BRIGHAM YOUNG UNIVERSITY

GEOLOGY STUDIES

Volume 9 Part 2 December 1962

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Brigham Young University Geology Studies

Volume 9, Part 2 — December, 1962

Contents

A publication of the
Department of Geology
Brigham Young University
Provo, Utah

Brigham Young University Geology Studies is published annually by the Department. Volume 9 is complete with part 2. *Geology Studies* consists of graduate student and staff research in the Department.

Distributed February 28, 1963

Price $4.00

Anisoceratidae and Hamitidae (Ammonoidea) from the Cretaceous of Texas and Utah*

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ABSTRACT.—A systematic study of the Texas and southern Utah heteromorph ammonite families Anisoceratidae and Hamitidae indicates the occurrence of one species of *Hamites*, three of *Stomohamites*, six of *Anisoceras*, three of *Idiohamites*, and six (?) of *Allocrioceras*. Several European species not previously reported from Texas, and two Texas species that are junior synonymns of previously described European species, are recorded. Members of the Anisoceratidae and Hamitidae families occur in Texas in nine formations which range from upper Middle Albian to Lower Turonian. Certain Anisoceratidae occur in rocks of Early Turonian age in Utah.

A biostratigraphic study of a portion of the Utah Tropic Formation and a correlation of the Tropic with the Texas Britton Formation was made on the basis of Anisoceratidae and other ammonites. The occurrence, in both the Tropic Formation and the Britton Formation of conspecific forms of the Anisoceratidae *Allocrioceras* and species of *Metoicoceras, Kanabiceras, Proplacenticeras* and others, establishes a definite correlation between the Utah and Texas rocks. Based on the occurrence of ammonites, most authorities would date the Tropic and the Britton as Early Turonian, although some regard their age as Late Cenomanian.

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*A thesis submitted to the Faculty of the Department of Geology, Brigham Young University, in partial fulfillment of the requirements for the degree Master of Science.

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INTRODUCTION

This study was undertaken as a systematic paleontological investigation of the Texas and southern Utah Cretaceous heteromorph ammonite families Anisoceratidae and Hamitidae. Although many species have been described previously, the literature concerning these groups is often confusing and inadequate. An attempt has been made to establish valid generic and specific identifications in the light of modern interpretation and the more complete collections now available for study.

Members of the Anisoceratidae and Hamitidae families are present in Middle and Upper Albian and Cenomanian strata of Texas, but are unknown in southern Utah because rocks of this age are either missing or poorly understood. Certain Anisoceratidae are common to both the Texas and southern Utah rocks of Early Turonian age and some biostratigraphic data concerning these rocks is presented.

Previous Work

Although Conrad (1855), Marcou (1858) and Shumard (1860) did some work on the Texas Anisoceratidae and Hamitidae, Adkins, Winton & Scott, in the early 1920's, were the first to show real interest in the groups. They described and studied the occurrence of species of both families. Moreman (1927; 1942) described species of *Allocrioceras* and the biostratigraphy of the Eagle Ford Group. More recently Clark (1958) conducted a study of several *Anisoceras* species.

White (1877) was the first to describe the heteromorph *Allocrioceras* from Utah. Stanton (1893) studied the Lower Turonian rocks and fauna of Utah (Tropic Formation) and made correlations with other localities. Gregory (1931; 1950; 1951) has described the stratigraphy and listed the fauna of the Tropic Formation for several southern Utah areas.

Acknowledgments

The writer wishes to express sincere appreciation to his major chairman, Dr. David L. Clark, for providing the opportunity for conducting this study, and for his valuable assistance in directing the research and editing the manuscript. Gratitude is also expressed to Dr. J. Keith Rigby for serving as committee member and for his critical evaluation of the manuscript.

Grateful acknowledgment is made for the funds for fieldwork and for a two-year graduate research assistantship which were made available by the Systematic Biology Section, National Science Foundation as a part of a grant to Dr. David L. Clark.

The Texas specimens studied were borrowed from the Bureau of Economic

Geology; University of Texas; Texas Christian University; the U.S. National Museum, Washington; and Mr. James P. Conlin, Ft. Worth, Texas.

The writer gives special thanks to his wife, Shirley, for aid in the field, typing the manuscript, and constant enthusiasm and encouragement.

Spath (1942) Wright & Wright (1951)		TEXAS STRATIGRAPHIC UNITS
Lower Turonian	*labiatus*	EAGLE FORD
	plenus	
Cenomanian	*subglobosus*	WOODBINE
		BUDA
	varians	GRAYSON–DEL RIO
		MAINSTREET
	?*dispar–perinflatum*	PAWPAW
Upper Albian	*substuderi*	WENO
	aequatorialis	DENTON
	auritus	FT. WORTH
	varicosum	DUCK CREEK
	orbignyi	KIAMICHI
Middle Albian	*cristatum*	COMANCHE PEAK

TEXT-FIGURE 1.—Correlation of Texas stratigraphic units with English Cretaceous zones.

ALBIAN AND CENOMANIAN STRATIGRAPHY AND HETEROMORPHS

In general, the upper-Middle Albian through Upper Turonian beds of the Texas Cretaceous consist of shales, marls, and limestones. The section has been subdivided into twelve formations whose ages and relationships are summarized in Text-fig. 1. For a detailed description of the stratigraphy the reader is referred to Perkins (1961).

The following lists indicate the stratigraphic occurrence of the Middle Albian through Turonian heteromorphs of the families Anisoceratidae and Hamitidae identified by the writer.

Comanche Peak

Hamites intermedius J. Sowerby

Kiamichi

? Idiohamites fremonti (Marcou)

? Stomohamites virgulatus (Brongniart)

Duck Creek

? Anisoceras armatum (J. Sowerby)
Anisoceras salei Clark
? Anisoceras sp. aff. A. subarcuatum Spath
? Anisoceras sp. aff. A. plicatile (J. Sowerby)
Hamites sp. aff. H. intermedius J. Sowerby
Idiohamites fremonti (Marcou)
Idiohamites varians (Scott)
Idiohamites sp.
Stomohamites nokonis (Adkins & Winton)
Stomohamites venetzianus (?) (Pictet)
Stomohamites virgulatus (Brongniart)

Ft. Worth

Stomohamites sp. aff. S. virgulatus (Brongniart)

Denton

Stomohamites sp.

Weno

Anisoceras perarmatum (Pictet & Campiche)
Anisoceras bendirei (Adkins)
Stomohamites venetzianus (Pictet)

Pawpaw

Anisoceras armatum (J. Sowerby)
Stomohamites venetzianus (Pictet)
? Idiohamites varians (Scott)

Mainstreet

Anisoceras perarmatum (?) (Pictet & Campiche)

Eagle Ford

Allocrioceras annulatum (Shumard)
Allocrioceras dentonense Moreman
Allocrioceras pariense (White)
Allocrioceras larvatum (Conrad)
? Allocrioceras (?) rotundatum (Conrad)

TURONIAN STRATIGRAPHY AND HETEROMORPHS

Tropic Formation

General

The Tropic Formation, named by Gregory & Moore (1931) from localities around Tropic, Utah, is exposed in parts of central and western-southern Utah. Generally the Tropic is an assemblage of coarse to fine sandstone; arenaceous, argillaceous, carbonaceous, gypsiferous and calcareous shale; and lesser amounts of earthy lignite and coal (Gregory, 1950). The dominant shales break down easily to form slopes and badlands which support little vegetation. The Tropic Formation overlies the Cretaceous Dakota (?) Sandstone and is overlain by the massive Cretaceous Straight Cliffs Sandstone. Gregory (1950) has listed the thickness of the Tropic in the Zion Park region as ranging from 498 to 1260 feet.

Commonly, the predominant drab, blue-gray or steel-gray shale that is characteristic of the Tropic is thickest near the top of the formation. Fossiliferous calcareous concretions are present at the base of this thick shale sequence in many sections. A study of the concretionary zone fauna was made at five localities in the areas of Tropic, Henrieville, and Mt. Carmel. Particular emphasis was placed on collecting specimens of the heteromorph *Allocrioceras*.

Location and Description of Collecting Areas

Henrieville-Tropic Areas.—The concretionary zone of the upper Tropic Shale sequence was measured and fossils were collected at sections one and one-half miles (B.Y.U. loc. 12052), two miles (B.Y.U. loc. 12053), and two and one-half miles (B.Y.U. loc. 12054) northeast of Henrieville, Utah, and one-quarter mile east of the Henrieville-Escalante highway (Utah Highway 54). An additional section was measured and fossils collected at a locality two miles southeast of Tropic, Utah, and one-quarter mile east of Highway 54 (B.Y.U. loc. 12055).

Partial sections were measured from the top of an eight to ten inch coal seam, which overlies the uppermost sandstone unit of the lower Tropic in this region, to the top of the concretionary zone. The shale in which the concretions occur is argillaceous, slightly carbonaceous, thinly laminated and generally gray-blue or medium gray in color. The concretions occur sparsely and irregularly in a zone that ranges from 10 to 18 feet in thickness and occurs some 5 to 30 feet above the base of the unit. They are rounded, dense, and composed of argillaceous, sub-lithographic limestone. Their size ranges from several inches to more than two feet in diameter and they usually contain an abundant and varied mollusk fauna.

An attempt was made in the field to establish subzones based on fossil occurrences within the concretionary zone. Due to the thinness of the zone, the irregular occurrence of the concretions within the zone, and the sporatic occurrence of fossils within the concretions, however, it was not possible to subdivide the unit. Subsequent identification of fossils indicated no species that was peculiar to only part of the zone.

Fossils identified from the concretion zone of the area:

Cephalopoda
- Allocrioceras annulatum (Shumard)
- Allocrioceras dentonense Moreman
- Allocrioceras pariense (White)
- Baculites gracilis Shumard
- Eucalycoceras sp.
- Kanabiceras septemseriatum (Cragin)
- Metoicoceras ornatum Moreman
- Metoicoceras whitei Hyatt
- Scaphites sp.

Gastropoda
- Anchura (Drepanocheilus) ruida White
- Aporrhais (Perissoptera?) prolabiata White
- Lunatia cocinna Hall & Meek
- Sigaretus (Eunaticina) textilis Stanton
- Tritonium kanabense Stanton
- Turritella whitei Stanton

Pelecypoda
- Camptonectes platessa White
- Corbula kanabensis Stanton
- Exogyra cf. E. costata Say
- Exogyra cf. E. laeviuscula Roemer
- Gryphaea newberryi Stanton
- Inoceramus fragilis Hall & Meek
- Inoceramus labiatus Schlotheim
- Lima utahensis Stanton
- Liopistha (Psilomya) elongata Stanton
- Liopistha (Psilomya) meeki White
- Lucina subundata Hall & Meek
- Unio sp.

Annelida
- Serpula intrica White

Mt. Carmel Area.—The concretionary zone was measured and fossils collected at a section three and one-half miles northeast of Mt. Carmel, Utah, and one-quarter mile west of U.S. Highway 89 (BYU loc. 12056).

A partial section was measured from the top of a two to three foot thick coal bed of the lower Tropic up through the zone of abundant concretions. The shale of the unit is argillaceous, thinly laminated, and ranges in color from brown gray to dark gray. The concretions occur abundantly in a zone

approximately 30 feet thick which lies 29 feet above the base of the unit. Two types of concretions were noted to occur. The majority are septarian concretions or geodes which are filled or partially filled with very coasely crystalline yellow calcite. These range in size from three to twelve inches and are generally unfossiliferous. The fossiliferous concretions are similar to those at Tropic and Henrieville in both size and composition. The large concretions usually contain large fossils as a nucleus with small mollusks occurring in the periphery.

From fragments and molds, it is evident that the majority of the larger dense limestone concretions contained species of *Metoicoceras, Proplacenticeras* and less often *Inoceramus* as a nucleus. Only one specimen of *Allocrioceras* was found at Mt. Carmel and this was recovered from float concretion fragments.

Fossils identified from the concretion zone at this area:

Cephalopoda
- Allocrioceras annulatum (Shumard)
- Baculites gracilis Shumard
- Metoicoceras ornatum Moreman
- Metoicoceras whitei Hyatt
- Proplacenticeras pseudoplacenta Hyatt
- Proplacenticeras stantoni Hyatt

Gastropoda
- Turritella whitei Stanton

Pelecypoda
- Exogyra cf. E. costata Say
- Inoceramus fragilis Hall & Meek
- Inoceramus labiatus Schlotheim
- Liopistha (Psilomya) elongata Stanton
- Liopistha (Psilomya) meeki White
- Parapholas sphenoideus (?) White

Eagle Ford Group

General

Rocks of this group were referred to by Shumard (1860), Marcou (1862), Hill (1887) and others, but C. A. White in 1887 was the first to use the name Eagle Ford (Adkins & Lozo, 1951). The type locality is at Eagle Ford, Dallas County, Texas. It is overlain by the Austin Chalk or its equivalents and is underlain generally by the Woodbine Sandstone, the Pepper Shale or the Buda Limestone.

In central Texas the Eagle Ford has been divided into three formations by Moreman. In ascending order they are: Tarrant sandy clay and limestone, Britton clay, and Arcadia Park shale (Adkins, 1933).

Lithology of the Britton Formation

Moreman (in Adkins, 1933, p. 425) has described the lithology of the Britton Formation as follows:

> *Britton clay.*—Type locality: Britton northwestern Ellis County. Typical thickness: 250 feet; near Dallas, about 300 or more feet. Lithology: mostly blue clay; a few flaggy limestone seams and calcareous concretions, the latter becoming more abundant near the top of the unit. The lower one-third of the unit is blue clay, capped by a 10-foot bed of black shale having near its top a three-inch bentonite seam; it is overlain by 20 feet of white or yellowish laminated marl. This basal third of the unit seems to disappear north of Denton County and south of Hill County, leaving the upper Britton in contact with the Grayson (or Pepper). The upper blue clay portion of the Britton is continuous from Red River to Austin. It is thickest in the latitude of Dallas, thinner to the north, being represented by 30 to 50 feet of blue sandy clay, and at Austin is reduced to a few feet mainly by thinning of the several beds. The Britton grades upward into the Arcadia Park.

Fossil Occurrences in the Britton

Moreman (1942) described two zones in the Britton Formation. The basal one-third is the zone of *Metoicoceras irwini* and the upper portion the zone of *Metoicoceras whitei.* Moreman (1942) has recorded a complete list of fossils from the Britton Formation, some of the more pertinent of which include:

Cephalopoda
- Allocrioceras annulatum (Shumard)
- Allocrioceras pariense (White)
- Baculites gracilis Shumard
- Eucalycoceras bentonianum (Cragin)
- Metoicoceras kanabense Hyatt
- Metoicoceras ornatum Moreman
- Metoicoceras whitei Hyatt
- Neocardioceras septem-seriatum = Kanabiceras (Cragin)
- Proplacenticeras pseudoplacenta var. occidentale (Hyatt)
- Proplacenticeras stantoni var. bolli (Hyatt)
- Scaphites brittonense Moreman

Pelecypoda
- Inoceramus labiatus Schlotheim
- Inoceramus fragilis Hall & Meek

Age and Correlation of the Tropic Formation and the Britton Formation

The identical occurrence, in both the Tropic Formation and the Britton Formation, of the heteromorph ammonite species *Allocrioceras annulatum* and *A. pariense* and such other species as *Metoicoceras whitei, Metoicoceras ornatum, Kanabiceras septemseriatum, Proplacenticeras pseudoplacenta* and *Inoceramus labiatus* establishes a definite correlation between the Utah and Texas rocks. Stanton (1893) made a similar comparison.

Other formations which are generally considered in part equivalent include the lower Mancos Shale of eastern Utah, western Colorado and New Mexico, and the Benton Group of the western interior, which includes the Graneros Shale, Greenhorn Limestone and Carlile Shale.

Based on the occurrence of ammonites, the age of the Tropic and Britton formations is probably Early Turonian, although some writers have disagreed with this age for the Britton Formation.

Stephenson, *et al.* (1942), Cobban & Reeside (1952), and Moreman (1942) have considered the Eagle Ford to be largely Turonian. Moreman regarded the Tarrant Formation as being Late Cenomanian and the Britton and Arcadia Park formations as being Turonian. Regarding the correlation of the Britton Formation he stated (p. 194) that:

> The fauna of the Britton formation corresponds very closely to that of the lower Turonian or "Salmurian" of Europe. *Metoicoceras irwini,* which occurs in the lower part of the Britton formation, is closely related to *Metoicoceras pontieri* Leriche in the base of the Salmurian. Such genera as *Neocardioceras* [*Kanabiceras*], *Eucalycoceras, Scaphites, Baculites, Proplacenticeras,* and *Allocrioceras* are characteristic of both the lower Turonian and the Britton formation. Another characteristic form found at about this same stratigraphic level in both Europe and America is *Inoceramus labiatus.*

Adkins (1933) places the Cenomanian-Turonian boundary in the Chispa Summit Formation (Eagle Ford equivalent) in such a manner that the *Neocardioceras septem-seriatum* (*Kanabiceras septemseriatum*), *Metoicoceras* spp. and *Allocrioceras* n.sp. (*A. annulatum*) zone occurs in the Upper Cenomanian, while the *Metoicoceras* and *Allocrioceras pariense* zone occurs in the Lower Turonian. Adkins & Lozo (1951) regard the lower half of the Britton Formation as Cenomanian and the upper Britton as Turonian. They place the bound-

ary at or just above the occurrence of the *Metoicoceras, Allocrioceras* and *Kanabiceras* species.

Loeblich & Tappan (1961), however, date the entire Eagle Ford Group, including the Britton and Arcadia formations, as Cenomanian. They base their dating on the absence of exclusively Turonian Foraminifera in the planktonic fauna.

The occurrence of the ammonites *Metoicoceras whitei* and *Kanabiceras septemseriatum* offers the best evidence for an Early Turonian age for both the Britton Formation and the Tropic Formation. Spath (1926) considered the occurrence of *Metoicoceras whitei* to mark the base of the Turonian, and Wright (*in* Arkell, *et al*, 1957) lists the *M. whitei* zone as Early Turonian and representing a standard ammonite zone in classic areas of western Europe. In addition, Matsumoto (1959a, b) regards *Kanabiceras septemseriatum* as being Early Turonian and further states that it is becoming important as a world-wide zonal index. Both *Metoicoceras whitei* and *Kanabiceras septemseriatum* are regarded by Popenoe, *et al.* (1960), as Early Turonian guides in correlating Cretaceous formations of the Pacific Coast. Reeside (1955), however, regarded the occurrence of these ammonites in the western interior as marking the Upper Cenomanian.

SYSTEMATIC PALEONTOLOGY

Repository locations are indicated by the following symbols:
BEG—Bureau of Economic Geology, University of Texas, Austin, Texas.
BYU—Brigham Young University, Department of Geology, Provo, Utah.
Conlin—J. P. Conlin collection (to be deposited in USNM) 3617 Baldwin Street, Ft. Worth, Texas.
TCU—Texas Christian University, Department of Geology, Ft. Worth, Texas.
USNM—U.S. National Museum, Washington, D.C.
UT—University of Texas, Department of Geology, Austin, Texas.

Suborder LYTOCERATINA Hyatt, 1889

Superfamily TURRILITACEAE Meek, 1876

Family HAMITIDAE Hyatt, 1900

Coiling rather irregular but typically an open plane spiral tending to end in 2 or 3 more or less parallel shafts; early whorls may be helical; section circular to compressed; dense, normally straight radial or oblique ribs, continuous over venter, in some shells interrupted on dorsum, no tubercles. Suture lytoceratoid. L. Cret. (U.Apt.)-U. Cret. (Turon.). (Wright *in* Arkell, Kummel, Wright, 1957, p. L 216).

Genus HAMITES Parkinson, 1811

Typically with 3 well-separated subparallel shafts but early helical coiling often persists; section circular, depressed or compressed; ribs typically strong, fine and dense to coarse and distant. Suture with small, not bifid 3rd lateral saddle. U. Apt. - U. Alb. (Wright *in* Arkell, Kummel, Wright, 1957, p. L 216).

Hamites intermedius J. Sowerby

pl. 1 figs. 10, 14

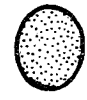
Hamites intermedius J. SOWERBY, 1814, Mineral Conchology, v. 1, p. 139, pl. LXII, figs. 4a, b; SPATH, 1941, Palaeont. Soc. Monograph, pt. XIV, p. 630-634, pl. LXX, figs. 19, 20, p. LXXI, figs. 3-6, text-fig. 229 a-g, m-p. (Complete synonymy through 1939).

Hamites adkinsi SCOTT, 1928, Jour. Paleont., v. 2, p. 116, 118, pl. 16, figs. 10, 13; ADKINS, 1928, Univ. Texas Bull. 2838, p. 208.

The specimen described by Scott (1928) as *Hamites adkinsi* differs slightly from the European species *Hamites intermedius,* but it is so similar in most aspects that it is here considered a junior synonym of *H. intermedius.* It is the oldest heteromorph known in Texas, occurring in the Middle Albian Comanche Peak Formation.

Generally the characteristics of the species include hamitid coiling with the hook fairly open, a slightly compressed whorl-section, and blunt ribs which are oblique, effaced on the dorsum and often with intercalated short ribs or branching ribs (Spath, 1941).

The Comanche Peak specimen is very similar to the distantly ribbed variety *H. intermedius distincta* described by Spath (1941). It is a hook-shaped specimen which consists of two essentially straight limbs joined by a curve. The shorter limb is the largest in diameter and represents the adapertural end. The whorl-section is slightly compressed (Text-fig. 2). The ribs have rounded tops and are oblique with the long axis of the shell. The size and spacing of the ribs are noticably different on the two limbs. On the smaller limb the ribs are high, prominent and widely spaced, with three ribs occurring in a length equal to a diameter. This spacing differs slightly from the majority of the *H. intermedius distincta* specimens figured by Spath (1941), which



TEXT-FIGURE 2.—Whorl-section of *Hamites intermedius,* X 1.

average about four ribs in a length equal to the diameter on the smaller limb. The ribs flare out most conspicuously along the dorsolateral margins and become lower as they extend upward and across the venter. Around the curved portion the ribs become more closely spaced and less prominent. On the larger limb they are low and numerous, between five and six occurring in a length equal to a diameter. There are several discontinuous and branching ribs across the venter on both limbs. The ribs are effaced on the dorsum.

An additional and somewhat similar specimen from the Duck Creek Formation seems to be quite close to *H. intermedius.* It is a widely open hook-shaped fragment which represents a younger portion of the shell than does the Comanche Peak specimen. The long limb is the largest in diameter and represents the adapertural end. The whorl-section is slightly compressed and the ribs are straight with rounded tops. Unlike the Comanche Peak specimen, the ribs of the smaller limb are low and closely spaced, with slightly more than five ribs occurring in a length equal to a diameter. Around the curve the ribs become higher and more widely spaced. On the larger limb they are prominent and average four ribs in a length equal to a diameter. There are no discontinuous or branching ribs on this specimen. The dorsum is smooth. Although its stratigraphic occurrence is somewhat higher than *H. intermedius,* its similar ornamentation gives it a closer affinity with that species than with other known species of *Stomohamites.*

No suture was observed on either of the Texas specimens.

Remarks.—This species is most similar to *H. maximus* J. Sowerby. It is considered distinct because of its more compressed whorl-section and its smooth dorsum. Other similar species include *H. subrotundus* Spath, *H. incurvatus* Brown and *Stomohamites funatus* (Brongniart). It differs from *H. subrotundus* and *H. incurvatus* by its whorl-section, blunt ribs and its smooth dorsum. It is distinct from *Stomohamites funatus* by its more blunt ribs and its less curved and less scaly ribs (Spath, 1941).

Occurrence.—The species occurs in the Albian of England at the top of the lower Gault (*cristatus*-subzone) and base of upper Gault (*orbignyi*- and *varicosum*-subzones) (Spath, 1941). The Texas specimen was collected from the middle of the Comanche Peak Limestone (Goodland Formation equivalent) near Valley Mills, Texas.

Repository.—TCU 1046, 1144.

Genus STOMOHAMITES Breistroffer, 1940

Typically with denser ribs than *Hamites* and at least some species have strongly collared and constricted aperture; venter tends to be flat. Suture with

3rd lateral saddle nearly as big as others and symmetrically bifid. U. Alb. - L. Turon. (Wright *in* Arkell, Kummel, Wright, 1957, p. L 217).
The Texas *Stomohamites* generally do not show a flattening of the venter.

Stomohamites nokonis (Adkins & Winton)
pl. 1 fig. 11; pl. 2 fig. 14

Hamites sp. B., WINTON & ADKINS, 1920, Univ. Texas Bull. 1931, p. 23.
Hamites nokonis ADKINS & WINTON, 1920, *ibid.* 1945, p. 18, 39-40, pl. 6, fig. 5, 6; WINTON & ADKINS, 1920, *ibid.* 1931, p. 22; SCOTT, 1926, Univ. Grenoble Thèse, Fac.

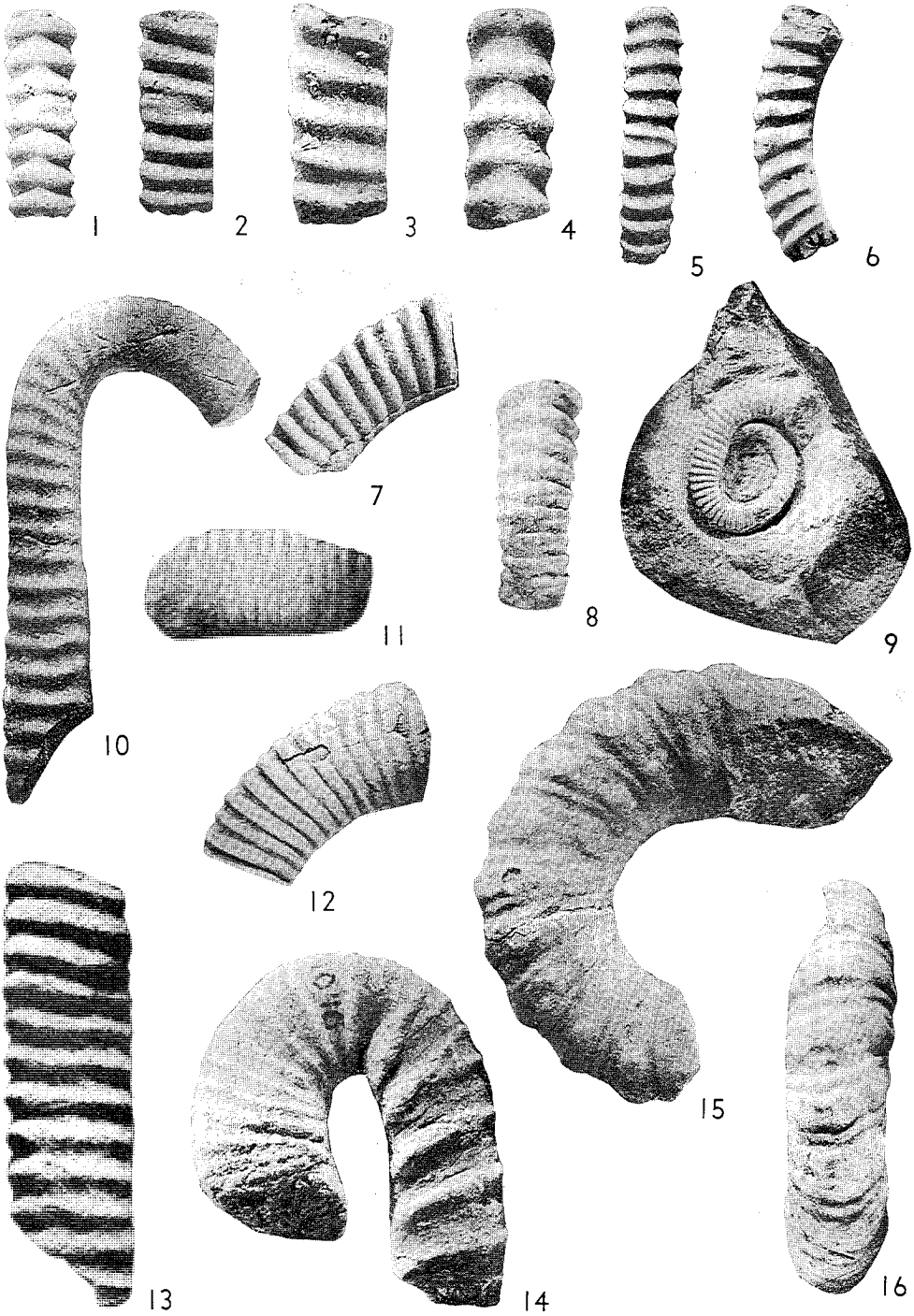
EXPLANATION OF PLATE 1

FIG. 1, 2.—*Stomohamites venetzianus* (Pictet). Pawpaw, TCU 1143, ventral and lateral view, X 2.4.
FIG. 3, 4.—*Stomohamites venetzianus* (Pictet). Pawpaw, TCU 1142, lateral and ventral view, X 2.4.
FIG. 5, 6.—*Stomohamites venetzianus* (Pictet). Pawpaw, BEG 20988, ventral and lateral view of *"Hamites tenawa"* holotype, showing a branching rib, X 2.1.
FIG. 7, 8.—*Allocrioceras dentonense* Moreman. Tropic, BYU 391, lateral and ventral view, X 1.5.
FIG. 9.—*Allocrioceras annulatum* (Shumard). Tropic, BYU 394, lateral view of early coil, X 1.5.
FIG. 10.—*Hamites* sp. aff. *H. intermedius* J. Sowerby. Duck Creek, TCU 1144, lateral view, X 1.6.
FIG. 11.—*Stomohamites nokonis* (Adkins & Winton). Holotype, Duck Creek, BEG 20984, lateral view, X 1.5.
FIG. 12.—*Allocrioceras* n. sp. Tropic, BYU 390, lateral view, X 2.8.
FIG. 13.—*Stomohamites virgulatus* (Brongniart). Duck Creek, UT 689, lateral view, X 1.8.
FIG. 14.—*Hamites intermedius* J. Sowerby. Comanche Peak, TCU 1046, lateral view of *"Hamites adkinsi"* holotype, X 1.5.
FIG. 15, 16.—*Anisoceras* sp. aff. *A. plicatile* (J. Sowerby). Duck Creek (?), TCU 1141, lateral and ventral view, X 1.5.

EXPLANATION OF PLATE 2

FIG. 1, 6.—*Idiohamites varians* (Scott). Duck Creek, BEG 35369, ventral and lateral view, X 1.7.
FIG. 2.—*Idiohamites varians* (Scott). Duck Creek, TCU 1098(a), lateral view, hypotype of *"Hamites polyseptus,"* X 5.5.
FIG. 3.—*Idiohamites varians* (Scott). Duck Creek, TCU 1094(b), ventral view, X 3.2.
FIG. 4.—*Idiohamites varians* (Scott). Duck Creek, BEG 35371, ventral view showing no tubercles on the larger half of the fragment, X 1.9.
FIG. 5.—*Idiohamites varians* (Scott). Duck Creek, BEG 35370, ventral view, X 1.9.
FIG. 7.—*Idiohamites varians* (Scott). Duck Creek, TCU 1148, ventral view, X 3.2.
FIG. 8.—*Idiohamites varians* (Scott). Holotype, Duck Creek, TCU 1079, lateral view, X 1.9.
FIG. 9.—*Idiohamites varians* (Scott). Duck Creek, TCU 1094(a), lateral view showing two ribs joining at one tubercle, X 1.6.
FIG. 10.—*Idiohamites varians* (Scott). Duck Creek, BEG 35372, ventral view showing several ribs with a single tubercle, X 6.3.
FIG. 11.—*Idiohamites fremonti* (Marcou). Duck Creek, BEG 20987, lateral view of holotype of *"Hamites comanchensis,"* X 1.6.
FIG. 12, 13.—*Allocrioceras pariense* (White). Tropic, BYU 395, ventral and lateral view, X 1.6.
FIG. 14.—*Stomohamites nokonis* (Adkins & Winton). Duck Creek, U.S.N.M. 1590, lateral view, X 1.5.
FIG. 15.—*Stomohamites virgulatus* (Brongniart). Duck Creek (?), BEG 35366, lateral view, X 1.4.
FIG. 16.—*Idiohamites* sp. Duck Creek, TCU 1147, lateral view, X 1.4.

PLATE 1



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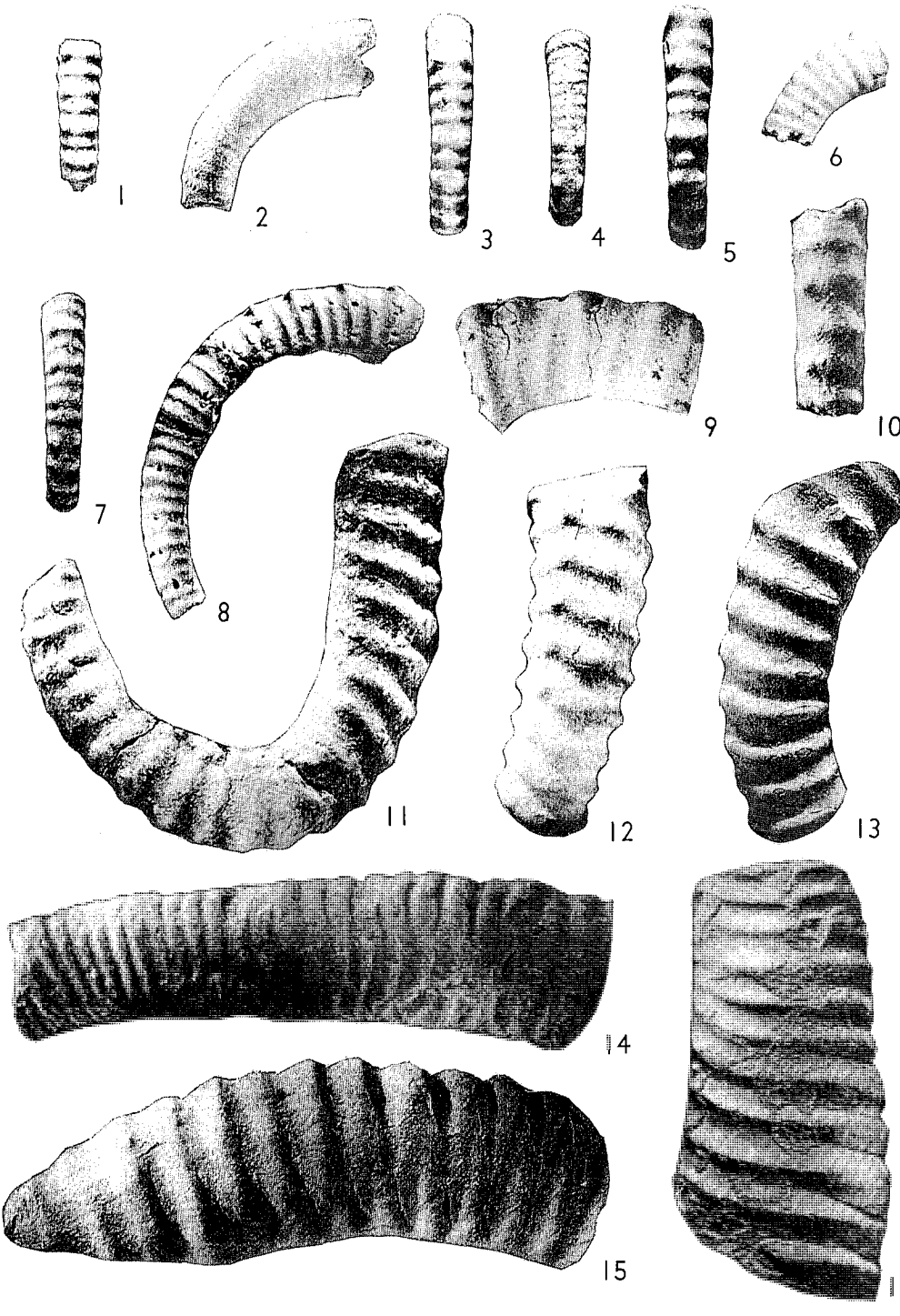
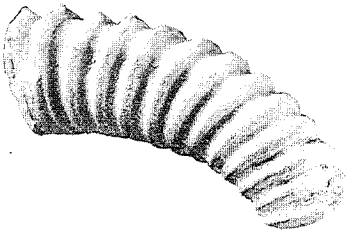


PLATE 3



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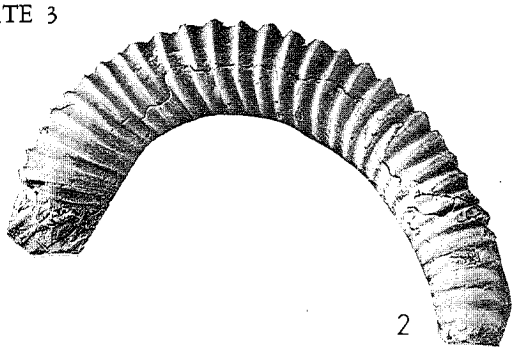

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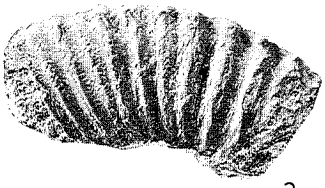

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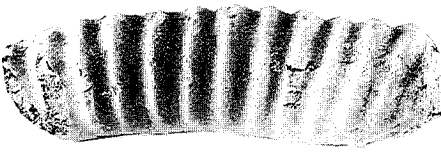

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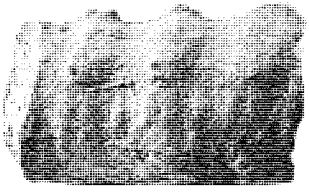

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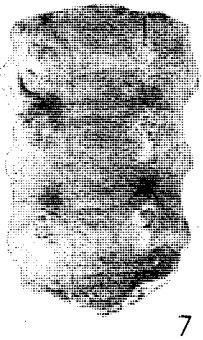

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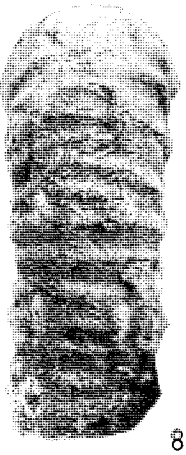

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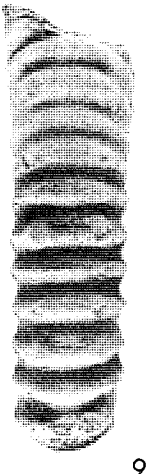

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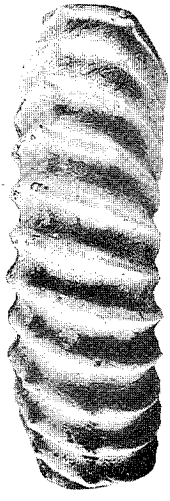

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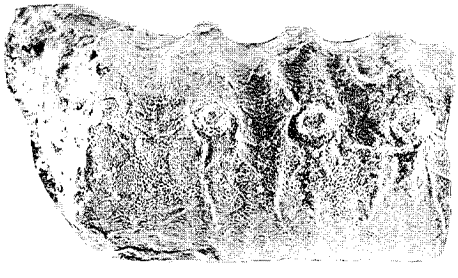

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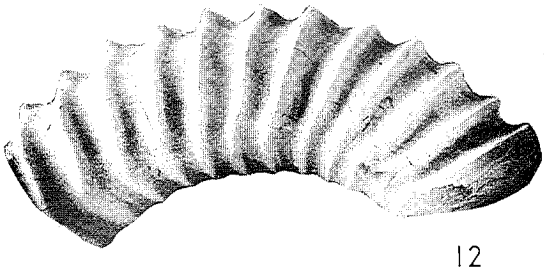

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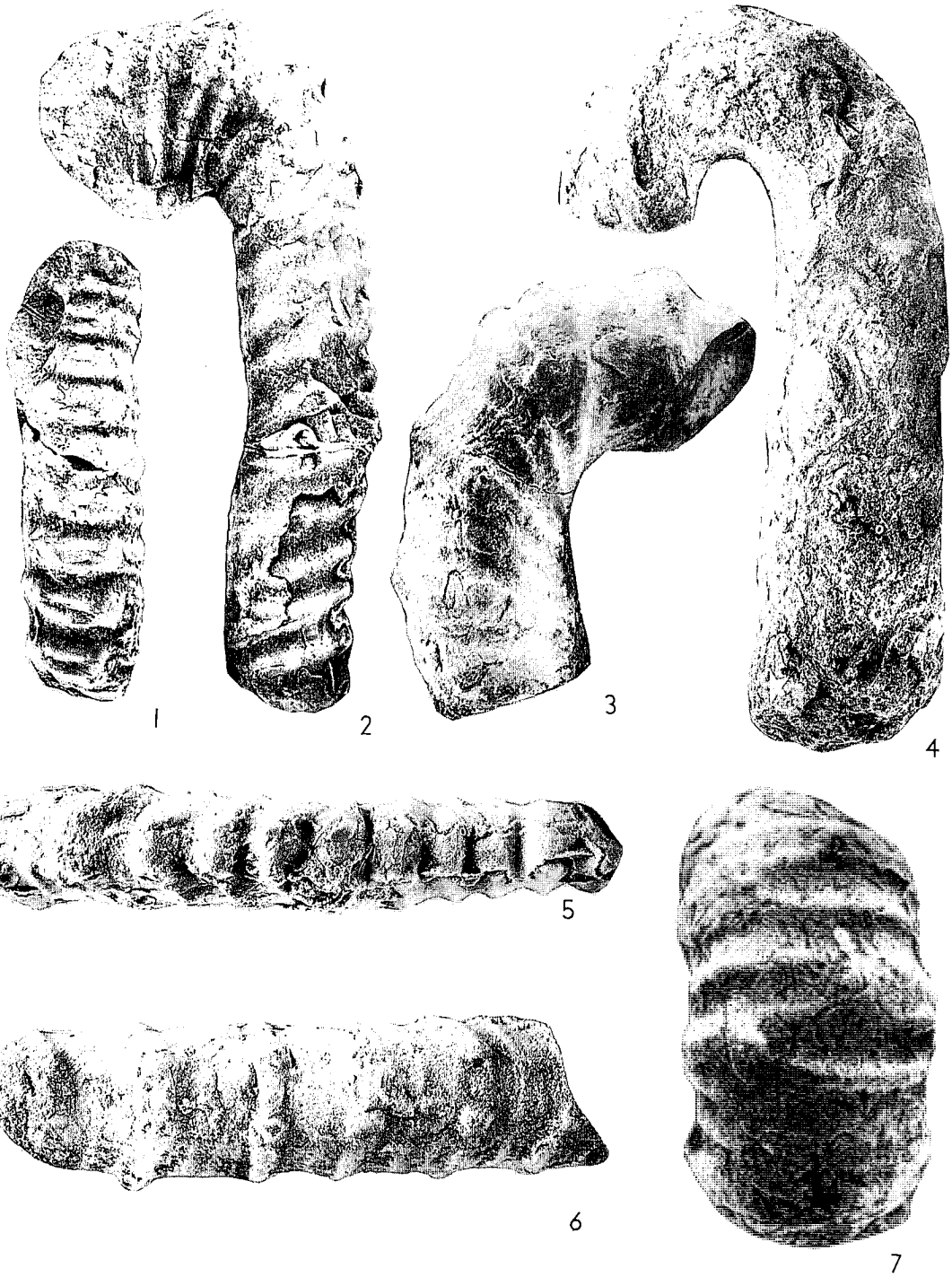
PLATE 4



Sci., p. 65; ADKINS, 1928, Univ. Texas Bull. 2838, p. 19, 208, pl. XII, fig. 2; PERKINS, 1961, Geol. Soc. Amer. Memoir 83, p. 27.

This easily recognizable species is characterized by its long elliptical whorl-section and its numerous closely spaced ribs. It is found associated with the more common *Idiohamites fremonti.*

Of the specimens of *Stomohamites nokonis* studied, the shorter fragments are generally straight while the longer fragments are very slightly curved. As shown by Text-fig 3, the whorl-section is strongly compressed. The ribs are simple, slightly flexuous and closely spaced, with between seven and eight ribs occurring in a length equal to a diameter. They are low and have flattened to slightly rounded tops. They are widest and most prominent across the venter and thin slightly along the sides toward the dorsal margins. Across the dorsum the ribs are faint or absent. Their size and prominence varies somewhat from rib to rib as well as their inclination with the long axis of the shell. No suture was observed.

TEXT-FIGURE 3.—Whorl-section of *Stomohamites nokonis,* X 1.

Remarks.—This unique species is easily distinguished from the Texas species *S. venetzianus* (Pictet) and *S. virgulatus* (Brongniart) by its whorl-section, closely spaced ribs and stratigraphic occurrence. It is distinct from the somewhat similar European species *S. duplicatus* (Pictet & Campiche) and *S. charpentieri* (Pictet) by its more strongly compressed whorl-section and low blunt ribs, and from *S. ptychoceratoides* Spath by its more compressed whorl-section and its more closely spaced ribs. The species also re-

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EXPLANATION OF PLATE 3

FIG. 1.—*Allocrioceras annulatum* (Shumard). Eagle Ford, BEG 35367, lateral view of transitional specimen with rounded ribs, X 1.6.
FIG. 2.—*Allocrioceras annulatum* (Shumard). Britton (Eagle Ford), BEG 19820, lateral view, X 1.3.
FIG. 3.—*Allocrioceras dentonense* Moreman. Holotype, Britton (Eagle Ford), BEG 19808, lateral view, X 1.2.
FIG. 4.—*Anisoceras armatum* (J. Sowerby). Duck Creek (?), BEG 35364, lateral view showing loops and prominent non-tuberculate ribs, X 1.7.
FIG. 5, 9.—*Idiohamites fremonti* (Marcou). Duck Creek, TCU 1145, lateral and ventral view, X 1.2.
FIG. 6, 7.—*Anisoceras bendirei* (Adkins). Weno, TCU 1139, lateral and ventral view, X 1.4.
FIG. 8.—*Anisoceras bendirei* (Adkins). Weno (?), BEG 21133, ventral view of hooked specimen showing prominent non-tuberculate rib, X 1.8.
FIG. 10, 12.—*Allocrioceras annulatum* (Shumard). Eagle Ford, BYU 393, ventral and lateral view, X 1.3.
FIG. 11.—*Anisoceras bendirei* (Adkins). Weno, TCU 1138, lateral view, X 1.3.

EXPLANATION OF PLATE 4

FIG. 1.—*Anisoceras perarmatum* Pictet & Campiche. Weno, TCU 1140, ventral view, X 1.2.
FIG. 2, 5.—*Anisoceras* sp. aff. *A. subarcuatum* Spath. Duck Creek (?), BEG 35365, lateral and ventral view, X .83.
FIG. 3, 7.—*Anisoceras perarmatum* Pictet & Campiche. Weno (?) BEG 35373, lateral view and ventral view of injured specimen showing offset ribs and tubercles, Fig. 3, X 1, Fig. 7, X 1.3.
FIG. 4.—*Anisoceras salei* Clark. Duck Creek, BEG 21135, lateral view, X .47.
FIG. 6.—*Anisoceras armatum* (J. Sowerby). Unknown horizon near Hondo, Texas, BEG 35362, ventral view, X 1.1.

sembles *Hamites compressus* J. Sowerby and *H. gardneri* Spath. It is distinct from these species by its more compressed whorl-section, blunt ribs, and lack of distinct ribs across the dorsum.

Occurrence.—Stomohamites nokonis occurs in the *"Hamites"* horizon at the base of the Duck Creek Formation from southern Oklahoma to central Texas (Adkins & Winton, 1920). The holotype was collected from the military road cut one-half mile north of Texas Christian University in Ft. Worth, Texas.

Repository.—Holotype, BEG 20984; USNM 1590.

Stomohamites venetzianus (Pictet)

pl. 1 figs. 1-6

Hamites venetzianus PICTET, 1847, Mèm. Soc. Phys. Hist. Nat. Genève, XI, pt. 2, p. 134, pl. XIV, fig. 6.

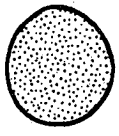
Hamites (Stomohamites) venetzianus SPATH, 1941, Palaeont. Soc. Monograph, pt. XIV, p. 638-640, pl. LXXI, figs. 11-13, text-fig. 231. (Complete synonymy through 1939).

Hamites tenawa ADKINS & WINTON, 1920, Univ. Texas Bull. 1945, p. 28, 43-44, pl. 6, fig. 4: WINTON & ADKINS, 1920, *ibid.* 1931, p. 21: ADKINS, 1920, *ibid.* 1856, p. 38, 51, 67, 69: SCOTT, 1924, Texas Christ. Univ. Quarterly, v. 1, p. 15, 17: SCOTT, 1926, Univ. Genoble Thèse, Fac. Sci., p. 80; ADKINS, 1928, Univ. Texas Bull. 2838, p. 24, 208, 210, pl. XX, fig. 14; BOSE, 1928, *ibid.* 2748, p. 146.

Hamites sp. WINTON & ADKINS, 1920, *ibid.* 1931, p. 69.

This species is typically found as small pyritized fragments which are similar in size and preservation to the Duck Creek *Idiohamites varians* specimens. In general they are short gently curved forms which are characterized by a moderately compressed to nearly circular whorl-section (Text-fig. 4) and blunt oblique ribs.

The ribs are prominent, evenly graded in size, usually simple and have broadly rounded tops. They are widest across the venter and thin somewhat toward the dorso-lateral margins. Across the dorsum they are faint or absent. Their spacing averages slightly less than four ribs in a length equal to a diameter. This varies somewhat from

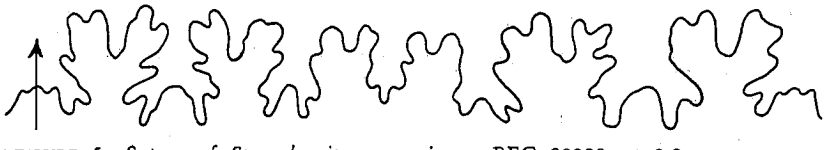


TEXT-FIGURE 4.—Whorl-section of *Stomohamites venetzianus,* X 3.

the English specimens figured by Spath (1941) which usually have slightly more than four ribs in a length equal to a diameter. The inclination of the ribs along the long axis of the shell varies somewhat in direction and degree from specimen to specimen. Usually, from the venter, they angle backward dorsally, although on several specimens studied they were straight or projected forward. The suture illustrated in Text-fig. 5 differs from the suture of *S. venetzianus* illustrated by Spath (1941) primarily by having a less oblique second lateral lobe. The suture of *S. virgulatus,* as illustrated by Spath (1941), is very similar to that of the Texas specimens.

Remarks.—The slight differences in the rib spacing and the suture of *Hamites tenawa* and *S. venetzianus* are not considered to be of specific importance and *H. tenawa* is here regarded as a junior synonym of *S. venetzianus.*

S. venetzianus is most similar to *S. virgulatus* (Brongniart). It differs primarily by its blunt and oblique ribs. Another somewhat similar species is *S. subvirgulatus* Spath. It is distinct from *S. subvirgulatus* by its more widely spaced and oblique ribs.



TEXT-FIGURE 5.—Suture of *Stomohamites venetzianus,* BEG 20988, at 3.9 mm.

Occurrence.—The species is primarily found in the basal part of the Pawpaw Formation and was formerly abundant in the Ft. Worth area. Specimen BEG 20988 was collected from the Pawpaw along Keller Road, nine miles northeast of Ft. Worth, and specimens 1142 and 1143 are from the Pawpaw along Sycamore Creek. Two non-pyritized specimens have been collected, one questionable specimen from the Duck Creek Formation and one from the Weno Formation. English specimens are found in the Upper Albian, *aequatorialis*—or *substuderi*—subzones (Spath, 1941).
Repository.—BEG 20988; TCU 1142, 1143.

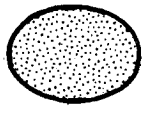
Stomohamites virgulatus (Brongniart)
pl. 1 fig. 13; pl. 2 fig. 15

Hamites virgulatus BRONGNIART, 1822, Environs de Paris, pl. 0, fig. 6; ADKINS, 1920, Univ. Texas Bull. 1856, p. 66; ADKINS & WINTON, 1920, *ibid.* 1945, p. 43.
Hamites (*Stomohamites*) *virgulatus* SPATH, 1941, Palaeont. Soc. Monograph, pt. XIV, p. 635-638, pl. LXXI, figs. 7-10; pl. LXXII, fig. 11; text-fig. 230. (Synonymy complete through 1939).
Stomohamites virgulatus WRIGHT *in* Arkell, *et al.*, 1957, Treatise on Invert. Paleont., pt. L, p. L 217.

Several specimens studied compare very well with the European species *S. virgulatus* and are being provisionally assigned to that species. The specific characters of *S. virgulatus* were described by Spath (1941, p. 636) as follows:

> Coiling probably more or less anisoceratid, without sudden bends, but often slightly helicoid; whorl-section compressed oval to almost circular. Ribs sharp, straight, effaced on smooth dorsum and not very closely spaced (normally four to five in a length equal to the diameter, but variable). Suture-line with bifid lateral lobes.

From Spath's description and by comparison with his illustrations of *S. virgulatus*, it is apparent that the Texas specimens differ only by their slightly more compressed whorl-section (Text-fig. 6) and possibly in part by their rib shape. The differences are not regarded to be of sufficient magnitude to warrant a species distinction. The Texas material has prominent ribs across the venter and along the sides which are equal, simple and straight. The sides of individual ribs, however, are somewhat asymmetrical, particularly across the venter. The slope on the adapertural side of the rib is gentle while the adapical slope is generally steeper. The tops of unweathered ribs would probably be quite sharp. The dorsum on the specimens is smooth.



TEXT-FIGURE 6.—Whorl-section of *Stomohamites virgulatus*, X 1.

Two additional specimens from the J. P. Conlin collection, no. 5755 and 8442, were identified as having affinity with *S. virgulatus*. They are similar to *S. virgulatus* in having a nearly circular whorl-section and similarly spaced ribs. They differ primarily in that their ribs are conspicuously rounded. The dorsal regions of both specimens were not preserved.

A somewhat unique specimen of *Stomohamites* (BEG 21139) from the Denton Formation at Leon Springs was examined, but was found to be too fragmentary to specifically identify. The specimen consists of a short portion of a medium sized straight shaft. The ribs are simple, equal and have rounded tops. They are most prominent across the venter. Along the sides they thin and angle sharply backward dorsally.

The suture was not observed on any of the specimens examined. Spath (1941) has illustrated the suture of the European specimens.
Remarks.—*S. virgulatus* is most similar to *S. venetzianus*. It is considered distinct primarily because its ribs are straight and sharp. In addition, the Texas specimens of *S. venetzianus* can be differentiated by their size, preservation, and stratigraphic occurrence. *S. virgulatus* is easily distinguished from *S. nokonis* by its whorl-shape, rib shape, and rib spacing. The numerous European species of *Stomohamites* have been finely subdivided and Spath (1941) has discussed in some detail the distinctive characters and comparisons of each type. Briefly, however, *S. virgulatus* is most similar to

S. subvirgulatus Spath and *S. parkinsoni* (Fleming). It is distinct from *S. subvirgulatus* and *S. parkinsoni* by its less closely spaced ribs. On the basis of stratigraphic occurrence, the Texas specimens are most similar to *S. parkinsoni.*

The two Conlin specimens identified as having affinity with *S. virgulatus,* are similar to *Hamites subrotundus* Spath and *Stomohamites ibex* Spath on the basis of their helical coiling and circular whorl-sections. They are distinct from *Hamites subrotundus* by their rounded ribs and stratigraphic occurrence and from *Stomohamites ibex* by their less coarse ribbing.

Occurence.—The figured specimens identified as *S. virgulatus* are from the Duck Creek Formation. Specimen BEG 35366 was collected from Grayson County at or near Fink, Texas. Specimen 689 was collected from a road cut along the Texoma Dam-Denton highway. Two additional specimens were labeled as having been collected from either the Duck Creek or the Kiamichi formations. The Conlin specimens were collected from the Ft. Worth Formation. English specimens occur in the ? *aequatorialis*—to *substuderi* —subzones of the Upper Albian (Spath, 1941), a somewhat higher stratigraphic occurrence than that of the Texas specimens.

Repository.—BEG 35366; UT 689.

Family ANISOCERATIDAE Hyatt, 1900

Loosely coiled, irregularly helical at first, later part typically in one plane, some with straight final shaft. There is normally a pair of ventral tubercles on some ribs at least and commonly lateral tubercles as well. Suture lytoceratoid except that in some genera trifid lobes may occur. Probably a monophyletic family derived from *Hamitidae.* L. Cret. (L. Alb.) - U. Cret. (U. Turon.). (Wright *in* Arkell, Kummel, Wright, 1957, p. L 218).

Genus ANISOCERAS Pictet, 1854

Has an early loosely coiled helical spire normally ending in one or two straight shafts. Both lateral and ventral tubercles are prominent. *Anisoceras* occurs in strata from Upper Albian to Upper Turonian. (Wright *in* Arkell, Kummel, Wright, 1957).

Turonian *Anisoceras* (Crioceras) specimens have been reported from the Boquillas flag facies at the top of the Eagle Ford Group in the Terlingua quadrangle, Brewster County, Texas (Adkins, 1932). The specimens are weathered and characters preserved are not diagnostic.

Anisoceras armatum (J. Sowerby)

pl. 3 fig. 4; pl. 4 fig. 6

Hamites armatus J. SOWERBY, 1817, Mineral Conchology, v. ii, p. 153, pl. CLXVIII; ADKINS, 1920, Univ. Texas Bull. 1856, p. 66, 67; SCOTT, 1924, Texas Christ. Univ. Quarterly, v. 1, p. 15, 17; ADKINS, 1928, Univ. Texas Bull. 2838, p. 24.

Anisoceras armatum SPATH, 1939, Palaeont. Soc. Monograph, pt. XIII, p. 543-548, pl. LIX, fig. 6; pl. LX, fig. 1, pl. LXI, figs. 9-11; pl. LXII, fig. 5; text-fig. 191. (Synonymy complete through 1939).

Hamites sp. aff. *H. armatus* ADKINS, 1920, Univ. Texas Bull. 1856, p. 51, 69-70; SCOTT, 1926, Univ. Grenoble Thèse, Fac. Sci., p. 80; BOSE, 1928, Univ. Texas Bull. 2748, p. 146; ADKINS, 1928, *ibid.* 2838, p. 24.

Anisoceras sp. aff. *A. armatum* ADKINS, 1928, *ibid.* 2838, p. 211.

Anisoceras cf. *A. armatum* CLARK, 1958, Jour. Paleont., v. 32, p. 1080, pl. 139, fig. 2.

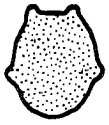
Spath (1939, p. 545) described the specific characters of this species as follows:

> Coiling anisoceratid. Whorl-section cylindrical or slightly compressed, with scarcely flattened sides and rather narrow venter. Small lateral tubercles below middle of the whorl-side; generally one or two intermediate ribs. Less regularity on the final shaft.

On larger Texas specimens the tuberculate ribs are wide and prominent along the sides and, though lower, are conspicuous across the venter. Across the dorsum they are narrow and flattened, sometimes dividing at the lateral tubercles to form a paired rib across the dorsum. The ventral tubercles are large and the venter narrow. The lateral tubercles are only about half as large as the ventral tubercles. They appear to occur below the mid-line of the whorl-section, although the deformation of the specimens studied may have distorted their true position. Generally one or two fine inconspicuous

ribs occur between the widely spaced tuberculate ribs. These ribs are most prominent along the sides and across the dorsum. They are more indistinct across the venter, sometimes merely occurring as fine costae.

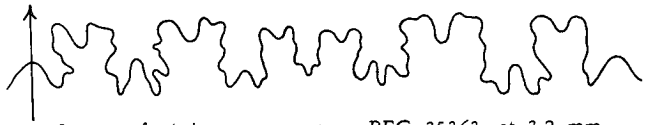
Early stages of *Anisoceras* are generally very difficult to identify. On juvenile specimens of *A. armatum* the tubercles often bridge two ribs to form loops similar to *A. saussureanum* (Pictet), and Spath (1939) has discussed the difficulties of separating them. *A. perarmatum* Pictet & Campiche initially had one or two intermediate ribs making it similar to both *A. armatum* and *A. saussureanum* (Spath, 1939). Adkins (1920) described several small fragments of ammonites that he identified as having affinity with *A. armatum*. The location of these specimens is unknown at the present time, but the description made of them does indicate they were of the *A. armatum* type (Clark, 1958). Of the smaller specimens studied, most are characterized by having one or two intermediate ribs almost as prominent as the tuberculate ribs. There is only a suggestion of looping in the smallest fragments, while the loops are somewhat more evident in the slightly larger curved specimens. The whorl shape is nearly cylindrical in the small fragments and is laterally compressed in the larger specimens (Text-fig. 7). On all of



TEXT-FIGURE 7.—Whorl-section of *Anisoceras armatum*, X 2.

the smaller specimens the ribs are effaced on the dorsum. One specimen studied differs from the other small fragments in that it has no suggestion of looping. The tuberculate ribs and tubercles are very large and prominent for the small size of the fragment, while the intermediate rib is quite indistinct. The suture of a juvenile stage is illustrated in Text-fig. 8. Spath has described the suture of English specimens of *A. armatum*.

Remarks.—In its adult stages, *Anisoceras armatum* is most similar to *A. salei* Clark and *A. saussureanum*. The narrow venter, slightly compressed whorl-section and the below-the-mid-line position of the lateral tubercles indicate its relationship to *A. salei*. *A. armatum*, however, has fewer intermediate ribs, particularly on the final shaft, and it lacks the broad connecting loops across the venter of *A. salei* (Clark, 1958). It differs from *A. saussureanum* by its lack of loops in adult stages, at least in the Texas specimens thus far found, and its one to two intermediate ribs. It differs from *A. bendirei* (Adkins), *A. perarmatum* and other *Anisoceras* species by its characteristic narrow venter, the broad heavy tuberculate ribs, the small lateral tubercles which occur below the mid-line of the whorl-section, and the intermediate ribs.



TEXT-FIGURE 8.—Suture of *Anisoceras armatum*, BEG 35363, at 3.2 mm.

Occurrence.—The large specimen, BEG 35362, was collected by R. S. Cannon in 1922 from an unknown horizon near King's waterhole north of Hondo, Medina County, Texas. Specimen BEG 35363 is from the Pawpaw. Specimen BEG 35364 was collected from the Duck Creek Formation (?) east of Texas Christian University along Dairy Creek. The specimens Adkins (1920) described were from the basal third of the Pawpaw Formation at locality 714. In addition, J. P. Conlin has collected four small helical specimens of the *A. armatum* type from the same locality as the Adkins' specimens. English specimens occur in the Upper Gault, *?auritus*—and *aequatorialis*—subzones, and especially *substuderi*—and *dispar*—subzones (Spath, 1939).

Repository.—The holotype figured by J. Sowerby is in the Oxford University Museum. BEG 35362, 35363, 35364.

Anisoceras perarmatum Pictet & Campiche

pl. 4 figs. 1, 3, 7

Anisoceras perarmatum PICTET & CAMPICHE, 1861, Matèriaux pour la Palèontologie Suisse. Description des fossiles du terrain Crètacè des environs de Ste. Croix, ii,

no. 2, p. 65, pl. XLVIII, figs. 7-8; pl. XLIX, figs. 1 (2-8); SCOTT, 1926, Univ. Grenoble Thèse, Fac. Sci., p. 61-62; SPATH, 1939, Palaeont. Soc. Monograph, pt. XIII, p. 548-550, pl. LIX, figs. 1-3; pl. LXI, figs. 3-7; text-fig. 192. (Synonymy complete through 1939).

The specimens assigned to this species are fragmentary and poorly preserved but are considered to belong to this species. Three of the fragments are at least half covered with matrix; the fourth is an injured specimen showing atypical characters.

Anisoceras perarmatum is abundant in the Upper Albian Cambridge Greensand of England. Spath (1939, p. 549) described its specific characters as follows:

> Coiling anisoceratid, with twist of early whorls often inconspicuous. Whorl-section hexagonal, sometimes slightly depressed on straight shafts or on bend. Ribbing first as in other *Anisoceras*, with one or even two fine intermediary ribs between the pronounced and quadrituberculate main ribs, but these soon increase in strength and all the intermediate ribs are lost. Irregular ornamentation on final portion. Tubercles connected by loops on venter and sides. Dorsum almost smooth. Suture-line with wide lobes and often also wide saddles.

Specimen 1140 (pl. 4, fig. 1), although poorly preserved, seems to fit Spath's description very closely. The sub-clavate tubercles symmetrically bridge two prominent and parallel ribs to make pronounced loops. Four tubercles occur per rib pair, two in a ventrolateral position and two in a midlateral position. The ribs appear to be mostly straight, although the dorsal half of the specimen is still covered with matrix. The ribs are strong across the venter and are slightly convex toward the aperture. There are no intermediate ribs visible on the specimen.

One specimen assigned to the species (pl. 4, figs. 3, 7) is particularly interesting because it shows the apparent effects of an injury prior to its maturity. The ribs and tubercles on each side of the venter are offset in such a way as to make the tubercles alternate in position from one side of the venter to the other along the long axis of the shell. As a result, the characteristic looping of the species occurs only alternately along the ventrolateral sides and not at all across the venter. In addition, there is a less prominent rib that is continuous across the venter and devoid of tubercles. The ribs cross the dorsum on this specimen as numerous costae, some of which are restricted to the dorsal region. Two additional similar specimens are known. In the collections of C. W. Wright in London there is a similar but smaller specimen. A specimen in the British Geological Survey Museum, no. 69797, is also very similar. Numerous other examples of distortions in ammonite ornamentation due to injuries have been cited by Arkell (1957).

There is not enough of the suture preserved on the Texas specimens to be diagnostic. However, Spath (1939) has illustrated a typical *A. perarmatum* suture.

Remarks.—This species is most similar to *Anisoceras bendirei* and *A. saussureanum*. It is distinct from *A. bendirei* particularly by the consistency of its loops and lack of conspicuous ribs on the dorsum, and from both *A. bendirei* and *A. saussureanum* by its lack of intermediate non-tuberculate ribs in all but juvenile specimens. In addition, its characteristic hexagonal whorl-section and mid-lateral tubercles exclude it from all other species of *Anisoceras*.

Occurrence.—Specimen 1140 was collected from the Weno Formation near Rio Vista by Winton and Scott. Specimen BEG 35373 is questionably from the Weno Formation. A poorly preserved specimen which may be *A. perarmatum* was collected from the Mainstreet. English specimens occur in the Upper Gault, *aequatorialis*—subzone ? and especially *substuderi*—and *dispar*—subzones (Spath, 1939).

Repository.—TCU 1140; BEG 35373.

Anisoceras bendirei (Adkins)

pl. 3 figs. 6-8, 11

Hamites sp. B, WINTON & ADKINS, 1920, Univ. Texas Bull. 1931, p. 22.

Ancycloceras bendirei ADKINS, 1920, *ibid.* 1856, p. 8, 48, 70-71, 103, 125, 137, 142, pl. 11, fig. 1; SCOTT, 1926, Univ. Grenoble Thèse, Fac. Sci., p. 74, 76, 190.

Ancyloceras bendirei BOSE, 1928, Univ. Texas Bull. 2748, p. 146; ADKINS, 1928, *ibid.* 2838, p. 21, 216.

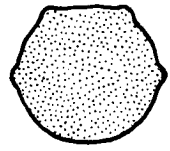
Anisoceras bendirei CLARK, 1958, Jour. Paleont., v. 32, p. 1077-1079, pl. 150, figs. 1, 2.

Generally the characteristic features of the species include a hexagonal-rounded whorl shape, prominent spinose tubercles, a wide flat venter, the occasional presence of

one or two non-tuberculate ribs which cross the venter, and from one to three fine intermediate ribs which occur only on the dorsum.

Originally described as an *Ancyloceras by Adkins* (1920), this species was recently redefined and the holotype refigured by Clark (1958). On the basis of additional specimens assigned to the species, the description is now broadened to encompass still additional characteristics.

The whorl-section is rounded-hexagonal in the ventral half and rounded in the dorsal half (Text-fig. 9). The four rows of spinose tubercles occur along the shaft, two



TEXT-FIGURE 9.—Whorl-section of *Anisoceras bendirei,* X 1.

ventrolaterally and two midlaterally. On straight shafts and hooked portions, the ventrolateral tubercles are sub-clavate, while those midlateral are slightly smaller and rounded. On curved fragments representing a part of the early coiled portion of the shell, the tubercles are rounded in both positions, although the ventral tubercles are again the larger. The tubercles occur on prominent ribs; four tubercles to a rib or rib pair. The ribs are strongest between the midlateral and ventrolateral tubercles. They are reduced in prominence across the venter and below the midlateral tubercles, and are narrow and low across the dorsum. They slant slightly forward ventrally toward the aperture. On most specimens the tubercles distinctly bridge two ribs with a resulting looping effect. Occasionally the loops are not as distinct when the tubercles fail to bridge both ribs. Looping is not evident on curved fragments because the tuberculate ribs are much broader and heavier than are the adjacent non-tuberculate ribs. In addition, a non-tuberculate rib occasionally crosses the venter in a position intermediate between the tuberculate ribs. This low rib is most prominent on hooked specimens and less conspicuous on curved specimens. It is faint or absent on straight specimens. All forms have from one to three additional fine ribs on the dorsum, but these only extend about half the distance to the midlateral tubercle.

The suture was illustrated by Adkins (1920) and is very similar to that of *Anisoceras saussureanum* as illustrated by Spath (1939) and by Wright (1957).

Remarks.—This species is most similar to *Anisoceras saussureanum* and *A. perarmatum.* It is distinct from both *A. saussureanum* and *A. perarmatum* by the occasional presence of intermediate ribs, and from *A. perarmatum* principally by the occurrence of ribs across the dorsum. These characteristics, coupled with its whorl-shape and midlateral position of the tubercles, exclude it from *A. armatum* and also from other Mexican, Indian, and French species (Clark, 1958).

Occurrence.—The holotype was collected from the basal Weno Formation about ten feet above the top of the Denton Marl, near Ft. Worth, Texas. Many specimens, all from the Weno, are in the collection of the Bureau of Economic Geology, the J. P. Conlin collection, and the Renfro collection of the U.S. National Museum.

Repository.—Holotype BEG 20271. BEG 21133; TCU 1138, 1139.

Anisoceras salei Clark

pl. 4 fig. 4

Anisoceras sp. SALE, 1957 *ms.,* M. A. thesis, Texas Christian Univ., p. ii, p. 33, 34, 92, pls. 18, 19.

Anisoceras salei CLARK, 1958, Jour. Paleont., v. 32, p. 1079-1080, pl. 140, fig. 3.

The characteristics of the holotype of this species were described by Clark (1958, p. 1079) as follows:

> Heavy tubercle bearing ribs are separated by four to six intermediate fine ribs on the main shaft. This shaft is connected by a 180 degree hook to a smaller straight shaft, the adapical portion. On the smaller shaft there are two intermediate ribs. The ribs are slightly oblique on the hook to vertical on the shafts. Two rows of ventral and lateral tubercles are present, a pair of each on every heavy rib. The ventral tubercles are large and on the holotype distorted. The

lateral tubercles are the larger and are situated below the middle of the whorl side. The tubercles on the final shaft are between 35 and 43 mm apart and average less than 38 mm. The whorl shape is highly compressed. The fragmentary suture shows clearly the *Anisoceras* type, i.e., two large dissected lateral lobes, and three lateral saddles, the medial one being deeply bifid and the largest, the dorsal-lateral being the smallest.

At the present time only four specimens of this species have been collected, including the holotype. Of these, BEG 21135 was available for this study. The specimen is poorly preserved but does show the gross characteristics of the species. The whorl shape is laterally compressed and the venter narrow. The tuberculate ribs are broad and heavy, each with two ventral and two lateral tubercles. The lateral tubercles are distinctly larger than those on the venter, and they occur below the mid-line of the whorl side on the large straight shaft and at about mid-line close to the hook. Due to the poor preservation, intermediate non-tuberculate ribs are only faintly distinct across the venter and dorsum and are obliterated along the sides. It appears, however, that there are two inconspicuous intermediate ribs near the hook, with the number increasing to about four ribs at the end of the large straight shaft. They are a great deal more numerous across the dorsum. There is not enough of the suture preserved on this specimen to be diagnostic.
Remarks.—Clark (1958) has made a complete comparison of *Anisoceras salei* with other species of *Anisoceras*. In general, however, *A. salei* is most similiar to *A. armatum* and *A. saussureanum*. It differs from *A. armatum* by its greater number of intermediate ribs on the final shaft, the hoops formed by the tuberculate ribs over the venter, and the greater distance apart of the outer tubercles (Clark, 1959). It is distinct from *A. saussureanum* primarly because of the smaller distance separating the outer tubercles. The tubercles on the final shaft of *A. saussureanum* are usually about 45 mm apart while those of *A. armatum* are half that distance. With equal sized specimens the average distance between outer tubercles in *A. salei* is less than 38 mm, intermediate between *armatum* and *saussureanum* (Clark, 1958). The large lateral tubercles and their position, the heavy tuberculate ribs with connecting hoops over the venter, the compressed whorl-section, and the number of intermediate ribs differentiate *A. salei* from other species of *Anisoceras*.
Occurrence.—The holotype was collected by Clarence M. Sale from about 20 feet above the base of the Duck Creek Formation in southwest Ft. Worth, Texas. A specimen from Bell County, BEG 17398, was found by M. T. Sheppard in the lower Duck Creek (?) south of Belton, Texas. A specimen in the J. P. Conlin collection (8323) was collected from the Duck Creek Formation at the junction between Highway 80 and 377 in Arlington Heights. Specimen BEG 21135 is also from the Duck Creek Formation.
Repository.—The holotype, 35003, is at the Museum of Paleontology, Southern Methodist University. BEG 21135.

Anisoceras sp. aff. *A. plicatile* (J. Sowerby)

pl. 1 figs. 15, 16

The specimen here identified as having affinity with *A. plicatile* is a small curved fragment from the early helical coiled part of an *Anisoceras*. Its ornamentation is quite distinct. The ribs are fine, equal in size and closely spaced. They are continuous over both the venter and the dorsum, crossing the latter as fine costae. The four rows of tubercles are large, round and flattened with commonly two and sometimes three ribs appearing to pass through them. One rib is generally distinctly non-tuberculate and intermediate in position. The whorl-section is compressed with the tubercles twisted strongly toward the upper lateral side of the section (Text-fig. 10).

TEXT-FIGURE 10.—Whorl-section of *Anisoceras* sp. aff. *A. plicatile*, X 1.

Remarks.—Because of the variability in ornamentation of young stages of *Anisoceras* and because no other specimens of this type have been found in Texas, a definite identification was not made. However, the prominent rounded tubercles, numerous fine and equal ribs, two or three of which pass through the tubercles, the intermediate non-tuberculate ribs, and the conspicuous ribbing across the dorsum all indicate its close

similarity in ornamentation to *A. plicatile*. It differs from *A. plicatile* principally by its compressed whorl-section. The hexagonal section of the helical specimen of *A. plicatile* was illustrated by Schlüter (1876) and a non-helical curved specimen was illustrated by Spath (1939). Both whorl-sections are distinctly more rounded than is the present specimen. In addition, Spath gives the age of *A. plicatile* as Cenomanian, while the Texas specimen was collected from Late Albian rocks.

The distinctive characteristics which give this specimen affinity with *A. plicatile* likewise distinguish it from all other species of *Anisoceras*. None of the other Texas *Anisoceras* specimens, whether juvenile or adult stages, have characters which are very similar, although it is recognized that the young helical coiled portions of certain species are unknown. No suture was observed.

Occurrence.—The specimen was found by J. P. Conlin in the upper Duck Creek Formation (possibly Ft. Worth) in the bed of a small creek at the southeast corner of Forest Park, Ft. Worth, Texas.

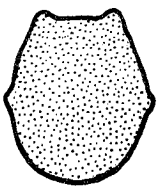
Repository.—TCU 1141.

Anisoceras sp. aff. *A. subarcuatum* Spath
pl. 4 figs. 2, 5

A medium sized ammonite from the Duck Creek (?) Formation, consisting of a straight shaft and a portion of a hook, shows characteristics of both the *Anisoceras* and the *Idiohamites* groups. Its characters are most similar to the transitional species *Anisoceras subarcuatum* Spath.

Spath (1939) described *A. subarcuatum* as having a compressed whorl-section, narrow venter, strong tuberculate ribs often with two intermediaries, no looping of ribs, and bifurcating ribs across the dorsal portions.

The Texas specimen has a compressed whorl-section and a narrow venter (Text-fig. 11). The ribs are large, equally prominent, and somewhat widely spaced. They are only slightly rounded and each is separated by a broad deep groove. Compared to Spath's



TEXT-FIGURE 11.—Whorl-section of *Anisoceras* sp. aff. *A. subarcuatum*, X 1.

(1939) illustrations of *A. subarcuatum*, the ribbing on the Texas specimen is more prominent and more widely spaced.

Unlike the typical *A. subarcuatum*, the tubercles of the Texas species occur on every rib along the straight shaft, although there are two non-tuberculate ribs, one at the beginning of the hooked portion, and another on the hook. Where present, there are four prominent tubercles per rib, two in a ventrolateral position and two in a mid-lateral position. Toward the hooked portion, the tubercles become greatly enlarged. The ventrolateral tubercles become clavate and twice as broad as the ribs on which they occur. Below the mid-lateral tubercles, the ribs divide to form two and sometimes three fine low ribs across the dorsum. No suture was observed on the specimen.

Remarks.—The compressed whorl-section of this specimen is suggestive of the genus *Idiohamites* and serves to distinguish the specimen from other species of *Anisoceras*. However, the prominence and position of the mid-lateral tubercles and the bifurcating ribs across the dorsum, characteristic of *Anisoceras*, make the specimen distinct from such intermediate species of *Idiohamites* as *I. spiniger* (J. Sowerby), *I. subspiniger* Spath and even *I. fremonti* (Marcou). In discussing the intermediate characteristics of *A. subarcuatum*, Spath (1939, p. 561) stated that:

> This species could well have been included in *Idiohamites*, as it is directly transitional between *I. spiniger* (J. Sowerby) and *I. subspiniger*. . . . on the one hand, and *Anisoceras armatum*, as understood . . . by d'Orbigny, on the other. It is now referred to *Anisoceras* on account of its early twist and the robustness of the ornament. . . .

Occurrence.—The specimen was collected from the Kiamichi Formation or Duck Creek Formation in Grayson County, at or near Fink, Texas. Based on color and preservation, it is probably from the Duck Creek. English specimens occur in the Upper Albian, *varicosus*—and *auritus*—subzones (Spath, 1939).
Repository.—BEG 35365.

Genus IDIOHAMITES Spath, 1925

Coiling rather irregular, in one plane; ribs straight or oblique, with pair of ventral tubercles, joined only by single rib on venter; lateral tubercles rarely present. U. Alb. - Cenom. (Wright *in* Arkell, Kummel, Wright, 1957, p. L 220).

Idiohamites fremonti (Marcou)
pl. 2 fig. 11; pl. 3 figs. 5, 9; pl. 5 figs. 1-7

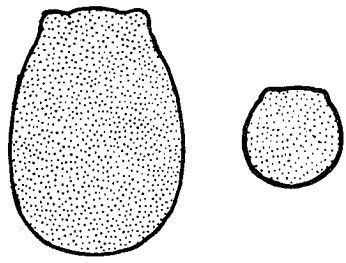
Hamites fremonti MARCOU, 1858, Geology of North America, pl. 1, fig. 3; SHUMARD, 1860, Trans. Acad. Sci. St. Louis, v. 1, p. 583, 587; HILL, 1891, Geol. Soc. Amer. Bull. 2, p. 516; BOYLE, 1893, Bull. U.S. Geol. Surv. 102, p. 144; HYATT, 1894, Amer. Phil. Soc. Proc., 32, p. 577; HILL, 1901, U.S. Geol. Surv. 21st Ann. Rept., pl. XXXV, fig. 3; WINTON & ADKINS, 1920, Univ. Texas Bull. 1931, p. 23, 51; ADKINS & WINTON, 1920, *ibid.* 1945, p. 18, 38, 40-41, 73, pl. 6, fig. 3; WINTON, 1925, *ibid.* 2544, p. 20; SCOTT, 1926, Univ. Grenoble Thèse, Fac. Sci., p. 65; ADKINS, 1927, Univ. Texas Bull. 2738, p. 41, 44, 51, 53, 55, 63, 65, 69, 72, pl. 4, fig. 2, ADKINS, 1928, *ibid.* 2838, p. 15, 17, 19, 208-209, 212, pl. VI, fig. 2; ADKINS & ARICK, 1930, *ibid.* 3016, p. 43; BULLARD & CUYLER, 1930, *ibid.* 3001, p. 74; BULLARD, 1931, *ibid.* 3125, p. 28; ADKINS, 1933, *ibid.* 3232, v. 1, p. 352, 355, 360, 368.
Hamites fromenti SCOTT, 1926, Univ. Grenoble Thèse, Fac. Sci., p. 61.
Hamites sp., ADKINS & WINTON, 1920, Univ. Texas Bull. 1945, pl. 6, fig. 3.
Exiteloceras fremonti ADKINS, 1928, *ibid.* 2838, p. 212.
Idiohamites fremonti ADKINS, 1933, *ibid.* 3232, v. 1, p. 352, 363, 368; FERAY, 1949, Guidebook, Seventeenth Ann. Field Trip, Shrev. Geol. Soc., p. 31, pl. 8; YOUNG, 1957, Jour. Paleont., v. 31, p. 18; SHELBURNE, 1959, Univ. Texas Pub. 5905, p. 117, pl. 38, fig. 4; YOUNG, 1959, Amer. Jour. Sci., v. 257, p. 759-761; PERKINS, 1961, Geol. Soc. Amer. Memoir 83, p. 27.
Idiohamites spp., ADKINS, 1933, Univ. Texas Bull. 3232, p. 354.
Hamites comanchensis ADKINS & WINTON, 1920, *ibid.* 1945, p. 13-15, 18-19, 21-23, 25, 38-39, 53, 73, pl. 6, fig. 10; WINTON & ADKINS, 1920 *ibid.* 1931, p. 22; 1925, *ibid.* 2544, p. 20, 53, pl. 6, fig. 5; SCOTT, 1926, Univ. Grenoble Thèse, Fac. Sci., p. 61, 65; ADKINS, 1927, Univ. Texas Bull. 2738, p. 41, 44, 51, 53, 55, 63, 65, 67, 68, 70-72; ADKINS, 1928, *ibid.* 2838, p. 15, 17, 19, 208-209, pl. XII, fig. 4; CUYLER, 1929, Amer. Assoc. Petrol. Geol. Bull. 13, p. 1297; ADKINS & ARICK, 1930, Univ. Texas Bull. 3016, p. 43; ADKINS, 1933, *ibid.* 3232, p. 352, 358; LOZO, 1943, Amer. Assoc. Petrol. Geol. Bull. 27, p. 1070.
Hamites sp. near *comanchensis* ADKINS & WINTON, 1920, Univ. Texas Bull. 1945, pl. 6, fig. 7-9.
Hamites aff. *comancheanus* ADKINS, 1933, *ibid.* 3232, p. 352.
Idiohamites comanchensis ADKINS, 1933, *ibid.* 3232, p. 353; PERKINS, 1961, Geol. Soc. Amer. Memoir 83, p. 23, 25, 27, 42.

This species is a widespread and important marker of the basal Duck Creek Formation. It is recognized by its hamitid coiling; compressed to circular whorl-section; variably sized ventrolateral tubercles which occur on every rib or on every second, third or fourth rib; and by its faint dorsolateral nodes or swellings.

The whorl-section is generally compressed, although the degree of compression is quite variable (Text-fig. 12). Usually juvenile fragments and large adult fragments show the most compression. Those intermediate in size, between approximately one and two cm, tend to be more circular and several are completely circular (Text-fig. 13). Although there are exceptions when comparing similar sized fragments, this would indicate a growth trend from a compressed section during young stages to slightly compressed or circular during intermediate stages, and then increasingly compressed again at maturity. The ribs are mostly equal in size, prominent, somewhat rounded, and separated by a broad moderately deep groove. They extend across the venter and along the sides, but become faint or absent across the dorsum. The spacing of the ribs varies

from three and one-half to slightly less than five ribs in a length equal to a diameter, with the smaller specimens tending to have the most widely spaced ribs. A plaster cast of the holotype shows the rib density to be slightly higher than the maximum of all the rest of the specimens studied.

Tubercles occur along the ventrolateral margins of the ribs when present. They are quite variable, both in size and occurrence. On some specimens they occur as extremely small sharp projections on each rib. On these forms the venter is strongly convex, giving the specimen the appearance of having a more rounded whorl-section. More



TEXT-FIGURE 12.—Whorl-section of *Idiohamites fremonti,* X 1.
TEXT-FIGURE 13.—Whorl-section of *Idiohamites fremonti,* X 1.

commonly the tubercles are large and rounded. They usually occur prominently on every second or third rib, although this too is variable. A few have as many as three intermediate non-tuberculate ribs. In addition, several fragments have prominent tubercles on every rib. Others have tubercles on several consecutive ribs which are interrupted by non-tuberculate ribs. The holotype (plastotype BEG 21059) shows still an additional trait. It has tubercles on every rib, but only those of every third or fourth rib are large and prominent. The smaller tubercles are inconspicuous. On all of the specimens bearing large tubercles, the venter is generally flattened.

In addition to the ventrolateral tubercles, the better preserved specimens have a faint node or swelling, sometimes elongate, along the dorsolateral margins of the tuberculate ribs. These nodes or swellings vary somewhat in their prominence from specimen to specimen, but are never really conspicuous.

No suture was observed on any of the specimens examined.

Remarks.—A study was made of over one hundred specimens of the *Idiohamites fremonti* and *I. comanchensis* type. This included the holotype of *I. comanchensis* and several other hypotypes labeled *"Hamites"* sp. near *comanchensis.* As a result it was determined that there were no characteristics sufficiently distinct among the specimens to warrant a species distinction and *I. comanchensis* is regarded as a junior synonym of *I. fremonti.* The variability of the whorl-section and tuberculation shown by typical specimens of *I. fremonti* make the characteristics of that species sufficiently broad to also encompass the specimens identified as *I. comanchensis.*

Idiohamites fremonti is most similar to *I. varians* (Scott) and the English species *I. dorsetensis* Spath and *I. subspiniger* Spath. It is distinct from *I. varians* primarily by its larger size. The smallest fragments of *I. fremonti* studied were larger than the largest specimens of *I. varians. I. fremonti* also occurs stratigraphically lower in the Duck Creek Formation than does *I. varians. I fremonti* differs from *I. dorsetensis* by the more variable occurrence of its tubercles, the variable whorl-section, and usually by its less dense ribbing. The variety *I. dorsetensis vectensis* Spath, which has more widely spaced ribs, would be very similar to compressed specimens of *I. fremonti* which had tubercles on every second or third rib. *I. fremonti* is considered distinct from *I. subspiniger* because of its less conspicuous dorsolateral nodes.

Additional species which may be similar to *I. fremonti* are *I. tuberculatus* (J. Sowerby) and *I. spiniger* (J. Sowerby). The variable occurrence of tubercles, the ribbing, and the faint lateral nodes make *I. fremonti* distinct from these and all other species of *Idiohamites.*

Occurrence.—This ammonite occurs in a definite and vertically restricted zone just above the Kiamichi-Duck Creek Formation contact (Adkins & Winton, 1920; Perkins, 1961). The thickness of the zone ranges from two to fifteen feet and consists of dense limestone which contains abundant specimens of *I. fremonti* (Adkins & Winton, 1920;

Perkins, 1961). Some questionable occurrences of *I. fremonti* have been reported in the upper Kiamichi.

The holotype was collected from the basal Duck Creek Formation at Preston, Grayson County, Texas. In addition to the numerous specimens in Texas collections, many specimens from the Duck Creek of Texas and Love County, Oklahoma, are in the Renfro collection, U.S. National Museum.

Repository.—The holotype is at the British Museum, no. 12667. BEG 21059 (plastotypes), 20987, 35368; TCU 1145, 1146.

Idiohamites varians (Scott)

pl. 2 figs. 1-10

Hamites varians SCOTT, 1924, Tex. Christ. Univ. Quarterly, v. 1, p. 8, 11-17, 19, pls. I-III; pl. VI, figs. 1, 2, 4, 7, 9; pl. VII, figs. 3, 4; pl. VIII, figs. 1-3; pl. IX, figs. 1, 3-5, 7; WINTON, 1925, Univ. Texas Bull. 2544, p. 53, pl. 6, fig. 1; SCOTT, 1926, Univ. Grenoble These, Fac. Sci., p. 62, 65; ADKINS, 1928, Univ. Texas Bull. 2838, p. 19, 208, 210, pl. XII, fig. 5; SPATH, 1939, Palaeont. Soc. Monograph, pt. XIII, p. 598.

Hamites polyseptus SCOTT, 1924, Tex. Christ. Univ. Quarterly, v. 1, p. 13, 17-18, pl. IV, fig. 3, 5, 6, 8; pl. IX, fig. 2; SCOTT, 1926, Univ. Grenoble Thèse, Fac. Sci., p. 62, 65; ADKINS, 1928, Univ. Texas Bull. 2838, p. 19, 208, 210.

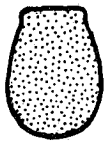
Idiohamites varians PERKINS, 1961, Geol. Soc. Amer. Memoir 83, p. 27.

As the name implies, this species is characterized by its extremely variable ornamentation. Scott (1924) stated that he expected to be able to differentiate several species and possibly genera from this group. His efforts, as well as those of the present writer, have merely demonstrated that there are gradational forms between each distinct type and that a further division of this species is impractical.

The specimens studied are all small and gently curving fragments. The majority are pyritized, although they have now mostly oxidized to limonite. Scott (1924) has discussed in detail the ecology and the preservation of this interesting dwarf fauna.

In general, the adult characteristics of the species include a compressed whorl-section; low, usually simple ribs which are effaced on the dorsum; and two ventrolateral tubercles which usually occur on every second or third rib, although this characteristic is highly variable.

As illustrated in Text-fig. 14, the whorl-section of the species is commonly strongly compressed, although the degree of compression is slightly variable. A study made of



TEXT-FIGURE 14.—Whorl-section of *Idiohamites varians*, X 3.

the whorl-sections of different sized specimens, from .8 to 4.8 mm in height, showed no average difference in whorl-shape ratios between juvenile and adult specimens, thus indicating that the compressed whorl-section is generally a constant character throughout ontogeny.

The ribs are low, fine and generally simple, although one specimen (pl. 2, fig. 9) has two ribs which join at one tubercle. They are continuous across the venter and along the sides, but are absent on the dorsum. Their spacing and the angle they make with the long axis of the shell often varies slightly with different individuals and may vary on the same individual.

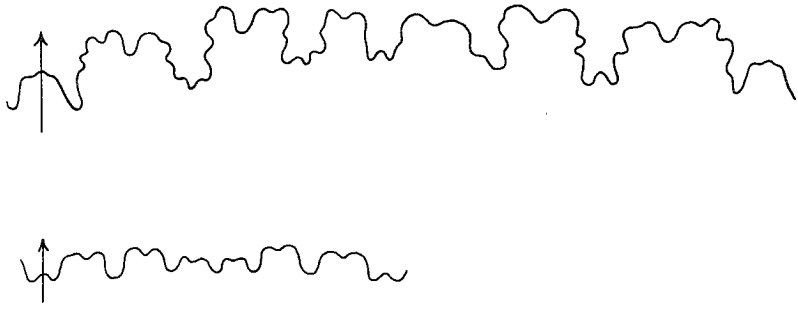
The occurrence of tubercles, however, is the most variable characteristic of the species. Although the very young are all non-tuberculate, the stage at which tubercles first appear varies greatly. Some specimens had tubercles developed at a whorl-section height of approximately 1.0 mm while many other specimens were non-tuberculate at a height of greater than 2.5 mm. Due to the short fragmentary nature of the specimens, however, it is probable that some of the larger non-tuberculate forms merely represented non-tuberculate portions of otherwise tuberculate specimens. For example,

one specimen has distinct tubercles on the small juvenile end and then completely lacks tubercles on the larger half of the fragment (pl. 2, fig. 4).

The tubercles, when present, always occur on the ribs as single small sharp projections along each ventrolateral margin. The venter between the tuberculate ribs appears somewhat flattened. Some specimens bear tubercles on each rib, but this trait is not persistent for more than several ribs. More commonly, the tuberculate ribs randomly alternate with one or two non-tuberculate ribs. The rate is sometimes cyclic, having regularly one or regularly two non-tuberculate ribs between the tuberculate ribs. A distinction could not be made on the two kinds, however, as some clearly had both types on the same specimen. Also, although less common, some forms had from three to six or more non-tuberculate ribs.

An additional pecularity, noted on ten specimens, is the occurrence of only one tubercle or one prominent tubercle per rib. These tubercles regularly alternate from one side of the venter to the other from rib to rib. One fragment has a non-tuberculate rib in between the tuberculate ribs, while another has both the common two tubercles per rib and the single tubercle per rib (pl. 2, fig. 10).

The suture of *I. varians* has been described by Scott (1924) and is shown in Text-fig. 15.



TEXT-FIGURE 15.—Suture of *Idiohamites varians*, TCU 1149, at 2.0 mm and TCU 1094 at 4.6 mm.

Remarks.—The species *Hamites polyseptus* Scott 1924 is considered to be a junior synonym of *Idiohamites varians* 1924. Scott (1924) described *H. polyseptus* as having sutures which are closely but not uniformly spaced and broad indistinct non-tuberculate ribs. He regarded the closely spaced sutures as being the most outstanding characteristic in recognizing the species. With the possible exception of the suture spacing, however, juvenile and non-tuberculate stages of *I. varians* would be indistinguishable from *H. polyseptus*. Suture spacing is a highly variable factor that is not considered to be a species characteristic, but rather a factor that is controlled primarily by environmental conditions. In addition, the suture spacing in *I. varians* can be highly diverse as discussed and illustrated by Scott (1924).

Idiohamites varians is most similar to *Idiohamites dorsetensis vectensis* and *I. fremonti*. It differs from *I. dorsetensis vectensis* primarily by the number, variability, and occurrence of its non-tuberculate ribs, although certain specimens of *I. varians* could be very similar to *I. dorsetensis vectensis*. *I varians* is a smaller species than *I. fremonti*. It also differs by the more variable occurrence and usually greater number of its non-tuberculate ribs and by its lack of dorsolateral nodes. In addition, *I. fremonti* occurs stratigraphically lower in the Duck Creek Formation than does *I. varians*.

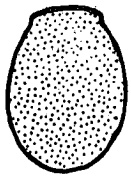
Occurrence.—The holotype and the specimens originally labeled *Hamites polyseptus* were collected from the Duck Creek Formation. Scott (1924) reported that the majority of his specimens were collected from three miles northeast of Denison. Numerous additional specimens were collected from localities near Ft. Worth and at various points between the Red River and the Brazos River. They occur above the *I. fremonti* zone in the Duck Creek. Two specimens studied were labeled as having been collected from the Pawpaw Formation.

Repository.—Holotype TCU 1079. TCU 1094(a), 1094(b), 1098(a), 1148; BEG 35369, 35370, 35371, 35372.

Idiohamites sp.
pl. 2 fig. 16

Two specimens that are otherwise similar to *I. fremonti* are here described separately because of their unique ribbing. Additional specimens are needed to properly evaluate their affinities with a species or to establish a new variety or species.

They have a compressed whorl-section with a narrow but rounded venter (Text-fig. 16). The ribs across the venter are broad and have flattened tops with the flat surface generally sloping toward the aperture. Laterally from the venter, the broad ribs taper toward the dorsum to form narrow rounded ribs. From an approximate mid-lateral position along the sides, the ribs curve gently backward and cross the dorsum as low and inconspicuous ridges. Generally two small rounded tubercles occur on each rib along the ventrolateral margins, although they vary in prominence and certain ribs appear to be non-tuberculate. No suture was observed.



TEXT-FIGURE 16.—Whorl-section of *Idiohamites* sp., X 1.

Remarks.—The size, whorl-section, tuberculation, and stratigraphic occurrence make these specimens very similar to *I. fremonti.* The distinctive shape and lateral curvature of the ribs, however, appear to make the specimens distinct from *I. fremonti* and from other species of *Idiohamites* known to the writer.
Occurrence.—The figured specimen was collected from the Duck Creek Formation at Ft. Worth, Texas.
Repository.—TCU 1147.

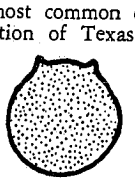
Genus ALLOCRIOCERAS Spath, 1926

Similar to the more finely ribbed and sharply tuberculate species of *Idiohamites* but early whorls at least are distinctly helical and twisted. Turon. (Wright *in* Arkell, Kummel, Wright, 1957, p. L 220).

Allocrioceras annulatum (Shumard)
pl. 3 figs. 1, 2, 10, 12; pl. 1, fig. 9

Ancyloceras annulatus SHUMARD, 1860, Acad. Sci. St. Louis Trans., v. 1, p. 595; BOYLE, 1893, U.S. Geol. Sur. Bull. 102, p. 40; SCOTT, 1926, Univ. Grenoble Thèse, Fac. Sci., p. 153; ADKINS, 1933, Univ. Texas Bull. 3232, v. 1, p. 432.
Ancyloceras ? annulatus STANTON, 1893, U.S. Geol. Surv. Bull. 106, p. 48.
Ancyloceras annulatum WHITE, 1883, U.S. Geol. Survey Terr. 12th Ann. Rept., pt. 1, p. 39, pl. 28, fig. 10; BOYLE, 1893, U.S. Geol. Surv. Bull. 102, p. 40; ADKINS, 1928, Univ. Texas Bull. 2838, p. 32, 216-217; ADKINS, 1933, *ibid.* 3232, p. 433-434, 439.
Helicoceras pariense MOREMAN, 1927, Jour. Paleont. v. 1, pl. 14, fig. 3.
Allocrioceras annulatum MOREMAN, 1942, Jour. Paleont., v. 16, p. 196, 208.
Allocrioceras n. sp. aff. *ellipticum* ADKINS, 1931, Univ. Tex. Bull. 3101, p. 38, 63, pl. II, figs. 6, 8.

Allocrioceras annulatum is the most common of the various *Allocrioceras* species, occurring in both the Britton Formation of Texas and the Tropic Shale of southern



TEXT-FIGURE 17.—Whorl-section of *Allocrioceras annulatum,* X 1.

Utah Its specific characters include a slightly compressed to nearly circular whorl-section (Text-fig. 17); fine closely spaced simple ribs, each of which bears a small sharp tubercle on each side of the ventrolateral margin; and a flat venter (Moreman, 1942).

All of the specimens of *A. annulatum* studied are gently curving fragments. Impressions of very young stages show loose open coils which are only slightly helical. The most pronounced twisting occurs in larger fragments, although striking variations exist when comparing similar sized specimens.

In general the whorl-section is most compressed in very small specimens and nearly circular or circular in larger specimens. The ribs are moderately sharp, equal, and closely spaced, with from four to five occurring in a length equal to a diameter. They completely encircle the shell but are less prominent across the dorsum. The ribs are generally inclined forward ventrally toward the aperture, although in young stages they are mostly straight and in some larger stages they are laterally convex toward the aperture. The tubercles are small, being no wider than the narrow ribs, and occur on each rib as two prominent sharp projections on each side of the venter. On some juvenile fragments tubercles are present at a whorl-section height of about 3 mm and on others they are still not present at nearly 5 mm. One specimen, representing nearly a half of a juvenile whorl, shows the tubercles starting gradually at about 3.7 mm.

The suture of a juvenile specimen is illustrated in Text-fig. 18.

TEXT-FIGURE 18.—Suture of *Allocrioceras annulatum,* BYU 392 at 4.8 mm.

Remarks.—This species is most similar to *Allocrioceras pariense* (White). Although the validity of *A. pariense* is questionable, *A. annulatum* is considered distinct by its fine somewhat sharp ribs, in contrast to the more rounded ribs of *A. pariense.* It differs from *A. dentonense* Moreman by its more rounded whorl-shape, from *A. larvatum* (Conrad) by its tubercles on every rib, and from *A. woodsi* Spath by the equal size of its tubercle pairs.

Occurrence.—The type locality for the species, as reported by Shumard (1860), is at Shawnee Creek, Grayson County, Texas. The characteristic specimen mentioned by Moreman (1942), BEG 19820, was collected from the Britton Formation (Eagle Ford Group) four miles south of Britton, Texas, on the Midlothian road. All other Texas specimens were collected from the Britton Formation. The species is also commonly found in concretions just above the base of the upper Tropic Formation of southern Utah.

Repository.—The location of the holotype is unknown. BEG 19820, 35367; BYU, 392, 393, 394.

Allocrioceras pariense (White)

pl. 2 figs. 12, 13

Helicoceras pariense WHITE, 1877, U.S. Geog. and Geol. Surv. W. of 100th Meridian, v. 4, p. 203, pl. 19, figs. 2 a-d; BOYLE, 1893, U.S. Geol. Surv. Bull. 102, p. 146; STANTON, 1893, *ibid.* 106, p. 35, 164-165, pl. XXXV, figs. 2-4; SCOTT, 1926, Univ. Grenoble These, Fac. Sci., p. 100, 102, 152; MOREMAN, 1927, Jour. Paleont., v. 1, p. 89, 91, 92, 93, 95, pl. 13, fig. 3; ADKINS, 1931, Univ. Texas Bull. 3101, p. 39, 67, 68-69; ADKINS, 1933, *ibid.* 3232, p. 434; GREGORY, 1951, U.S. Geol. Surv. Prof. Paper 226, p. 65.

Exiteloceras pariense HYATT, 1894, Amer. Phil. Soc. Proc., 32, p. 577; ADKINS, 1928, Univ. Texas Bull. 2838, p. 29-30, 32, 212, pl. 26, fig. 3; GREGORY, 1950, U.S. Geol. Surv. Prof. Paper 220, p. 104; GREGORY, 1951, *ibid.* 226, p. 36.

Allocrioceras pariense ADKINS, 1933, Univ. Texas Bull. 3232, v. 1, p. 434, 437, 439; MOREMAN, 1942, Jour. Paleont., v. 16, p. 193, 194, 196, 208; ADKINS & LOZO, 1951, Fondren Sci. Ser., no. 4, p. 136, 156.

This species was originally described and figured by White (1877). His description in part is as follows (p. 203-204):

> . . . whorls distinct, subcircular or very broadly oval in transverse section, increasing somewhat rapidly in size; surface marked by comparatively strong, rather abruptly-rounded annulations, which cross the whorls obliquely; annula-

tions only slightly prominent upon the inner side of the whorls, but more prominent upon the upper and under sides; upon the outer side of the whorl each annulation bears a pair of prominent nodes, one on each side of the siphuncle, forming two dorsal rows of nodes along the whole length of the shell, the portion of the annulation between each pair of nodes being straightened and slightly flattened upon the back. The annulations are apparently always simple, never coalescing, and never failing to completely encircle the volution. The nodes are moderately prominent upon exfoliated specimens, and where the test is preserved they are seen to be subspinous or sharply nodose.

Apparently White did not designate a holotype, or if he did, its locality is now unknown. Only two of the nearly fifty specimens of *Allocrioceras* available for this study showed the abruptly rounded ribs characteristic of *A. pariense*. One of the specimens was identified by Moreman (1942) as belonging to the species *A. pariense*. This curved fragment, partially exposed in a rock matrix, has ribs which are only slightly more rounded than those of the typical *A. annulatum*. The other specimen, a gently curved fragment from Utah, shows a very conspicuous rounding of the ribs. They are heavy, blunt and completely encircle the shell. They are somewhat distantly spaced, with approximately four occurring in a length equal to a diameter. The tubercles are moderately large and rounded. The whorl-section is circular (Text-fig. 19). The suture was not observed on either of the specimens.

TEXT-FIGURE 19.—Whorl-section of *Allocrioceras pariense*, X 1.

Remarks.—This species is most similar to *Allocrioceras annulatum*. It differs from *A. annulatum* primarily by its rounded ribs, although the degree of rounding is gradational toward the sharper ribs of *A. annulatum*. Other characteristics of the two species are very similar or identical. At is it probable that the rounded rib characteristic is merely a population variation, it is questionable whether *A. pariense* should be considered a distinct species on this basis alone. Since the round rib trait is quite rare, it is apparent from the numerous times that *A. pariense* has been reported, particularly from Utah, that the species has often been confused with *A. annulatum*. This confusion has been largely a result of the original descriptions of the two species. When Shumard (1860) described *Ancyloceras annulatus* (*Allocrioceras annulatum*) he did not specify whether the ribs were rounded or sharp, and he did not figure his specimens. White (1877) described *A. pariense* under the genus *Helicoceras*. He neither mentioned nor compared it with Shumard's species and hence may have been unaware of it. His figured specimens show no characteristics which would make *A. pariense* distinct from *A. annulatum* inasmuch as the abruptly rounded ribs he described are not apparent in the line drawings. Stanton (1893) recognized that *Ancyloceras annulatus* (*Allocrioceras*) was closely related or even identical with *Helicoceras pariense*. His figure of an early coiled portion of *A. pariense* shows no characteristics which would distinguish it from *A. annulatum*. Moreman (1942) was the first to describe the ribbing of *A. annulatum* as being fine and sharp in contrast to the rounded ribbing of *A. pariense*.

Occurrence.—The specimens described by White (1877) were collected from the "Cretaceous strata, southeast of Paria, Utah" (Tropic Shale). BYU 395 was collected from the Tropic Shale in southern Utah. The Texas specimen was collected from the Britton Formation, two and one-half miles south of Britton and one-half mile east of the road.

Repository.—The location of the holotype or any of White's original specimens is unknown. BYU 395.

Allocrioceras dentonense Moreman

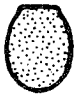
pl. 1 figs. 7, 8; pl. 3 fig. 3

Allocrioceras dentonense MOREMAN, 1942, Jour. Paleont., v. 16, p. 196, 209, pl. 34, fig. 4, text-fig. 2 h.

The holotype of this species is a gently curving fragment of a body chamber. Although partially crushed, the whorl-section is conspicuously compressed. The ribs are closely spaced, moderately coarse and completely encircle the shell. Across the venter

they are somewhat flattened and bear a simple prominent rounded tubercle on each ventrolateral margin. From the venter the ribs extend obliquely backward and cross the dorsum with less than one-half the height they have on the venter (Moreman, 1942). It should also be noted that the ribs are finer on the adoral end of the fragment and that one of these ribs is non-tuberculate.

A smaller specimen from southern Utah is uncrushed and shows the strongly compressed whorl-section which is particularly distinctive of the species (Text-fig. 20). The



TEXT-FIGURE 20.—Whorl-section of *Allocrioceras dentonense,* X 1.

ribs of this specimen are fine, equal in size, and closely spaced with approximately five ribs occurring in a length equal to a diameter. The tubercles are small and rounded and the venter is narrow.

Several small juvenile stage fragments are being questionably assigned to the species. These specimens have a slightly more compressed whorl-section than the specimens assigned to *A. annulatum,* which are also compressed in juvenile stages. It is recognized, however, that the distinction is quite conjectural as the specimens are identical at this stage in other respects.

Remarks.—This species is most similar to *A. annulatum* and *A. pariense.* It is considered distinct because the whorl-section of adult specimens of *A. dentonense* is considerably more compressed than those of either *A. annulatum* or *A. pariense.* The occurrence of the tubercles distinguishes *A. dentonense* from other species of *Allocrioceras.* No suture was observed on the specimens.

Occurrence.—The holotype was collected from the Britton Formation, east of Lewisville, Texas. BYU 391 is from the Tropic Shale of southern Utah.

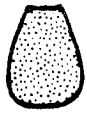
Repository.—Holotype BEG 19808; BYU 391.

Allocrioceras n. sp.

pl. 1 fig. 12

A fragment of *Allocrioceras* from southern Utah has a whorl-section that is sufficiently different to make the specimen distinct from all other species of *Allocrioceras.* The data is insufficient to propose a name, however, as the specimen is small and the writer knows of no other similar specimens.

The fragment is about 14 mm long and 5.8 mm at its greatest height. The greatest width on the ventral half is approximately 3 mm and on the dorsal half about 4 mm.



TEXT-FIGURE 21.—Whorl-section of *Allocrioceras* n. sp., X 3.

As shown by Text-fig. 21, the whorl-section is conspicuously wider on the dorsal half than on the ventral half. The venter is very narrow. The ribs are fine, equal in size and closely spaced. Between five and six ribs occur in a length equal to a diameter. Two small sharp tubercles occur on each rib along the ventrolateral margins. Across the dorsum the ribs are less conspicuous. No suture was observed.

Remarks.—The close spacing of the ribs and the over-all compressed whorl-section make this specimen most similar to *A. dentonense.* The wide dorsum, however, distinguishes it from *A. dentonense* and all other species of *Allocrioceras.* In addition to the distinct whorl-section, the specimen also differs from *A. annulatum* and *A. pariense* by its more closely spaced ribs and from *A. larratum* by the occurrence of its tubercles on every rib.

Occurrence.—The specimen was collected from the Tropic Shale at an unknown locality in southern Utah.

Repository.—BYU 390.

Allocrioceras larvatum (Conrad)

Hamites larvatus CONRAD, 1855, Philadelphia Acad. Nat. Sci. Proc. 7, p. 265; CONRAD, 1857, *in* W. H. Emory, Report U.S. and Mex. Boundary Surv., v. 1, pt. 2, pl. 21, fig. 8; BOYLE, 1893, U.S. Geol. Surv. Bull. 102, p. 144; ADKINS, 1927, Univ. Texas Bull. 2738, p. 67-68; ADKINS, 1928, *ibid.* 2838, p. 208-209.
Allocrioceras larvatum ADKINS, 1933, *ibid.* 3232, v. 1, p. 439; MOREMAN, 1942, Jour. Paleont., v. 16, p. 196, 208, 209, text-fig. 2 i.

A specimen labeled *Hamites larvatus* Conrad from the Academy of Natural Sciences of Philadelphia no. 4790, was described by Moreman (1942, p. 209) as follows:

> Specimen consists of a cast of only a portion of the living chamber.
>
> Cross section of whorl ovate, only slightly higher than wide; ribs directed obliquely backward, prominent on venter but low and poorly defined on dorsum, alternate ribs have prominent ventrolateral tubercles which cause the rib to be flat across the venter, other ribs devoid of tubercles and rounded across venter. Suture not preserved.
>
> The writer knows of no additional specimens with these characteristics.

Remarks.—The relatively coarse and widely spaced ribs with tubercles on alternate ribs would readily distinguish this species from all other species of *Allocrioceras.*
Occurrence.—The specimen was collected from the Britton Formation in Dallas County, Texas.
Repository.—Academy of Natural Sciences of Philadelphia, no. 4790.

Allocrioceras ? rotundatum (Conrad)

Hamites rotundatus CONRAD, 1855, Acad. Nat. Sci. Philadelphia Proc. 7, p. 266; BOYLE, 1893, U.S. Geol. Surv. Bull. 102, p. 144; ADKINS, 1928, Univ. Texas Bull. 2838, p. 209.
Allocrioceras rotundatum ADKINS, 1933, *ibid.* 3232, v. 1, p. 439.
Allocrioceras ? rotundatum MOREMAN, 1942, Jour. Paleont., v. 16, p. 196, 209.

From Conrad's original description it is not possible to classify this species. He did not figure the specimen, and its locality at the present is unknown. Conrad (1855, p. 266) described the species as follows:

> Rounded, ribs distant, acute, the intervening spaces regularly and profoundly concave; back flattened with the ribs obsolete and three indistinct longitudinal lines. A cast.

As there is no mention of tubercles in the description, it is possible that the species does not belong with the genus *Allocrioceras.* Conrad reported the species from Dallas County, Texas, and Moreman (1942) stated that it was no doubt from the Britton Formation.

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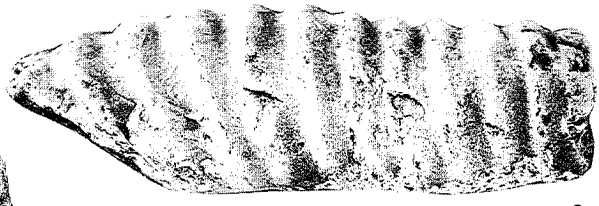
Manuscript submitted, May 18, 1962.

EXPLANATION OF PLATE 5

FIG. 1.—*Idiohamites fremonti* (Marcou). Duck Creek, UT 10542, lateral view, X .94.
FIG. 2, 4.—*Idiohamites fremonti* (Marcou). Duck Creek, BEG 35368, lateral and ventral view, X .80.
FIG. 3, 7.—*Idiohamites fremonti* (Marcou). Plastotype, Duck Creek, BEG 21059, lateral views, X .94.
FIG. 5, 6.—*Idiohamites fremonti* (Marcou). Duck Creek, TCU 1146, ventral and lateral view showing slight swelling of ribs along dorsolateral margin, X 1.1.

PLATE 5

1



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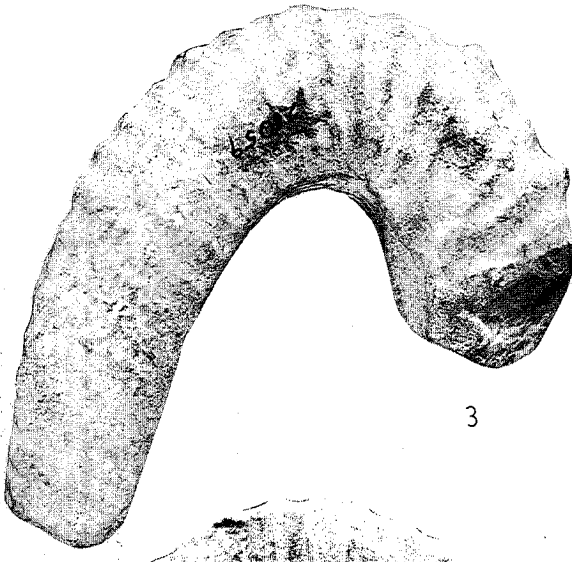

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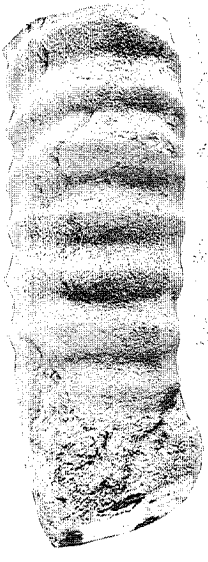

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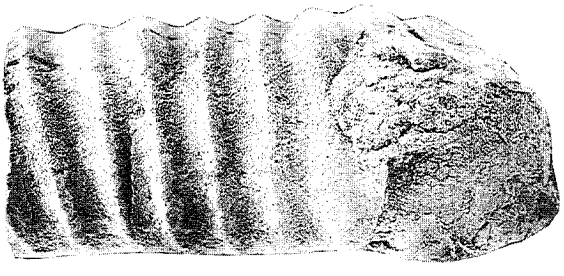

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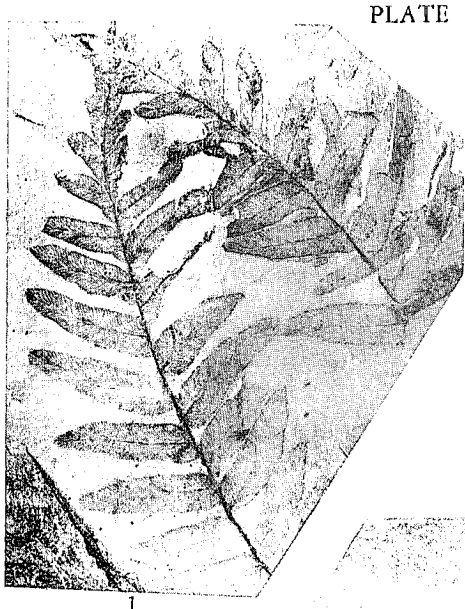
PLATE 1



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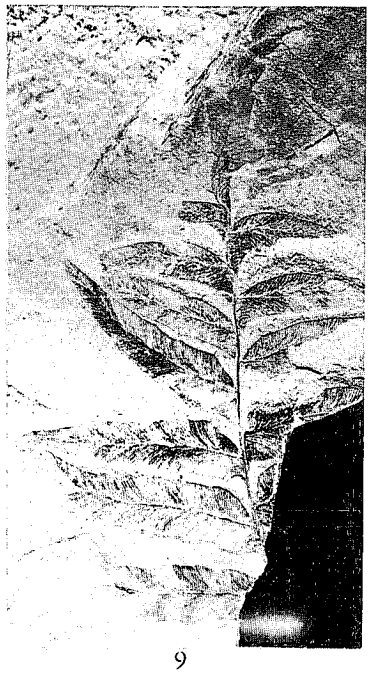

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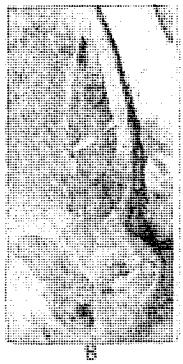

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