian ammonites from Touraine, western France. *Cret. Res.* 5, 29–45.

Kennedy, W. J., Amédro, F. & Colleté, C. 1986. Late Cenomanian and Turonian ammonites from Ardennes, Aube and Yonne, eastern Paris Basin. *Neues Jb. geol. Paläont. Mh.* 172, 193–217.

Kennedy, W. J: & Cobban, W. A. 1976. Aspects of ammonite biology, biogeography, and biostratigraphy. *Spec. Pap. Palaeont.* 17, 94 pp.

Kennedy, W. J. & Cobban, W. A. 1988. The Upper Cretaceous ammonite *Romaniceras* Spath, 1923 in New Mexico. *Bull. New Mex. Bur. Min. Miner. Res.* 114, 23–34.

Kennedy, W. J. & Cobban, W. A. in press. Woodbine and basal Eagle Ford (Cenomanian) ammonite faunas from Texas. *Palaeontology* 33.

Kennedy, W. J., & Cobban, W. A., & Hook, S. C. 1988. Middle Cenomanian (Upper Cretaceous) molluscan fauna from the base of the Boquillas Formation, Cerro

de Muleros, Dona Ana County, New Mexico. *Bull. New Mex. Bur. Min. Miner. Res.* 114, 35–44.

Kennedy, W. J. & Juignet, P. 1983. A revision of the ammonite faunas of the type Cenomanian. 1. Introduction, Ancyloceratina. *Cret. Res.* 4, 3–83.

Kennedy, W. J., Lindholm, R. C., Helmold, K. P. & Hancock, J. M. 1977. Genesis and diagenesis of hiatus and breccia-concretions from the mid-Cretaceous of Texas and northern Mexico. *Sedimentology* 24, 833–844.

Kennedy, W. J. & Wright, C. W. 1979. Vascoceratid ammonites from the type Turonian. *Palaeontology* 22, 665–683.

Kennedy, W. J., Wright, C. W. & Hancock, J. M. 1980a. The European species of the Cretaceous ammonite *Romaniceras* with a revision of the genus. *Palaeontology* 23, 325–362.

Kennedy, W. J., Wright, C. W. & Hancock, J. M. 1980b. Collignoniceratid ammonites from the mid-Turonian of England and northern France. *Palaeontology* 23, 557–603, pls. 62–77.

Kennedy, W. J., Wright, C. W. & Hancock, J. M. 1980c. Origin, evolution and systematics of the Cretaceous ammonoid *Spathites*. *Palaeontology* 23, 821–837.

Kennedy, W. J., Wright, C. W. & Hancock, J. M. 1987. Basal Turonian ammonites from west Texas. *Palaeontology* 30, 27–74.

Kler, M. O. 1908. [Neoceratites from eastern Bukhara.] *Trudy geol. miner. Mus.* 2, 157–173.

Klinger, H. C. & Kennedy, W. J. 1978. Turrilitidae (Cretaceous Ammonoidea) from South Africa, with a discussion of the evolution and limits of the family. *J. Moll. Stud.* 44, 1–48.

Kossmat, F. 1895–1898. Untersuchungen über die südindische Kreideformation. *Beitr. Paläont. Geol. Öst. Ung.* 9 (1895), 97–203 (1–107); 11 (1897), 1–46 (108–193); 11, (1898), 89–152 (154–217).

Kummel, B. & Decker, J. M: 1954. Lower Turonian ammonites from Texas and Mexico. *J. Paleont.* 28, 310–319.

Lamarck, J. B. P. A. de M. de. 1799. Prodrome d'une nouvelle classification des coquilles. *Mém. Soc. Hist. nat. Paris* (1799), 63–90.

Lamarck, J. B. P. A. de M. de. 1801. *Système des animaux sans vertebrès*. . . 432 + viii pp. The author, Déterville, Paris.

Laube, G. C. & Bruder, G. 1887. Ammoniten der böhmischen Kreide. *Palaeontographica* 33, 217–239.

Leonhard, R. 1897. Die Fauna der Kreideformation in Oberschlesien. *Palaeontographica* 44, 11–70.

Lewy, Z., Kennedy, W. J. & Chancellor, G. R. 1984. Co-occurrence of *Metoicoceras geslinianum* (d'Orbigny) and *Vascoceras cauvini* (Chudeau) (Cretaceous Ammonoidea) in the southern Negev (Israel) and its stratigraphic implications. *Newsl. Stratigr.* 13, 67–76.

Linnaeus, C. 1758. *Systema Naturae* 1 10th Edn. 823 + 1 p. Stockholm.

Logan, W. N. 1898. The invertebrates of the Benton, Niobrara and Fort Pierre Groups. *Kansas Geol. Surv.* 4, 431–518.

Logan, W. N. 1899. Some additions to Cretaceous invertebrates of Kansas. *Kansas Univ. Q.* 8, Series A, 87–98.

Luppov, N. P. & Drushchits, V. V. (Eds.) 1958. [Mollusca-Cephalopoda II Ammonoidea (Ceratites and Ammonites) and Endocochlia] In Orlov, Y. A. (Ed.) [*Fundamentals of Palaeontology. A guide for palaeontologists and geologists of the U.S.S.R.*] 6, 359 pp. [In Russian.]

McNeil, D. H. & Caldwell, W. G. E. 1974. The *Ostrea beloiti* beds – – a Cenomanian time-stratigraphic unit in the western interior of Canada and the United States [abs.]. *Bull. geol. Soc. Am.* 6 (7), 867.

McNulty, C. L. Jr., 1966. Nomenclature of uppermost Eagle Ford Formation in northeastern Texas. *Bull. Am. Ass. Petrol. Geol.* 50, 375–379.

McNulty, C. L. Jr., Neybert, D. S. & Reaser, D. F. 1978. Foraminifers of the Lower Ojinaga Formation (Cretaceous), southern Quitman Mountains, Hudspeth County, Texas. *Trans. Gulf Cst Ass. geol. Socs.* 35, 467–472.

Mantell, G. A. 1822. *The fossils of the South Downs; or illustrations of the geology of Sussex*. 327 + xvi pp. Lupton Relfe, London.

Marcou, J. 1858. *Geology of North America; with two reports on the prairies of Arkansas and Texas, the Rocky Mountains of New Mexico and the Sierra Nevada of California*. 144 pp. Zurcher & Furrer, Zurich.

Matheron, P. 1842. *Catalogue Méthodique et Descriptif des Corps Organisés Fossiles du Départment des Bouches-du-Rhône et lieux circonvoisins* . . . 269 pp. Marseille.

Matsumoto, T. 1959. Upper Cretaceous Ammonites of California Part 2. *Mem. Fac. Sci. Kyushu Univ. Series D. Geology* Special Volume 1, 172 + iii pp.

Matsumoto, T. 1960. On some type ammonites from the Gulf Coast Cretaceous. *Sci. Rep. Fac. Sci. Kyushu Univ. Geology* 5 (1), 36–49. [in Japanese].

Matsumoto, T. 1965. A monograph of the Collignoniceratidae from Hokkaido, Part. 1. *Mem. Fac. Sci. Kyushu Univ. Series D. Geology* 16, 1–80.

Matsumoto, T. 1969. *In* Matsumoto, T., Muramoto, T. & Takahashi, I. 1969. Selected acanthoceratids from Hokkaido. *Mem. Fac. Sci. Kyushu Univ. Series D. Geology* 19, 251–296.

Matsumoto, T. 1971. A monograph of the Collignoniceratidae from Hokkaido. Part 5. *Mem. Fac. Sci. Kyushu Univ. Series D Geology* 21, 129–162.

Matsumoto, T. & Muramoto, I. 1969. *In* Matsumoto, T. Muramoto, I. & Takahashi, I. 1969. Selected acanthoceratids from Hokkaido. *Mem. Fac. Sci. Kyushu Univ. Series D Geology* 19, 251–296.

Matsumoto, T. & Noda, M. 1983. Restudy of *Inoceramus incertus* Jimbo with special reference to its biostratigraphic implications. *Proc. Japan. Acad.* 59 (B), (5), 109–112.

Matsumoto, T. & Obata, I. 1963. A Monograph of the Baculitidae from Japan. *Mem. Fac. Sci. Kyushu Univ. Series D Geology* 13, 1–116.

Matsumoto, T. & Obata, I. 1982. Some interesting acanthoceratacean from Hokkaido (Studies of Cretaceous ammonites from Hokkaido-XLII). *Bull. Nat Sci. Mus. Tokyo Series C (Geology & Palaeontology)* 8, (2), 67–92.

Matsumoto, T., Saito, R. & Fukada, A. 1957. Some acanthoceratids from Hokkaido. *Mem. Fac. Sci. Kyushu Univ. Series D Geology* 6, 1–45.

Meek, F. B. 1870. A preliminary list of fossils, collected by Dr. Hayden in Colorado, New Mexico and California, with brief descriptions of a few of the new species. *Proc. Am. Phil. Soc.* 11, 425–431.

Meek, F. B. 1871. Preliminary paleontological report, consisting of lists of fossils, with descriptions of some new types, etc. *U.S. Geological Survey of Wyoming (Hayden) Preliminary Report* 4, 287–318.

Meek, F. B. 1876. Report on the invertebrate Cretaceous and Tertiary fossils of the Upper Missouri country. *In* Hayden, F. V. *Report of the United States Geological Survey of the Territories* 9, 629 + lxiv pp.

Meek, F. B. & Hayden, F. V. 1860. Descriptions of new organic remains from the Tertiary, Cretaceous, and

Jurassic rocks of Nebraska. *Proc. Acad. nat. Sci. Philad.* 1860, 175–185.
Meek, F. B. & Hayden, F. V. 1862. Descriptions of new Cretaceous fossils from Nebraska Territory, collected by the Government under the command of Lieut. John Mullan, U.S. Topographical Engineers, for the location and construction of a wagon road from the sources of the Missouri to the Pacific Ocean. *Proc. Acad. nat. Sci. Philad.* 1862, 21–28.
Merewether, E. A. & Cobban, W. A. 1972. Unconformities within the Frontier Formation, northwestern Carbon County, Wyoming. *Prof. Pap. U.S. geol. Surv.* 800-D, 57–66.
Merewether, E. A., Cobban, W. A. & Cavanaugh, E. T. 1979. Frontier Formation and equivalent rocks in eastern Wyoming. *Mount. Geologist* 16, 67–101.
Moreman, W. L. 1927. Fossil zones of the Eagle Ford of north Texas. *J. Paleont.* 1, 89–101.
Moreman, W. L. 1942. Paleontology of the Eagle Ford Group of north and central Texas. *J. Paleont.* 16, 192–220.
Morrow, A. L. 1935. Cephalopods from the Upper Cretaceous of Kansas. *J. Paleont.* 9, 463–473.
Nagao, T. & Matsumoto, T. 1939. A monograph of the Cretaceous *Inoceramus* of Japan, Part 1. *J. Fac. Sci. Hokkaido Imp. Univ.* (4) 4 (3–4), 241–299.
Neumayr, M. 1875. Die Ammoniten der Kreide und die Systematik der Ammonitiden. *Z. dt. geol. Ges.* 27, 854–892.
Newberry, J. S. 1876. Geological report. *In* Macomb, J. N. Report of the exploring expedition from Santa Fe, New Mexico, to the junction of the Grand and Green Rivers of the Great Colorado of the West in 1859. *U.S. Army, Engineering Department*, 9–118.
Newell, N. D. 1965. Classification of the Bivalvia. *Am. Mus. novit.* 2206, 25 p.
Noda, M. 1984. Notes on *Mytiloides incertus* (Cretaceous Bivalvia) from the Upper Turonian of the Pombets area, Central Hokkaido. *Trans. Proc. Pal. Soc. Japan* 136, 455–473.
Nowak, J. 1916. Über die bifiden Loben der oberkretazischen Ammoniten und ihre Bedeutung für die systematik. *Bull. Acad. Sci. Cracovie Série B* 1916, 1–10, 67.
Obata, I., Kanie, Y., Ranaivoson, C. & Ratsimba, Y. 1981. On the occurrence of Late Cretaceous molluscan assemblages from the Menabe area, southeastern Madagascar. *Bull. Nat. Sci. Mus. Tokyo Series C (Geology & Palaeontology)* 7 (4), 155–170.
Orbigny, A. d'. 1840–1842a. *Paléontologie française; Terrains crétacés* 1, *Céphalopodes.* 1–120 (1840); 121–430 (1841); 431–662 (1842a). Masson, Paris.
Orbigny, A. d'. 1842b. *Coquilles et Echinodermes fossiles de Colombie (Nouvelle-Grenade), recueillis de 1821 a 1833 par M. Boussingault et décrits par Alcide d'Orbigny.* 64 pp. Chez P. Bertrand, Liberaire-Editeur, Paris; Chez Levrault, Strasbourg.
Orbigny, A. d'. 1850. *Prodrome de Paléontologie Stratigraphique Universelle des Animaux Mollusques et Rayonnés.* 2, 428 pp. Masson, Paris.
Parkinson, J. 1811. *On the Organic Remains of a Former World* 3, 479 + xvi pp. London
Passy, A. 1832. *Description Géologique du Department de la Seine-Inférieure. 371 pp. + Atlas.* Nicétas Periaux, Rouen.
Peron, A. 1889–1895. Description des mollusques fossiles des terrains Crétacés de la région sud des Hauts-Plateaux de la Tunisie recuillis en 1885 et 1886 par M. Phillipe Thomas. *Exploration Scientifique de la Tunisie* 405 + xii pp. Masson, Paris.
Pervinquière, L. 1907. *Études de Paléontologie tunisienne.* 1. *Céphalopodes des terrains secondaires.* 438 + v pp. *Carte Geólogique de la Tunisie.* Paris, de Rudeval.
Pessagno, E. 1967. Upper Cretaceous planktonic Foraminifera from the western Gulf coastal plain. *Palaeontogr. am.* 5, 245–445.
Pessagno, E. 1969. Upper Cretaceous stratigraphy of the western Gulf Coast area, Mexico, Texas and Arkansas. *Mem. geol. Soc. Am.* 111, 139 pp.
Pictet, F. J. & Renevier, E. 1866. Notices géologiques et paléontologiques sur les Alpes Vaudoises et les régions environnantes. IV. Céphalopodes de Cheville. *Bull. Soc. vaudoise Sci. nat.* 9, 93–114.
Popoff, M., Wiedmann, J. & Klasz, I. de 1986. The Upper Cretaceous Gongila and Pindiga Formations, northern Nigeria: subdivision, age, stratigraphic correlations and paleogeographic implications. *Eclog. geol. Helv.* 79, 343–363.
Powell, J. D. 1963a. Cenomanian-Turonian (Cretaceous) ammonites from Trans-Pecos Texas and northeastern Chihuahua, Mexico. *J. Paleont.* 37, 309–322.
Powell, J. D. 1963b. Turonian (Cretaceous) ammonites from northeastern Chihuahua. *J. Paleont.* 37, 1217–1232.
Powell, J. D. 1965. Late Cretaceous platform-basin facies, northern Mexico and adjacent Texas. *Bull. Am. Ass. Petrol. Geol.* 49, 511–525.
Powell, J. D. 1970. Early Upper Cretaceous faunal zones southwest of the Diabolo-Coahuila Platform. Pp. 96–99 *In* Guidebook. Geology of the southern Quitman Mountains area, Trans-Pecos Texas. *Permian Basin Section of the Society of Economic Geologists and Paleontologists* Guidebook 70–12.
Rafinesque, C. S. 1815. *Analyse de la nature ou tableau de l'Univers et des Corps organisés* etc. 224 pp. Palermo.
Reagan, A. B. 1924. Cretacic Mollusca of Pacific Slope. *Pan-Am. Geol.* 41, 179–190.
Reeside, J. B. 1923. A new fauna from the Colorado group of southern Montana. *Prof. Pap. U.S. geol. Surv.* 132-B, 25–33.
Reeside, J. B. 1927. Cephalopods from the lower part of the Cody Shale of Oregon Basin, Wyoming. *Prof. Pap. U.S. geol. Surv.* 150-A, 19 p.
Renz, O. 1982. *The Cretaceous ammonites of Venezuela.* 132 pp. Maraven, Basel.
Reyment, R. A. 1954. Some new Upper Cretaceous ammonites from Nigeria. *Colon. geol. Surv. Min. Resour. Div.* 4, 248–270.
Reyment, R. A. 1955. The Cretaceous Ammonoidea of southern Nigeria and the Southern Cameroons. *Bull. geol. Surv. Nigeria* 25, 112 pp.
Roman, F. 1912. Coup d'oeil sur les zones de Céphalopodes du Turonien du Vaucluse et du Gard. *Comptes Rendus de l' Association française pour l' Avancement des Sciences, Congrès de Nimes, 1912, Géologie et Mineralogie* 1–15.
Roman, F. 1938. *Les Ammonites Jurassiques et Crétacées: Essai de Genera.* 554 pp. Masson, Paris.
Roman, F. & Mazerin, P. 1913. Monographie paléontologique du Bassin d'Uchaux et ses dépendances. *Archiv. Mus. Hist. Nat. Lyon* 12, 1–137.
Schlotheim, E. F. von 1813. Beiträge zur Naturgeschichte der Versteinerungen in geognostischer Hinsicht. *Leonards Taschenbüch für Mineralogie* 7, 3–134.
Schlüter, C. 1871–72, 1876. Cephalopoden der oberen deutschen Kreide. *Palaeontographica* 21, 1–120; 24, 121–264.
Schneegans D. 1943. Invertebrès du crétacé supérieur du Damergou (Territoire du Niger); avec une Note sur les echinides de Marma par J. Lambert. *Bull. Dir. Mines Afr. occid. fr.* 7, 87–166.

Schöbel, J. 1975. Ammoniten der Familie Vascoceratidae aus dem unteren unterturon des Damergou-Gebietes, République du Niger. *Publications from the Palaeontological Institution of the University of Uppsala* Special Volume 3, 136 pp.

Scott, G. 1924. Some gerontic ammonites of the Duck Creek Formation. *Tex. Christ. Univ. Quart.* 1, 31 pp.

Seitz, O. 1935. Die Variabilitat des *Inoceramus labiatus* Schlotheim. *Geol. Jb.* 55, 429–474 (1934 imprint).

Sharpe, D. 1853–1857. Description of the fossil remains of Mollusca found in the Chalk of England. 1. Cephalopoda. *Palaeontographical Society (Monographs).* 1–26 (1853); 27–36 (1855); 37–68 (1857).

Shattuck, G. B. 1903. The Mollusca of the Buda Limestone. *Bull. U.S. geol. Surv.* 205, 36 pp.

Shimer, H. W. & Shrock, R. R. 1944. *Index fossils of North America.* 837 + ix pp., Wiley, New York.

Shumard, B. F. 1860. Descriptions of new Cretaceous fossils from Texas. *Trans. acad. Sci. St. Louis* 1, 590–610.

Sidwell, R. 1932. New species from the Colorado group, Cretaceous in south central Wyoming. *J. Paleont.* 6, 312–318.

Sornay, J. 1955. *Baculites undulatus. Pal. Univers.* (N.S.) 15.

Sowerby, J. 1812–1822. *The Mineralogy Conchology of Great Britain.* 1, pls. 1–9 (1812), pls. 10–44 (1813), pls 45–78 (1814), pls 79–102 (1815); 2, pls. 103–114 (1815), pls. 115–150 (1816), pls. 151–186 (1817), pls. 187–203 (1818); 3, pls. 204–221 (1818), pls. 222–253 (1819), pls. 254–271 (1820); 4, pls. 307–318 (1821), pls. 319–383 (1822). The author, London.

Sowerby, J. de C. 1829. *The Mineral Conchology of Great Britain* (continued) 7, pl. 604. London: The Author.

Sowerby, J. de C. 1850. Description of the Shells of the Chalk Formation. Pp. 346–359 *In* Dixon, F. *The Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex.* 1st. Edn. 423 + xxxii pp. Longman, Brown, Green & Longmans, London.

Spath, L. F. 1921. On Cretaceous Cephalopoda from Zululand. *Ann. S Afr. Mus.* 12, 217–321.

Spath, L. F. 1922. On the Senonian ammonite faunas of Pondoland. *Trans. R. Soc. S. Afr.* 10, 113–147.

Spath, L. F. 1923. On the ammonite horizons of the Gault and contiguous deposits. *Summ. Progr. geol. Surv. Lond. for 1922*' 139–149.

Spath, L. F. 1925. On Upper Albian Ammonoidea from Portuguese East Africa. *Ann. Transv. Mus.* 11 (3), 179–200.

Spath, L. F. 1926. On new ammonites from the English Chalk. *Geol. Mag.* 63, 77–83.

Spath, L. F. 1931. A monograph of the Ammonoidea of the Gault Part 8. *Palaeontographical Society (Monographs),* 313–378.

Spath, L. F. 1939. A monograph of the Ammonoidea of the Gault, Part 13. *Palaeontographical Society (Monographs),* 541–608.

Stankevich, E. S. & Pojarkova, Z. N. 1969. [Vascoceratids from the Turonian of southern Kirgisia and the Tadzhiksian depression] 86–111 *In [Continental Formations of eastern regions of Soviet Central Asia and Kazakhstan. Lithology and Biostratigraphy.]* [In Russian.]

Stanton, T. W. 1894. The Colorado formation and its invertebrate fauna. *Bull. U.S. geol. Surv.* 106, 288 pp. (1893 imprint).

Stephenson, L. W. 1953. Larger invertebrate fossils of the Woodbine Formation (Cenomanian) of Texas. *Prof. Pap. U.S. geol. Surv.* 242, 226 + iv pp. (1952 imprint).

Stephenson, L. W. 1955. Basal Eagle Ford fauna (Cenomanian) in Johnson and Tarrant Counties, Texas. *Prof. Pap. U.S. geol. Surv.* 274-C, 53–67.

Stoliczka, F. 1863–1866. The fossil cephalopoda of the Cretaceous rocks of southern India. Ammonitidae with revision of the Nautilidae & co. *Mem. geol. Surv. India* (1), *Pal. Indica* 3, (1), 41–56 (1863); (2–5), 57–106 (1864) (6–9), 107–154 (1865), (10–13), 155–216 (1866).

Strain, W. S. 1968. Cerro de Muleros (Cerro de Cristo Rey) p. 82 *In* Delaware basin Exploration. *West Texas Geological Society Publication* 68–55.

Strain, W. S. 1976. Appendix 2 – New Formation names in the Cretaceous at Cerro de Cristo Rey, Dona Ana county, New Mexico. *Mem. New Mex. Bur. Min. Miner. Res.* 31, 77–82.

Termier, H. & Termier, G. 1960. Trias-Jurassique-Crétacé, pt. 3 *of Paléontologie stratigraphique.* Paris, Imprimèrie Alençonnaise, 221–357.

Thomel, G. 1966. *In* Pourthault, B., Thomel, G. & Villoutreys, P. de. Étude biostratigraphique du Cénomanien du bassin supérieur de l' Esteron (Alpes-Maritimes). Le problème de la limite Cénomanien-Turonien dans le Sud-Est de la France. *Bull. Soc. géol. fr.* 8, 423–439.

Thomel, G. 1969. Reflexions sur les genres *Eucalycoceras* et *Protacanthoceras* (Ammonoidea). *C.r. hébd. Seanc. Acad. Sci., Paris* (D) 268, 649–652.

Thomel, G. 1972. Les Acanthoceratidae Cénomaniens des châines subalpines méridionales. *Mém. Soc. géol. Fr.* (N.S.) 116, 204 pp.

Tokunaga, S. & Shimizu, S. 1926. The Cretaceous formation of Futuba in Iwaki and its fossils. *J. Fac. Sci. Tokyo Univ.* Section 2 1, 181–212.

Tröger, K. A. 1967. Zur Paläontologie, Biostratigraphie und faziellen Ausbildung der unteren Oberkreide (Cenoman bis Turon). Teil 1, Paläontologie und Biostratigraphie der Inoceramen des Cenomans bis Turons Mitteleuropas. *Abh. Dresden Staatl. Mus. min. geol.* 12, 13–207.

Twiss, P. C. 1959. Geological Map of the Van Horn Mountains, Texas. Texas Bureau of Economic Geology Quadrangle Map 23.

Udden, J. A. 1907. A sketch of the geology of the Chisos country, Brewster County, Texas. *Bull. Univ. Tex.* 93 101 pp.

White, C. A. 1874. Preliminary report upon invertebrate fossils collected by the expeditions of 1871, 1872, and 1873. *U.S. Army Engineering Department, Geographical and Geological Explorations and Surveys West of the 100th Meridian* 27 pp.

White, C. A. 1877. Report upon the Cretaceous invertebrate fossils collected in portions of Nevada, Utah, Colorado, New Mexico, and Arizona, by the parties of the expeditions of 1871, 1872, 1873, and 1874. *U.S. Geographical and Geological Explorations and Surveys west of the 100th Meridian Report* 4, part 1, 219 pp.

White, C. A. 1880. Contributions to paleontology, no. 2. Cretaceous fossils of the western states and territories: *advance print from U.S. Geological and Geographical Survey of the Territories (Hayden) Twelfth Annual Report* 1, 1–39.

White, C. A. 1883. Contributions to invertebrate paleontology, no. 2; Cretaceous fossils from the Western States and Territories. *U.S. Geological andGeographical Survey of the Territories (Hayden) Twelfth Annual Report* 1, 1–39.

White, C. A. 1884. A review of the fossil Ostreidae of North America; and a comparison of the fossil with the living forms. *U.S. 48th Congress, 1st Session, Report of the Secretary of Interior* 3, 273–308 (misdated 1883).

Whitfield, R. P. 1877. Preliminary report on the paleontology of the Black Hills, containing descriptions of new species of fossils from the Potsdam, Jurassic, and Cretaceous formations of the Black Hills of Dakota. *U.S. Geographical and Geological Survey Rocky Mountain Report* 49 pp.

Whitfield, R. P. 1880. Paleontology of the Black Hills of Dakota. *In* Newton, H. & Jenney, W. P. Report on the Geology and resources of the Black Hills of Dakota. *U.S. Geographical and Geological Survey Rocky Mountain Region* 325–468.

Wiedmann, J. 1966. Stammesgeschichte und System der posttriadischen Ammonoideen: Ein Überblick. *Neues Jb. Geol. Paläont. Abh.* 125, 49–79.

Wiedmann, J. 1980. Itineraire géologique à travers le Crétacé Moyen des Châines Vascogotiques et Celtiberiques (Espagne du Nord). *Cuad. geol. Iber.* 5, 127–214.

Wiedmann, J. & Kauffman, E. G. 1978. Mid-Cretaceous biostratigraphy of northern Spain *Ann. Mus. Hist. Nat. Nice* 4, iii.1–iii.34 (1976 imprint).

Woods, H. 1896. The Mollusca of the Chalk rock: Part 1. *Q. Jl. geol. Soc. Lond.* 52, 68–98.

Woods, H. 1911. A monograph of the Cretaceous Lamellibranchia of England. Volume 2, part 7, *Palaeontographical Society (Monographs)* 261–284.

Woods, H. 1912. A monograph of the Cretaceous Lamellibranchia of England. Volume 2, part 8. *Palaeontographical Society (Monographs)* 285–340.

Wozny, E. & Kogbe, E. A. 1983. Further evidence of marine Cenomanian, Lower Turonian and Maastrichtian in the upper Benue Basin of Nigeria (West Africa). *Cret. Res.* 4, 95–99.

Wright, C. W. 1952. A classification of the Cretaceous ammonites. *J. Paleont.* 26, 213–222.

Wright, C. W. 1953. Notes on Cretaceous ammonites. 1. Scaphitidae. *Ann. Mag. Nat. Hist.* (12) 6, 473–476.

Wright, C. W. 1957. *In. Treatise on Invertebrate Paleontology. Part L, Mollusca 4, Cephalopoda Ammonoidea.* 490 pp. Geological Society of America and University of Kansas Press, New York & Lawrence.

Wright, C. W. 1979. The ammonites of the English Chalk Rock (Upper Turonian). *Bull. Br. Mus. nat. Hist. (Geol.)* 31, 281–332.

Wright, C. W. & Kennedy, W. J. 1973. Paléontologie systèmatique. *In.* Juignet, P., Kennedy, W. J. & Wright, C. W. La limite Cénomanien – Turonien dans la région du Mans (Sarthe): stratigraphie et paléontologie. *Ann. Paléont.* 59, 207–242.

Wright, C. W. & Kennedy, W. J. 1980. Origin, evolution and systematics of the dwarf acanthoceratid *Protacanthoceras* Spath, 1923 (Cretaceous Ammonoidea). *Bull. Br. Mus. nat. Hist. (Geol.)* 34, 65–107.

Wright, C. W. & Kennedy, W. J. 1981. The Ammonoidea of the Plenus Marls and the Middle Chalk. *Palaeontographical Society (Monographs)* 148 pp.

Wright, C. W. & Kennedy, W. J. 1984. The Ammonoidea of the Lower Chalk. Part 1. *Palaeontographical Society (Monographs)* pp. 1–126.

Wright, C. W. & Kennedy, W. J. 1987. the Ammonoidea of the Lower Chalk. Part 2. *Palaeontographical Society (Monographs)* pp. 127–217.

Wright, C. W. & Wright, E. V. 1951. A survey of the fossil Cephalopoda of the Chalk of Great Britain *Palaeontographical Society (Monographs).* 40 pp.

Yabe, H. 1904. Cretaceous Cephalopoda from the Hokkaido. Part 2. *J. coll. Sci. imp. Univ. Tokyo* 20, 1–45.

Yang Hen-Ren et al. 1983. A preliminary study of the Upper Cretaceous of the western Tarim Basin (South Xinjiang, China) with special reference to its transgressions. *Zitteliana* 10, 115–122.

Young, K. 1958. Cenomanian (Cretaceous) ammonites from Trans-Pecos Texas. *J. Paleont.* 32, 286–294.

Young, K. 1959. Index fossils of the Trans-Pecos area. Pp. 79–84 *In Geology of the Val Verde Basin and field trip Guidebook, West Texas Geological Society.*

Young, K. 1979. Lower Cenomanian and Late Albian (Cretaceous) ammonites, especially Lyelliceratidae, of Texas and Mexico. *Bull. Tex. Meml. Mus.* 26, 99 pp.

Young, K. 1986. The Albian-Cenomanian (Lower Cretaceous-Upper Cretaceous) boundary in Texas and northern Mexico. *J. Paleont.* 60 (6) 1212–1219.

Young, K. & Powell, J. D. 1978. Late Albian-Turonian correlations in Texas and Mexico. *Ann. Mus. Hist. Nat. Nice* 4, xxv. 1–xxv. 36 (1976 imprint).

Zaborski, P. M. P. 1986. Internal mould markings in a Cretaceous ammonite from Nigeria. *Palaeontology* 29 (4), 725–738.

Zaborski, P. M. P. 1987. Lower Turonian (Cretaceous) ammonites from south-east Nigeria. *Bull. Br. Mus. nat. Hist. (Geol.)* 41, 31–66.

Zázvorka, V. 1958. Acanthoceras kallesi n. sp. (Ammonoidea) ze spodního turonu na bílé hoře v praze (Střědni Čechy) a Acanthoceras sharpei n. sp. z anglické Křidy. *Casopsis Národního Museo* 127, 38–45.

Zittel, K. A. von 1884. *Handbüch der Palaeontologie* Abt. 1, 2 (Lief 3), *Cephalopoda* 329–522. R. Oldenbourg, Munich & Leipzig.

Zittel, K. A. von. 1895. *Grundzüge der Paläontologie (Paläozoologie).* 972 + vii pp. R. Oldenbourg, Munich & Leipzig.

Printed by Ekenäs Tryckeri Ab, Ekenäs, Finland November 10th, 1989.