Mississippian Cephalopods of Northern and Eastern Alaska

GEOLOGICAL SURVEY PROFESSIONAL PAPER 283

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By MACKENZIE GORDON, JR.

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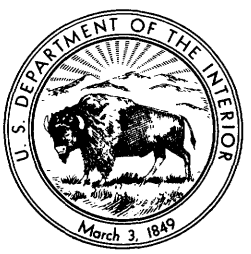
Descriptions and illustrations of 43 nautiloids and ammonoids and correlation of the assemblages with European Carboniferous goniatite zones



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MISSISSIPPIAN CEPHALOPODS OF NORTHERN AND EASTERN ALASKA

By MACKENZIE GORDON, Jr.

ABSTRACT

Cephalopods of Mississippian age occur in the rocks of the Brooks Range of northern Alaska and along the Yukon River in the Eagle-Circle district in eastern Alaska. The cephalopod faunas include goniatites that can be correlated with zones in northwest Europe, especially the British Isles.

The earliest Mississippian goniatites are found in the western part of the Brooks Range, where an unnamed black shale unit on Iligluruk Creek and a calcareous sandstone unit on a branch of the Kiligwa River have yielded *Münsteroceras* probably of late Tournaisian age. Loose limestone blocks on the lower Noatak River and black shale on the Kiligwa River, both tentatively referred to the lower part of the Lisburne group, contain the genus *Ammonellipsites* at a stage of development that suggests very late Tournaisian or early Viséan age.

In the central Brooks range most of the cephalopods found have come from the upper middle part of the Alapah limestone of the Lisburne group. These fossils can be correlated with three faunal units of the British Carboniferous section, the upper *Beyrichoceras* or *Goniatites maximus* (B_2) zone, the *G. crenistria* (P_{1a}) subzone, and the *G. elegans* (P_{1c}) subzone, the first of Middle Viséan and the last two of Upper Viséan age. They come, however, from within rather narrow stratigraphic limits in the Alaskan section.

The *Goniatites granosus* (P_2) zone, the uppermost of the Viséan goniatite zones, is known only from the Eagle-Circle district where it occurs in the lower middle part of the Calico Bluff formation. *Cravenoceras* sp. possibly representing the *Eumorphoceras pseudobilingue* (E_1) zone of early Namurian age has been found in the Calico Bluff formation at one locality in the Eagle-Circle area.

The 19 nautiloid species described in this report have been referred to 12 genera, as follows: *Rayonnoceras, Michelinoceras, Bactrites?, Cycloceras, Kionoceras?, Dolorthoceras, Adnatoceras, Euloxoceras, Pseudorthoceras, Endolobus, Knightoceras,* and *Stroboceras.* Six new species of nautiloids are described. The 24 goniatite species are referred to 14 genera: *Ammonellipsites, Münsteroceras, Bollandites, Beyrichoceras, Goniatites, Sudeticeras, Neoglyphioceras, Cravenoceras, Girtyoceras, Entogonites, Eothalassoceras, Dimorphoceras, Protocanites?,* and *Pronorites?.* Ten of the 24 species are new.

INTRODUCTION

Geologic reconnaissance and field mapping in the Brooks Range has greatly increased our knowledge of the late Paleozoic faunas of northern Alaska. Most of this work was done from 1945 to 1953 by geologists of the Geological Survey, in connection with the exploration of Naval Petroleum Reserve No. 4. Among the less abundant groups of invertebrate fossils found during these Alaskan investigations, the cephalopods are one of the most important because their relatively short stratigraphic ranges make them excellent tools for stratigraphic correlation.

Twenty-four collections of fossil cephalopods described in this paper were made during the course of the Navy's oil exploration. A collection from near Cape Lisburne and one from the lower Noatak River valley near the west end of the Brooks Range are from earlier reconnaissance work of the U. S. Geological Survey, as are twelve additional collections from the Eagle-Circle district of eastern Alaska. The 38 collections studied shed considerable light on the distribution of the cephalopods in a region where previously very little was known about them. A rough correlation can now be made with the Carboniferous goniatite zones of northwest Europe, particularly those of the British Isles.

The writer is especially indebted to J. T. Dutro, Jr., for stratigraphic information assembled for use in this report. Other unpublished stratigraphic data have been supplied by A. L. Bowsher, W. P. Brosgé, W. W. Patton, Jr., and I. L. Tailleur. J. B. Reeside, Jr., and W. A. Cobban have contributed many helpful suggestions. The writer also wishes to express his appreciation to members of the Geological Survey of Great Britain, particularly to T. Robertson, C. J. Stubblefield, F. M. Trotter, G. A. Kellaway, and D. McGraw, who greatly facilitated his visit in 1952 to Carboniferous sections in northern and western England. This made it possible for correlations of Alaskan with British goniatite zones in this paper to be based largely on first-hand information. Thanks also are due to L. F. Spath who made cephalopod types and specimens available for study at the British Museum (Natural History).

PREVIOUS WORK

Several records of Alaskan cephalopods of Mississippian age have appeared in faunal lists prepared by G. H. Girty from collections made by geologists of the U. S. Geological Survey. The earliest of these records was a single fragmentary goniatite collected near Cape

Lisburne by Collier (1906, p. 23). A small collection from unit 1 of their section at Calico Bluff on the Yukon River, was published by Brooks and Kindle (1908, p. 293). Other records have been published by Smith (1913, p. 78) and Mertie (1930, p. 105, 106; 1932, p. 421, 422). All of these cephalopods have been restudied and, except for those too poorly preserved, are described in this report.

Listed below are cephalopods from northern and eastern Alaska that have appeared in faunal lists in bulletins of the U. S. Geological Survey. The authors and references are given and below them, in three columns, the collection number, the name given to the fossil by Girty in the earlier faunal list, and the name given to it in the present report. Those cephalopods not described in the systematic part of the present report are marked with an asterisk (*). The single collection of Brooks and Kindle, mentioned above, appears in the list below as collection number 2644A in Mertie's 1930 paper.

Smith, P. S., U. S. Geol. Survey Bull. 536, p. 78, 1913.

11AS77 (12785)	*Orthoceras* sp.	*Kionoceras?* sp. B
		Dolorthoceras? sp.
	Eumorphoceras? sp.	*Ammonellipsites* aff. *A. polaris* n. sp.

Collier, A. J., U. S. Geol. Survey Bull. 278, p. 23, 1906.

4AC17	*Goniatites* sp.	*Goniatites?* sp. indet.
(3586)	*Orthoceras* sp.	*Rayonnoceras Rangifer* n. sp.

Mertie, J. B., Jr., U. S. Geol. Survey Bull. 816, p. 105, 106, 1930; U. S. Geol. Survey Bull. 872, p. 137, 138, 1937.

843		
1797A	*Nautilus?* sp.	*Nautiloid? indet.
2644A	*Orthoceras* sp.	*Rayonnoceras rangifer*, n. sp.
	Goniatites sp.	*Goniatites* cf. *G. granosus?*
5279	*Orthocreas* sp.	**Dolorthoceras?* sp. indet.
	Gastrioceras sp.	*Goniatites* cf. *G. granosus*
5302	*Orthocreas* sp.	*Adnatoceras alaskense* n. sp.
5303	*Goniatites* sp.	*Goniatites* cf. *G. granosus?*
5843	*Goniatites?* sp.	*Goniatites* cf. *G. granosus*
	Gastrioceras? sp.	*Not identifiable
5843C	*Orthoceras* cf. *O. epigrus*	**Dolorthoceras?* sp. indet.

Mertie, J. B., Jr., U. S. Geol. Survey Bull. 836–E, p. 421, 422, 1932.

6841	*Gastrioceras?* sp.	*Goniatites* cf. *G. granosus*
		Girtyoceras? sp. indet.
6846A	*Goniatites* cf. *G. choctawensis*	*Goniatites* cf. *G. granosus*
6846B	*Gastrioceras* cf. *G. caneyanum*	*Neoglyphioceras* sp.

COMPOSITION OF THE CEPHALOPOD FAUNA

Twelve genera of nautiloids and fourteen of ammonoids have been recognized in the Mississippian rocks of northern and eastern Alaska. Most of the nautiloids belong in well known long-ranging genera. Two of the nautiloid genera, *Euloxoceras* and *Knightoceras*, are recognized in rocks older than Pennsylvanian for the first time, as is one of the ammonoid genera, *Eothalassoceras*. The goniatites likewise belong to ubiquitous genera, but are much more restricted in stratigraphic range than the nautiloids. Genera typical of European goniatite zones ranging in age from late Tournaisian to early Namurian are present.

As might be expected in a region rather remote from other previously described cephalopod localities, many of the species are new. However, specimens identified as *Goniatites crenistria* Phillips, *G.* cf. *G. granosus* Portlock, *G.* cf. *G. sphaericus* (Sowerby), and *Beyrichoceras micronotum* (Phillips) appear to be identical with British shells.

One of the most striking features of the goniatite fauna, taken as a whole, is the relative abundance of *Beyrichoceras* and the closely related *Bollandites*. They are common in England, but rather uncommon on the continent of Europe and in North Africa. In the United States only one specimen of *Beyrichoceras* has thus far been described (Miller, 1947). The relative abundance of these genera in Alaskan rocks of Mississippian age emphasizes the boreal aspect of the fauna.

The complete list of the cephalopod fauna and its distribution among the various fossil localities is given in table 1.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF THE CEPHALOPODS

BROOKS RANGE

The northernmost mountain mass in Alaska, the Brooks Range, forms a slightly crescentic barrier from west to east across almost the entire territory. It includes several lesser groups of mountains, such as the Baird and De Long Mountains in the western part of the range, and the Endicott Mountains in the central part (fig. 1). Exposed on its slopes are the northernmost outcrops of late Paleozoic rocks in United States territory. Most of the marine Mississippian rocks in this region have in the past been referred to the Lisburne limestone, named by Schrader (1902, p. 241) and referred to the Lower Carboniferous and correlated with the Mississippian by Girty (*in* Collier, 1906, p. 22–26). The formation extends from Cape Lisburne on the Arctic Ocean, eastward for nearly 600 miles, and is composed largely of limestone and chert,

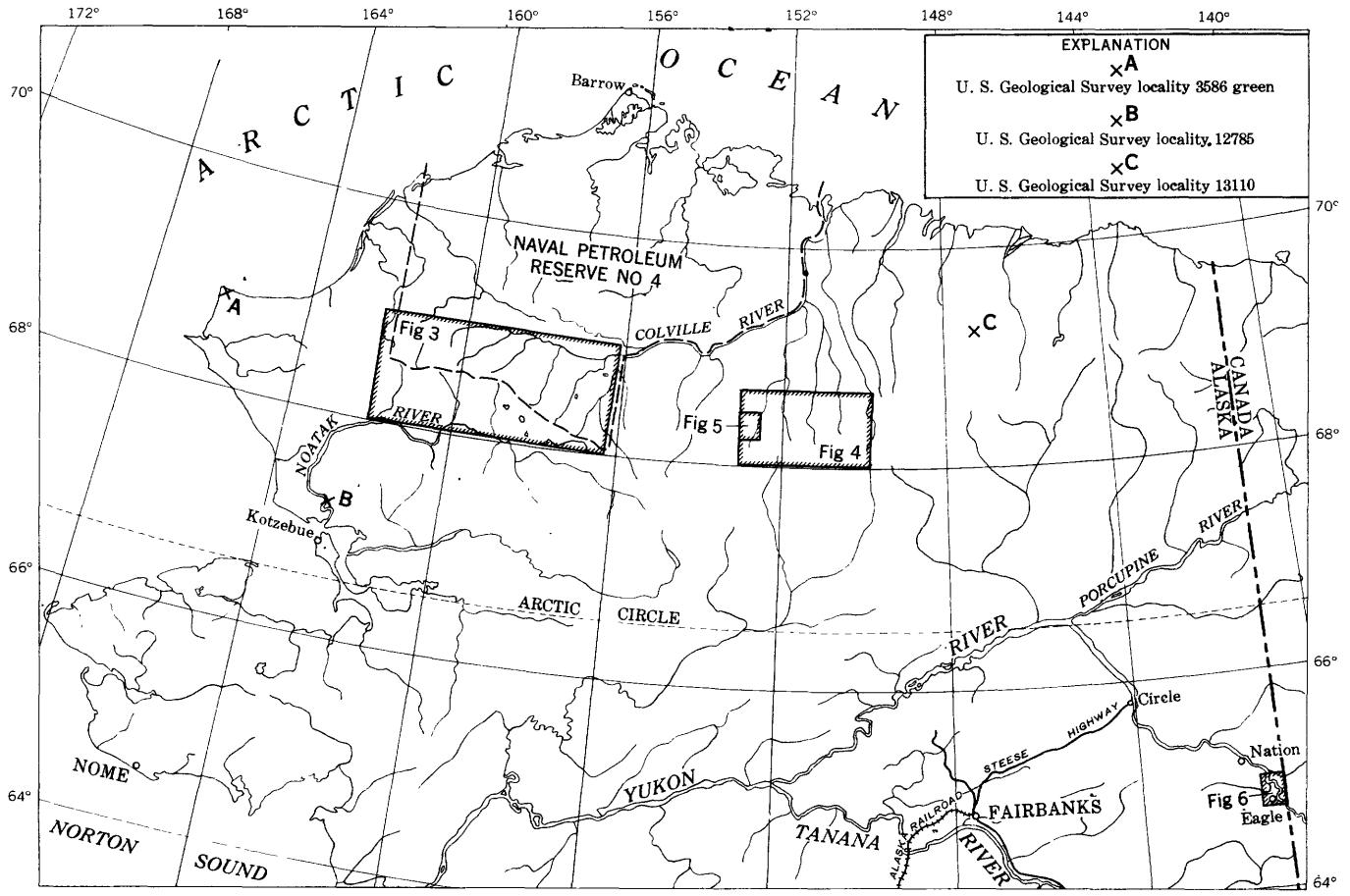

FIGURE 1.—Index map of the northern part of Alaska, showing locations of areas where fossil cephalopods were obtained.

but it also contains a considerable amount of shale, siltstone, and local beds of sandstone.

Recent mapping in connection with petroleum investigations has resulted in subdivision of these rocks. In the western part of the De Long Mountains three separate and as yet unnamed divisions of the Lisburne group have been mapped. The lower and middle units are each approximately 2,000 feet thick, and the upper unit is in excess of 500 feet. A probable pre-Lisburne shale, the upper part of which may be of Lisburne age, has been recognized on Iligluruk Creek, in the northern foothills of the De Long Mountains. An unnamed sequence of clastic rocks and an unnamed unit of dark limestone and black shale, both apparently equivalent, at least for the most part, to the Lisburne group, have been mapped in the basin of the Kiligwa River in the eastern part of the De Long Mountains.

In the central part of the Brooks Range the rocks of Mississippian age are divided into three formations, in ascending order: the Kayak shale, Wachsmuth limestone, and Alapah limestone (Bowsher and Dutro, in press). The upper two formations comprise the Lisburne group in this region which, incidentally, is the type area of the Lisburne limestone (Schrader, 1902, p. 241). At the type locality near Shainin Lake in Kanayut valley the Kayak shale is approximately 960 feet thick, the Wachsmuth limestone 1,230 feet, and the Alapah limestone 970 feet. The Alapah limestone has been mapped westward about as far as the Ipnavik River.

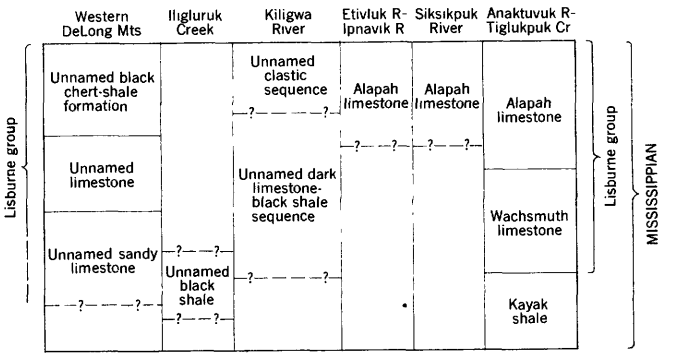

FIGURE 2.—Preliminary correlation of Mississippian rocks in the western and central Brooks Range. After Dutro.

These stratigraphic units and their tentative correlation are shown in figure 2. Cephalopods have been found at scattered localities in most of these units. The cephalopods of the Alapah limestone occur in a

dark limestone, black chert, and shale facies similar to the "Culm facies" of European stratigraphers. This facies does not occupy a constant position in the section, although a "black chert-shale member" can be mapped over a considerable area in the central Books Range, where its position changes little. It has been recognized in the Anaktuvuk, Tiglukpuk, Siksikpuk, and Kiruktagiak valleys. Two other tongues of this facies are present in the Alapah limestone but have not yielded goniatites. Westward, this facies thickens and occupies a position lower in the section. It attains its greatest development probably in the eastern part of the Kiligwa River basin, where the entire Mississippian sequence apparently is composed of rocks of this type.

The Brooks Range cephalopod localities are described below in a general order from west to east. The locations of the collections from the western part of the Brooks Range are shown on figure 3, and from the eastern part, on figure 4.

CAPE LISBURNE REGION

The Lisburne Hills, the westernmost highlands of the Brooks Range, reach the shore of the Arctic Ocean along a stretch several miles long just east of Cape Lisburne. About three miles southeast of Wevok, in a dark brown shale belonging in the Lisburne group (USGS [1] loc. 3586 green), Collier collected a silicified fragment of a goniatite here identified as *Coniatites?* sp. The geologic structure in this region is complex and nothing is known about the stratigraphic position of the fossil within the formation. The poorly preserved collection contains the following fossils:

Productella? sp.
Avonia? sp.
Laevidentalium? sp.
Goniatites? sp.

LOWER NOATAK RIVER BASIN

A fossil collection containing cephalopods was made by P. S. Smith in 1911 from dark, nearly black limestone float in the northern part of the lower gorge of the Noatak River (Smith, 1913, p. 76, 78). This locality (USGS loc. 12785, given under its field number 11AS77 in Smith's report) is approximately 21 miles N. 20° E. of Kotzebue. The following poorly preserved cephalopods were associated with a rich fauna of bryozoans, brachiopods, other mollusks, and ostracodes.

Kionoceras? sp. B
Dolorthoceras? sp.
Ammonellipsites (*Fascipericyclus*) aff. *A. polaris* Gordon n. sp.

A complete list of the fossils was given by Girty (*in* Smith, 1913, p. 78). The float blocks were presumed by Smith to have come from nearby outcrops assigned to the Lisburne formation. The surrounding bedrock has been mapped as early Paleozoic, possibly Silurian or older. Recent work in the Noatak region indicates that early Mississippian rocks crop out in the western part of the Baird Mountains and could have been the source of these boulders (Dutro, 1954, personal communication).

WESTERN DE LONG MOUNTAINS

Three collections that include fossil cephalopods were made by E. G. Sable on the north slope of the De Long Mountains. A single specimen of *Münsteroceras saginatum* Gordon, n. sp. was found in a calcareous nodule collected from an unnamed dark gray shale on the south side of the easternmost tributary to the east fork of Iligluruk Creek (USGS loc. 11877). As near as could be determined the collecting locality is 125 feet stratigraphically above the base of the Mississippian. The enclosing shale beds are believed to be pre-Lisburne in age.

From the lowest of the three unnamed lithologic units into which the Lisburne group in this area is divisible, two fragments of orthoconic nautiloids and several other poorly preserved invertebrates, listed below, were collected. The fossils were found near the headwaters of the Utukok River, in dark gray silty limestone interbedded with quartzite, at a stratigraphic level roughly 600 feet below the top of the unit (USGS loc. 11867).

"Productus" sp.
Composita aff. *C. humilis* Girty
Bellerophontid gastropod, genus and species indet.
Strobeid gastropod, genus and species indet.
Kionoceras? sp. A
Dolorthoceras? sp.

From the uppermost of the three units a new species of *Rayonnoceras* together with several other invertebrates, listed below, were collected near the head of Kogruk Creek, which is the west fork of the Utukok River, in thinly bedded black chert and limestone (USGS loc. 11865). The exact stratigraphic position of this collection within the unit is not known.

[1] The abbreviations used in catalog, collection, and locality numbers are: BMNH, British Museum (Natural History); GSGB, Geological Survey Great Britain; LSJU, Leland Stanford Junior University; USGS, United States Geological Survey; and USNM, United States National Museum.

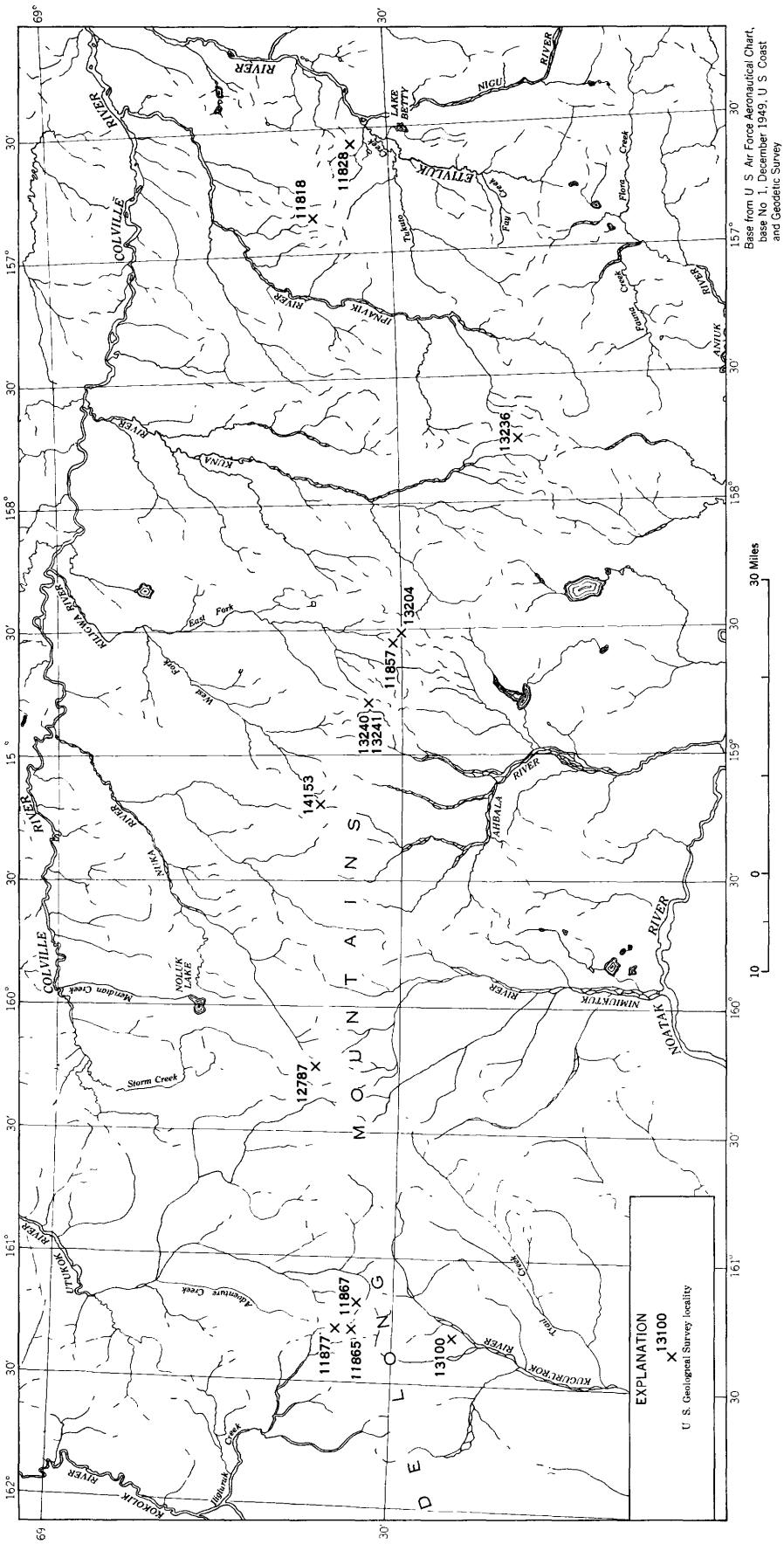

FIGURE 3.—Index map of the western part of the Brooks Range, showing cephalopod localities in the De Long Mountains and drainage basins of the Ipnavik and Etivluk Rivers.

Corals, not determined
Lingula sp.
Orbiculoidea sp.
"Productus" sp.
Leiorhynchus cf. *L. carboniferum* Girty
Spirifer aff. *S. arkansanus* Girty
Echinocoelia cf. *E. pilosa* (Girty)
Mourlonia sp.
Rayonnoceras rangifer Gordon, n. sp.
Ostracodes, not determined

South of the crest of the De Long Mountains the lowest of the three unnamed stratigraphic divisions of the Lisburne group has furnished a single specimen of *Kionoceras?* sp. A at an exposure on the south slope of a westerly trending ridge between two forks of the Kugururok River, about 2¼ miles N. 10° E. of their junction. This collection was made from the top and north end of a limestone cliff at the east end of the ridge. The exact stratigraphic position of this collection is not known. The fossils from this locality (USGS loc. 13100) are as follows:

Cup coral, indet.
Crinoid columnals
Chonetes n. sp.
Schuchertella? sp. indet.
Leptaena cf. *L. analoga* Phillips
Naticopsis? sp. indet.
Kionoceras? sp. A
Griffithides sp.

On the north bank of the Nuka River, near its headwaters, an outcrop of interbedded shale and sandstone (USGS loc. 12787) has yielded a single goniatite referred here with slight question to *Bollandites bowsheri* Gordon, n. sp. The rocks are contained in a fault block between rocks of Cretaceous and Devonian age, and their stratigraphic relation to other Mississippian rocks of the region is not known.

EASTERN DE LONG MOUNTAINS

Five collections containing cephalopods were made by Tailleur in the eastern part of the De Long Mountains near the headwaters of several branches of the Kiligwa River. The collecting localities are scattered roughly along a west-northwesterly line a short distance north of the crest of the range.

The westernmost collection is from a sandstone unit of Mississippian age interbedded with dark fetid limestone and shale, on the west branch of the west fork of the Kiligwa River, near its head. This collection (USGS loc. 14153) contains several specimens of *Goniatites* cf. *G. sphaericus* (Sowerby). The beds belong to a facies considerably different from the black shales of the Lisburne group farther east in the same river basin, but fossils indicate that they are in part of the same age. The beds of Mississippian age are overlain by a similar clastic sequence of Permian age, from which they can not be readily distinguished lithologically.

On the east side of a northward-trending ridge of the De Long Mountains, between the two main branches of the Kiligwa River, the lower part of the Mississippian sequence is represented by gray-black chert and dark silicified limestone in beds 1–2 inches thick and dark shaly limestone and calcareous shale, in which are intercalated several thick sills of diabase. Each of two collections from a 1,500-foot composite section measured by Tailleur (at station T–106) contains a poorly preserved goniatite, *Münsteroceras* sp. in the lower collection and *Protocanites?* sp. in the upper. The lower collection (USGS loc. 13240) contains the following fossils (invertebrates other than the goniatites identified by Dutro):

Schellwienella? sp.
Chonetes sp.
"Productus" sp.
Linoproductus sp.
Spirifer sp.
Nuculana sp.
Cypricardinia sp.
Pectenoid pelecypod, genus and sp. indet.
Loxonema? sp.
Mourlonia? sp.
Straparollus? sp.
Münsteroceras sp.
Ostracodes, not identified

The upper collection lies 475 feet stratigraphically above the lower and this thickness does not include a 105-foot diabase sill that intervenes between the two collections. The higher collection (USGS loc. 13241) contains the following fossils:

"Productus" sp.
Eumetria sp.
Pelecypods, indet.
Gastropods, indet.
Protocanites? sp.

Another fossil collection, in a stratigraphic position 160 feet above the lower one and containing no goniatites, was tentatively correlated by Dutro (1954 personal communication), on the basis of the brachiopods, with the upper part of the Kayak shale of the central Brooks Range.

About seven miles farther to the southeast, an isolated 125-foot section of black platy shale containing calcareous nodules, near a tributary creek on the west side of the east fork of the Kiligwa River (USGS loc. 11857) has yielded the following cephalopods:

Cycloceras sp.
Ammonellipsites (*Fascipericyclus*) *polaris* Gordon, n. sp.

A little more than 1 mile farther southeast, in cut banks on another tributary creek of the east fork of the Kiligwa River, roughly 3 miles from its headwaters, a

section resembling that of the middle part of the Alapah limestone of the central Brooks Range is exposed. Tailleur (1954 personal communication) reports the following sequence at this locality:

	thickness (feet)
Chert, black, thickly bedded	150
Shale, black, platy above, more fissile below	200
Interbedded black chert and shale with limestone concretions, fossiliferous at the middle	300

Calcareous concretions from the middle of the lower unit, about 500 feet below the top of the section (USGS loc. 13204) contain the following fossils:

Posidonia? sp. indet.
Bollandites kiligwae Gordon, n. sp.

Near the eastern end of the De Long Mountains, on a tributary of the Kuna river, about 2 miles from its headwaters, a section measured by Tailleur (at station T–99) has been the source of several fossil collections. A bed 185 feet above the base of the section (USGS loc. 13236) contained the following fossils (invertebrates other than cephalopods identified by Dutro):

Zaphrentid coral, genus and sp. indet.
Lingula sp.
"Productus" sp.
Buxtonia? sp.
Dielasma? sp.
Spirifer aff. *S. striatiformis* Meek.
Pelecypod, genus and sp. indet.
Platyceras sp.
Gastropod, indet.
Dolorthoceras? sp.
Nautiloid, fragment
Ostracodes, fragmentary

IPNAVIK RIVER BASIN

In the high ground between the Ipnavik and Etivluk Rivers a west-northwesterly trending belt of outcrop exposes beds of the Alapah limestone. From an isolated outcrop of black cherty shale containing calcareous concretions, about 2 miles south of Lisburne Ridge, 4 miles northeast of Ekakevik Mountain, and 8 miles due east of the Ipnavik River, the following fossils were collected (USGS loc. 11818):

Fossil plant
Orthoconic nautiloid imprint
Bollandites cf. *B. sulcatum* (Bisat)

ETIVLUK RIVER BASIN

A little over 8 miles east-southeast of the last locality, about 4 miles south of Lisburne Ridge, and 2½ miles northwest of the junction of the Etivluk and Nigu Rivers, there is a small isolated outcrop of Alapah limestone. Ten feet of thin-bedded black chert is overlain by 8 feet of hard calcareous shale that contains the following cephalopods (USGS loc. 11828):

Bactrites? sp. indet.
Endolobus sp.
Goniatites crenistria Phillips
Pronorites? sp.

This locality is along the same structural trend as USGS locality 11818.

KIRUKTAGIAK RIVER BASIN-CHANDLER LAKE AREA

Reconnaissance in this area by G. Gryc and K. Stefansson, followed by field mapping by W. W. Patton, Jr., I. L. Tailleur, and A. S. Keller, have yielded several collections of well preserve cephalopods (figs. 4 and 5). Most of these are referable to the *Goniatites crenistria* zone, which is widespread in western Europe and northwest Africa, and in the United States has been recognized in Arkansas. Nearly half of the cephalopods described in the present paper are found in this area. They occur, for the most part, in calcareous concretions scattered through beds of black shale associated with black chert in the middle part of the Alapah limestone.

About 230 feet of the Alapah limestone is exposed on Monotis Creek and on the Kiruktagiak River near their confluence. A section was measured here by Patton, and is described below in descending stratigraphic order.

	Thickness (feet)
Post-Lisburne rocks of late Paleozoic and early Mesozoic age.	
Black chert and shale member of the Alapah limestone:	
g. Shale, clay, black, fossiliferous, pyritiferous	6
f. Limestone, thin to medium-bedded, dense, gray, siliceous. Minor black silty shale interbedded	11
e. Limestone, medium-bedded, dense, dark gray, siliceous. Minor interbedded dark shaly limestone. Black nodular chert abundant toward base	52
d. Limestone, massively bedded, dense, gray, siliceous. Minor interbedded dark shaly limestone. Black chert nodules and lenses abundant throughout	42
c. Limestone and shale. Interbedded gray, massively bedded, finely crystalline limestone and black calcareous shale. Black nodular chert abundant	71
b. Shale and limestone. Dark-gray, calcareous shale and black oolitic, phosphatic limestone. Black dense siliceous, highly fossiliferous limestone concretions and lenses	40
a. Chert, massively bedded, dark	8
Lower part of the Alapah limestone.	

Fossils were obtained at this locality from limestone concretions in a cut bank on the west side of the Kiruktagiak River. Two collections (USGS locs. 10864 and 14149), both from bed *b* of the section above, contain the following species:

Moorefieldella cf. *M. eurekensis* (Walcott)
Caneyella cf. *C. percostata* Girty
Aviculopecten sp.
Bactrites? carbonarius Smith?

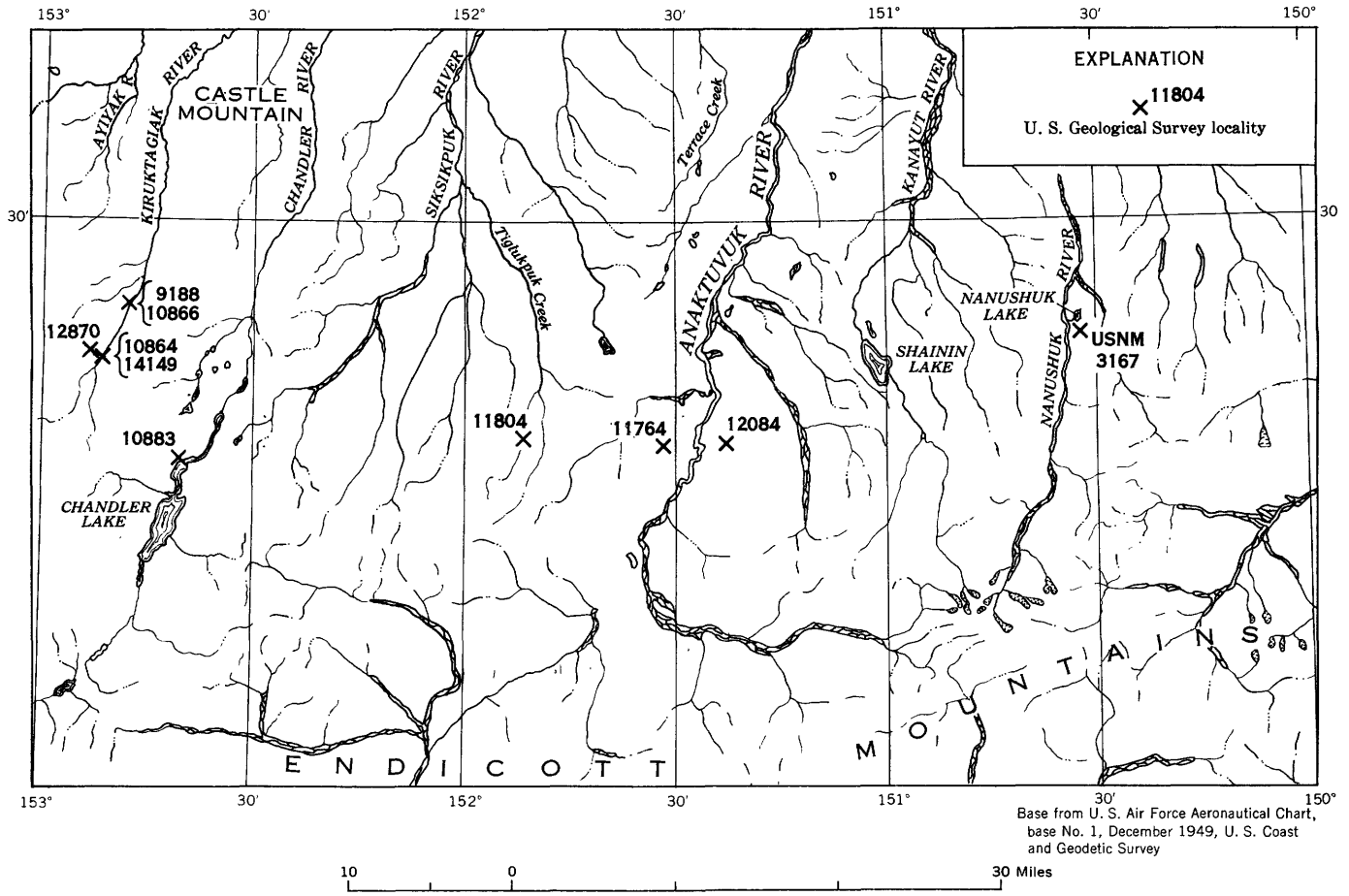

FIGURE 4.—Index map of the central part of the Brooks Range, including the drainage basins of the Kiruktagiak, Siksikpuk, and Anaktuvuk Rivers, showing localities at which fossil cephalopods were obtained.

Knightoceras pattoni Gordon, n. sp.
Beyrichoceras micronotum (Phillips)
Goniatites crenistria Phillips (wide form)
Girtyoceras arcticum Gordon, n. sp.
Entogonites borealis Gordon, n. sp.
Dimorphoceras algens Gordon, n. sp.

The same bed, on Monotis Creek, contains the following species (USGS coll. 12780):

Platycrinites sp. (columnal)
Entogonites borealis Gordon, n. sp.

At another locality about 3½ miles north-northeast of Patton's measured section, the same part of the Alapah limestone is exposed along the Kiruktagiak River (fig. 5) but the beds are associated with a mafic intrusive igneous rock and are structurally complex so that no section could be measured. Two collections from this locality represent the same faunal zone as that of the collections 3½ miles to the south-southwest. The following fossils have been identified:

Collection 9188

Posidonia cf. *P. wapanuckensis* (Girty)
Dolorthoceras medium Gordon, n. sp.
Adnatoceras alaskense Gordon, n. sp.
Mooreoceras aff. *M. crebriliratum* (Girty)
Bactrites? carbonarius Smith
Goniatites crenistria Phillips (wide form)

Collection 10866

Spirifer sp.
Aviculopecten sp.
Gastropod, indet.
Rayonnoceras? sp.
Bactrites? carbonarius Smith?
Kionoceras? sp. C
sp. D
Dolorthoceras medium Gordon, n. sp.
Stroboceras crispum Gordon, n. sp.
Beyrichoceras micronotum (Phillips)
sp.
Goniatites crenistria Phillips (wide form)

One other collection from this area includes a coiled nautiloid belonging to the same genus, but possibly not the same species, as one from Patton's section of the member Alapah limestone measured near the confluence of Monotis Creek and the Kiruktagiak River. This collection was made by Stefannson during early reconnaissance of the region, from a limestone exposure on the north shore of Chandler

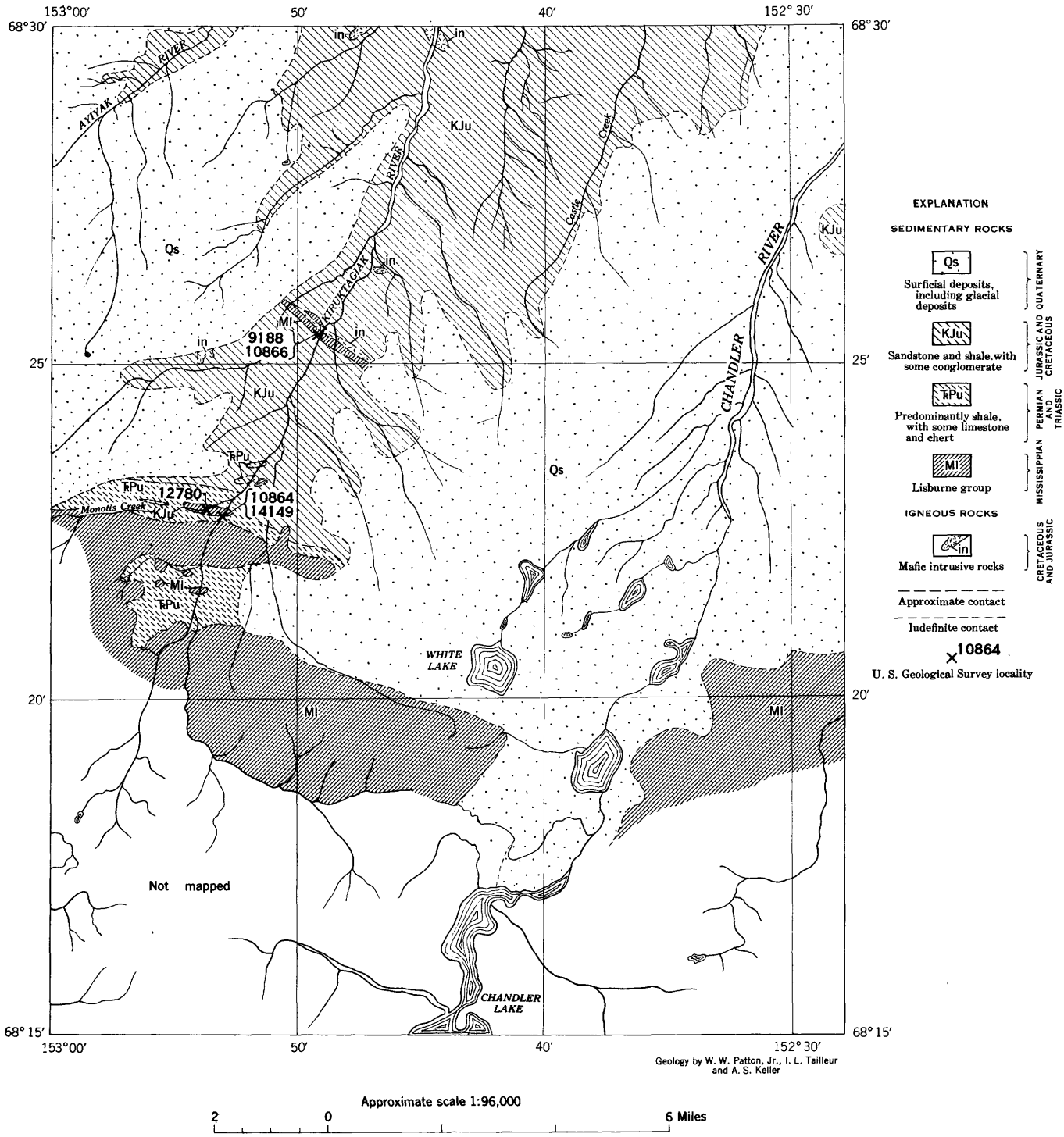

FIGURE 5.—Geologic sketch map of the Kiruktagiak-Chandler Lake area, showing localities at which fossil cephalopods were collected.

Lake, about 10 miles southeast of Patton's measured section. The limestone exposure is part of the Lisburne group, but its exact stratigraphic position in the group is not known. The following fossils have been identified. (USGS coll. 10883):

Productid aff. *Setigerites setiger* (Hall)
Spirifer aff. *S. haydenianus* Girty
Spiriferoid, genus and species indet.
Naticopsis? sp.
Knightoceras sp.

The brachiopods, though few and poorly preserved, are reminiscent of forms from the lower Brazer limestone of Utah and Idaho.

SIKSIKPUK RIVER BASIN

On Tiglukpuk Creek, in the southern part of the Siksikpuk River basin, a collection was made by Reiser from the black chert and shale member of the Alapah limestone, 525 feet below the top of the formation in measured section B–19. The following cephalopods are identified (USGS loc. 11804):

Euloxoceras sp.
Sudeticeras alaskae Gordon, n. sp.
Eothalassoceras aurorale Gordon, n. sp.

This collection is of special interest because it combines the first records of the genera *Euloxoceras* and *Eothalassoceras* in rocks earlier than Pennsylvanian age with the first record of *Sudeticeras* in the western hemisphere. *Euloxoceras* occurs in rocks of Mississippian age elsewhere but this has not yet been recorded in the literature. *Sudeticeras* is not known above the *Goniatites granosus* (P_2) zone. At this locality the total thickness of the Alapah limestone is approximately 1,870 feet, according to Brosgé and Reiser (1951, written communication), the black chert and shale member is 185 feet thick, and the fossil collection came from a horizon 60 feet above the base of the member and a few feet above a phosphatic shale zone.

ANAKTUVUK RIVER BASIN

Crushed goniatites and other fossils were collected by Bowsher and Gryc from calcareous shale in the upper part of the black chert and shale member of the Alapah limestone, from a dip slope on a hill on the west side of the upper Anaktuvuk River, a little more than 8 miles northeast of Anaktuvuk pass. Unfortunately, the goniatites are too badly crushed and silicified for positive identification, even as to genus. The following fossils occur in this collection (USGS loc. 11764):

Cup coral, genus and sp. indet.
Leiorhynchus cf. *L. carboniferum* Girty
Nuculana sp.
Posidonia sp.
Michelinoceras dutroi Gordon, n. sp.
Dolorthoceras medium Gordon, n. sp.?
Goniatites?, sp. indet.
Girtyoceras? sp. indet.
Goniatite, indet.

A section measured by Brosgé and his associates along the west side of the Anaktuvuk River shows the Alapah limestone to be 2,280 feet thick here (Brosgé and Reiser, 1951, written communication). The black chert and shale member is about 325 feet thick and the base of it is 1,690 feet above the base of the formation.

On the east side of the Anaktuvuk River, goniatites were collected by Bowsher from fine-grained limestone nodules in grayish black shale interbedded with black chert, on a ridge 1,500 feet east of Kanaktuk Lake. The fossils came from a zone 43 feet above the base of the black chert and shale member of the Alapah limestone. The following species are represented (USGS loc. 12084):

Cypricardella sp.
Adnatoceras alaskense Gordon, n. sp.
Endolobus sp.
Nautiloid fragment
Bollandites bowsheri Gordon, n. sp.
Girtyoceras endicottense Gordon, n. sp.

NANUSHUK RIVER BASIN

From a section measured by Bowsher on the west slope of a ridge on the east side of the Nanushuk River valley, 6,200 feet south of the southeast corner of Nanushuk Lake, a large collection of fossils, including corals, bryozoans, brachiopods, mollusks, and ostracodes, was obtained from the lower part of the Alapah limestone, 312 feet above the base. A single orthoconic nautiloid from this locality (USNM loc. 3167) has been identified as *Dolorthoceras?* sp.

ECHOOKA RIVER BASIN

The northeasternmost cephalopod locality in the Brooks Range is on the west bank of the Echooka River, 5 miles upstream from the large icefield at the front of the range. A single fragment of *Cycloceras*, associated with brachiopods and mollusks, was found in black shale and argillaceous limestone, 30 feet below the top of the Kayak shale. The following fossils have been identified (USGS loc. 13110), the brachiopods by Dutro:

Crinoid columnals
"Productus", gen. and sp. indet.
Dictyoclostus?, sp. indet.
Echinoconchus sp.
Spirifer aff. *S. gregeri* Weller
aff. *S. osagensis* Swallow
aff. *S. striatiformis* Meek
Nuculana sp.
Myalina sp.
Bellerophontid gastropod, indet.
Platyceras sp.
Cycloceras sp.

EAGLE-CIRCLE DISTRICT

Ever since stratigraphic work was begun by Collier in 1902 along the Yukon River, geologists have stopped at the famous Calico Bluff, 8 miles due north of Eagle, to familiarize themselves with the Mississippian strata exposed there (fig. 6). Both the limestones and interbedded shales of the Calico Bluff formation have yielded a few poorly preserved cephalopods associated, particularly in the limestone beds, with a rather large number of other invertebrates, mainly brachiopods and mollusks. The fauna of the Calico Bluff formation in its entirety has been summarized in a table prepared by Girty and published by Mertie (1930, p. 101–106),

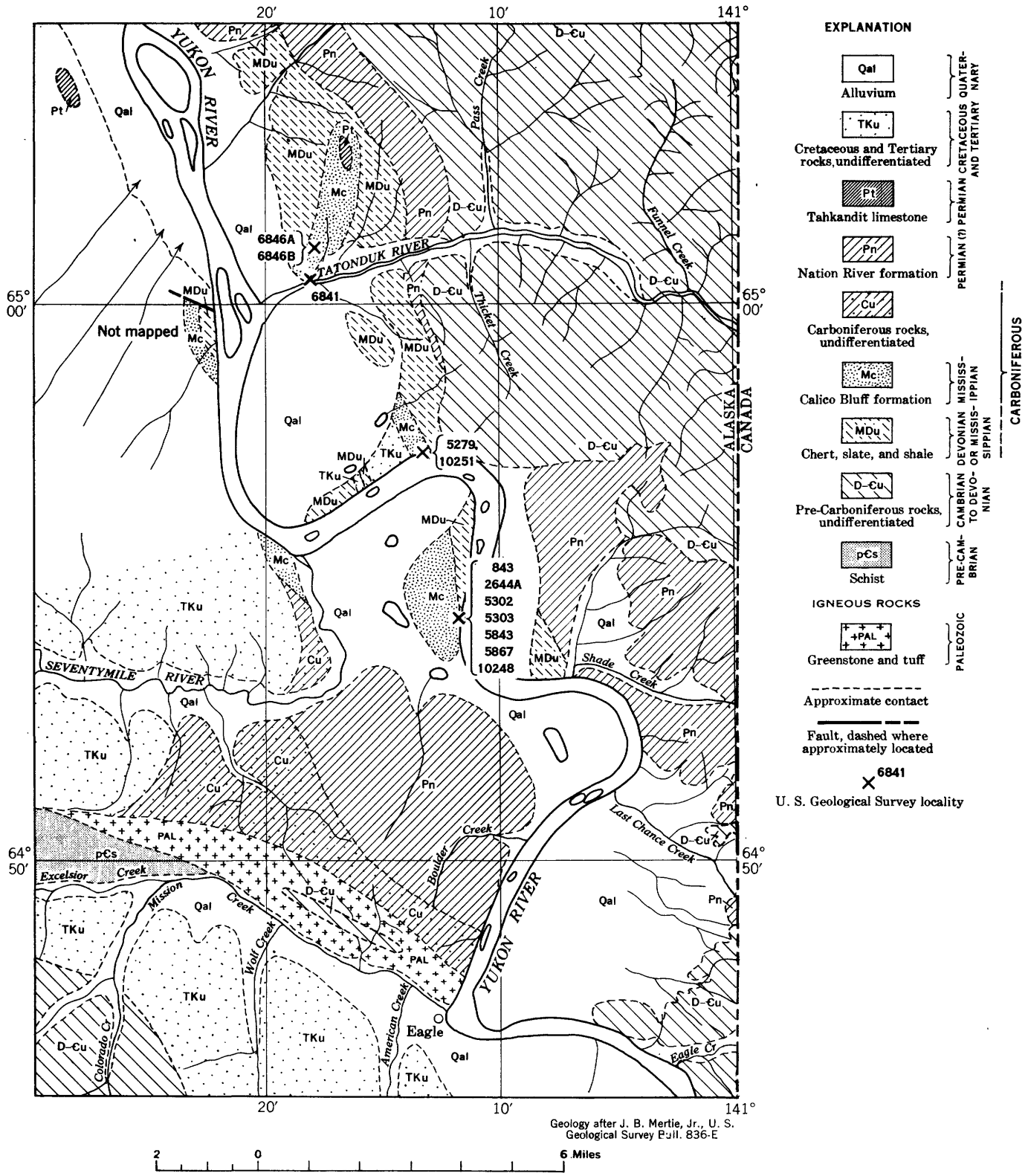

FIGURE 6.—Index map of part of the Eagle-Circle district, showing localities at which fossi cephalopods were collected

listing all of the collections made in that area prior to 1930. Fossil determinations by Girty for several additional collections from the nearby Tatonduk River were also listed by Mertie (1932, p. 421, 422). The cephalopods from all of these collections have been restudied by the present writer. A list comparing the present names with those appearing in earlier faunal lists will be found in the section on Previous Work.

The Calico Bluff formation at its type locality is approximately 1,270 feet thick, according to Mertie (1930, p. 98). Some beds are missing at this locality, having been eroded from the top of the formation. The following is a slightly abbreviated description of the section measured by Mertie (1930, p. 97):

Section of Calico Bluff formation in south side of Calico Bluff, on Yukon River below Eagle

	Thickness (feet)
Covered, drab shale and limestone in lower part	60
Slope of shale, gray with a little limestone, 3- to 4-ft sandstone beds in upper part	95
Calcareous shale, light to dark gray, weathering light gray; upper calcareous shale, light to dark gray, weathering light gray; upper 20 ft covered	194
Limestone, black, carbonaceous, massive, weathers light gray. Zone *e*	8
Thinly interbedded limestone and black shale, both weathering light and dark gray, fossiliferous	215
Cliff-forming unit: at top, thin-bedded limy shale, weathering chocolate; in middle, a 2 ft white-weathering limestone bed; at base, black shale	14
Shale, black, fissile, weathering bronze-colored except in middle 10 to 15 ft, which is chocolate weathering	119
Upper 56 ft, thin-bedded limestone with some shale, weathering to light chocolate color; lower 27 ft, black fissile shale weathering blackish brown. Zone *d*	83
Shale, fissile, black, weathering brown at base and red and yellow farther up, giving bronze color to beds	48
Alternating thin beds of white-weathering limestone and fissile black shale. Fossils in thin band at top	10
Limestone, fetid, dark gray weathering light gray, fossiliferous at base	4
Shale, fissile, dark gray weathering yellow brown	15
Limestone in beds up to 3 ft thick, alternating with shale; a 2-ft fossiliferous limestone bed near middle	26
Limestone, dark gray weathering light gray, fetid, fossiliferous. Zone *c*	14
Alternating dark gray limestone and fissile black slate in beds 2 to 8 in thick	24
Slate, black, somewhat siliceous; a 6-in bed of fetid black fossiliferous white-weathering limestone. Zone *b*	39
Alternating beds of limestone and shale with some chert. Includes one thick zone of black siliceous slate, which is zone *a*. Thickness estimated	300

The section at Calico Bluff was first described and the formation named by Brooks and Kindle (1908, p. 288, 289, 292–294). Cephalopods occur in one of three collections of fossils they submitted to Girty for identification. This collection, from unit *1* of Brooks and Kindle's section which they described as constituting 50 feet of black shale, the base of which is 6 feet above the top of the lowest limestone bed containing abundant Carboniferous fossils, has received the USGS locality number 2644A (Mertie, 1930, p. 107). The collection includes a moderately well preserved orthoconic nautiloid and impressions of a spirally lirate goniatite, which have been identified as follows:

Rayonnoceras rangifer Gordon, n. sp.
Goniatites cf. *G. granosus Portlock?*

Also, from an unrecorded stratigraphic zone at Calico Bluff, Kindle (USGS no. 843, E. Kirk locality register) collected *Rayonnoceras rangifer* Gordon, n. sp. The same species was collected by J. S. Williams from talus at the north end of the bluff (USGS loc. 10248).

Mertie (1930, p. 99) has correlated Brooks and Kindle's unit *1* with zone *b* of his own section measured at Calico Bluff. From just below zone *b*, about 300 feet above the base of the formation, Mertie collected (USGS loc. 5843) a poorly preserved *Goniatites* cf. *G. granosus* Portlock.

At the south end of Calico Bluff, from beds 440 feet above river level, Girty (USGS loc. 5302) collected a small orthoconic nautiloid referred here to *Adnatoceras alaskense* Gordon, n. sp. From talus at the north end of the bluff (USGS loc. 5303) Girty collected a single juvenile goniatite doubtfully referred here to *Goniatites* cf. *G. granosus* Portlock.

Finally, from a collection made by Collier on his early visit to Calico Bluff (USGS loc. 5867), *Dolorthoceras?* aff. *D. crebriliratum* (Girty) has been identified.

In summary, the cephalopods from the type locality of the Calico Bluff formation are as follows:

Rayonnoceras rangifer Gordon, n. sp.
Dolorthoceras? aff. *D. crebriliratum* (Girty)
Adnatoceras alaskense Gordon, n. sp.
Goniatites cf. *G. granosus* Portlock

The same formation has also yielded cephalopods at several localities a few miles west and north of Calico Bluff. At an exposure on the north bank of the Yukon River, nearly opposite Seventymile River, Girty collected, from loose blocks mostly from the middle part of the exposure (USGS loc. 5279), the following goniatites:

Goniatites cf. *G. granosus* Portlock
Girtyoceras? sp. indet.

The same two species were collected by Mertie from a shale bluff on the Tatonduk River, about 2¼ miles from its confluence with the Yukon River (USGS loc. 6841).

Goniatites cf. *G. granosus* Portlock also was collected from an argillaceous limestone bed on a topographic bench, 2 miles northeast of the mouth of the Tatonduk

River (USGS loc. 6846A). The overlying black shale (USGS loc. 6846B) contained *Neoglyphioceras* sp.

The youngest known Mississippian cephalopods in Alaska were collected by James Steele Williams at the exposure on the north side of the Yukon River, 1 to 1½ miles upstream from the mouth of the Seventymile River. In loose blocks, mostly from a single bed near the middle of the exposure, crushed specimens of *Pseudorthoceras* sp. and *Cravenoceras* sp. were found. As Girty's specimens of *Goniatites* cf. *G. granosus* came from also the middle part of the same exposure it would appear that here the spirally lirate goniatites of the *Goniatites granosus* (P_2) zone are followed, as they are in the British Carboniferous section, by cravenoceratids representing the *Eumorphoceras pseudobilingue* (E_1) zone. Williams' specimens are not well enough preserved for specific determination.

The distribution of the cephalopods listed in the preceding pages is summarized in the table below. These constitute the presently known Mississippian cephalopods of Alaska.

AGE AND CORRELATION OF THE CEPHALOPOD-BEARING BEDS

Because the localities at which the Alaskan cephalopods were collected are so scattered, it is very difficult to evaluate the stratigraphic relations between one collection and another. In a general way, however, an evaluation can be reached by comparing the stratigraphic positions of the few collections that have come from measured sections and by correlating all the collections containing goniatites with the Carboniferous goniatite zonal sequence that has been set up in the northwest Europe and particularly in the British Isles.

TABLE 1.—*Distribution of cephalopod species in the Brooks Range and in the Eagle-Circle District*

[Localities listed by USGS upper Paleozoic collection number]

Species	Eagle-Circle district												Brooks Range																									
	843	2644a	5279	5302	5303	5843	5867	6841	6846a	6846b	10248	10251	3586	9188	10864	10866	10883	11764	11804	11818	11828	11857	11865	11867	11877	12084	12785	12787	12870	13100	13110	13204	13236	13240	13241	14149	14153	*3167
Nautiloids:																																						
Rayonnoceras rangifer Gordon, n. sp.	X	X									X												X															
Rayonnoceras? sp.																X																						
Michelinoceras dutroi Gordon, n. sp.																		X																				
Bactrites? carbonarius Smith														X	?	?					?																	
Cycloceras sp.																						X									X							
Kionoceras? sp. A																								X						X								
sp. B																											X											
sp. C																X																						
sp. D																X																						
Dolorthoceras medium Gordon, n. sp.														X		X		?																				
Dolorthoceras? aff. *D. crebriliratum* (Girty)							?							X																								
? sp.																											X						X					X
Adnatoceras alaskense Gordon, n. sp.				X										X												X												
Euloxoceras sp.																			X																			
Pseudorthoceras sp.												X																										
Endolobus sp.																					X					X												
Knightoceras pattoni Gordon, n. sp.															X																							
sp.																	X																					
Stroboceras crispum Gordon, n. sp.																X																						
Ammonoids:																																						
Ammonellipsites (Fascipericyclus) polaris Gordon, n. sp.																						X																
aff. *A. polaris*																											X											
Münsteroceras saginatum Gordon, n. sp.																									X													
sp.																																		X				
Bollandites bowsheri Gordon, n. sp.																										X		?										
kiligwae Gordon, n. sp.																																X						
cf. *B. sulcatum* Bisat																				X																		
Beyrichoceras micronotum (Phillips)															X	X																				X		
sp.																X																						
Goniatites crenistria Phillips														X	X	X					X															X		
cf. *G. sphaericus* (Sowerby)																																					X	
cf. *G. granosus* Portlock		?	X		?	X		X	X																													
Goniatites? spp.													X					X																				
Sudeticeras alaskae Gordon, n. sp.																			X																			
Neoglyphioceras sp.										X																												
Cravenoceras sp.												X																										
Girtyoceras arcticum Gordon, n. sp.															X																					X		
endicottense Gordon, n. sp.																										X												
Girtyoceras? spp.			X					X										X																				
Entogonites borealis Gordon, n. sp.															X														X							X		
Eothalassoceras aurorale Gordon, n. sp.																			X																			
Dimorphoceras algens Gordon, n. sp.															X																					X		
Protocanites? sp.																																			X			
Pronorites? sp.																					X																	

*U. S. National Museum locality number.

TABLE 2.—*Tentative correlation of the goniatite-bearing beds of northern and eastern Alaska*

	Northwest Europe					Brooks Range								
	Stages		Goniatite zones			Lower Noatak River basin	Western De Long Mountains	Eastern De Long Mountains	Ipnavik River basin	Etivluk River basin	Kiruktagiak River basin	Siksikpuk River basin	Anaktuvuk River basin	Eagle-Circle district
			British	German	Characteristic species									
Upper Carboniferous	Namurian	Lower	H	IIIδ	*Homoceras beyrichianum*									
			E_2		*Eumorphoceras bisulcatum*									Beds with *Cravanoceras* sp.
			E_1		*Eumorphoceras pseudobilingue*									
Lower Carboniferous	Viséan	Upper	P_2	IIIγ	*Goniatites granosus*									Beds with *Goniatites* cf. *G. granosus* and *Neoglyphioceras* sp.
			P_{1c-d}	IIIβ	*Goniatites sphaericostriatus*			—?—?— — Sandstone with *Goniatites* cf. *G. sphaericus*				Beds with *Sudeticeras* and *Eothalassoceras*		
			P_{1a}		*Goniatites crenistria*					Beds with *Goniatites crenistria*	Beds with *Goniatites crenistria* and *Beyrichoceras micronotum*			
		Middle	B_2	IIIα	*Beyrichoceras delicatum*			—?—?— — Beds with *Bollandites kiligwae*	Shale with *Bollandites* cf. *B. sulcatum*				Beds with *Bollandites bowsheri*	
			B_1		*Beyrichoceras hoderense*									
		Lower	S_1	IIδ	*Ammonellipsites carinatus*									
			C_2	IIγ	*Ammonellipsites kochi*									
				IIβ	*Ammonellipsites plicatilis*	—?—?— — Boulder with *Ammonellipsites* aff. *A. polaris* — — —?—	—?—?— — Shale with *Münsteroceras saginatum* —?—?— —	—?—?— — Shale with *Ammonellipsites polaris*						
	Tournaisian		C_1	IIα	*Ammonellipsites princeps*			—?—?— — Beds with *Münsteroceras* sp.						
			Z_2	Iβ	*Protocanites geigensis*			—?—?— —						
			Z_1	Iα	*Protocanites lyoni*									

In table 2 the goniatite-bearing beds of Alaska are correlated with the British and German goniatite zones on the basis of their nearest counterparts in the European section and without reference to their position in the Alaskan section. The results do not conflict materially with their actual stratigraphic position. The chart shows that the Brooks Range goniatites fall into two general age groups: those of early Mississippian age (late Tournaisian and early Viséan) in the western part of the range, and those of middle Mississippian age (middle and late Viséan) in the eastern De Long Mountains and the central part of the range.

Probably the oldest of the collections is that from Iligluruk Creek (USGS loc. 11877) in the western part of the De Long Mountains containing *Münsteroceras saginatum* Gordon, n. sp. The stratigraphic position of this fossil, 125 feet above the top of the Upper Devonian in a black shale regarded as pre-Lisburne in age by the field geologists, together with its similarity to an Irish species of late Tournaisian age, suggest that the enclosing beds are Tournaisian [Kinderhook] in age.

A collection from the Kiligwa River valley (USGS loc. 13240) in the eastern part of the De Long Mountains with *Münsteroceras* sp. is roughly equivalent to the last. It occurs stratigraphically below a collection of other invertebrates correlated by Dutro (1954, personal communication) with beds of late Tournaisian [Kinderhook] age. A collection from a higher part of

the same section (USGS loc. 13241) containing *Protocanites?* sp. may also be Tournaisian in age but the shell is too small and poorly preserved to permit positive generic assignment.

The black shales with *Ammonellipsites* (*Fascipericyclus*) *polaris* Gordon, n. sp. in the Kiligwa River basin (USGS loc. 11857) and the loose blocks containing *Ammonellipsites* (*Fascipericyclus*) aff. *A. polaris* in the lower gorge of the Noatak River (USGS loc. 12785) are roughly equivalent in age. The shape of the sutures in these shells indicate that they are more advanced than related forms in late Tournaisian beds of Europe. An early Viséan age is therefore indicated, although very late Tournaisian is also a possibility. A fragment of *Cycloceras* in the upper part of the Kayak shale on the Echooka River (USGS loc. 13110) seems to be conspecific with the *Cycloceras* sp. associated with *A. polaris* at USGS locality 11857. Other fossils show that the upper part of the Kayak shale is probably late Tournaisian or early Viséan in age (Dutro, 1954, personal communication).

The sandstone beds with *Goniatites* cf. *G. sphaericus* (Sowerby) in the Kiligwa River basin (USGS loc. 14153) and the shale beds with *Bollandites kiligwae* Gordon, n. sp. (USGS loc. 13204) are roughly equivalent to the black chert and shale member in the upper middle part of the Alapah limestone in the central Brooks Range, but the shale with *Bollandites* is probably the older of the two.

In the black chert, shale, and limestone of the structural belt between the Ipnavik and Etivluk Rivers, the cephalopods collected are equivalent to those of the black chert and shale member farther east. *Bollandites* cf. *B. sulcatum* Bisat from USGS locality 11818 is very close to the species originally described from Cowdale Clough, near Barnoldswick, Yorkshire, England, which Bisat (1952, p. 161) has referred to the upper part of the *Goniatites maximus* (B_2) zone, and the *Goniatites crenistria* Phillips from USGS locality 11828 appears identical with the typical form from the overlying *G. crenistria* (P_{1a}) subzone.

In the central part of the Brooks Range all of the cephalopods collected have come from the black chert and shale member. The composite fauna now known from this member is as follows:

Rayonnoceras? sp.
Michelinoceras dutroi Gordon, n. sp.
Bactrites? carbonarius Smith
Kionoceras? sp. C
sp. D
Dolorthoceras medium Gordon, n. sp.
Dolorthoceras? aff. *D. crebriliratum* (Girty)
Adnatoceras alaskense Gordon, n. sp.
Euloxoceras sp.
Endolobus sp.
Knightoceras pattoni Gordon, n. sp.
Stroboceras crispum Gordon, n. sp.
Bollandites bowsheri Gordon, n. sp.
Beyrichoceras micronotum (Phillips)
sp.
Goniatites crenistria Phillips
Sudeticeras alaskae Gordon, n. sp.
Girtyoceras arcticum Gordon, n. sp.
endicottense Gordon, n. sp.
Girtyoceras? sp. indet.
Eothalassoceras auroraale Gordon, n. sp.
Dimorphoceras algens Gordon, n. sp.

The beyrichoceratids have their closest counterparts in the upper part of the *Goniatites maximus* (B_2) zone of the British Isles. The rocks with *Goniatites crenistria* Phillips and associated cephalopods seem to be equivalent to the *G. crenistria* (P_{1a}) subzone. Of interest is the occurrence of *Beyrichoceras micronotum* (Phillips) with *G. crenistria* at two Alaskan localities. Most of the British records place *B. micronotum* in the *Goniatites maximus* (B_2) zone several tens of feet below the earliest occurrence of *G. crenistria*. In the borehole at Alport, north Derbyshire, England, abundant crushed goniatites including members of the *G. crenistria* and *B. micronotum* groups were found associated in dark shaly limestones at depths from 1,500 to 1,542 feet and these were referred to the uppermost part of the *Goniatites maximus* zone (Hudson and Cotton, 1945, p. 284, 285).

Sudeticeras alaskae Gordon, n. sp. appears to be nearest to *S. regina* Bisat from the *Goniatites elegans* (P_{1c}) subzone. *Sudeticeras* is not found in lower beds in England, but is rather common in the higher *Goniatites granosus* (P_2) zone.

In the British section, forms identical with and closely related to the Alaskan species of the black chert and shale member are distributed through stratigraphic thicknesses of from 150 to nearly 400 feet. In the northern Alaska section the fossils are, for the most part limited to the lower 60 feet of the black chert and shale member. Goniatites suggesting three different subzones (B_2, P_{1a}, and P_{1c}) have been found at roughly the same stratigraphic level, but each in a different river valley. Whether this means that the ranges of certain goniatite genera are somewhat telescoped in the Alaskan section, or whether the black chert and shale member transgresses the section rather irregularly, is not determinable on the basis of the present evidence.

Goniatites correlating with the *G. crenistria* (P_{1a}) subzone (zone IIIα of Schmidt) are widespread in Europe and North Africa. In the United States they occur in the Moorefield formation of Arkansas and the lower part of the Chainman shale in western Utah and eastern Nevada.

The *Goniatites granosus* (P_2) zone is represented only in the Eagle-Circle district in eastern Alaska. This is the uppermost zone of the Viséan stage of northwest Europe. Most typical of the Alaskan shells of this zone are *Goniatites* cf. *G. granosus* Portlock and *Neoglyphioceras* sp. As pointed out earlier, these fossils have been found in place in the lower middle part of the Calico Bluff formation.

Goniatites correlating with the *G. granosus* (P_2) zone (IIIγ of Schmidt) are widely distributed in Europe and in the United States occur in rocks of late Meramec and early Chester age; the Floyd shale of Georgia and Mississippi, in unidentified beds in Kentucky, in the Ruddell shale, Batesville sandstone, and lower part of the Fayetteville shale in Arkansas, in the lower part of the Caney shale in Oklahoma, in the Barnett and Helms formation in Texas, in the lower part of the Chainman shale in western Utah, and in the Brazer limestone of northern Utah and southern Idaho.

Goniatites of the *G. granosus* (P_2) zone have not yet been found in the Brooks Range. It is believed that this zone may be roughly equivalent to beds containing the brachiopod *Gigantoproductus* that lie above the black chert and shale member in the central part of the Brooks Range. *Gigantoproductus* has not been found in the upper of three divisions of the Lisburne group in the De Long Mountains, western Brooks Range. Both the *Gigantoproductus*-bearing beds and the upper of the three unnamed divisions lie above the highest occurrence of lithostrotionoid corals. In addition, both are at the top of the Lisburne group in their respective areas, indicating at least partial equivalence. *Rayonnoceras rangifer* Gordon, n. sp. from the upper division of the Lisburne group in the De Long Mountains occurs also associated with goniatites of the *G. granosus* (P_2) zone in the Eagle-Circle district. This is a further indication of the possible equivalence of the two stratigraphic units.

The only known goniatites of lower Namurian age in Alaska occur at an exposure on the north bank of the Yukon River in the Eagle-Circle district. The bed containing *Cravenoceras* sp. occurs near the middle of the exposure, but its exact stratigraphic relation to beds with *Goniatites* cf. *G. granosus* Portlock from the same exposure is not known.

In most sections over the northern hemisphere *Cravenoceras* follows *Goniatites* without overlap, but in the Barnett formation of Texas the two genera have been reported to occur together (Miller and Youngquist, 1948, p. 652, 656). Until proof to the contrary is available, the Alaskan occurrence is considered to be a typical one, without overlap of the stratigraphic ranges of the two genera. The bed with *Cravenoceras* sp. is believed to be equivalent to the earliest Namurian goniatite zone of England, the *Eumorphoceras pseudobilingue* (E_1) zone. Thus the Calico Bluff formation probably includes beds both of upper Viséan and lower Namurian age, as do various black shale and limestone units in the continental United States, such as the Fayetteville shale of Arkansas, Floyd shale of Georgia, Caney shale of Oklahoma, Barnett formation of Texas, and Chainman shale of Utah and Nevada.

MISSISSIPPIAN CEPHALOPOD COLLECTING LOCALITIES IN ALASKA

[Coordinates given below are based on the latest topographic mapping and do not necessarily agree with those at locations shown on index maps]

U. S. Geol. Survey upper Paleozoic locality	Collector's field No.	Collector, year of collection, description of locality and stratigraphic information
843 [1]		E. M. Kindle and V. H. Barnett, 1906. Eagle-Circle district, Calico Bluff formation, horizon not known.
1797A [2]	1504D	Elliott Blackwelder, 1915. North bank of the Yukon River at big bend north of Calico Bluff, 2 miles upstream from Star. Calico Bluff formation, horizon not known.
2644A	9K	V. H. Barnett, 1906. Eagle-Circle district, Calico Bluff, Yukon River. Calico Bluff formation, bed 1 of A. H. Brooks' section (G. S. A. Bull., vol. 19, p. 288, 1908).
3586 [3]	4AC17	A. C. Collier, 1904. Cape Lisburne district, 3 miles southeast of camp 4, near Wevok. Lisburne group, from dark gray shale.
5279	75	G. H. Girty, 1918. Eagle-Circle district, bank of the Yukon River nearly opposite Seventy-Mile River. Calico Bluff formation, loose blocks along river probably all from middle two-fifths of exposure.
5302	73	G. H. Girty, 1918. Eagle-Circle district, south end of Calico Bluff, Yukon River. Calico Bluff formation, in place 440 feet above river level.
5303	74	G. H. Girty, 1914. Eagle-Circle district, north end of Calico Bluff, Yukon River. Calico Bluff formation, fossils from talus.
5843	25AMt134	J. B. Mertie, Jr., 1925. Eagle-Circle district, Calico Bluff, Yukon River. Calico Bluff formation, just below base of zone *b*, about 300 feet above base of formation.

See footnotes at end of table.

MISSISSIPPIAN CEPHALOPOD COLLECTING LOCALITIES IN ALASKA—Continued

[Coordinates given below are based on the latest topographic mapping and do not necessarily agree with those at locations shown on index maps]

U. S. Geol. Survey upper Paleozoic locality	Collector's field No.	Collector, year of collection, description of locality and stratigraphic information
5843C [2]	25AMt137	J. B. Mertie, Jr., 1925. Eagle-Circle district, Calico Bluff, Yukon River. Calico Bluff formation, 41 feet above top of zone *c*, 418 feet above base of formation.
5867	2AC53	A. J. Collier, 1902. Eagle-Circle district, cliff on west bank of Yukon River at bend 6 miles above mouth of Seventy-Mile River. Calico Bluff formation, horizon not known.
6841	30AMt4	J. B. Mertie, 1930. Tatonduk-Nation district, shale bluff a quarter of a mile west of limestone point on north side of Tatonduk River, about 2½ miles from mouth. Calico Bluff formation, stratigraphic position not known.
6846a	30AW80	A. E. Waters, Jr., 1930. Tatonduk-Nation district, bench 2 miles northeast of Miller's cabin at mouth of Tatonduk River. Calico Bluff formation, argillaceous limestone overlying calcareous shale.
6846b	30AW81	A. E. Waters, Jr., 1930. Tatonduk-Nation district, same locality as 6846a. Calico Bluff formation, shale overlying argillaceous limestone of 6846a.
9188	45AGr16	G. Gryc, 1945. Brooks Range, Chandler Lake quadrangle, lat. 68°25′25″ N., long. 152°49′09″ W., west bank of Kiruktagiak River at the narrows 9½ miles southwest of its confluence with Castle Creek. Alapah limestone, middle part, from lenses and nodules of petroliferous limestones in a 50-foot section of bituminous shale.
10348	1 of 7/22/40	J. S. Williams, 1940. Eagle-Circle district, Yukon River at Calico Bluff, approximate lat. 64°55′ N., long. 141°12′ W., float from steep talus slope below lowest trees at north end of bluff, from Calico Bluff formation.
10251	2 of 7/23/40	J. S. Williams and H. Biederman, 1940. Eagle-Circle district, Yukon River, northeast bank about 16 miles below Eagle, at bend about 1 to 1½ miles upstream from mouth of Seventymile River, approximately at lat. 64°57′ N., long. 141°12′ W. Calico Bluff formation, float from bed near middle of exposure.
10864	49APa390	W. W. Patton, Jr., 1949. Brooks Range, Chandler Lake quadrangle, lat. 68°22′45″ N., long. 152°53′05″ W., on the Kiruktagiak River, 13 miles southwest of its junction with Castle Creek. Alapah limestone, black chert and shale member, fossiliferous limestone concretions and lenses in dark gray calcareous shale, a 40-foot unit 8 feet above base of member.
10866	49APa399	W. W. Patton, Jr., 1949. Brooks Range, Chandler Lake quadrangle, lat. 68°25′25″ N., long. 152°49′09″ W., west bank of Kiruktagiak River at the narrows 9½ miles southwest of its confluence with Castle Creek. Alapah limestone, middle part, from calcareous concretions in black phosphatic shale. Approximately same locality as 9188.
10883	48ASt123a	K. Stefansson, 1948. Brooks Range, Chandler Lake quadrangle, lat. 68°17′ N., long. 152°40′ W., mountains at north end of Chandler Lake. Alapah(?) limestone, lower middle part of a 576-foot section.
11764	F–7 of 11 June	A. L. Bowsher and G. Gryc, 1950. Brooks Range, Chandler Lake quadrangle, lat. 68°17′ N., long. 151°33′ W., dip slope of hill on west side of Anaktuvuk River valley. Alapah limestone, black chert and shale member, near top.
11804	50ARrF59	H. N. Reiser, 1950, Brooks Range, Chandler Lake quadrangle, lat. 68°15′ N., long. 151°50′ W., Siksikpuk River valley southern part, Alapah limestone, middle part, 525 feet below top of measured section B–19, and 60 feet above base of black chert-shale member.
11818	50AKt89	B. N. Kent, 1950. Brooks Range, Howard Pass quadrangle, lat. 68°37′ N., long. 156°52′ W., roughly 2 miles south of Lisburne Ridge, 4 miles northeast of Ekakevik Mountain, and 8 miles east of the Ipnavik River. Alapah limestone, calcareous concretions in an outcrop of black cherty shale, exact stratigraphic position not known, but roughly along strike from locality 11828.
11828	50ATr45	I. L. Tailleur, 1950. Brooks Range, Howard Pass quadrangle, lat. 68°35′ N., long. 156°38′ W., about 4 miles south of Lisburne Ridge and 2½ miles northwest of junction of Etivluk and Nigu Rivers. Alapah limestone, isolated outcrop of hard calcareous shale (8 feet thick) overlying thin-bedded black chert (10 feet thick).
11857	50ATr300	I. L. Tailleur, 1950. Brooks Range, Howard Pass quadrangle, eastern part of the DeLong Mountains, near a tributary creek on the west side of the east fork of the Kiligwa River. Lisburne group undifferentiated, calcareous nodules in platy shale, in an 125-foot isolated section.
11865	50ASa150f	E. G. Sable, 1950. Brooks Range, Misheguk Mountain quadrangle, lat. 68°33′32″ N., long. 161°17′45″ W., near head of Kogruk Creek (west fork of Utukok River). Lisburne group undifferentiated, from interbedded, finely laminated, black chert and limestone in the upper part.
11867	50ASa236f	E. G. Sable, 1950. Brooks Range, Misheguk Mountain quadrangle, lat. 68°33′22″ N., long. 161°10′15″ W., near headwaters of Utukok River. Lisburne group undifferentiated, lower part, interbedded dark gray silty limestone and quartzite, approximately 600 feet below top of lowest of three unnamed stratigraphic units.

MISSISSIPPIAN CEPHALOPOD COLLECTING LOCALITIES IN ALASKA—Continued

[Coordinates given below are based on the latest topographic mapping and do not necessarily agree with those at locations shown on index maps]

U. S. Geol. Survey upper Paleozoic locality	Collector's field No.	Collector, year of collection, description of locality and stratigraphic information
11877	50ASa202f	E. G. Sable, 1950. Brooks Range, Misheguk Mountain quadrangle, lat. 68°34′57″ N., long. 161°14′50″ W., south side of easternmost tributary of east fork of Iligluruk Creek. Mississippian undifferentiated, dark gray shale, probably 125 feet above base of Mississippian.
12084	F–3 of 12 June	A. L. Bowsher, 1950. Brooks Range, Chandler Lake quadrangle, lat. 68°18′ N., long. 151°21′ W., Anaktuvuk River valley, on ridge 1,500 feet east of Kanaktuk Lake. Alapah limestone, middle part, interbedded grayish black shale, fine-grained limestone nodules and black chert, 43 feet above base of black chert-shale member.
12785	11AS77	P. S. Smith, 1911. Noatak quadrangle, lat. 67°11′30″ N., long. 162°30′ W., near north end of lower gorge of Noatak River. Lisburne (?), group, loose limestone block.
12787	51ASa1064f	N. Drewes, 1951. Brooks Range, Misheguk Mountain quadrangle, lat. 68°37′35″ N., long. 160°14′20″ W., on north bank of Nuka River, Mississippian undifferentiated, sandstone and shale in fault block, stratigraphic position not known.
12870	51ABe7	W. P. Brosgé, 1951. Brooks Range, Chandler Lake quadrangle, lat. 68°22′52″ N., long 152°53′40″ W., Monotis Creek about ½ mile from its confluence with the Kiruktagiak River. Alapah limestone, black chert and shale member, from approximately same horizon as 10864.
13100	50ALa180f	A. H. Lachenbruch, 1950. Brooks Range, Misheguk Mountain quadrangle, lat. 68°24′45″ N., long. 161°16′ W., south slope of westerly trending ridge between two forks of the Kugururok River, about 2¼ miles N. 10° E. of their junction. Lisburne group, lowest of three unnamed subdivisions, exact stratigraphic position not known.
13110	52ABe17f	W. P. Brosgé, 1952. Brooks Range, Sagavanirktak quadrangle, lat. 69°15′ N., long. 147°15′ W., west bank of the Echooka River, Kayak shale, 30 feet below top, black shale and argillaceous limestone.
13204	51ATr319	I. L. Tailleur, 1951. Brooks Range, Howard Pass quadrangle, lat. 68°31′ N., long. 158°29′ W., in cut banks on east fork of Kiligwa River, roughly 3 miles from headwaters. Alapah limestone, concretions in interbedded black chert and shale member about 500 feet below top of exposed section.
13236	51ATr352	I. L. Tailleur, 1951. Brooks Range, Howard Pass quadrangle, lat. 68°20′ N., long. 157°42′ W., on tributary of Kuna River, about two miles from headwaters. Wachsmuth (?), limestone, 185 feet above base of measured section.
13240	51ATr392	I. L. Tailleur, 1951. Brooks Range, Howard Pass quadrangle, lat. 68°32′ N., long. 158°51′ W., northward-trending ridge of DeLong Mountains between tributaries of the two major forks of Kiligwa River. Lisburne group undifferentiated, about 440 feet stratigraphically below base of 105-foot thick sill.
13241	51ATr393	I. L. Tailleur, 1951. Brooks Range, Howard Pass quadrangle, same general locality as 13240. Lisburne group undifferentiated, limestone about 30 feet above top of 105-foot sill of igneous rock.
14149	53APa103	W. W. Patton, Jr. and A. L. Bowsher, 1953. Brooks Range, Chandler Lake quadrangle. Same locality and horizon as 10864.
14153	53ASa52f	E. G. Sable, 1953. Brooks Range, Misheguk Mountain quadrangle, lat. 68°37′ N., long. 159°12′ W., east side of west branch of west fork of Kiligwa River, near its headwaters in De Long Mountains. Mississippian undifferentiated, unnamed sandstone, exact stratigraphic position not known.
-USNM 3167.	F–6 of 24 July	A. L. Bowsher and J. T. Dutro, Jr., 1949. Brooks Range, Chandler Lake quadrangle, lat. 68°22′30″ N., long. 150°28′25″ W., on west slope of ridge east of Nanushuk River valley, 6,200 feet south of southeast corner of Nanushuk Lake. Alapah limestone, lower part, basal 15 feet of brownish-gray bioclastic limestone, just above brown-weathering zone, 312 feet above base of formation.

[1] U. S. Geological Survey collection number from E. Kirk register of Paleozoic localities (white paper labels).
[2] Cephalopods from this locality too poorly preserved for description. Not included in systematic part of text.
[3] U. S. Geological Survey collection number from Walcott register (green paper labels).

SYSTEMATIC DESCRIPTIONS

Genus RAYONNOCERAS Croneis, 1926

Rayonnoceras rangifer Gordon n. sp.

Plate 1, figs. 1, 2, 9; text fig. 7

Diagnosis: *Rayonnoceras* with the conch expanding 1 in 6 or 7, approximately circular in cross section, with 2.7 camerae per shell diameter; siphuncle excentric; connecting rings longer than wide; cameral deposits thick, partly filling the chambers and meeting dorsad to form pseudosepta.

Four incomplete phragmacones from two localities roughly 600 miles apart are referred to this species. They have unusually long chambers and differ from typical *Rayonnoceras* in their longer than wide connecting rings. The shells appear to be conspecific, despite considerable difference in size and in medium of preservation.

The holotype, a silicified fragment from a locality in the western part of the Brooks Range, is 86 mm long and includes a little more than four chambers. The three orad chambers are partly collapsed on the ventral side, as is shown somewhat diagrammatically in text figure 7. The shell is approximately circular in cross section, the diameter at the narrow end about 53 mm. Owing to the partly collapsed shell, it is difficult to determine the increase in diameter during growth, but the rate is gradual, probably between 1 in 6 and 1 in 7. The siphuncle is located about a third of the way across the shell. The shell surface, judging from small silicified fragments remaining, is smooth.

FIGURE 7.—*Rayonnoceras rangifer* Gordon, n. sp. Diagrammatic vertical section of the holotype (USNM 118931) showing siphuncular connecting rings (*cr*), remains of the endosiphuncle (*e*), silicified episeptal (*es*) and hyposeptal (*hs*) cameral deposits, and pseudosepta (*p*). Chamber walls at the left or dorsal side are nearly intact, but at the right, are crushed. Natural size.

The septa are saucer shaped, their concavity approximately equal to the length of one chamber. At a diameter of 55 mm, they are 20.2 mm apart and about 20 mm deep. The camerae are spaced approximately 2.7 to one lateral diameter of the conch. In the farthest apicad chamber the siphuncle has a maximum diameter of 17 mm narrowing to 8.6 mm at the septum; the connecting ring is 19.5 mm long and the septal neck 2.0 mm long. The siphuncle is badly macerated in the two orad camerae and in the orad part of the third. The calcite-filled endosiphuncle appears distorted, possibly partly due to the silicification of its wall after burial, and also partly as the result of collapse of a portion of the ventral side of the shell due to postdepositional compaction of the enclosing sediments. Its diameter in the farthest apicad chamber, where it is best preserved, ranges from 2.8 to 3.7 mm. Several short thornlike rayonnettes extend from it into siphuncular segments. Very thick hyposeptal and episeptal cameral deposits, filling most of the camerae and rounding toward the siphuncle, have been largely replaced by chalcedony in the specimen. Between these deposits in the dorsad part of the chambers irregular pseudosepta are present. The remaining spaces between these deposits and the silicified siphuncular segments are filled with crystalline calcite.

The paratypes are smaller shells than the holotype. The larger one (USNM 118992), about 150 mm long and with a maximum diameter of approximately 30 mm, has been preserved in part in limonite. The conch expands at a rate of 1 in 7.3. Approximately 2.4 camerae occur in the space of one diameter of the conch. The siphuncle is one-third of the way from the ventral to the dorsal side of the shell and, at the widest part of each connecting ring, is approximately one third the diameter of the shell. The figured section of the apicad part of the phragmacone (pl. 1, fig. 9) shows the saucer-shaped septa, the longer-than-wide connecting rings, the endosiphuncle, and the cameral deposits typical of *Rayonnoceras*.

The second paratype has not been sectioned. It is a fragment of a phragmacone, approximately 40 mm long and 16 mm across the greater width at the wider end, slightly depressed dorso-ventrally, probably due to compaction after burial. There is little doubt that it is conspecific with the other paratype.

A third specimen from Calico Bluff (USGS loc. 10248) that superficially resembles the paratypes is included here with some question. It differs in having 3.8 camerae in the space of one shell diameter and a surface sculpture of faint, slightly sinuous transverse lirae. The siphuncle has been damaged before or during burial so that its original outline cannot be ascertained and

hyposetal and episeptal cameral deposits, although present, are rather thin.

Rayonnoceras rangifer can be distinguished from all other known species of the genus by its connecting rings that are longer than wide.

Holotype, USNM 118931; paratypes, USNM 118992, 118993, one specimen from each of two additional localities.

Type locality: USGS locality 11865, upper part of the Lisburne group, at head of west fork of Utukok River, Brooks Range. Paratypes are from USGS locality 2644A and locality 843 (E. Kirk USGS register), both from the Calico Bluff formation, Calico Bluff, Yukon River, Eagle-Circle district.

Occurrence: Known from the type locality and from Calico Bluff, Yukon River, Eagle-Circle district.

Rayonnoceras? sp.

Plate 1, figs. 7, 8

A single fragment, approximately 74 mm long, of the living chamber and the final septum of the phragmacone is tentatively assigned to the genus *Rayonnoceras*. The shell, nearly circular in outline, increases from a width of about 65 mm near the narrow end to a width of about 71 mm at the wide end in a distance of 51 mm, or 1 in 8.5. The septum is saucer shaped, 17 mm deep, and meets the edge of the shell at an angle of 145 degrees.

The specimen has been sectioned but shows no trace of the siphuncle or of other septa. An indistinct roughly circular gap in the final septum, about 12 mm across and a little over two fifths of the distance across the shell, is believed to mark the position of the siphuncle. Parts of the outer shell remaining are somewhat abraded but indicate that the shell surface was smooth.

Not enough of the shell remains to identify the species, or even the genus, with complete assurance, the generic assignment being made principally on the basis of size. Nor can it be said with certainty that this fragment does not represent the same species described in this paper as *Rayonnoceras rangifer*, n. sp., although there are minor differences in the position of the siphuncle and the rate of increase of the diameter of the shell.

Figured specimen: USNM 118932.

Occurrence: USGS locality 10866, associated with *Goniatites crenistria* Phillips in the black chert and shale member of the Alapah limestone, west side of Kiruktagiak River, 9½ miles southwest of its junction with Castle Creek, Brooks Range.

Genus Michelinoceras Foerste, 1932

Michelinoceras dutroi Gordon, n. sp.

Plate 1, figs. 3–6

Diagnosis: A very slender orthoconic nautiloid with roughly 2 to 3 camerae per shell diameter, a narrow subcentral orthochoanitic siphuncle, and prominent episeptal and hyposeptal deposits lining and almost completely filling the camerae.

The holotype is part of a phragmacone approximately 45 mm in length, the orad third preserved only as an external mold, but the rest containing the calcareous cast. The specimen has been sectioned. The conch with a diameter near the apicad end of about ½ mm, expands very gradually about 1 mm in 15 or 16. The septa are saucershaped, their depth equal to about one-third of the shell diameter. The camerae are irregularly spaced, individual camerae ranging from 1.2 to 3.0 per shell diameter, with the average in most sections of the conch upwards of 2.3. Siphuncle narrow, orthochoanitic, pinching and swelling slightly, somewhat excentric in the early chambers but shifting to an almost central position in the later ones. At a shell diameter of 2.4 mm the siphuncle is 0.3 mm wide. Septal necks are short, indistinct, and not recurved. Narrow brownish siphuncular deposits are rather irregularly discontinuous along both sides of the sectioned siphuncle. Camerae are nearly filled with thin-layered episeptal and hyposeptal deposits.

A paratype shows the sutures to be faintly sinuous and very slightly inclined. Details of shell surface are not preserved, but apparently the shell was smooth, or nearly so. In cross section the shell is slightly compressed laterally, but this may be due to distortion after burial.

Few species referable to *Michelinoceras* are known from Mississippian rocks but much work remains to be done on the Mississippian orthoceracones and their proper generic assignments. The Caney shale species, *Orthoceras wapanuckense* Girty, apparently belongs in this genus, as indicated by sections of specimens from Girty's type material. It is a larger species than *Michelinoceras dutroi*, with consistently higher camerae, from about 1.2 to 1.8 per shell diameter, a more regularly cylindrical siphuncle, and it lacks the episeptal and hyposeptal cameral deposits of *M. dutroi*.

M. dutroi is named for J. T. Dutro, in recognition of his contribution to the stratigraphy and paleontology of the central Brooks Range.

Holotype, USNM 118990; paratype, USNM 118991.

Type locality: USGS locality 11764, dip slope of hill on west side of Anaktuvuk Valley, near top of measured section, from black chert and shale member of Alapah limestone.

Occurrence: Known only from the type locality where it occurs associated with *Dolorthoceras medium* Gordon? and unidentifiable goniatites.

Genus BACTRITES Sandberger, 1843

Bactrites? carbonarius Smith

Plate 1, figs. 10–13

1903. *Bactrites carbonarius* Smith, U. S. Geol. Survey, Mon. 42, p. 31, 32, pl. 6, figs. 9–11.

1911. *Bactrites? carbonarius* Smith. Girty, U. S. Geol. Survey, Bull. 439, p. 96, pl. 13, figs. 3–5.

?1928. *Orthoceras carbonarium* (Smith). Thomas, Geol. Mag., v. 65, p. 290, pl. 10, figs. 3, 3a.

Diagnosis: Orthoceracone with circular cross section and marginal siphuncle; angle of divergence 4 or 5°; approximately 1½ camerae per diameter. Shell surface sculptured by slightly oblique growth lines crossed by very faint longitudinal grooves.

Two incomplete specimens from the *Goniatites crenistria* beds on the Kiruktagiak River are believed to be conspecific with Smith's Arkansas species. Both specimens are slightly elliptical in cross section, probably due to distortion after deposition, as the narrower one is nearly circular on one end and partly crushed on the other. The better preserved specimen, the one figured, is 55 mm long. Near the narrow end its maximum and minimum diameters are 18.2 mm and 17.0 mm, respectively, and near the wide end, 21.5 and 20.6 mm. The average diameter increases 3.5 mm in a distance of 42 mm, or 1 in 12, the angle of divergence being approximately 4°. The septa are spaced 15 mm apart and are 6 mm deep. On the narrower specimen the septa are 8.5 mm apart at a diameter of 11.5 mm. Thus there are approximately 1½ camerae per diameter on both specimens.

The siphuncle is at the margin of the septa tangent to the inner surface of the conch. It has an outside diameter of 2.0 mm. The suture is nearly straight, with a shallow apicad deflection at the siphuncle.

Much of the shell surface is preserved on the wider specimen. It is marked by faintly sinuous, slightly oblique lines of growth that are farthest apicad on the siphonal side and farthest orad on the antisiphonal side of the conch. These are crossed by faint longitudinal grooves that in places give the shell surface a minutely reticulate appearance. On the narrower specimen longitudinal striae can be seen only locally.

A reexamination of Smith's types of *Bactrites? carbonarius* in the paleontological type collection of Stanford University discloses that the holotype (LSJU 5610), like the Alaska specimens, has very faint longitudinal grooves, not mentioned by Smith in his original description. The paratype (LSJU 5611), a decoricated fragment of a phragmacone, has the septa spaced about 8 mm. apart at a diameter of 12.5 mm, thus there are 1.6 camerae per diameter. Smith (1903, p. 31) described the angle of divergence of *B.? carbonarius* as 5°30′. Although this is true for the apicad end of the holotype, the orad part has subparallel sides and the small paratype has an angle of divergence of about 4° or, stated in another way, the rate of increase of the diameter is about 1 in 12. The Alaskan shells fit easily within this range of variation.

Several fragments of the crushed body chambers have a distinct pattern on both the internal and external surfaces of the shell. The figured fragment shows both patterns clearly, the inner one impressed on the surface of the internal cast. The exterior of the shell is ornamented by faint closely spaced growth lines, crossed by very shallow longitudinal grooves, of which there are 13 to 15 in the space of 5 mm. The interior of the shell is decorated by closely spaced minutely wavy transverse striae that give the effect of an "inner lining" to the shell. The shell material as preserved is about 0.3 mm thick.

The external markings coincide with those of *Bactrites? carbonarius* Smith as described above and the figured specimen comes from the same locality, but was collected in a different year by a different collector. Similar internal markings, but oriented diagonally, have been observed by the writer in another species of *Bactrites?* associated with *Goniatites choctawensis* Shumard from the lower part of the Caney shale in northeast Oklahoma. These markings apparently are developed on the body chamber and the orad part of the phragmacone.

It seems likely that the fragments of Alaskan shells marked in this manner are parts of the body chamber of *Bactrites? carbonarius* Smith and they are referred here with question.

There has been considerable question among students of the cephalopods as to whether Carboniferous and Permian species assigned to the genus *Bactrites* are ammonoids or nautiloids. Thomas (1928, p. 290) placed *B. carbonarius* in the genus *Orthoceras* because characters other than the marginal position of the siphuncle, "particularly the siphuncle itself, indicate the relations of the present species with the Nautiloidea and not with the Ammonoidea." Girty (1909, p. 52) assigned *B. carbonarius* Smith and a couple of other species with considerable question to *Bactrites*, stating, "I should judge that what is regarded as a lobe in *Bactrites* is not homologous with the deflection of the suture which J. P. Smith regards as a lobe in the Carboniferous species."

The writer is among those who consider *B.? carbonarius* and related species to be nautiloids with marginal siphuncles and follows Miller and Youngquist (1949, p. 32, 33) in tentatively assigning the genus *Bactrites* to the Nautiloidea and questionably assigning the North American Carboniferous and Permian species to the genus *Bactrites*.

Figured specimen: USNM 118945, 118946.

Occurrence: In association with the wide form of *Goniatites crenistria* Phillips at USGS locality 9188, black chert and shale member of the Alapah limestone, west side of Kiruktagiak River, 9½ miles southwest of its junction with Castle Creek, Brooks Range.

Internally striated fragments referred with question to this species occur at three localities, associated with *Goniatites crenistria* Phillips in the Alapah limestone: USGS locality 10864, Kiruktagiak River, 13 miles southwest of its junction with Castle Creek; USGS locality 10866, same as 9188; USGS locality 11828, Etivluk River valley; Brooks Range.

Genus CYCLOCERAS McCoy, 1844

Cycloceras sp.

Plate 2, fig. 11

Orthoconic cephalopods with annulations and fine transverse lirae are rare in the Alaskan collections under study. There are only two such specimens, from localities about 280 miles apart; these may belong to a single species.

The better preserved fragment, the one figured, is about 30 mm long and consists of the last five camerae of the phragmacone and part of the body chamber, and is ornamented by seven annulations. The conch is slightly depressed in cross section and at the narrow end of the fragment has a diameter of 11.5 mm from venter to dorsum and 12.1 mm from side to side. The septum farthest apicad is about 3 mm deep. There are four camerae in the space of 9.8 mm at the narrow end, or about five camerae in the space of one diameter. The suture appears faintly sinuous, but is approximately horizontal.

Annulations are spaced on an average of 4.2 mm apart and are slightly sinuous. They slope shallowly orad toward the antisiphonal side, a plane roughly parallel to the annulation crossing the plane of the suture at an angle of a little less than 5°. The annulations are sharply convex in cross section and the spaces between are broadly concave. The surface of the shell is marked also by fine transverse lirae, of which there are 15 or 16 between the crests of two adjacent annulations, more closely spaced on the annulations than in the depressions between.

The subcylindrical siphuncle is 1.5 mm in diameter where it passes through the septum farthest apicad and its center is 4.7 mm in from the venter. Preservation does not permit determining whether the siphuncle is crytochoanitic or orthochoanitic.

The second specimen is a crushed fragment about 70 mm long and reaching a width (distorted) of 33 mm. Fourteen narrow elevated annulations are present, most of them spaced 4.2 mm apart. At least two more at one end apparently did not develop. At one end can be seen faint transverse lirae.

As Flower (1943, p. 103, 124, 126) has pointed out, the siphuncle of the type species of *Cycloceras*, *Orthoceras annulare* Fleming, is not known, so the genus remains in rather doubtful standing. Most of the Mississippian species that have been referred to *Cycloceras* have cyrtochoanitic siphuncles. The assignment of this species to *Cycloceras*, therefore, is tentative. Apparently the Alaskan shell does not belong to the genus *Neocycloceras* Flower and Caster, 1935, which was erected for similar shells that have nummuloidal siphuncles.

Figured specimen: USNM 118933.

Occurrence: USGS locality 11857, associated with *Ammonellipsites (Fascipericyclus) polaris*, n. sp., in platy shale, near a tributary creek on the west side of the east fork of the Kiligwa River, eastern part of the De Long Mountains; USGS locality 13110, in black shale and argillaceous limestone, 30 feet below top of the Kayak shale, west bank of the Echooka River, Brooks Range.

Genus KIONOCERAS Hyatt, 1884

Kionoceras? sp. A

Plate 2, figs. 1–4

Two small longitudinally ribbed orthoconic cephalopods from the lower part of the Lisburne group at localities about ten miles apart are referred to *Kionoceras*. Although similar in size and number of ribs, there appear to be differences in outline and sculpture, and it is not clear if the two represent the same species.

One specimen (pl. 2, figs. 3, 4) is a fragment about 27 mm long, slightly depressed in cross section, increasing from diameters of 8.7 × 9.3 mm to 10.2 × 10.6 mm in a distance of 18 mm, or about 1 in 11. The fragment apparently is the orad part of the body chamber, as no septa can be seen and the larger end terminates in what appears to be the orad edge of the shell. Surface sculpture is well preserved on one side, almost obliterated on the other. There are nine longitudinal ridges on this side, very narrow, angular, and only slightly raised, separated by much wider flattish interspaces, each with a faintly convex longitudinal area in the middle on which can be seen faint longitudinal striae. These are crossed by very slightly oblique transverse striae, rather straight across the interspaces and directed very slightly apicad where they cross the ribs. There are 11 transverse striae in the space of 1 mm.

The other specimen (pl. 2, figs. 1, 2) is 32 mm long, circular in cross section, with a diameter of 7.7 mm at the apicad end, increasing in diameter 1 mm in 15, with a broad shallow constriction near the orad end. This apparently consists of the final septum and apicad part of the body chamber. The one septum is 1.8 mm deep and shows the location of the siphuncle, 1 mm in diameter, the center of which is 3 mm from the ventral side. The conch is marked by 20 nearly straight, narrow longitudinal ridges, with wide flattish interspaces. No fine surface sculpture can be seen.

Figured specimens: USNM 118934, 118935.

Occurrence: USGS locality 11867, dark gray silty limestone interbedded with quartzite, near headwaters of the Utukok River; USGS locality 13100, south slope of westerly-trending ridge between two forks of Kugururok River, about 2¼ miles N. 10° E. of major fork, Brooks Range.

Kionoceras? sp. B

Plate 2, fig. 12

Another longitudinally lirate orthoconic cephalopod differs in its greater rate of expansion of the conch and finer longitudinal sculpture from the last described. It is a small fragment of the apicad end of a phragmacone, about 12 mm long, increasing in diameter from 0.7 mm to 2.3 mm in a distance of 10 mm, or about 1 in 6. The whorl section appears slightly depressed, but the specimen may be partly crushed. There are 7 camerae in the space of 5.7 mm at an average diameter of 1.2 mm, or approximately 1½ camerae per diameter. The surface of the conch is ornamented by fine straight longitudinal lirae of which, near the orad end, there are about nine in the sector constituting one quarter of the whorl. These are crossed by very fine transverse striae. The siphuncle is not known.

Figured specimen: USNM 118936.

Occurrence: USGS locality 12785, Lisburne (?) group from a loose limestone block in the lower Noatak River valley, Brooks Range.

Kionoceras? sp. C

Plate 2, figs. 15, 16

Several fragments of the body chambers of orthoconic cephalopods have a finely reticulate sculpture pattern similar to that of *Protokionoceras* Grabau and Shimer. Flower (personal communication, April 1954) has suggested to the writer that, in the absence of specimens showing the nature and structure of the siphuncle, such fragments should be referred with question to the genus *Kionoceras*.

The best preserved specimen is a partly crushed section of a body chamber, about 50 mm long, with a circumference of about 80 mm at the narrow end. The rate of expansion of the shell is about 1 in 4½. There are a number of closely spaced transverse lines and coarser lirae of growth, nearly horizontal and forming a shallow sinus on one side, probably the ventral. These are crossed by stronger, almost imperceptibly wavy longitudinal lirae with wider interspaces, of which there are approximately 35 in the space of 5 mm.

Whether this fragment belongs to *Kionoceras*, *Protokionoceras*, *Palmeroceras*, or any of another half dozen similarly ornamented genera cannot now be determined, owing to the absence of any part of the phragmacone. But the pattern of the surface sculpture is distinctive and does not appear on any of the Alaskan orthoceracones of which the phragmacone is known.

Figured specimen: USNM 118942.

Occurrence: With *Goniatites crenistria* Phillips in the black chert and shale member of the Alapah limestone at USGS locality 10866, on the west bank of the Kiruktagiak River, 9½ miles southwest of its junction with Castle Creek, Brooks Range.

Kionoceras? sp. D

Plate 2, figs. 17, 18

Associated with *Kionoceras* sp. C is another fragment of the body chamber of an orthoconic cephalopod, showing a slightly different pattern of surface sculpture. On this shell the sculpture consists of closely spaced transverse lamellae that are crenulated in discontinuous longitudinal rows resembling lirae. Both the transverse lamellae and the longitudinal rows of crenulations are spaced approximately 18 in 5 mm, but the lamellae are stronger.

It seems unlikely that the fragment with this sculpture pattern belongs in the same species as the one described as *Kionoceras*? sp. C, which has longitudinal lirae much stronger than the transverse sculpture and about twice as closely spaced as those of *Kionoceras*? sp. D. It is even possible that the two shells do not belong in the same genus, but in the absence of any part of the phragmacone, there is no way of telling.

Figured specimen: USNM 118943.

Occurrence: USGS locality 10866, black chert and shale member of Alapah limestone, Kiruktagiak River, 9½ miles southwest of its junction with Castle Creek, Brooks Range.

Genus DOLORTHOCERAS Miller 1931

Dolorthoceras medium Gordon n. sp.

Plate 2, figs. 14, 21

Diagnosis: *Dolorthoceras* with shell expanding roughly 1 in 7 or 8, a little over 2½ chambers per diameter. Siphuncle about one-sixth of shell diameter and subcentral.

The holotype is a part of a phragmacone about 40 mm in length. The conch, straight, and approximately circular in cross section, expands gradually from a diameter of 9.0 mm to 13.0 mm in a distance of 32 mm, or 1 in 8. The saucer-shaped septa are moderately shallow, their depth about two-sevenths of their diameter. There are 2.6 camerae per diameter near the middle of the specimen. The sutures are nearly horizontal. Surface sculpture consists of very fine sinuous growth striae.

The cyrtochoanitic siphuncle is subcentral, at a shell diameter of 10.4 mm having its center 4.7 mm from the ventral edge of the conch. Its greatest diameter is approximately one-sixth of the shell diameter. The

segments of the siphuncle are subcylindrical; at a shell diameter of 9.8 mm the connecting ring has a maximum diameter of 1.6 mm and a length of 3.5 mm and the opening between the short, strongly recurved septal necks is 0.7 mm across. The area of adnation is a little narrower than the septal brim. In the holotype the siphuncle is filled with impure calcite grains and the chambers outside of the siphuncle are filled mostly with chert; siphuncular and cameral deposits cannot be distinguished.

In the paratype, part of a phragmacone nearly 80 mm in length, connecting rings are visible only in the younger whorls. Silicification has affected the outer parts of the camerae adjacent to the septa. In the apicad part of the specimen camerae are spaced 3.4 in one diameter of the shell.

Another specimen is referred with some question to this species. It is the apical end of a phragmacone, a fragment 40 mm long, and has the camerae spaced about 3.4 in one shell diameter. Bluntly rounded at the tip, it is 1½ mm wide near the end and expands gradually at a rate of 1 mm in 8.5. The siphuncle appears cyrtochoanitic, with subcylindrical segments, but the septa have been disturbed and recrystallization has obscured and obliterated the septal necks. This specimen is associated with *Michelinoceras dutroi*, n. sp. at USGS locality 11764.

The smaller subcentral siphuncle, with its area of adnation narrower than the septal brim, and the shallower septa distinguish this species from *Adnatoceras alaskense*, n. sp. The two species, superficially similar, are associated at USGS locality 9188. *Dolorthoceras tersum* (Hall) from the Middle Devonian of New York State, as well as *D. elegans* Flower, *D. palmerae* (Flower and Caster), and *D. solitarium* Flower from the Upper Devonian of New York and Pennsylvania, are similar to *D. medium* in possessing small subcentral siphuncles, but all have four or five camerae in the space of one diameter, as compared to roughly 2½ to 3½ for *D. medium*.

Holotype, USNM 118937; paratype, USNM 118938.

Type locality: U. S. G. S. locality 9188, from *Goniatites crenistria* beds on the Kiruktagiak River, 9½ miles southwest of its junction with Castle Creek, Brooks Range. The paratype is from USGS locality 10866, the same as locality 9188.

Occurrence: Known from the type locality and questionably from USGS locality 11764, Alapah limestone, black chert and shale member, dip slope of hill west side of Anaktuvuk Valley.

Dolorthoceras? aff. D. crebriliratum (Girty)

Plate 2, figs. 8–10

Under this name is included a single incomplete orthoconic nautiloid with surface sculpture of fine transverse lirae that comes from the same beds that contain *Goniatites crenistria*. It is circular in cross section, 55.6 mm long, expanding gradually from a diameter of 7.6 mm at the narrow end to a diameter of 12.2 mm at the wide end, or about 1 in 11, and the sides diverge at an angle of 5°. The specimen apparently represents the apicad part of the body chamber of the shell. A well rounded septum is present at the narrow end and its depth equal to about one third the shell diameter shows the slightly offcenter position of the siphuncle (diameter, 1.3 mm). The shell and its filling are composed of recrystallized calcite and, as other septa may have been destroyed by recrystallization, the specimen might represent part of the phragmacone. This seems unlikely, however, because the surface sculpture has been fairly well preserved.

Transverse lirae are best preserved near the wide end, where there are 25 in the space of 5 mm. They are very slightly sinuous and the interspaces are about the same width as the lirae.

Although closely related to *Orthoceras crebriliratum* Girty (1909, p. 46, pl. 6, figs. 9, 9a, 10) from the Caney shale of Oklahoma, the Alaskan form has slightly coarser sculpture. Girty's holotype, with which the Alaskan shell has been compared, has about 9 lirae in the space of 1 mm at a diameter of 5 mm. The same spacing of the lirae can be observed on a small patch of shell surface preserved on the large, partly crushed fragment mentioned by Girty (1909, p. 46) as having a diameter of 15 mm. The Alaskan shell, with about 5 lirae in the space of 1 mm, resembles specimens in Geological Survey and National Museum collections from the Barnett formation of Texas that have a similar spacing of the transverse lirae. The Barnett form was referred by Miller and Youngquist (1948, p. 653, pl. 94, figs. 4, 5) to *O. crebriliratum* Girty, which they placed in the genus *Mooreoceras*. Part of the type lot of *O. crebriliratum* and other material from the Caney shale of Oklahoma have been sectioned by the writer and this species was found to have a cyrtochoanitic siphuncle similar that in *Dolorthoceras*. Hence the Alaskan form is tentatively referred to this genus.

A small fragment of a similar shell, from the Eagle-Circle district, is related to the specimen above. The transverse lirae, however, are more irregular, some of them being finer and more closely spaced and others coarser than those on the shell described above. This particular group of orthoconic nautiloids and its range of variation is in need of considerable study.

Figured specimen: USNM 118944.

Occurrence: USGS locality 9188 in the black chert and shale member of the Alapah limestone on the west side of the Kiruktagiak River, 9½ miles southwest of its junction with Castle Creek, Colville Valley region, Brooks Range; USGS locality 5867, Calico Bluff Formation, Calico Bluff, Yukon River, Eagle-Circle district.

Dolorthoceras? sp.

Among the orthoconic nautiloids of the Brooks Range are several that have approximately 4.7 camerae per diameter, with slightly depressed to nearly circular cross sections, and the siphuncle a little ventrad of the center. One of these, from USGS locality 13236, increases from a diameter of 9.5 mm to 13.0 mm in the space of 28 mm, or 1 in 8. In the larger specimens that have been sectioned the siphuncle was not preserved.

A small specimen, from USGS locality 12785, about 20 mm long and 2.3 mm in diameter at the narrow end, with an increase in diameter of roughly 1 in 7 and approximately five camerae in the space of one diameter, shows the siphuncle at the narrow end. It is cyrtochoanitic with subcylindrical segments. The septa have been destroyed in this part of the shell, so a comparison of the area of adnation to the septal brim cannot be made, but the general shape of the segments indicates that the area of adnation is narrow. A septum at a diameter of 3.8 mm shows the position of the siphuncle, 0.7 mm in diameter, with its center 1.4 mm from the nearest edge of the conch. The surface of the conch is ornamented only by transverse growth lines.

These shells have shallower camerae than *Dolorthoceras medium*, n. sp. and *Adnatoceras alaskense*, n. sp. and all are from lower horizons in the Mississippian strata than the shells referred to the new species. It is possible that more than one species, or even more than one genus, is represented.

Occurrence: USGS locality 12785, one specimen, Lisburne (?), group from float block near north end of lower gorge of the Noatak River; USGS locality 13236, three specimens, Wachsmuth limestone, 185 feet above the base, on a tributary of the Kuna River; USNM locality 3167, one specimen, Alapah limestone, 312 feet above the base, Nanushuk Lake section, Brooks Range.

Genus ADNATOCERAS Flower 1939

Adnatoceras alaskense Gordon n. sp.

Plate 2, figs. 5–7, 13

Diagnosis: *Adnatoceras* with shell expanding roughly 1 in 8 or 9, a little over 2½ chambers per diameter; sutures gently sinuous. Siphuncle reaching one-quarter of shell diameter and located about two-fifths of the way ventrad of the center. Cameral deposits are mural and ventral.

The holotype is part of a phragmacone about 112 mm in length. The orthoconic conch is approximately circular in cross section and expands gradually from a diameter of 9.3 mm to 21.5 mm in a distance of 95 mm, or 1 in 7.8. The septa are saucer shaped, of moderate depth, the depth equal to about three-eighths of the diameter. There are about 2.4 camerae per diameter near the narrow end and 2.7 per diameter near the wide end. The sutures are about horizontal and slightly sinuous, extending a little further apicad at the venter and dorsum than on the sides.

Surface sculpture consists mainly of very gently sinuous lines of growth. They form a shallow orad bow on the dorsal side and a broad, shallow sinus on the ventral, and a shallow lateral sinus can be seen on the side preserving most of the outer shell. Several fragments of shell on the orad part of the phragmacone show faint closely spaced longitudinal striae and grooves where the outermost shell layer is peeled away.

The siphuncle is cyrtochoanitic and situated two-fifths of the distance from the center to the venter. At the narrow end it is a little more centrally located. Its greatest diameter is equal to approximately one quarter of the shell diameter. The segments of the siphuncle are subcylindrical to barrel shaped, very slightly tapered apicad, and strongly contracted at the passage of the siphuncle through the septa. At an outside shell diameter of 10.3 mm the connecting ring has a maximum diameter of 2.9 mm and a length of 3.9 mm, and the opening between the short, strongly recurved septal necks is 0.7 mm across. The area of adnation is wider than the septal brim and the width of the septal brim is greater than the length of the septal neck. The shell is filled with grains of crystalline calcite, but well-developed mural deposits are visible on the ventral side of the camerae.

Another specimen from the same locality is recrystallized and partly distorted and cannot be identified positively, even as to genus. It preserves the last septum and part of the body chamber and shows the position of the siphuncle, which at a shell diameter of 34 mm is represented by an opening 4 mm across, its center located 12 mm in from the ventral edge of the conch. This specimen may be conspecific with the holotype of *A. alaskense*, with which it is associated.

A paratype from USGS locality 9188, broken into several pieces, the largest of which is figured on plate 2, figs. 5, 6, probably belongs to the same species. It expands a little less rapidly than the holotype, 1 in 9.6 near the narrow end and 1 in 8.9 near the wide end. In the narrow part there are 2.8 camerae per diameter. The siphuncle has the same width as compared to the diameter of the shell and the same position as in the holotype. Much of the shell surface is covered with a black limy deposit, but in several places small patches of the original polished shell surface ornamented by fine growth striae can be seen.

A small specimen from the Eagle-Circle district apparently belongs also in this species. It consists of the first 20 camerae of the phragmacone and is very slightly curved at the tip. It is 37 mm long, 6.4 mm across the orad end, and increases in diameter at a rate of 1 in 9.2. The camerae are rather variable in length,

there being about 1.7 camerae in one diameter near the narrow end, and 2.5 in one diameter near the wide end. The connecting rings of the siphuncle have a wide area of adnation and at their widest part are about one-fourth the width of the shell. Mural cameral deposits are well developed, particularly on the ventral side.

Adnatoceras alaskense is distinguished from *Dolorthoceras medium*, with which it is associated at USGS locality 9188, by its more robust and excentrically situated siphuncle, wider area of adnation, and deeper septa. Flower (1939, p. 127, pl. 8, fig. 1) illustrated a specimen of *Adnatoceras* from the Tournaisian at Tournai, Belgium, which he compared with *Orthoceras neglectum* de Koninck. Flower's shell has much shallower camerae (five to six in the space of one diameter) than *A. alaskense*. *Adnatoceras ciscoense* (Miller, Dunbar, and Condra) from the Pennsylvanian of Texas also has shallower camerae (three and one-half to five in the space of one diameter) and differs also from *A. alaskense* in having a depressed whorl section and in the presence of episeptal and hyposeptal deposits in the camerae.

Holotype, USNM 118940; paratype, USNM 118941.

Type locality: USGS locality 12084, limestone nodules from black chert and shale unit of the Alapah limestone, on ridge 1,500 feet east of Kanaktuk Lake, Anaktuvuk Valley, Brooks Range. The paratype is from USGS locality 9188.

Occurrence: At the type locality (see above) and at USGS locality 9188, from *Goniatites crenistria* beds on the west bank of the Kiruktagiak River, 9½ miles southwest of its junction with Castle Creek, Brooks Range; USGS locality 5302, Calico Bluff formation, 440 feet above river level, south end of Calico Bluff, Eagle-Circle district.

Genus EULOXOCERAS Miller, Dunbar, and Condra, 1933

Euloxoceras sp.

Plate 2, figs. 19, 20

Associated with the holotypes of *Sudeticeras alaskae*, n. sp. and *Eothalassoceras aurorale*, n. sp. is a single orthoconic nautiloid that can be assigned to the genus *Euloxoceras*. It is a fragment of a phragmacone, about 44 mm long, partly compressed and slightly distorted approximately laterally. The conch increases from a diameter (distorted) of 3.8 mm at the narrow end at an approximate ratio of increase of 1 in 9 or 10. The septa are saucer shaped and inclined at a slight angle orad-dorsal to the horizontal. There are approximately three camerae in the space of one diameter of the conch. The surface of the conch is smooth.

The siphuncle is crytochoanitic and located about one-fourth of the way from the center to the edge of the conch. The connecting rings are subcylindrical, concave exteriorly at the center, and abruptly contracted at the ends. At a diameter of the conch of 4.2 mm the connecting ring is 1.3 mm long and has a maximum diameter of 0.7 mm. In the specimen the siphuncle is filled with brown calcite, in contrast with the white calcite that fills the camerae adjacent to the siphuncle. There are laminar espiseptal and hyposeptal deposits within the camerae, thickly developed on the side where the siphuncle is nearest to the wall of the conch.

The inclined septa, the excentric position of the siphuncle, its narrow-waisted connecting rings, and the episeptal and hyposeptal cameral deposits all are characteristic of the genus *Euloxoceras*. The relative depth of the camerae is similar to that of *E. milleri* Flower, from the Jacksboro limestone member of the Graham formation of north central Texas, of Pennsylvanian age, but that species has a quadrangular outline apparently not possessed by the Alaskan shell. The other Pennsylvanian species, *E. greenei* Miller, Dunbar and Condra has slightly deeper camerae, spaced approximately 2½ to one shell diameter. Probably the Alaskan shell represents an undescribed species, but the present single poorly preserved specimen is not considered sufficient material upon which to base a new name.

Figured Specimen: USNM 118989.

Occurrence: USGS locality 11804, Alapah limestone, black chert and shale member, approximately 525 feet below the top of measured section B19, southern part of the Siksikpuk River Valley, Brooks Range.

Genus PSEUDORTHOCERAS Girty 1911

Pseudorthoceras sp.

Plate 2, fig. 22

Two fragments of a phragmacone, partly distorted by compression subsequent to burial, are referred to this genus. One is about 50 mm long and includes nearly 27 chambers, and the other, 20 mm long and includes 3 chambers. Although distortion precludes accurate measurement of the shell, general proportions can be ascertained.

The shell expands rather rapidly with growth, about 1 in 4½. The septa are shallowly saucer shaped and there are approximately five camerae in the space of one diameter of the shell. The sutures appear to be nearly straight but slightly sinuous, perhaps due to crushing of the shell.

The siphuncle is cyrtochoanitic and, as near as can be determined, subcentral. Connecting rings are subpyriform in longitudinal section, the septal necks trongly recurved, the brims a little wider than the areas of adnation. Siphuncular deposits are strongly developed on the side that is a little further away from the edge of the shell in the random section cut. The center of the deposit in each segment has been removed by solution on this side. On the opposite side of the siphuncle a thinner discontinuous deposit is present. Within the camerae mural deposits are developed.

The surface, apical part of the phragmacone, living chamber, and aperture are not known.

Figured specimen: USNM 118994.

Occurrence: With *Cravenoceras* sp. at USGS locality 10251, Yukon River, northeast bank, about 1 to 1½ miles upstream from mouth of Seventymile River, Calico Bluff formation, from float at about middle of exposure, Eagle-Circle district.

Genus ENDOLOBUS Meek and Worthen, 1865

Endolobus sp.

Referred to this genus are fragments from two different localities. One specimen is 11 mm long, and consists of not quite four camerae of a slightly crushed phragmacone. The whorl section is 15 mm wide and 7½ mm high, and the camerae are 3.5 mm deep along the venter. The venter is broadly and shallowly rounded, the sides rather abruptly rounded, the dorso-lateral slopes more gently rounded, and the dorsum indented to a depth of not quite 2 mm by the preceding whorl. Along the sides the subangular lateral zone of the whorl is ornamented by broad shallow nodes spaced about 1½ camerae apart. Sutures are nearly straight across the whorl, but form a broad, very shallow ventral lobe. The siphuncle and dorsal lobe have not been observed. A patch of shell surface on the dorso-lateral slope shows a half-dozen narrow longitudinal lirae with rather wide interspaces, crossed by closer spaced lines of growth.

The second fragment, about 34 mm long, is of the side of the conch and bears four shallow nodes along the subangular lateral zone of the whorl.

Occurrence: USGS locality 12084, limestone nodules from black chert and shale member of the Alapah limestone, on ridge 1,500 feet east of Kanaktuk Lake, Anaktuvuk River valley. USGS locality 11828, black chert and shale member of the Alapah limestone, 4 miles south of Lisburne Ridge, near the Etivluk River; Brooks Range.

Genus KNIGHTOCERAS Miller and Owen 1934

Knightoceras pattoni Gordon n. sp.

Plate 3, figs. 5–8, text fig. 8

Diagnosis: *Knightoceras* with subangular lateral zone located approximately at the middle of the side of the whorl. Suture with a narrowly rounded dorsal lobe.

The holotype is a septate specimen retaining parts of 1⅔ whorls, with a diameter (estimated) of 45 mm. The conch is subglobose, nautiliconic, and expanded rapidly orad. Whorls depressed dorso-ventrally, lenticular in cross section, with broadly rounded venter, ventro-lateral and dorso-lateral slopes, and a subangular lateral zone about midway on the sides; the dorsal impressed zone is rather shallow and a little less than one third the width of the whorl. Septa are shallowly concave; the width of one exposed septum is 20 mm, the height 12 mm, and the siphuncle, 1.7 mm in diameter, has its center 3.8 mm from the venter. The camerae are shallow and the distance between adjacent sutures is about one fifth the width of the whorl.

The shell is widely umbilicate, the umbilicus perforate and the perforation about 7 mm in diameter. The apicad end of the conch expands very rapidly and is more rounded in cross section than the adult part, but takes on the subangular lateral zones of the adult shell by the end of the first half turn. The tip is ornamented by longitudinal lirae crossed and beaded by weaker growth lines, forming a finely cancellate pattern. Surface sculpture in the adult part of the conch consists only of growth lines, which form a broad and moderately deep sinus over the venter. The adult suture forms a broad and very shallow ventral lobe and a narrow prominent sharply rounded dorsal lobe, with shallow subacute saddles at the periphery at each side of the whorl.

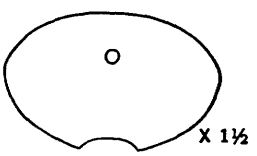

FIGURE 8.—*Knightoceras pattoni* Gordon, n. sp. Cross section through the mature whorl of the holotype (USNM 118947) showing the position of the siphuncle, ×1½.

Knightoceras pattoni is the first example of this genus to be described from rocks of Mississippian age. Its stratigraphic position near the middle of the Mississippian is a considerable extension of range, the earliest previously known specimens being from rocks of early Pennsylvanian (Atoka) age.

The median position of the subangular lateral zone distinguishes this species from the type species *Knightoceras missouriense* Miller and Owen and from *K. abundum* Miller, Lane, and Unklesbay and the lower Permian form *K. kempae* Miller and Youngquist in all of which the angulation is ventrad of the middle of the side. From *K. oxylobatum* Miller and Downs the Alaskan species differs in having a slightly more elevated whorl and the siphuncle located well ventrad of the center, rather than almost central. *K. tiltoni* (Miller, Dunbar, and Condra) is a much larger shell with straighter sutures and relatively shallower camerae. *K. subcariniferum* (Tzwetaev) from the Upper Carboniferous of the U. S. S. R. differs in having broad shallow umbilical lobes.

This species is named for W. W. Patton, Jr., who mapped the Kiruktagiak River area geologically and collected the holotype.

Holotype, USNM 118947.

Type locality: USGS locality 10864, associated with *Goniatites crenistria* Phillips in the black chert and shale member of the Alapah limestone, Kiruktagiak River, 13 miles southwest of its confluence with Castle Creek, Brooks Range.

Knightoceras sp.

Plate 3, fig. 9.

Another specimen from a locality less than 10 miles from the place where the holotype of *Knightoceras pattoni* n. sp. was collected appears to be referable to the same genus. The shell is silicified and much of the left half of it is missing. It consists of not quite two whorls, the last third of a whorl occupied by the body chamber, and it has a diameter of approximately 60 mm. It differs in several particulars from the holotype of *K. pattoni* but is similar in others and as the range of variation in *K. pattoni* is not known, it is not possible to say at this time whether or not the two shells are conspecific.

The conch is thick-discoidal, rapidly expanded, and more loosely coiled orad. The venter and ventro-lateral shoulders are evenly rounded and more elevated than in typical *K. pattoni*, and the dorsolateral slopes are very gently rounded. The lateral zone is subangular and is situated about three-eighths of the way from the dorsum to the venter at the end of the phragmacone. There is a shallow sulcus occupying about one-third of the slope just dorsad of the periphery. The maximum diameter of the umbilicus is about 35 mm and of the umbilical perforation, about 6 mm. The suture forms shallow ventral and dorsal lobes and shallow subacute lateral saddles, as in typical *Knightoceras*. The camerae appear to be a little shallower than in *K. pattoni*.

Figured specimen: USNM 118948.

Occurrence: USGS locality 10883, Alapah(?) limestone at the north end of Chandler Lake, Brooks Range.

Genus STROBOCERAS Hyatt 1884

Stroboceras crispum Gordon n. sp.

Plate 3, figs. 1–4, text fig. 9 *A*, *B*.

Two specimens belong to a new species of *Stroboceras*. Both are partly crushed but show the adult characters. The larger specimen, with an estimated diameter of 60 mm before crushing, has 2⅛ whorls, the last half-whorl occupied by the living chamber. The smaller specimen of approximately 1½ whorls, with an estimated diameter of 42 mm before partial crushing of the final quarter-whorl, is taken as the holotype.

The conch of the holotype is discoidal, nautilicone; a large slightly elliptical perforate umbilicus has long and short dimensions of 13.3 mm and 11.5 mm, respectively. The young stage is gently cyrtocone. There are approximately 11 camerae in the first 11 mm, the fourth, fifth, and sixth a little longer than the others. The cross section of the whorl at this stage is nearly circular, the ventral part slightly impressed in the succeeding whorl. The surface sculpture is not preserved in this part, but faint longitudinal lirae show on the surface of the internal mold. The exposed part of the suture is nearly straight across the dorsum, with an almost imperceptible narrow dorsal lobe and a gently bowed lateral lobe on each side; the ventral part is concealed.

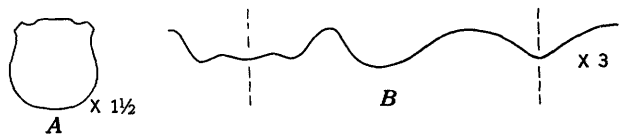

FIGURE 9.—*Stroboceras crispum* Gordon, n. sp. *A*, Cross section of the holotype (USNM 118949) at early maturity near the end of the first whorl, ×1½. *B*, Suture of the holotype at four-fifths of the first coil, shell diameter 21 mm, ×3.

At the twelfth camera the curvature becomes greater, but by the end of the first half-whorl lessens slightly and becomes constant. The adult characters are already fairly well developed at this point. The dorsum and sides are well rounded, the venter nearly flat, with a marked carina at the ventro-lateral shoulder, a well-channeled groove dorsad of this carina, and a shallower groove separating the carina from a slightly raised flat platform in the middle of the venter.

The whorl becomes proportionally higher and the dorsum flatter with growth. At the end of the first whorl the dimensions are as follows: diameter, 28.5 mm; height of whorl, 9.0 mm; width, 9.7 mm. The shield-shaped cross section near the end of the first whorl is shown in text figure 9,*A*. A pair of weak subsidiary carinae bound the raised platform of the venter on the later whorls, but do not approach the strength of the carina at each ventro-lateral shoulder.

The surface ornament on the mature shell consists of closely spaced sinuous transverse lirae; these are fairly straight across the dorsum, curve apicad and form a prominent rounded lateral sinus, a strong orad salient at the ventro-lateral shoulder and a moderately deep hyponomic sinus over the ventral platform. The transverse lirae on the later whorls are crossed by fine longitudinal lirae, strongest on the venter and ventro-lateral shoulders and progressively weaker dorsad on the sides. They are interrupted by the stronger transverse lirae, but in places give the surface a subreticulate appearance. There are 10 to 12 of these longitudinal threads in the space of 1 mm on the venter at a diameter of 40 mm. Part of the inner surface of the living chamber adheres to the specimen and is smooth except in a

couple of small areas where it appears finely and regularly papillose.

The suture in the adult shell (text fig. 9,*E*) has three small shallow lobes, one in the middle of the venter and the others in the grooves at either side separated by small shallow saddles, a subacute deeper saddle at each ventro-lateral carina, a well-rounded moderately deep lateral lobe somewhat ventrad on each side, a gently bowed umbilical saddle on the dorso-lateral shoulder, and a narrower well-rounded dorsal lobe.

The paratype has a slightly smaller perforated umbilicus than the holotype, its long and short dimensions measuring 12.0 and 10.4 mm, respectively. This specimen also bears a pair of weak subsidiary carinae on each side, crossing the transverse lirae at the lateral sinus.

The flattened venter, with its central platform that is not markedly elevated as in typical *Stroboceras* Hyatt 1884, allies this species with *Nautilus stygialis* de Koninck 1844, the Namurian (Chokier) species that Foord (1891, p. 105) selected as the type of his new genus *Coelonautilus*. Miller and Garner (1953, p. 136) regard *Coelonautilus* as a subjective synonym of *Stroboceras*, which has priority. *Stroboceras crispum* bears a close superficial resemblance to *S. trifer* Schmidt (1951, p. 34, 35, pl. 4, figs. 8, 9, text fig. 3d) from the *Goniatites crenistria* (IIIα) zone of Silesia, which also has keeled ventro-lateral shoulders, rounded dorso-lateral shoulders and fine longitudinal lirae crossed by closely spaced sinuous transverse lirae. Schmidt's cross section (1951, text fig. 3d) shows *S. trifer* with a pair of strong carinae bounding a moderately raised concave platform. This is contrast to the nearly flat platform of *S. crispum*. *S. trifer* also has a smaller perforate umbilicus (diameter about 7 mm), a shallower lateral sinus than *S. crispum*, and strong longitudinal ridges on the first half-whorl that do not appear to be present in *S. crispum*.

The trivial name of *S. crispum* calls attention to the sinuous transverse lirae that resemble locks of wavy hair appressed to the shell surface.

Holotype, USNM 118949; paratype, USNM 118950.

Type locality: USGS locality 10866, Alapah limestone, *Goniatites crenistria* bed at "The Notch" on the Kiruktagiak River, 9½ miles southwest of its junction with Castle Creek, Brooks Range.

Genus AMMONELLIPSITES Parkinson, 1822

1822. *Ammonellipsites* Parkinson [part], An Introduction to the Study of Fossil Organic Remains, p. 164.
1882. *Pericyclus* Mojsisovics, K. K. Geol. Reichsanstalt, Abh., Band 10, p. 141.
1884. *Pericyclus* Mojsisovics. Hyatt, Boston Soc. Nat. History Proc., v. 22, p. 330.
1889. *Pericyclus* Mojsisovics. Holzapfel, Palaeont. Abh. Dames und Kayser, neue Folge, Band 1, Heft 1, p. 33, 34.
1897. *Pericyclus* Mojsisovics. Foord and Crick, Catalogue of the Fossil Cephalopoda in the British Museum (Natural History), pt. 3, p. 143, 144.
1898. *Pericyclus* Mojsisovics. Haug. Soc. Géol. France, Paléont. Mém., v. 18, p. 28, 29.
1903. *Pericyclus* Mojsisovics. Smith, U. S. Geol. Survey, Mon. 42, p. 60.
1903. *Pericyclus* Mojsisovics. Foord, Carboniferous Cephalopoda of Ireland, pt. 5, p. 218.
1922. *Pericyclus* Mojsisovics. Schindewolf, Senckenbergiana, Band 4, p. 16, 17.
1922. *Caenocyclus* Schindewolf, Senckenbergiana, Band 4, p. 16, 17.
1925. *Pericyclus* Mojsisovics. Schmidt, Preuss. geol. Landesanstalt, Jahrbuch, Band 45, p. 529, 552, 553.
1929. *Pericyclus* Mojsisovics. Schmidt, Tierische Leitfossilien des Karbon, p. 65.
1940. *Pericyclus* Mojsisovics. Delépine, Mus. royale histoire nat. Belgique, Mém. no. 91, p. 38.
1940. *Pericyclus* Mojsisovics. Librovitch, Akad. Nauk S. S. S. R., Paleont. S. S. S. R., tom 4, chast 9, vyp. 1, p. 115–122, 267.
1941. *Pericyclus* Mojsisovics. Delépine, Maroc, Serv. Géol., Notes et Mém. no. 56, p. 48.
1948. *Pericyclus* Mojsisovics. Turner, Leeds Geol. Assoc., Trans., v. 6, pt. 2, p. 50, 51.
1948. *Rotopericyclus, Fascipericyclus, Trapezopericyclus,* and *Kaypericyclus* Turner, Leeds Geol. Assoc., Trans., v. 6, pt. 2, p. 50, 51.
1951. *Ammonellipsites* Parkinson. Smyth, Royal Irish Acad., Proc., v. 53, sec. B, p. 296.
1951. *Pericyclus* Mojsisovics. Schindewolf, Neues Jahrbuch Geol. Paläont., Abh., Band 93, Heft 1, p. 73–77.
1951. *Helicocyclus, Hammatocyclus, Eurycyclus, Schizocyclus,* and *Stenocyclus* Schindewolf, Neues Jahrbuch Geol. Paläont., Abh., Band 93, Heft 1, p. 76, 78, 79, 81, 86.
1951. *Pericyclus* Mojsisovics. Miller and Collinson, Jour. Paleontology, v. 25, no. 4, p. 474, 475.
1951. *Ammonellipsites* Parkinson. Schindewolf, Neues Jahrbuch Geol. Paläont., Monatsheft 1951, p. 306, 309.

Diagnosis: Discoidal to globular shells, generally ornamented by nearly straight, arcuate, or sinuous ribs, growth lines, and constrictions, but in some species limited mainly to nodes along the umbilical shoulder. Umbilicus usually large, but small in some species; whorls generally stepped within. Suture goniatitid, with eight pointed lobes and the same number of broadly to narrowly rounded saddles; first lateral saddles pointed in some species, including type of genus.

Type of genus: *Ellipsolithes funatus* Sowerby, 1814, by subsequent designation of Schindewolf (1951b, p. 309).

The writer is following the suggestion of Schindewolf (1951b, p. 307, 308) in keeping all of the Lower Carboniferous ribbed and noded goniatites together in a single broad genus. As is shown below, they do not easily fall into well-defined separate groups and in our present incomplete state of knowledge as to their phylogeny they should not be divided into separate genera.

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The earlier name *Ammonellipsites* Parkinson, though all but forgotten until recently, now has clear priority over *Pericyclus*, through the designation by Schindewolf (1951b, p. 309) of *Ammonellipsites funatus* (Sowerby) as the type species.

As Turner (1948, p. 51) pointed out, Parkinson (1822, p. 164, 233) based his genus *Ammonellipsites* on two species, *Ellipsolithes funatus* Sowerby (1813, p. 81, pl. 32) and *E. compressus* Sowerby (1813, p. 84, pl. 38). Sowerby's generic name was preoccupied by *Ellipsolithes* Montfort, 1808, erected for a different group of mollusks. *E. funatus* is a pericyclid, and *E. compressus* belongs in the genus *Merocanites* Schindewolf, 1922. Turner suggested that *E. funatus*, being somewhat similar in ornament to *Pericyclus fasciculatus* (McCoy) and with its suture as yet unknown, might eventually prove to belong in his new genus *Fascipericyclus* Turner (1948, p. 50). He concluded, "then *Fascipericyclus* may lapse in favor of Parkinson's *Ammonellipsites*."

Smyth (1951, p. 296) was able to uncover enough of the suture of a topotype of *E. funatus* figured by Foord (1903, pl. 39, fig. 1) to demonstrate that it belongs in the *Pericyclus kayseri-P. kochi* group for which Turner (1948, p. 51) proposed the genus *Kaypericyclus* (=*Eurycyclus* Schindewolf, 1951). Apparently both Smyth (1951, p. 296) and Schindewolf (1951b, p. 307) mistook Turner's statement for a designation of *E. funatus* as the type of *Ammonellipsites*, but such a designation was not actually made until Schindewolf (1951b, p. 309) listed *E. funatus* as the type species.

Several attempts to subdivide the pericyclids (ammonellipsitids) have been made and a number of genera or subgenera have been proposed. The earliest of these, the subgenus *Caenocyclus* Schindewolf (1922, p. 16, 17), was erected for pericyclids with intercalary (polyschizotomous) ribbing as typified by *Pericyclus* (*Caenocyclus*) *perisphinctoides* Schindewolf (1926, p. 84–86, text fig. 9). Although cited in the original description of the subgenus as the only known species of *Caenocyclus*, *P. perisphinctoides* was a nomen nudum until adequately described in the later publication. Its suture is still unknown, and Schindewolf (1951a, p. 79) has since expressed doubt as to the justifiability of basing a subgenus on the presence of intercalary ribbing, a rather variable characteristic in this group.

Turner (1948, p. 49–52) in a paper on the Mid-Dinantian reef limestones of Dublin and Cork, subdivided the pericyclids into several genera, based principally on the configuration of the first lateral saddle of the suture which, he had noticed, is well rounded in the earlier species and is increasingly narrower and sharper orad in the later species. His classification is expressed in the following key, after Turner (1948, p. 51):

First lateral saddles well rounded: (zone C_1)
- Flanks parallel ..... *Rotopericyclus* Turner
  - Type: *Pericyclus rotuliformis* Crick, 1899
- Flanks not parallel:
  - Shell without spiral ornament ..... *Pericyclus* s. s.
    - Type: *Goniatites princeps* de Koninck, 1844
  - Shell with spiral ornament ... *Trapezopericyclus* Turner
    - Type: *Pericyclus trapezoidalis* Crick, 1899

First lateral saddles somewhat narrowed anteriorly: (zones C_2 and C_2-S_1)
- Median saddle low ..... *Fascipericyclus* Turner
  - Type: *Goniatites fasciculatus* McCoy, 1844

First lateral saddles pointed: (zone C_2-S_1)
- Median saddle high ..... *Kaypericyclus* Turner
  - Type: *Pericyclus kayseri* Schmidt, 1925

To *Pericyclus* s. s. Turner referred *P. bailyi* Crick, *P. clanensis* Crick, P. *doohylensis* Foord and Crick, *P. foordi* Crick, *Prolecanites leesoni* Crick, *Goniatites princeps* de Koninck, P. *subplicatilis* Crick, and, tentatively, *Coniatites ryckholti* de Koninck of which the suture is unknown. To *Rotopericyclus* he assigned, besides the type species, *Goniatites plicatilis* de Koninck and *G. divisus* de Koninck; and because they possess umbilical nodes, as does *Pericyclus rotuliformis* Crick, he provisionally included *Coniatites crenulatus* de Koninck and "*G.*" (*Pericyclus?*) *tuberculatus* Delépine. To *Trapezopericyclus* he referred only the type species.

Besides the type, Turner referred *Pericyclus multicostatus* Foord to *Fascipericyclus* and also suggested that *Ellipsolithes funatus* Sowerby might belong here, as discussed earlier. Finally, to *Kaypericyclus* he assigned, besides the type species, *P. kochi* Holzapfel and *P. subglaber* Holzapfel, species with less sharply terminated first lateral saddles than *P. kayseri* Schmidt, and he tentatively included *Goniatites virgatus* de Koninck, of which the suture is not known.

Unaware that Turner in a paper on Irish stratigraphy had proposed a classification for the pericyclids, Schindewolf (1951a, p. 73–94) presented his own arrangement and erected a number of new subgenera, some of which are synonyms of Turner's "genera." In Schindewolf's classification the pericyclids are divided into two groups, depending upon whether the sides of the ventral lobe of the suture are parallel or divergent. The two groups are further subdivided on the basis of differences in shape and sculpture of the conch. The following key is after Schindewolf (1951a, p. 75, 76):

Ventral lobe with parallel sides, not widened orad:
- In youth without umbilical nodes, regularly ribbed:
  - Shell thick-discoidal, moderately to widely umbilicate; ribs strong, mainly unsplit, convex, strongly retractive, with ventral sinus; constrictions with the same configuration ..... *Pericyclus* s. s.
    - Type: *Goniatites princeps* de Koninck, 1844.
  - Shell thin-discoidal, very widely umbilicate; ribs weak, mainly unsplit, straight, more or less radial, without

ventral sinus; constrictions with weak ventral bow. *Helicocyclus* Schindewolf
Type: *Pericyclus* (*Helicocyclus*) *gracillimus* Schindewolf, 1951.

In youth with umbilical nodes and ribs, otherwise smooth:
Shell thick-discoidal to globular, widely umbilicate; umbilical ribs weak in old age, straight to slightly bent; constrictions with ventral bow in youth, nearly straight in adult.....*Hammatocyclus* Schindewolf
Type: *Pericyclus* (*Hammatocyclus*) *homoceratoides* Schindewolf, 1951.

Ventral lobe with divergent sides strongly widened orad:
Shell thick-discoidal to subglobular, moderately widely umbilicate; ribs unsplit, straight or convex on the flanks.....*Eurycyclus* Schindewolf
Type: *Pericyclus kochi* Holzapfel, 1889.
Shell moderately to widely umbilicate; ribs split, with flattish sinus on the flanks.*Schizocyclus* Schindewolf
Type: *Goniatites fasciculatus* McCoy, 1844.
Shell very narrowly umbilicate; ribs split, straight or convex on the flanks.....*Stenocyclus* Schindewolf
Type: *Pericyclus carinatus* Schindewolf *in* Schmidt 1925.

To *Pericyclus* s. s. Schindewolf assigned *P. blairi* (Miller and Gurley), *P. bailyi* Crick, *P. clanensis* Crick, *Goniatites plicatilis* Koninck, *P. trapezoidalis* Crick, and tentatively, *P. dilitatus* Schindewolf, of which the suture is not known. To *Helicocyclus* he referred, besides the type, *P. tianshanicus* Librovitch and, with some question, *P. evolutus* Librovitch, of which the suture is not known, and he also added the thick-discoidal forms *P. djaprakensis* Librovitch and *P. sonkulensis* Librovitch as they, too, are widely umbilicate. To *Hammatocyclus* Schindewolf assigned, besides *P. homoceratoides*, *Goniatites crenulatus* de Koninck and "*G.*" (*Pericyclus?*) *tuberculatus* Delépine of which the sutures are so far not known.

In *Schizocyclus* Schindewolf included *P. funatus* (Sowerby) and, tentatively, *P. nasutus* Schmidt, in both of which the sutures were not known. In *Stenocyclus*, although the type species *P. carinatus* has a ventral keel, he gathered together involute species without a keel, such as *P. niger* Delépine, *Goniatites ryckholti* de Koninck and *G. impressus* de Koninck, which have ribs that are slightly convex orad and form a ventral sinus, and in none of which is the suture known. Lastly, in *Eurycyclus* he grouped, along with the type species, *P. kayseri* Schmidt, *P. hauchecornei* Holzapfel, and *P. nikitini* Librovitch.

On learning of Turner's earlier classification and Smyth's illustration of the external suture of *P. funatus* (Sowerby), Schindewolf (1951b, p. 305–310) wrote another paper comparing the two classifications. He accepted *Ammonellipsites* Parkinson as replacing *Pericyclus*, s. l., with *A. funatus* (Sowerby) as the type of *Ammonellipsites*, he retained *Pericyclus* as a subgenus of *Ammonellipsites*, s. l., and relegated both *Kaypericyclus* Turner and *Eurycyclus* Schindewolf to the synonomy of *Ammonellipsites*, s. s. He also pointed out that *Schizocyclus* Schindewolf should be suppressed as a direct synonym of *Fascipericyclus* Turner. *Helicocyclus*, *Hammatocyclus*, and *Stenocyclus*, having no counterparts in Turner's classification, Schindewolf retained as valid subgenera. He questioned the validity of *Trapezopericyclus* Turner, differentiated from *Pericyclus* by the presence of spiral sculpture, because, he said, similar sculpture can be seen in well-preserved specimens of *P. hauchecornei* Holzapfel, *P. kochi* Holzapfel, *P. homoceratoides* Schindewolf, and possibly *P. plicatilis* (de Koninck), most of which differ in other important characters from *P. trapezoidalis* Crick.

Schindewolf expressed doubt that the character of a parallel-sided first lateral saddle, upon which Turner based *Rotopericyclus*, was sufficient to distinguish it from *Pericyclus* s. s., but suggested that the umbilical nodes in the young stages of the type species *P. rotuliformis* Crick might indicate some relationship to *Hammatocyclus* Schindewolf. He retained *Caenocyclus* with question as a still uncertain subgenus.

An eloquent plea was made by Schindewolf (1951b, p. 307, 308) for the retention of paleontologists of the old broader genera. He advocated the use of subgenera for the finer divisions, pointing out that Turner's genera had been split even a little finer than his (Schindewolf's) subgenera. The ease with which certain species may be transferred from one subdivision of ammonellipsitids to another, depending upon which characters are more strongly stressed in defining the subdivisions, emphasizes the difficulty involved, at the present time, in regarding each of these subdivisions as a genus.

An example in point is *Ellipsolithes funatus* Sowerby, which both Turner and Schindewolf grouped together with *Goniatites fasciculatus* McCoy because both species have bifurcating ribs ornamenting the conch. Smyth later showed that the suture of *E. funatus* is like that of the *Ammonellipsites kayseri-A. kochi* group, which have nonbifurcating ribs. Obviously a decision has to be made as to whether the configuration of the suture or the behaviour of the ribs is the more important character to be stressed in assigning this species to its proper taxonomic group.

Another case in point is the problem of correctly assigning the Alaskan species described herein as *Ammonellipsites* (*Fascipericyclus*) *polaris* Gordon, n. sp. Its rather broadly rounded first lateral saddle suggests a possible relationship with the subgenus *Pericyclus* s. s., but the divergent sides of the ventral lobe as well as the rather straight ribs and shallow ventral sinus of the conch would not permit assigning this species to that subgenus. On the basis of its shallow median

sinus *A. polaris* might be referred to *Fascipericyclus*, but the nonbifurcating ribs suggest a relationship rather with *Kaypericyclus*, and a single variant of *A. polaris* with coarser ribs, some of them intercalary, suggests *Caenocyclus*.

Because Schindewolf in his later paper did not attempt to reassess the major criteria upon which his own and Turner's classifications of the pericyclids were based, the writer has found it necessary to do so, in order that the species already described and particularly the species about to be described can be fitted into a single classification. The writer agrees with both Turner and Schindewolf that the configuration of the suture is the most fundamental character upon which a subdivision of the pericyclids should be based. Like Schindewolf, he makes the first division on parallelism versus divergence of the sides of the ventral lobe, but lays less stress on differences in sculpture than Schindewolf (1951a). The following key, based on those of Turner and Schindewolf, will permit assigning to one or the other subgenus the presently known species of *Ammonellipsites* s. l. *Trapezopericyclus* Turner is not included in this key as the writer feels that it should be suppressed as a synonym of the subgenus *Pericyclus* because the differences that set *P. trapezoidalis* Crick apart from its associated and stratigraphically equivalent species of *Pericyclus* are only of specific rank. *Caenocyclus* Schindewolf is held in abeyance until the suture of its type species is known. As this species is thought to be a rather late form stratigraphically, it is likely that *Caenocyclus* will eventually prove to be the same as either *Fascipericyclus* or *Ammonellipsites s. s.*

Key to the subgenera of Ammonellipsites

Ventral lobe with parallel sides, not widened orad:
- Shell without umbilical nodes in young stages, regularly ribbed:
  - Ribs convex, strongly retractive, forming prominent ventral sinus ..... *Pericyclus*
  - Ribs nearly straight, approximately radial, shallow ventral bow or sinus ..... *Helicocyclus*
- Shell with umbilical nodes and ribs in young stages:
  - Shell smooth in adult ..... *Hammatocyclus*
  - Shell ribbed in adult ..... *Rotopericyclus*

Ventral lobe with divergent sides, strongly widened orad:
- First lateral saddle moderately to narrowly rounded, median saddle shallow ..... *Fascipericyclus*
- First lateral saddle sharply rounded to pointed, median saddle deep:
  - Shell moderately to widely umbilicate ..... *Ammonellipsites s. s.*
  - Shell narrowly umbilicate ..... *Stenocyclus*

The following is an arrangement of the species of *Ammonellipsites* under the subgenera in which they seem to belong. Asterisks (*) indicate species in which the suture is not yet known.

Subgenus *Pericyclus* Mojsisovics
- *Pericyclus asiaticus* Librovitch, 1940
  - var. *semi-involuta* Librovitch, 1940
  - var. *simplex* Librovitch, 1940
- *bailyi* Crick, 1899
- **Goniatites blairi* Miller and Gurley, 1896
- *Pericyclus clanensis* Crick, 1899
- *dichotomus* Librovitch, 1940
- **dilitatus* Schindewolf, 1926
- **Goniatites divisus* de Koninck, 1880
- *Pericyclus doohylensis* Foord and Crick, 1897
- *foordi* Crick, 1899
- *Prolecanites leesoni* Crick, 1899
- *Goniatites plicatilis* de Koninck, 1881
- *Ammonites princeps* de Koninck, 1844
- *Pericyclus pulcher* Lissitzyn, 1909
- **Goniatites ryckholti* de Koninck, 1880
- *Pericyclus sokurensis* Librovitch, 1940
- *subplicatilus* Crick, 1899
- *trapezoidalis* Crick, 1899

Subgenus *Helicocyclus* Schindewolf
- **Pericyclus evolutus* Librovitch, 1927
- (*Helicocyclus*) *gracillimus* Schindewolf, 1951
- *tianshanicus* Librovitch, 1927

Subgenus *Hammatocyclus* Schindewolf
- **Goniatites crenulatus* de Koninck, 1880
- *Pericyclus* (*Hammatocyclus*) *homoceratoides* Schindewolf, 1951
- **"Goniatites"* (*Pericyclus?*) *tuberculatus* Delépine, 1940

Subgenus *Rotopericyclus* Turner
- **Pericyclus princeps* var. *multiplicatus* Delépine, 1940
- *rotuliformis* Crick, 1899

Subgenus *Fascipericyclus* Turner
- *Goniatites fasciculatus* McCoy, 1844
- *Pericyclus multicostatus* Foord, 1891
- **nasutus* Schmidt, 1941
- *Ammonellipsites* (*Fascipericyclus*) *polaris* Gordon, n. sp.
- *Pericyclus toisaiganensis* Librovitch, 1940
- var. *constricta* Librovitch, 1940

Subgenus *Ammonellipsites* s. s.
- *Pericyclus djaprakensis* Librovitch, 1927
- *Ellipsolithes funatus* Sowerby, 1813
- *Pericyclus grandicostatus* Librovitch, 1927
- *hauchecornei* Holzapfel, 1889
- *kayseri* Schmidt, 1925
- *kochi* Holzapfel, 1889
- *nikitini* Librovitch, 1927
- var. *inflata* Librovitch, 1927
- var. *subcompressa* Librovitch, 1927
- *sonkulensis* Librovitch, 1927
- *subglaber* Holzapfel, 1889

Subgenus *Stenocyclus* Schindewolf
- *Pericyclus carinatus* Schindewolf, 1925
- **Goniatites impressus* de Koninck, 1880
- **Pericyclus niger* Delépine, 1934
- **Goniatites virgatus* de Koninck, 1880

*Subgenus *Caenocyclus* Schindewolf
- **Pericyclus* (*Caenocyclus*) *perisphinctoides* Schindewolf, 1926

This arrangement has been made with the intent of using the available taxonomic subdivisions as far as possible and avoiding the addition of new names to the

growing list. Exhaustive study should precede the erection of any new subdivision. Several involute shells from northern Kazakhstan, U. S. S. R., described by Librovitch (1940, p. 122–134, 138–145, 268–274, 276–282) including *Pericyclus asiaticus* and its varieties, *P. dichotomus*, and *P.? sokurensis*, may eventually prove to belong in a subgenus separate from *Pericyclus*, into which they have been placed because of their parallel-sided ventral lobes. This subgenus would correspond to *Stenocyclus* Schindewolf, under which the later involute species with more advanced sutures have been placed. Possible *P. divisus* (de Koninck) and *P. ryckholti* (de Koninck) from the Upper Tournaisian of Belgium belong with the Siberian species.

Ammonellipsites multiplicatus Delépine, originally described as a variety of *A. princeps* (de Koninck), has been assigned in the list above to *Rotopericyclus* because of the umbilical nodes on one of Delépine's original figured specimens (1940, p. 40, pl. 1, figs. 18, 19). The thick-discoidal species *A. djaprakensis* Librovitch and *A. sonkulensis* (Librovitch) which Schindewolf referred to *Helicocyclus* have been transferred to *Ammonellipsites*, s. s. *A. sonkulensis* has a ventral lobe which, as shown in Librovitch's figure (1927, text fig. 11), has the sides diverging at an angle of about 11°. The ventral lobe of *A. djaprakensis* likewise has slightly divergent sides. This leaves in *Helicocyclus* only narrowly discoidal, highly evolute species.

Stratigraphic and geographic distribution.—The ammonellipsitids apparently are confined to beds of Late Tournaisian and Early Viséan age. The subgenus *Pericyclus* as interpreted above is restricted to beds of late Tournaisian age in northwest Europe and their equivalents in other parts of the world. These include the C_1 zone of Ireland, the zone T_3c of Belgium, Schmidt's zone $II\alpha(=T_3c)$, and beds believed by Librovitch to be of Late Tournaisian age in northern Kazakhstan, southwest Siberia. In the United States *Pericyclus* is found in beds of late Kinderhook (Chouteau) age in Missouri and Arkansas and in equivalent beds (Caballero formation of Laudon and Bowsher (1941)) in New Mexico. The writer also has specimens from the lower part of the Madison group in Montana.

Rotopericyclus occurs in the late Tournaisian zone C_1 of Ireland and zone T_3c of Belgium, associated with *Pericyclus*. Species referred to *Hammatocyclus* come from the late Tournaisian of Belgium, as well as from beds of Lower Viséan age in Germany. *Helicocyclus* is known from beds of Lower Viséan age in Germany, and from beds of similar age in the Tien Shan Mountains of East Turkestan.

Species referable to *Fascipericyclus* are known in zones C_2 and C_2-S_1 of Ireland, in Lower Viséan beds of the Waulsortian facies in Belgium, in Schmidt's zones $II\beta$ and $II\alpha$ of Germany, and their stratigraphic equivalents in Montenegro and East Turkestan, and possibly in southern Morocco. The Kazakhstan species *P. toisaiganensis*, placed here provisionally, is associated with other pericyclids that Librovitch believed are late Tournaisian in age. The new Alaskan species extends the geographic range of this subgenus to North America.

Ammonellipsites s. s. is limited to beds of early Viséan age, occurring in zone C_2-S_1 in Ireland, in zone $II\gamma$ in Germany, and in equivalent beds in Montenegro, Morocco, and East Turkestan. *Stenocyclus* and *Caenocyclus* are known from the Lower Viséan of Germany and species referred to *Stenocyclus* occur in the Lower Viséan of Belgium and Montenegro.

Subgenus *Fascipericyclus* Turner

Diagnosis: Shell thick-discoidal, narrowly to widely umbilicate; ribs fairly prominent, unsplit or strongly forked, forming a shallow ventral sinus. Ventral lobe of suture with divergent sides widening orad, notched by the median saddle to less than one-fourth of its height; first lateral saddle somewhat narrowed orad, rounded to sharply rounded.

Type of subgenus: *Goniatites fasciculatus* McCoy, 1844, by original designation of Turner (1948, p. 50).

Ammonellipsites (Fascipericyclus) polaris Gordon n. sp.

Plate 4, figs. 1–13, text figs. 10 *A*, B

Diagnosis: Thick-discoidal, moderately evolute *Ammonellipsites* with fine to moderately coarse somewhat irregular radial ribs, forming a shallow sinus over venter. Ventral lobe of suture with sides diverging orad, median saddle short, first lateral saddle asymmetrically rounded.

The holotype is a thick-discoidal shell with a broadly rounded venter, very gently rounded sides, and broadly rounded umbilical shoulders; whorl section reniform to semilunar; umbilicus about one-quarter to a little over one-third of the diameter; umbilical wall convex.

Surface sculpture consists of transverse ribs, growth lirae, and constrictions; these form a very shallow sinus over the umbilical shoulder, are nearly straight and radial over the sides and ventrolateral shoulder, and form a moderately shallow hyponomic sinus over the venter. The ribs are fine and poorly developed over the umbilical shoulder and are gradually stronger ventrad; over the venter they are of moderate strength, with considerably wider interspaces. At a shell diameter of 23 mm the ribs are spaced about 1 mm apart on the venter and the hyponomic sinus is 1.7 mm deep. There is a tendency toward irregularity in the strength of the ribs, particularly on the flanks, near the umbilicus. There are seven or eight shallow constrictions on the last whorl of the holotype.

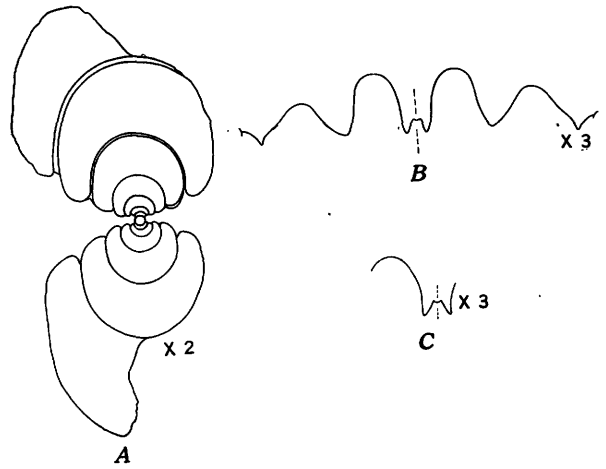

FIGURE 10.—*Ammonellipsites* from two localities: *A*, *A.* (*Foscipericyclus*) *polaris* Gordon, n. sp., cross section of a paratype (USNM 118953) ×2. *B*, External suture of another paratype (USNM 118953) at shell diameter of 9 mm, ×3. *C*, *A.* (*F.*) aff. *A. polaris* Gordon, fragment of the external suture of a specimen (USNM 118955) showing the ventral lobe and part of the first lateral saddle, ×3.

The external suture (text fig. 10, *B*) consists of the following elements: (1) a ventral lobe with sides diverging orad at an angle of approximately 20°, divided into two symmetrical points by a somewhat trapezoidal median saddle that extends orad to approximately a fifth of the length of the ventral lobe, (2) a first lateral saddle with gently converging sides, broadly and asymmetrically rounded orad, (3) a bluntly pointed V-shaped first lateral lobe with gently bulging sides, (4) an asymmetrically rounded second lateral saddle, and (5) a small pointed lobe near the umbilical seam. The internal suture is not exposed.

Dimensions and proportions	Holotype	Paratypes				Hypotype
		A	B	C	D	
Diameter (D)----------mm--	25.7	26.0	17.1	13.9	10.5	24.6
Height of last whorl (H)--mm--	12.5	12.0	8.3	7.3	5.8	12.0
Width of last whorl (W)--mm--	14.2	14.0	10.0	8.3	6.5	13.6
Width of umbilicus (U)--mm--	7.0	8.5	5.5	3.8	2.7	7.0
U/D----------	.27	.33	.32	.27	.26	.28
W/D----------	.55	.54	.58	.60	.62	.55
W/H----------	1.14	1.17	1.20	1.14	1.12	1.13

One specimen (USNM 118954) differs in several particulars from typical *A. polaris* with which it is associated, but because the suture and the general proportions of the conch are about the same as in typical *A. polaris*, it is believed to be only a variant. In this specimen the ribs are coarser, being spaced 1.6 to 1.8 mm apart at a diameter of 20 mm. From the umbilical shoulder where most of them terminate abruptly, the ribs cross the sides of the conch approximately radially and are nearly straight across the venter. Some show a very shallow ventral sinus. Several of the ribs are intercalary and die out on the sides a short distance dorsad of the ventro-lateral shoulder. The shell is rather thick and the two small patches of shell on the venter, representing the inside of the succeeding whorl, completely mask the underlying ribs. The suture has a ventral lobe with its sides gently diverging orad and a well-rounded first lateral saddle, as in typical *A. polaris*.

The dimensions above indicate a slight narrowing of the conch during growth of *Ammonellipsites polaris*. The Alaskan species somewhat resembles *A. hauchecornei* Holzapfel and *A. subglaber* Holzapfel of the Erdbach beds of Germany (Schmidt's zone IIγ). Both of the German species have radial ribs that are fairly straight across the sides of the conch and in *A. hauchecornei* there is a shallow ventral sinus. Both also have ventral lobes with divergent sides and rounded first lateral saddles, but the German species have narrower first lateral saddles, deeper median saddles notching the ventral lobe, and hence are closer to typical *Ammonellipsites s. s.* In general shape *A. polaris* is a little thicker and a little less evolute than *A. hauchecornei* and a little narrower and more evolute than *A. subglaber*.

Another species with a suture somewhat similar to that of *A. polaris* is the Siberian shell *A. toisaiganensis* Librovitch, the ventral lobe of which has slightly divergent sides and the first lateral saddle is broadly and asymmetrically rounded orad. The ribs of *A. toisaiganensis* are more sinuous and more subdued and the shell more involute than in *A. polaris*.

As *A. polaris* comes from an isolated outcrop and there is no associated fauna, its age cannot be determined with certainty. One may surmise from what is known about the stratigraphic distribution of the ammonellipsitids that we are dealing with the sort of species that should occur very near the Tournaisian and Viséan boundary. The suture of *A. toisaiganensis*, which occurs with a fauna probably equivalent to Schmidt's zone IIα, appears to be a little more primitive than that of *A. polaris*, while the sutures of *A. hauchecornei* and *A. subglaber*, from Schmidt's zone IIγ, are a little more advanced. The relatively straight ribs and shallow sinus of *A. polaris* suggests a closer relationship to the Early Viséan shells than to the majority of the Late Tournaisian species, with their sinuous ribs and deeper ventral sinus.

Holotype, USNM 118952; paratypes, USNM 118953, seven specimens and fragments collected with the holotype; hypotype, USNM 118954.

Type locality: USGS locality 11857, calcareous nodules in platy shale, part of a 125-foot section in an isolated exposure of the Lisburne group near a tributary creek on the west side of the east fork of the Kiligwa River, eastern part of the De Long Mountains, Brooks Range.

Ammonellipsites (Fascipericyclus) aff. A. polaris Gordon, n. sp.

Text fig. 10,*c*

From an early collection made in the western part of the Brooks Range, a broken specimen partly embedded in limestone matrix appears close to *Ammonellipsites polaris*, n. sp. This shell was referred by Girty, in a faunal list published by P. S. Smith (1913, p. 78), to *Eumorphoceras*? sp., a ribbed goniatite genus that, partly due to its state of preservation, it also resembles.

The shell at a diameter of 14.5 mm is about 8 mm wide and the width of the umbilicus is equal to about one third of the diameter of the conch. In cross section the shell is like *A. polaris*, but has a slightly narrower venter. At a diameter of 10 mm transverse ribs, about seven in the space of 3 mm and forming a very shallow orad bow over the flanks, are preserved on both sides of the conch, but the shell is peeled away over the venter, where part of the suture is exposed. The ventral lobe of the suture (text fig. 10,C), has divergent sides and is shallowly notched by the median saddle, but the base is wider than in typical *A. polaris*, the tips being slightly divergent. The first lateral saddle is broadly and asymmetrically rounded, as in typical *A. polaris*.

The dimensions, obtained with some difficulty and a slight uncertainty from the broken specimen, are close to those of *A. polaris*, as is also what can be seen of the surface sculpture and the suture, but the venter appears to be little narrower and the transverse ribs a trifle more bowed than in typical *A. polaris*. Whether the shell represents only a variant or actually a different species closely allied to *A. polaris* cannot be determined from the material at hand.

Figured specimen: USNM 118955.

Occurrence: USGS locality 12785, Lisburne(?) group, from float block near north end of lower gorge of the Noatak River, Brooks Range.

Genus MÜNSTEROCERAS Hyatt 1884

Münsteroceras saginatum Gordon n. sp.

Plate 4, figs. 14–16, text fig. 11, *A*, *B*

A very rotund and rather widely umbilicate *Münsteroceras* comes from a locality in the Iligluruk Creek drainage, in the western part of the Brooks Range. The shell, a phragmacone with part of the body chamber attached and part of one side broken away before final entombment, is subglobose, with a broad rounded venter, strongly rounded ventro-lateral shoulders, and flattened sides that on the last whorl of the phragmacone occupy a band 4 to 5 mm wide flanking the umbilicus. The umbilicus is not quite a third of the diameter of the shell, stepped within; the umbilical shoulder is subangular; the umbilical wall is gently convex and nearly vertical.

Surface sculpture is lacking on most of the specimen, but where preserved within the umbilicus consists only of closely spaced growth lines. The internal mold has a polished surface crossed by four rather narrow growth constrictions on the last whorl of the phragmacone and with indistinct subparallel "fluting" along the flattened zone that borders the umbilicus. The growth constrictions and indistinct "fluting" are retractive across the flattened sides and the constrictions cross the venter in a very broad, nearly straight, shallow sinus.

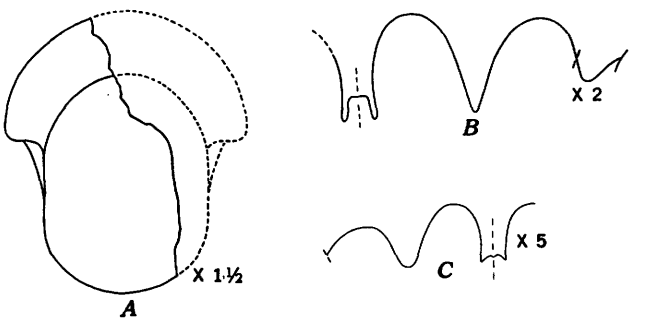

FIGURE 11.—*Münsteroceras* from two localities: *A*, *M. saginatum* Gordon n. sp., reconstructed front view in outline of the only specimen (USNM 118956), ×1½. *B*, External suture and umbilical lobe of the same specimen, at a shell diameter of 18 mm, ×2. *C*, *M.* sp., external suture of the only specimen (USNM 118957) at a shell dimaeter of 5mm , ×5.

The external suture (text fig. 11, *B*) has a narrow ventral lobe, of which the apicad half has nearly parallel sides and the orad half curves gradually outward. The first lateral saddle is asymmetrically rounded and has a median width a little more than twice that of the ventral lobe. The first lateral lobe is V-shaped and the second lateral saddle rounds rather evenly across the umbiiical shoulder to the umbilical wall, where there is a conspicuous abruptly rounded umbilical lobe. Part of the internal suture is preserved on the penultimate whorl of the phragmacone, where there is a narrow dorsal lobe flanked by a wider, broadly rounded saddle. The surface on which the dorsal lobe is preserved also shows a "wrinkle layer" of minute, longitudinally elongate, warty wrinkles.

Dimensions: diameter (D), 24.5 mm; height of last whorl (H), 9.5 mm; width of the last whorl (W), 22.0 mm; width of umbilicus (U), 7.4 mm. The shell ratios are as follows: U/D=0.30, W/D=0.90, and W/H=2.32.

This form is related to *Münsteroceras sphaeroidale* (McCoy) from which it differs in having a larger umbilicus and in greater width. The suture of Irish specimens of *M. sphaeroidale* is not completely known, but de Koninck (1880, p. 99) has illustrated the external suture of a Belgian specimen, from which the Alaskan shell differs in having a longer and narrower ventral

lobe and a simple V-shaped first lateral lobe with nearly straight sides. *M. browni* (McCoy) is another similar species, but is narrower and has a larger umbilicus than the Alaskan form.

The exact stratigraphic position and age of the Alaskan shell is not known, as the specimen was collected from an isolated exposure in a structurally deformed area and no associated megafossils were found. Its age can be indicated in only a broad manner by correlation, as there are similar rotund species of *Münsteroceras* in the Upper Tournaisian as well as in the Lower Viséan of northwest Europe. These forms are generally restricted to the zone of *Pericyclus* [*Ammonellipsites*].

Holotype, USNM 118956.

Type locality: USGS locality 11877, from a sequence of undifferentiated Mississippian dark gray shale, probably 125 feet above the base, south side of the easternmost tributary of the east fork of Iligluruk Creek, Brooks Range.

Münsteroceras sp.

Text fig. 11,*C*

A subspherical species of *Münsteroceras* is represented by a single small septate specimen, partly crushed on one side, about 5.4 mm in diameter and 5.2 mm wide. The umbilicus is small but its actual size cannot be determined because the shell is crushed; the umbilical shoulder is subrounded. One patch of shell material adhering to the crushed side shows no sign of surface sculpture, and the shell is presumed to have been smooth or nearly so.

The suture has a narrow ventral lobe with subparallel sides in the apicad half, curving wider apart orad, the median saddle very short; first lateral saddle moderately wide and asymmetrically well rounded orad; first lateral lobe narrowly rounded at the tip, rather narrow; second lateral saddle rounded asymmetrically to the umbilical shoulder.

The configuration of the suture is generally similar to that of *Münsteroceras saginatum* Gordon, n. sp., but the two cannot be compared satisfactorily because the small involute *Münsteroceras* under consideration is much less mature than the holotype of *M. saginatum.*

Figured specimen: USNAM 118957.

Occurrence: USGS locality 13240, Lisburne group undifferentiated, about 440 feet stratigraphically below the base of a sill 105 feet thick, north spur of De Long Mountains between branches of the Kiligwa River, Brooks Range.

Genus BOLLANDITES Bisat, 1952

1924. *Beyrichoceratoides* [part] Bisat, Yorkshire Geol. Soc., v. 20, pt. 1, p. 88.

1934. *Beyrichoceras* Foord [part]. Bisat, Yorkshire Geol. Soc., v. 22, pt. 4, p. 284, 285.

1952. *Bollandites* Bisat, Leeds Geol. Assoc., Trans., v. 6, pt. 4 p. 163, 164.

Diagnosis: Münsteroceratid with discoidal to thick-discoidal conch, narrowly to rather widely umbilicate; periphery of whorl well rounded, sides compressed, umbilical shoulder subangular. Surface ornament of noncrenulate transverse striae, rather strong in some species. Suture with small narrow ventral lobe, its sides subparallel in apicad half but increasing in width orad more than 10 percent of the depth of the lobe in the distance from half to three-quarters the height of the lobe; median saddle low; first lateral saddle rounded, its median width at least 1⅓ times that of the ventral lobe; first lateral lobe generally with rather sinuous sides and a small terminal spike.

Type of genus: *Beyrichoceratoides castletonense* Bisat, 1924, by original designation.

Bisat erected this genus for the *B. castletonense* group. Originally describing *B. castletonense* as a *Beyrichoceratoides* (1924, p. 88) he transferred it later to *Beyrichoceras* (Bisat, 1934, p. 285) and included with it in the same group *Beyrichoceras phillipsi* Bisat, *B.* cf. *B. excavatum* (Phillips), *B. mutabile* (Phillips), and *B. hodderense* Bisat.

Bollandites appears to be midway between *Beyrichoceras* and *Beyrichoceratoides*. In some ways it is close to *Münsteroceras*, in which *Beyrichoceratoides* probably should be included as a subgenus. In *Bollandites* the sides of the ventral lobe of the suture diverge gradually orad, although at the apicad end the sides may be subparallel for a short distance. In this respect the genus differs from *Münsteroceras* in which the ventral lobe has approximately parallel sides for most of its length in the adult conch. *Bollandites* differs from *Beyrichoceras* in that the tips of the ventral lobe do not diverge apicad, but are subparallel or slightly convergent in that direction.

Although the most commonly collected specimens, those in early maturity, are thick discoidal in shape, Neaverson (1943, p. 137, pl. 5, figs. 1a, b) has shown that the complete mature conch of *B. castletonense* is discoidal in shape, with a narrowly rounded venter. The shell becomes increasingly involute with growth.

Included here in *Bollandites* are a number of shells that are decidedly involute, as well as those that have a relatively wide umbilicus in early maturity. Two species, *B. greencastlense* (Miller and Gurley) and *B. mempeli* (Schmidt), have fine longitudinal lirae ornamenting the shell surface.

The following species are included in the genus *Bollandites:*

Bollandites bowsheri Gordon, n. sp.
Beyrichoceratoides castletonensis Bisat, 1924
Münsteroceras euryomphalus Schindewolf, 1926

Beyrichoceras furyense Padget, 1952
Goniatites greencastlensis Miller and Gurley, 1896
Bollandites kiligwae Gordon, n. sp.
Goniatites malladae Barrois, 1882
Beyrichoceras mempeli Schmidt, 1941
?*Münsteroceras mitchelli* Miller, 1935
?*Goniatites mutabilis* Phillips, 1836
Beyrichoceras phillipsi Bisat, 1934
Bollandites sulcatus Bisat, 1952

The genus *Bollandites* is distributed widely in the northern hemisphere, particularly in the northern part, in rocks of Early and Middle Visean age.

Bollandites bowsheri Gordon n. sp.

Plate 4, figs. 27–29, text fig. 12, *A*, *B*

Diagnosis: Conch subglobose, moderately involute, with fine transverse striae and sparse constrictions forming an orad bow over venter, crossed by faint longitudinal lirae on venter and near umbilicus. Beyrichoceratid suture with narrow ventral lobe, wide first lateral saddle and lobe.

Six specimens, most of them partly crushed, constitute the type lot. The holotype, a phragmacone preserving much of the shell surface, is subglobose with a broadly rounded venter, well-rounded ventro-lateral and umbilical shoulders, and rather flattened sides; umbilicus open, its width equal to one-fifth of the diameter. Shell surface semipolished and shining, sculptured by very fine transverse striae that form a small shallow sinus on the umbilical shoulder, are rather straight across the sides and ventro-lateral shoulder, and cross the venter in a gentle orad bow. Very faint longitudinal lirae on the venter and in the vicinity of the umbilical shoulder are less prominent than the transverse striae; two very faint constrictions of growth are strongest on the sides and ventro-lateral shoulders and die out over the venter.

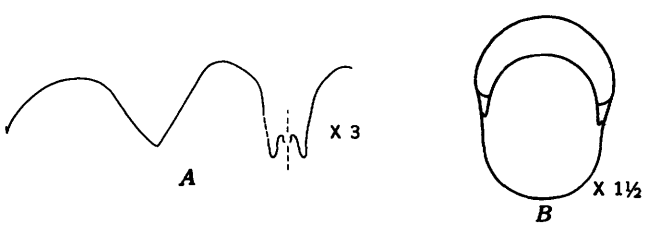

FIGURE 12.—*Bollandites bowsheri* Gordon, n. sp. *A*, External suture of a paratype (USNM 118959) at a shell diameter of 15 mm, ×3. *B*, Front view in outline of the holotype (USNM 118958), ×1½.

Plate 4, figs. 27–29, text fig. 12, *A*, *B*

Parts of the last few sutures of the phragmacone are visible on the holotype but are broken and incomplete. The outermost external suture of a paratype (text fig. 12, *A*), at a diameter of approximately 15 mm, shows a narrow ventral lobe slightly bulged in the middle, with a height of 3.2 mm and a median width of 1.7 mm, notched to a depth of 0.6 mm by a squarish median saddle; the first lateral saddle is asymmetrically rounded, about 3 mm in median width; the first lateral lobe is V-shaped, acuminate, with a median width of 2.5 mm; and the second lateral saddle is broadly and asymmetrically rounded to the umbilical shoulder.

Dimensions and proportions	*Holotype*	*Paratype*
Diameter (D)----------mm--	17. 3	13. 0
Height of last whorl (H)----------mm--	7. 4	6. 3
Width of last whorl (W)----------mm--	[1] 12. 2	6. 3
Width of umbilicus (U)----------mm--	3. 5	2. 3
U/D----------	. 20	. 18
W/D----------	. 71	. 78
W/H----------	1. 65	1. 62

[1] Twice the half-width.

Two paratypes show patches of sculpture with slightly stronger longitudinal lirae on the venter than in the holotype. There appear to be about three lirae in the space of 1 mm at a diameter of roughly 15 mm. The smaller specimen, the dimensions of which are given above, shows a well-developed growth constriction on the internal mold, crossing the venter in a shallow orad bow.

A large specimen with a similarly shaped conch, but with the left side crushed, comes from a locality about 230 miles west of the type locality. The suture is not exposed, but important similarities in shape and surface sculpture suggest that it be referred with slight question to *B. bowsheri*. The diameter of this specimen is 30.0 mm and the width of the umbilicus, 6.3 mm. The umbilical wall is nearly flat and almost vertical. Fine longitudinal lirae surround the umbilicus and a single strong growth constriction forms a broad shallow orad bow over the venter.

The narrow ventral lobe of the suture of *Bollandites bowsheri* indicates the relationship of this species with the *B. castletonense* group for which Bisat (1952, p. 163, 164) proposed the generic name *Bollandites*. On the other hand, the presence of weak longitudinal sculpture on the venter and near the umbilicus suggests the genus *Beyrichoceras*, s. s., which has, however, a wider ventral lobe in proportion to the first lateral saddle.

The presence of a ventral orad bow of the growth lines and constrictions, instead of the ventral sinus so typical of the beyrichoceratids distinguishes *B. bowsheri* from any other presently known species. Indeed, this feature is an uncommon one in Mississippian goniatites. However, the writer does not regard it as necessarily indicating a fundamental generic separation from the beyrichoceratids, similar in other respects. Typical representatives of *Bollandites*, such

as *B. castletonense* Bisat and *B. phillipsi* Bisat, have a very shallow hyponomic sinus, the transverse striae being rectilinear in most young specimens and hence fairly close to *B. bowsheri*.

This species is named in honor of A. L. Bowsher, who collected the type specimens and who made many of the preliminary studies of the Brooks Range Paleozoic invertebrate fauna.

Holotype, USMN 118958; paratypes, five additional specimens, USNM 118959. Figured specimen, USNM 118960.

Type locality: USGS locality 12084, limestone nodules from black chert and shale member of the Alapah limestone, on ridge 1,500 feet east of Kanaktuk Lake, Anaktuvuk Valley, Brooks Range.

Occurrence: At the type locality (see above) and at USGS locality 12787, north bank of the Nuka River, Brooks Range.

Bollandites kiligwae Gordon n. sp.

Plate 4, figs. 20–26, text fig. 13,A,B

Diagnosis: A small involute beyrichoceratid sculptured by sinuous growth lines and transverse constrictions that form a moderately shallow hyponomic sinus. Suture with a narrow ventral lobe as in *B. castletonense* but shorter and with faintly sinuous sides, first lateral lobe V-shaped and narrow.

The holotype, is a partly broken phragmacone, thick-discoidal with well-rounded venter and ventro-lateral shoulder, rather flattened side, and subangular umbilical shoulder; the whorl wider than high, its greatest width at the umbilical shoulder; umbilicus open, its width equal to about one-tenth of the diameter.

Surface sculpture, showing in small patches retained by the specimen, consists of fine closely spaced gently sinuous lines and parallel constrictions of growth. There are four constrictions on the outermost whorl. These form an exceedingly gentle bow orad over the sides and ventro-lateral shoulders and a moderately prominent hyponomic sinus.

External suture with a rather narrow ventral lobe with slightly divergent sides, subparallel near the base and faintly bulged at the middle, indented to about one-fifth of its height by the median saddle; first lateral saddle with a median width about 1.4 times that of the ventral lobe, rounded and slightly flattened orad; first lateral lobe narrow, V-shaped, and bluntly pointed; second lateral saddle broadly and asymmetrically rounded to the umbilicus.

Dimensions and proportions	*Holotype*	*Paratype*	*Paratype*
Diameter (D)----------mm--	12. 5	9. 1	7. 0
Height of last whorl (H)--------mm--	6. 6	5. 0	3. 9
Width of last whorl (W)--------mm--	8. 2	[1] 7. 7	5. 5
Width of umbilicus (U)--------mm--	1. 6	. 7	. 7
U/D----------	. 13	. 08	. 10
W/D----------	. 66	. 85	. 79
W/H----------	1. 24	1. 54	1. 41

[1] Twice the half-width.

This small species is represented by several specimens, most of them with remains of partly crushed body chambers. Some of the paratypes have subglobose shells.

The narrow ventral lobe allies *B. kiligwae* with the *B. castletonense* group for which Bisat (1952, p. 163, 164) erected *Bollandites*, most of whose members have widely umbilicate shells. In general proportions, involution, and configuration of the aperture *B. kiligwae* resembles the Irish species *B. furyense* Padget (1952), but it lacks the umbilical ring of that species and has a narrow V-shaped first lateral lobe in contrast to that of *B. furyense* which is wider, more rounded, and mammilate. It is distinguished from *Bollandites bowsheri* n. sp. by its smaller size, more rounded venter, presence of a hyponomic sinus, and the narrower first lateral lobe of the suture.

Holotype, USNM 118961; paratypes, USNM 118962, 16 specimens collected with the holotype.

Type locality: USGS locality 13204, Alapah limestone, concretions in interbedded black chert and shale member about 500 feet below top of section in cut banks on east fork of the Kiligwa River, Brooks Range.

Bollandites cf. B. sulcatum (Bisat)

Plate 4, figs. 17–19, text fig. 14, *A*, *B*

1952. *Bollandites sulcatum* Bisat, Leeds Geol. Assoc., Trans., v. 6, pt. 4, p. 175–177, pl. 3, figs. 4, 5, 8, text fig. 2 (e).

A small beyrichoceratid of the *B. castletonense* group is represented by four partly silicified specimens from a locality in the valley of the Ipnavik River. The conch is thick-discoidal, moderately evolute, with well-rounded venter and sides and a sharply rounded umbilical shoulder; umbilical wall gently convex; umbilicus tapered within, its sides diverging at an angle of about 50°. The largest specimen (text fig. 14, *A*) is a natural cross section of approximately six whorls. All the whorl sections but the last one are well rounded and crescentic; the last is rounded-subtriangular, with flattened sides (the flattening is believed to be due at least in part to crushing). In the small specimen of slightly over four whorls figured on plate 4, three rather

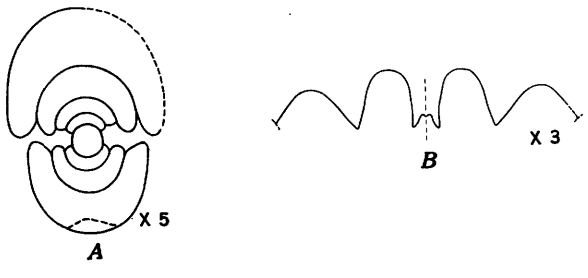

FIGURE 13.—*Bollandites kiligwae* Gordon, n. sp. *A*, Cross section of an immature paratype (USNM 118962), ×5. *B*, External suture of the holotype (USNM 118961) at a shell diameter of 10 mm, ×3.

weak growth constrictions can be seen on the last whorl. They are slightly protractive across the sides and form a very shallow hyponomic sinus over the venter. Silicification has obliterated the details of surface sculpture in all the specimens.

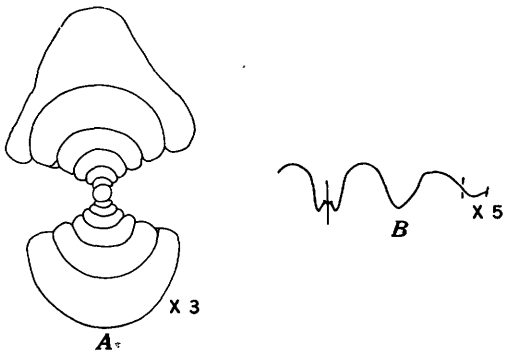

FIGURE 14.—*Bollandites* cf. *B. sulcatum* Bisat. *A* Cross section of a specimen (USNM 118963) with a distorted outer whorl, ×3. *B* External suture and umbilical lobe, from another specimen (USNM 118963) at a shell diameter of 5.7 mm, ×5.

The suture (text fig. 14, *B*) is taken from the small specimen. At a diameter of 5.7 mm the ventral lobe is short, of moderate width, and very shallowly notched by the median saddle; first lateral saddle well rounded orad, its median width 1.4 times that of the ventral lobe; first lateral lobe moderately wide, indistinctly mamillate; second lateral saddle rather narrow, asymmetrically rounded; umbilical lobe very shallow and broadly rounded.

Dimensions and proportions	*A*	*B*
Diameter (D)----------mm--	12. 1	7. 0
Height of last whorl (H)----------mm--	5. 6	3. 0
Width of last whorl (W)----------mm--	6. 9	4. 6
Width of umbilicus (U)----------mm--	3. 5	2. 5
U/D----------	. 29	. 36
W/D----------	. 57	. 66
W/H----------	1. 23	1. 53

Several widely umbilicate beyrichoceratids bear a superficial resemblance to the Alaskan form under discussion. They are: *Beyrichoceras* (*Beyrichoceras*) *umbilicatum* (Phillips), *B.* (*Bollandoceras*) *globosum* Bisat., *B.* (*Bollandites*) *castletonense* (Bisat), *B.* (*B.*) *phillipsi* Bisat, and *B.* (*B.*) *sulcatum* (Bisat). The first two may be distinguished from the Alaskan form by the rather broad ventral lobe and correspondingly narrow first lateral saddle of their sutures. *B. umbilicatum* also has a more compressed shell.

Comparison with a specimen of *B. castletonense* in the USGS collection, from Treak Cliff, Derbyshire, England, shows that the British species at a diameter of roughly 15 mm is more widely umbilicate (U/D=0.45) than the Alaskan shell. Moreover, Bisat (1924, p. 92, 93) pointed out that up to a diameter of at least 21 mm, the umbilicus of *B. castletonense* expands with growth. The rather meager information given in the table of dimensions suggests that the umbilicus of the Alaskan form becomes smaller with growth.

Typical *B. phillipsi* Bisat has a narrower umbilicus (U/D=0.21–0.23) than *B. castletonense*, and narrower also than the Alaskan form.

B. sulcatum, like the Alaskan shell, has an umbilicus whose width (U/D=0.28) is between those of *B. castletonense* and *B. phillipsi*. Whether the Alaskan shells in maturity would develop a ventral longitudinal sulcus, as do some specimens of *B. sulcatum*, is not known. The dimensions given by Bisat (1952, p. 176) for *B. sulcatum* show that it has a slightly narrower shell (W/D=0.52) than the Alaskan form. The proportions of the Alaska shells, however, are similar to those of two specimens of an unidentified species of *Beyrichoceras* (USNM coll. 636) from Poolvash, Isle of Man, England. In these at diameters of 13 and 20 mm U/D= 0.39 and 0.36, respectively, and W/D=0.62 in both.

As the range of variation of the beyrichoceratids has not yet been determined and as the Alaskan material at hand is not regarded as adequate for establishing a new species, it appears most reasonable for the present to point out the general similarity of the Alaskan shell to the British species, *B. sulcatum* Bisat. Left to future collecting of better material and future studies of the group is the decision as to whether a new name is needed for this form.

The stratigraphic position and correlation of the Alaskan form does not appear to present as much of a problem, as all of the similar widely umbilicate species in England occur in the upper *Beyrichoceras* (B_2) zone.

Figured specimens: USNM 118963.

Occurrence: USGS locality 11818, from concretions in an outcrop of black cherty shale, roughly 2 miles south of Lisburne Ridge and 8 miles east of the Ipnavik River, Brooks Range.

Genus BEYRICHOCERAS Foord 1903, emend. Bisat, 1924

1903. *Beyrichoceras* Foord [part], Carboniferous Cephalopoda of Ireland, pt. 5, p. 219.
1924. *Beyrichoceras* Foord [part]. Bisat, Yorkshire Geol. Soc., v. 20, pt. 1, p. 83, 84.
1934. *Beyrichoceras* Foord [part]. Bisat, Yorkshire Geol. Soc., 22, pt. 4, p. 284, 285.
1940. *Beyrichoceras* Foord [part]. Delépine, Mus. royale histoire nat. Belgique, Mém no. 91, p. 60–63.
1941. *Beyrichoceras* Foord. Delépine, Maroc, Serv. Géol., notes et mém, no. 56, p. 62.
1947. *Beyrichoceras* Foord. Miller, Jour. Paleontology, v. 21, no. 1, p. 19, 20.
1952. *Beyrichoceras* Foord. Delépine *in* Piveteau, Traité de Paléontologie, tome 2, p. 572.
1952. *Beyrichoceras* Foord. Bisat, Leeds Geol. Assoc., Trans., v. 6, pt. 4, p. 164, 167–171.
1952. *Bollandoceras* Bisat, Leeds Geol. Assoc., Trans., v. 6, pt. 4, p. 164, 167.

Diagnosis: Shell generally subdiscoidal, moderately involute, with well rounded venter and ventro-lateral shoulders and gently rounded sides. Surface sculpture consists of delicate noncrenulate transverse striae and narrow growth constrictions that are gently sinuous and usually form a shallow hyponomic sinus over the venter; some species have faint longitudinal striae, strongest on the ventro-lateral shoulders, but most species lack longitudinal sculpture. Suture goniatitid, externally with a narrow ventral lobe commonly with slightly bulging sides and with the points diverging apicad; a pair of rounded or spatulate first lateral saddles, a pair of pointed V-shaped lateral lobes, and a pair of short rounded umbilical lobes. The median width of the first lateral saddle is less than 1⅓ times that of the ventral lobe.

Type of genus: *Goniatites obtusus* Phillips 1836, by subsequent designation of Bisat (1924, p. 84).

Beyrichoceras can be distinguished from *Münsteroceras* Hyatt by the fine transverse striae on the shell and generally by the more advanced suture. From *Beyrichoceratoides* Bisat it differs in having a more compressed shell, a ventral lobe which diverges more rapidly in the orad half, and a deeper median sinus. From *Sudeticeras* Patteisky it differs in the lack of crenulate transverse striae and the slightly narrower and more deeply notched ventral lobe of the suture.

A variety of species were included originally by Foord (1903) in *Beyrichoceras*, which he proposed as a subgenus of *Clyphioceras* Hyatt. Bisat (1924) redefined the genus more or less as it is now understood and selected *B. obtusum* (Phillips), the first species mentioned by Foord, as its type. Of the eighteen species included by Foord in *Beyrichoceras*, Bisat recognized only two as still belonging in this genus. The others are now distributed among other genera, such as *Beyrichoceratoides* Bisat, *Münsteroceras* Hyatt, *Homoceras* Hyatt, *Reticuloceras* Bisat, and *Neoglyphioceras* Brüning.

Bisat (1924, 1934) described several new species of *Beyrichoceras* and in his 1934 paper called attention to three principal stocks or subgeneric groups of species that he said comprise the genus, the groups of *B. castletonense* Bisat, *B. micronotum* (Phillips), and *B. obtusum* (Phillips). He did not propose formal names for these groups at that time. In a later paper, Bisat (1952) restricted the name *Beyrichoceras* to the *B. obtusum* group and proposed as new genera the names *Bollandites* and *Bollandoceras* for the other two groups.

The writer does not believe that the *B. micronotum* group differs markedly from the *B. obtusum* group in essential characters. He is therefore suppressing *Bollandoceras* as a synonym of *Beyrichoceras*. *Bollandites*, on the other hand, erected for the *B. castletonense* group, appears to be intermediate between *Beyrichoceras* and *Münsteroceras* (including *Beyrichoceratoides*) and is here recognized as a separate genus.

The following species are included in the genus *Beyrichoceras:*

Beyrichoceras delicatum Bisat, 1924
Bollandoceras globosum Bisat, 1952
Beyrichoceras hodderense Bisat, 1924
  hornerae Miller, 1947
  micronotoides Bisat, 1934
Goniatites micronotus Phillips, 1836
  obtusus Phillips, 1836
Beyrichoceras parkinsoni Bisat, 1934
  rectangularum Bisat, 1934
  submicronotum Bisat, 1934
  umbilicatum Bisat, 1934
  vallense Delepine, 1940
Goniatites vesciculifer de Koninck, 1880

These species occur in rocks of middle Viséan age in the northern hemisphere, particularly in the boreal part of it.

Beyrichoceras micronotum (Phillips)

Plate 4, figs. 33–41, text fig. 15, A–C

1836. *Goniatites micronotus* Phillips, Illustrations of the Geology of Yorkshire, pt. 2, p. 234, pl. 19, figs. 22, 23.
1880. *Goniatites micronotus* Phillips. Branco, Palaeontographica, Band 27, p. 24, pl. 4, figs. a–1.
1897. *Glyphioceras micronotum* (Phillips). Foord and Crick, Catalogue of the Fossil Cephalopoda in the British Museum (Natural History), pt. 3, p. 173–175, text fig. 74.
1903. *Glyphioceras (Beyrichoceras) micronotum* (Phillips). Foord, Carboniferous Cephalopoda of Ireland, pt. 5, p. 177, 178, pl. 44, figs. 5a, b.
1924. *Beyrichoceras micronotum* (Phillips). Bisat, Yorksbire Geol. Soc., v. 20, pt. 1, p. 85, 86, pl. 9, figs. 4, 5.
1934. *Beyrichoceras micronotum* (Phillips). Bisat, Yorkshire Geol. Soc., v. 22, pt. 4, p. 291, 292, pl. 24, fig. 2, text fig. 18.
1940. *Beyrichoceras micronotum* (Phillips). Delépine, Mus. royal histoire nat. Belgique, Mém. no. 91, p. 68, 69, pl. 4, figs. 9–12.
1941. *Beyrichoceras micronotum* (Phillips). Delépine, Morocco, Service Géol., Notes et Mém., no. 56, p. 62, 63, pl. 3, figs. 25–32.

Three specimens from beds containing *Goniatites crenistria* at two localities on the Kiruktagiak River are probably conspecific with *Beyrichoceras micronotum* (Phillips). All are close in general proportions to the lectoholotype of that species. The shell is subdiscoidal, the width not quite half the diameter, with a well-rounded venter, gently rounded sides and a sharply rounded umbilical shoulder, the greatest width of the whorl about one quarter of the way from the umbilicus to the venter, and the whorl a little higher than wide. The umbilicus is small, its width about one-fourteenth the diameter, probably open, but owing to the nature of the preservation of the shell it is difficult to tell

whether or not the umbilicus was closed by shell material.

Surface sculpture consists of fine closely spaced gently sinuous lines of growth, forming a gentle orad bow on the inner flank, a shallow lateral sinus on the outer flank, a gentle vento-lateral salient, and a shallow hyponomic sinus over the venter. The best preserved specimen also has three constrictions of growth with the same configuration as the growth lines, well developed on the internal mold, but on the outer shell limited to shallow grooves on the sides. Two of the specimens show a "wrinkle layer" superimposed on the shell surface.

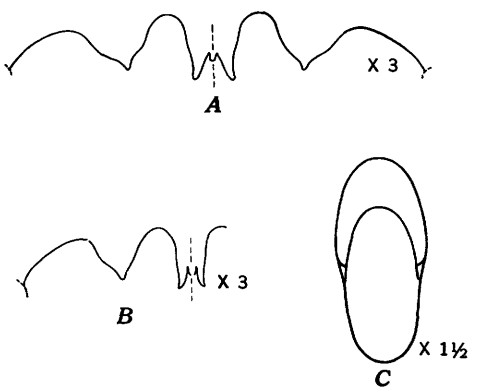

FIGURE 15.—*Beyrichoceras micronotum* (Phillips). *A*, External suture of a specimen (USNM 118965) at a shell diameter of 14 mm, ×3. *B*, External suture of another specimen (USNM 118966) from the same general locality as the last, at a shell diameter of 10.5 mm, ×3. *C*, Front view in outline of the shell, from the same specimen as figure 14*A*, ×1½.

One specimen, a phragmacone with a small part of the body chamber attached, shows the external suture clearly. At a shell diameter of 14 mm (text fig. 15, *A*) the relatively wide ventral lobe with slightly diverging gently bulging sides is 2.9 mm long, 2.0 mm in median width, and the dorsad curved pointed tips are 1.5 mm apart; the first lateral saddle is well rounded at the end, with a median width of about 1.7 mm; the first lateral lobe is short, mamilliform, acuminate, with a median width of about 2.2 mm; and the second lateral saddle is shallow, wide, and curved asymmetrically to the umbilical shoulder.

Dimensions and proportions	*A*	*B*	*C*	*D*
Diameter (D)_____mm__	17. 8	17. 2	14. 6	11. 7
Height of last whorl (H)_mm__	9. 8	9. 7	8. 3	6. 3
Width of last whorl (W)_mm__	8. 2	8. 5	7. 1	6. 0
Width of umbilicus (U)_mm__	1. 2	1. 2	1. 0	1. 2
U/D_____	. 07	. 07	. 07	. 10
W/D_____	. 46	. 49	. 49	. 51
W/H_____	. 84	. 88	. 86	. 95

A and *C* are from USGS locality 10866, *B* and *D* from USGS localities 10864 and 14149, respectively.

A specimen from USGS locality 14149 (same locality as 10864) is referred with some question to *Beyrichoceras micronotum*. Its dimensions have been included in the table above. Its proportions are nearly identical with those of the lectoholotype of *B. micronotum* (see below) and very close to those of the three Alaskan shells described above. The umbilicus is open. The suture (text fig. 15) differs from that of *B. micronotum* in having a narrower ventral lobe, but close inspection shows that the first lateral lobe and saddle are also proportionally narrower and the individual elements of the suture have the same general shapes as those of the suture of *B. micronotum*. It would seem that this shell is merely a variant of the beyrichoceratid with which it is associated, rather than a distinct species.

Foord and Crick (1897, p. 175) designated the larger of two specimens (no. C262a in the BMNH collection) in Phillips' original lot from Bolland, Yorkshire as the type of *B. micronotum*. The dimensions of the lectoholotype given by Bisat (1934, p. 291) agree very well with those of the Alaskan specimens under consideration. The ratios for the lectoholotype, computed from Bisat's measurements, are as follows: U/D=0.10, W/D =0.50, and W/H=0.93. The suture line exposed in the septate Alaskan specimen is almost identical with that of the type specimen of *B. micronotum* as figured by Foord and Crick (1897, text fig. 81) and also closely resembles Bisat's figure of part of a suture from the same specimen (Bisat, 1934, text fig. 18), though the ventral lobe of the Alaskan specimen is a little more deeply notched by the median saddle than shown by Bisat for the lectoholotype. The greatest area of uncertainty in comparing the two lies in the umbilicus of the three Alaskan shells which is very small and may have been closed.

Distribution: Beyrichoceratids of the *B. micronotum* group occur high in the upper *Beyrichoceras* (B_2) zone of northern England. Bisat (1952, p. 162) has suggested that *B. micronotum* may also occur above beds containing *Goniatites crenistria*, s. l. *B. micronotum* is known from many localities in the British Isles. Delépine (1940, p. 68, 69, pl. 4, figs. 9–12) has described poorly preserved specimens from the Viséan at Visé which appear to be a little more widely umbilicate than the British form. He also has recognized this species at several localities in French Morocco (Delépine, 1941, p. 62, 63, pl. 3, figs. 25–32).

Figured specimens: USNM 118964–66.

Occurrence: USGS locality 10864, Kiruktagiak River, 13 miles southwest of its junction with Castle Creek, one specimen; USGS locality 10866, Kiruktagiak River, 9½ miles southwest of its junction with Castle Creek, Brooks Range, two specimens; USGS locality 14949, same as 10864, one specimen. Fossils are from the black chert and shale member of the Alapah limestone.

Beyrichoceras sp.

Plate 4, figs. 30–32, text fig. 16 *A*, *B*

A single specimen, probably an immature individual, is a little plumper than *Beyrichoceras micronotum* (Phillips) with which it is associated and also differs slightly in particulars of the suture. It consists of the phragmacone and almost a complete volution of the body chamber and can be described as follows: Conch thick-discoidal, with well-rounded venter, gently rounded sides, and strongly rounded umbilical shoulder. Umbilicus small, equal to about one-tenth of the diameter. Body whorl a little wider than high, widest near the umbilical shoulder. Surface sculpture is not preserved in the specimen. There are about five rather faint gently sinuous constrictions of growth on the last whorl, forming shallow hyponomic and lateral sinuses.

Outermost suture at a diameter of approximately 8 mm (text fig. 16, *A*) has a short broad ventral lobe

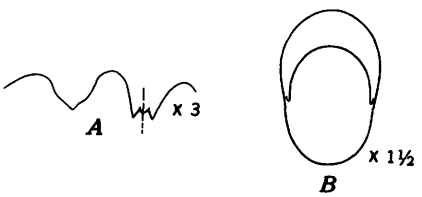

FIGURE 16.—*Beyrichoceras* sp. *A*, External suture of a specimen (USNM 118967) at a shell diameter of 8 mm, ×3. *B*, Front view in outline of the same shell, ×1½.

with rather straight sides diverging at an angle of approximately 40°, indented to about one-fifth of its length by a wide subangular median saddle; first lateral saddle broadly spatulate, its median width about 1.1 times that of the ventral lobe; first lateral lobe short and broad, a little wider than the first lateral saddle, rounded and mammilate; second lateral saddle broadly and asymmetrically rounded.

The dimensions of the shell are as follows: diameter (D), 13.3 mm; height of last whorl (H), 7.5 mm; width of last whorl (W), 8.8 mm; and width of umbilicus (U), 1.3 mm. The shell ratios are: U/D=0.10, W/D=0.66 and W/H=1.17.

The first lateral lobe of the suture is very similar to that of *Beyrichoceras micronotum* with which this shell is associated, but the ventral lobe differs in having straighter, more divergent sides and sharp subtriangular points, and the shell is wider. Whether these differences are due to immaturity of the specimen is not resolvable at present because of the lack of sufficient specimens. Bisat's figure (1934, text fig. 18) of the suture of the lectoholotype of *B. micronotum* shows similarities to the suture of *Beyrichoceras* sp., but has a slightly narrower first lateral saddle and the sides of the ventral lobe a little less widely divergent.

Figured specimen: USNM 118967.

Occurrence: USGS locality 10866, black chert and shale member of the Alapah limestone, Kiruktagiak River, 9½ miles southwest of its confluence with Castle Creek, Brooks Range.

Genus GONIATITES De Haan 1825

Goniatites crenistria Phillips

Plate 5, figs. 1–16, text fig. 17 *A–D*

1836. *Goniatites crenistria* Phillips, Illustrations of the Geology of Yorkshire, pt. 2, p. 234, pl. 19, figs. 7–9.
1836. *Goniatites vesica* Phillips, Illustrations of the Geology of Yorkshire, pt. 2, p. 236, pl. 20, figs. 19–21.
1897. *Glyphioceras incisum* Hyatt [part]. Smith, California Acad. Sci., Proc., 3d ser., Geology, v. 1, no. 3, p. 111–121, pl. 13, figs. 1, 2, 6–12, pl. 14, figs. 1–9, pl. 15, figs. 1–11 (not pl. 13, figs. 3–5).
1903. *Goniatites crenistria* Phillips [part]. Smith, U. S. Geol. Survey, Mon. 42, p. 68–76, pl. 14, figs. 1, 2, 7–12, pl. 15, figs. 1–9, pl. 16, figs. 1a–j, pl. 26, figs. 1–4 (not pl. 10, figs. 12–16, pl. 14, figs. 4–6, pl. 26, fig. 5).
1910. *Goniatites crenistria* Phillips. Grabau and Shimer, North American Index Fossils, v. 2, p. 141, fig. 1393, f–h.
1911. *Goniatites choctawensis* Shumard [part]. Girty, U. S. Geol. Survey, Bull. 439, p. 97–99, pl. 15, figs. 7, 7a (not figs. 1–6).
1911. *Goniatites crenistria* Phillips. Girty, U. S. Geol. Survey, Bull. 439, p. 99–101, pl. 15, figs. 8, 9.
1924. *Goniatites crenistria* Phillips. Bisat, Yorkshire Geol. Soc., Proc., v. 20, pt. 1, p. 78–82, pl. 3, figs. 4, 5, pl. 9, fig. 1.
1925. *Glyphioceras crenistria* (Phillips) [part]. Schmidt, Preuss. geol. Landesanstalt, Jahrbuch, Band 45, p. 565, 566, pl. 21, figs. 1, 3, pl. 23, fig. 14 (not pl. 21, fig. 2, pl. 23, fig. 13).
1952. *Goniatites crenistria* Phillips. Bisat, Leeds Geol. Assoc., Trans., v. 6, pt. 4, p. 173, 174, text fig. 3 (b).

Diagnosis: Shell globose in the young, becoming subglobose to thick-discoidal in the adult; involute, umbilicus roughly one-tenth the diameter of the shell. Shell surface crenistriate; transverse striae faintly sinuous. Suture of eight lobes and corresponding saddles, ventral and first lateral lobes with sigmoidal sides and first lateral saddle pointed in the adult.

Young shells of this species are globose, with a broadly rounded venter and well-rounded sides. In the first two or three whorls the width of the shell is slightly less than the diameter, but at diameters of roughly 3 to 4 mm in the typical form the width slightly exceeds the diameter. From this stage on, the gradual increase in the diameter of the shell is proportionally greater than the increase in width, so that immature and young mature shells are subglobose and fully mature shells, thick-discoidal. The mature shell has very gently rounded sides, but the venter and ventro-lateral areas are well rounded. The shell is involute during growth, the width of the umbilicus about one-tenth of the diameter, normally ranging from 7 to 12 percent of the

diameter. A cross section of an Alaskan shell (text fig. 17*D*) shows its extreme involution.

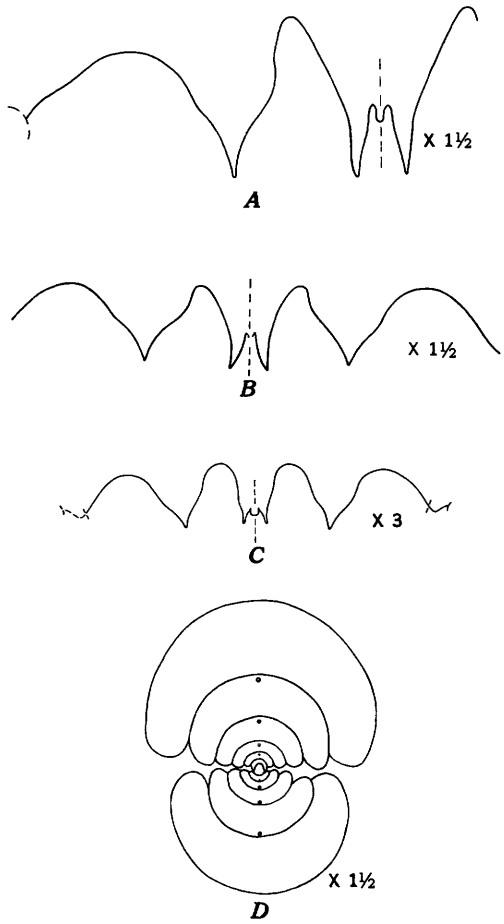

FIGURE 17.—*Goniatites crenistria* Phillips. *A*, External suture of a specimen (USNM 118970) at a shell diameter of 41 mm, ×1½. *B*, External suture of another specimen (USNM 118968) at a shell diameter of 29 mm, ×1½. *C*, External suture of an immature specimen (USNM 118968) at a shell diameter of approximately 9 mm, ×3. *D*, Cross section of the wide form (USNM 118969), ×1½.

Surface ornamentation consists principally of transverse striae, not perceptibly crenulate in the young up to a diameter of about 9 mm, but gently sinuous, with a shallow hyponomic sinus already developed at a diameter of 2 mm and flanked by a pair of very gentle salients. At diameters greater than 9 mm, the transverse striae are crenulate, the crenulations becoming gradually stronger with growth until, in the adult, they resemble the perforations along the edge of a postage stamp. On some adult specimens the salient points of the crenulations are crossed by faint flattish interrupted longitudinal lirae that are generally weaker than the transverse striae. Growth constrictions are present on some internal molds, two to three per whorl, but are not common.

The earliest stages of the suture of this species have been illustrated by Smith (1897, p. 114–120, pl. 15, figs. 1–11; 1903, p. 70–75, pl. 16, figs. 1a–j) from Arkansas specimens. In young shells the first lateral saddle is evenly rounded and the ventral lobe is barely notched by the median saddle. With growth the first lateral saddle becomes more tapered and in late maturity is commonly pointed and the median saddle becomes progressively deeper, extending to about two-fifths of the height of the ventral lobe in a specimen at a diameter of 45 mm.

This widespread European species was first recognized in North America by Smith (1903). Most subsequent American authors, however, have included Smith's Arkansas specimens in the synonymy of *Goniatites choctawensis* Shumard. Recent studies of Arkansas and Oklahoma material by the writer show that *G. crenistria* and *G. choctawensis* can be separated and that Smith's specimens from the Moorefield formation belong in *G. crenistria*. Comparisons show that the Moorefield specimens are conspecific with the Alaskan specimens here described and are close to the wide form. A more complete synonymy of *G. crenistria* than the one given above is included in a paper on the Carboniferous cephalopods of Arkansas (Gordon, in preparation).

The writer has had the privilege of examining the primary types of *G. crenistria* in the British Museum (Natural History). The lectotype is the middle-sized of five specimens in the original lot and preserves much of the shell surface, showing the delicate crenistriate pattern. The transverse striae curve gently across the venter and form a shallow sinus a little less than 2 mm deep. The dimensions of the lectoholotype are given in the table above. The largest paratype, an internal cast retaining about four-fifths of a whorl of the body

Dimensions and proportions	Typical form							Wide form							
	Holotype	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Diameter (D) mm	38.3	47.3	45.3	34.2	21.4	12.2	3.7	78.3	43.7	33.7	25.1	24.7	19.6	9.6	6.9
Height of last whorl (H) mm	20.5	23.6	22.0	18.5	11.0	6.6	1.5	42.5	21.3	16.7	13.7	13.0	9.4	5.6	3.7
Width of last whorl (W) mm	25.0	30.1	29.2	24.2	15.1	10.2	4.0	43.7	29.2	25.2	20.5	19.0	[1] 16.6	9.3	6.9
Width of umbilicus (U) mm	3.7	4.0	3.7	3.3	1.4	.9	.6	9.2	5.0	4.0	1.7	1.8	1.6	1.0	.7
U/D	.10	.08	.08	.10	.07	.07	.16	.12	.11	.12	.07	.07	.08	.11	.10
W/D	.65	.64	.64	.70	.71	.84	1.08	.56	.67	.75	.82	.77	.85	.97	1.00
W/H	1.22	1.28	1.33	1.31	1.37	1.55	2.66	1.03	1.37	1.51	1.49	1.46	1.77	1.66	1.86

[1] Twice the half-width.

NOTE.—A to F from USGS locality 11828; G, K–M from USGS locality 9188; H–J, N from locality 10866.

chamber, has a diameter of 62.0 mm and a width of 36.4 mm. Bisat (1924, p. 79, 81) has pointed out that *Goniatites vesica* Phillips (1836, p. 236) was based on young shells of *G. crenistria*.

The type lot represents a relatively narrow form of *G. crenistria*, similar to Alaskan specimens from the Etivluk River valley (USGS loc. 11828). As Phillips pointed out in his original description of this species, some varieties are more globular than the figured lectotype. The wider form from the Kiruktagiak River valley (USGS locs. 9188, 10864, 14149) is shown separately in the table of dimensions above. This form is similar to specimens from the P_{1a} subzone at Dinckley and Little Mearley Clough, Lancashire, England sent by E. W. J. Moore to G. H. Girty and now in the USGS collection. The narrower typical form is similar to those in another lot from the P_{1a} subzone in Cowdale Clough, 2½ miles west of Barnoldswick, Yorkshire, also sent by Moore to Girty, except that the Cowdale Clough specimens have a slightly wider umbilicus.

Bisat (1952, p. 174) says that variants of *G. crenistria* are very numerous and that eventually a detailed succession of subspecies will be established. However, he informed the writer (July 1952, personal communication) that differences in suites of *G. crenistria* from different localities in the north of England do not seem to have stratigraphic significance over any considerable area.

The following varieties and a subspecies of *G. crenistria* have already been described.

Goniatites crenistria dinckleyensis Bisat (1928, p. 132, pl. 6A, figs. 1, 1a), the holotype of which has been examined by the writer, appears to be like the typical form but a little more widely umbilicate (U/D=0.15). The holotype (BMNH C33150) has the following dimensions: diameter, 44.4 mm; height of last whorl, 22.0 mm; width of last whorl, 27.5 mm; width of umbilicus, 6.7 mm. Entirely septate, it has 16½ chambers on the exposed whorl and its relative width (W/D=0.62) agrees closely with that of typical *G. crenistria* at the same size. Thus Bisat's description of the subspecies *dinckleyensis* as being broader than the typical form and having 15 septa per whorl rather than the normal 17 is not borne out by the holotype.

Glyphioceras fimbriatum Foord and Crick (1897, p. 165, 166, text fig. 77a–c) is a broader (W/D=0.79–0.93 in the adult) and more widely umbilicate form (U/D= 0.14–0.22) than typical *G. crenistria*, with slightly coarser sculpture, believed by Bisat (1928, p. 80) to be a variety of *G. crenistria*.

Glyphioceras crenistria var. *globoides* Schmidt (1925, p. 566, pl. 21, fig. 1) is an extremely globose form resembling *G. sphaericus* (Sowerby) in shape but having a crenistriate shell surface. Schmidt's measurements indicate that adult specimens (W/D=0.70 at 30 and 40 mm diam.) are somewhat narrower.

Goniatites crenistria var. *pseudostriatus* Bisat (1928, p. 81) is a narrow form (W/D=0.53 at 62 mm diam.) with a very small umbilicus (U/D=0.05) and typical crenate striae, according to Bisat's original description.

Goniatites crenistria var. *reticulatus* Bisat (1928, p. 81) is a variety shaped like the typical species, but with a wider umbilicus (U/D=0.17) and with the longitudinal lirae very noticeable, though not equal in strength to the transverse striae. The name is a homonym of *Goniatites reticulatus* Phillips (1836, p. 235), the type of the genus *Reticuloceras* Bisat (1924, p. 114).

Only one of these five might be recognized in the Alaska material. Some of the wider specimens from the Kiruktagiak River valley (USGS locs. 9188, 10864 and 14149) are globose in the younger stages and in this respect resemble *Goniatites crenistria* var. *globoides* (Schmidt), but they appear to be a little more involute than Schmidt's figured cross section.

Goniatites crenistria Phillips can be distinguished from all the other North American species by its crenistriate sculpture, which persists through the mature stages of the shell. The closest American species is *Goniatites choctawensis* Shumard, which is about as narrow as an extremely slender form of *G. crenistria*. *G. choctawensis* is crenistriate in the young stages, but becomes finely lirate longitudinally in the mature conch, there being over 200 slightly wavy longitudinal lirae on the sides and venter of a typical specimen. Young shells of *G. choctawensis* are slightly narrower than those of *G. crenistria*, their width approaching but at no place (except for the protoconch) exceeding the diameter. Other American species, *G. cumminsi* (Hyatt) and *G. kentuckiensis* Miller have rounded-quadrilateral cross sections and are more coarsely longitudinally lirate in the mature stages than *G. choctawensis*.

Distribution: In North America it occurs in the black chert and shale member of the Alapah limestone Lisburne group in the Brooks Range, Alaska; and in the Moorefield formation of Arkansas. In western Europe it is a common and characteristic zonal fossil in the lower part of the Upper Viséan (zones V3a and V3b) of Belgium; in Germany and parts of Poland and Czechoslovakia in zone IIIα of German authors; in the British Isles in subzone P_{1a} of British authors; and in equivalent beds in the Mediterranean region in the French and Spanish Pyrenees, Portugal, Jugoslavia and French Morocco.

Lectotype, no. C282a (602) in the collection of the British Museum (Natural History), designated as the type by Foord and Crick (1897, p. 163). This is the specimen figured by Phillips (1836, pl. 19, figs. 7–9). Paratypes, four specimens in the same lot as the lectotype.

Type locality: The type lot is from Bolland, Yorkshire, but the exact locality is not known.

Figured specimens: USNM 118968–70.

Occurrence: USGS locality 9188, Kiruktagiak River, Brooks Range, 15 specimens; USGS locality 10866, same locality as 9188, 101 specimens; USGS locality 11828, Etivluk River valley, 32 specimens; USGS locality 10864, Kiruktagiak River, 13 miles southwest of its junction with Castle Creek, one fragment; USGS locality 14149, same as 10864, three specimens.

Goniatites cf. G. sphaericus (Sowerby)

Plate 6, figs. 1–7, text figs. 18, *A–C*

1814. *Ammonites sphaericus* Sowerby, The mineral conchology of Great Britain, v. 1, p. 116, pl. 53, fig. 2.

1924. *Goniatites* cf. *G. sphaericus* (Sowerby). Bisat, Yorkshire Geol. Soc., Proc., v. 20, pt. 1, p. 74.

Three fairly complete specimens and one fragment are included under this title. They differ somewhat in proportions, but all have goniatitid sutures and show traces of the surface ornament. Apparently they represent a single species of *Goniatites* with a shell that is globose in youth and early maturity and subglobose to thick-discoidal in the adult, and with longitudinal lirae ornamenting the mature conch.

The smallest of the three specimens at a diameter of 12 mm is barrel shaped, the width exceeding the diameter, venter broadly rounded and sides strongly rounded. The umbilicus is relatively large, its width equal to nearly a quarter of the diameter. A poorly preserved, partly recrystallized patch of surface ornament on the ventro-lateral shoulder at a diameter of approximately 9 mm shows fine transverse lirae dominant. The external suture at a diameter of about 11 mm has a rather narrower ventral lobe notched by a median saddle to roughly a third of the height of the lobe; the first lateral saddle asymmetrical, subangular at the end; and the first lateral lobe pointed, with bulging sides; the broadly asymmetrical second lateral saddle crossing the ventro-lateral shoulder of the conch.

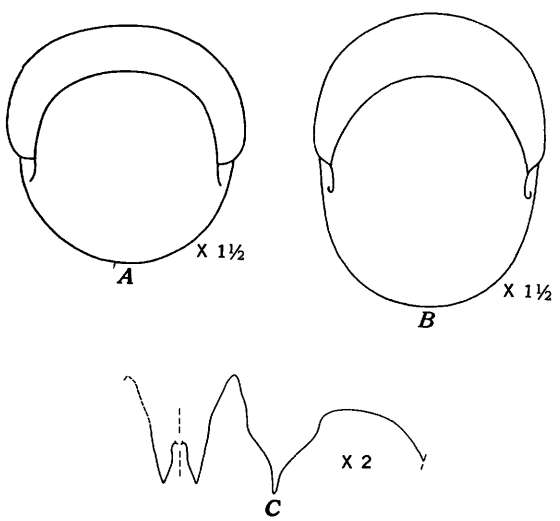

FIGURE 18.—*Goniatites* cf. *G. sphaericus* (Sowerby). *A*, Front view in outline of an early mature specimen (USNM 118971), ×1½. *B*, Front view in outline of a slightly more mature individual from the same locality, ×1½. *C*, External suture of the specimen shown in figure 17 (*B*) at a shell diameter of 20.5 mm, ×2.

The next largest specimen (text fig. 18, *A*) is globose, almost spherical, the diameter and width of the conch equal, the venter and sides broadly rounded, with stronger rounding at the ventro-lateral shoulders. The width of the umbilicus is equal roughly to one-sixth of the diameter of the shell. A patch of shell surface on the venter at an estimated diameter of 14 mm shows fine transverse and longitudinal lirae crossing to form a reticulate pattern. Another patch of surface ornament, on the venter at a diameter of 21 mm, shows the longitudinal lirae dominant and faintly beaded where crossed by the transverse threads, about four liraes in the space of 1 mm. At a diameter of 20 mm, the first lateral saddle of the suture is more pointed than in the smaller specimen.

The third specimen (text fig. 18, *B, C*), at a diameter of nearly 25 mm, is subglobose and more involute than the other two, the width of the umbilicus equal to about one-eighth of the diameter. Parts of the surface ornamentation are preserved, particularly on the sides. The spacing of the longitudinal lirae is closer on the umbilicus, where there are about five in the space of 1 mm, than it is over the venter or the ventro-lateral shoulder, where there are about 3½ in the space of 1 mm. Not enough of the surface is preserved for an accurate count of the longitudinal lirae, but there appear to be between 70 and 80 lirae from mid-venter to the umbilical shoulder. There are three constrictions of growth and 15 sutures on the last whorl of this specimen.

The remaining fragment, representing a little less than half of a shell slightly over 40 mm in diameter, indicates a further narrowing of the conch with growth, this specimen being thick-discoidal in section.

Dimensions and proportions	*A*	*B*	*C*
Diameter (D)——mm—	24. 6	21. 4	12. 5
Height of last whorl (H)——mm—	13. 2	10. 2	5. 0
Width of last whorl (W)——mm—	22. 0	21. 3	[1] 15. 3
Width of umbilicus (U)——mm—	3. 0	3. 5	3. 0
U/D	. 12	. 16	. 24
W/D	. 89	1. 00	1. 24
W/H	1. 66	2. 09	3. 06

[1] Twice the half-width.

The lectotype of *Goniatites sphaericus* (Sowerby), the type species of the genus *Goniatites* De Haan, is in the British Museum (BMNH 43871) where it has been examined by the writer. This specimen was designated as the type of *G. sphaericus* (Sowerby) by Stubblefield (1951, p. 121) as it appears to be the only specimen upon which Sowerby's brief description was based and may also be the specimen upon which Martin based

his earlier description and figures (1793, pl. 7, figs. 3–5; 1809, pl. 7, figs. 3–5). Martin's names have been rendered invalid by a ruling of the International Commission on Zoological Nomenclature (1950, p. 450) because they do not meet the requirements of correct binomial usage.

Sowerby's type is, unfortunately, devoid of surface ornamentation. One cannot, therefore, exclude the possibility of it being a globose and widely umbilicate form of *Goniatites crenistria* Phillips. Following Phillips (1836, p. 234, pl. 19, figs. 4–6), most authors have referred to *G. sphaericus* globose shells ornamented principally by fine longitudinal lirae. Bisat (1924, p. 74), however, stated that as it is impossible to assign any specimen other than Sowerby's type to *G. sphaericus*, he would use the designation *Goniatites* cf. *G. sphaericus* for shells like those that Phillips (1836, p. 234, pl. 19, figs. 4–6) referred to *G. sphaericus*. The Alaskan shells appear to be conspecific with a shell from Yorkshire identified as *G. sphaericus* in the national collection (USNM 34065). The name *Goniatites* cf. *G. sphaericus* is used here in the sense suggested by Bisat.

Other North American species that are ornamented principally by longitudinal lirae in the adult, such as *G. choctawensis* Shumard, *G. cumminsi* (Hyatt), and *G. kentuckiensis* Miller differ from *Goniatites* cf. *G. sphaericus* (Sowerby) in having the conch considerably narrower in the early mature stage. *G. cumminsi* and *G. kentuckiensis* differ further in having rounded-quadrilateral cross sections and have the median saddle of the ventral lobe in the suture commonly extending to more than half the height of the ventral lobe.

The stratigraphic range of *Goniatites* cf. *G. sphaericus* (Sowerby) in the British Carboniferous section is not fully known. Bisat (1924, p. 74) reported this species from the top of the Pendleside limestone at Chipping, England. This presumably would be approximately at the top of Bisat's *Beyrichoceras* (B) zone. He added subsequently (Bisat, 1934, p. 300) that *Goniatites sphaericus* may be a late form of the globose variant of *G. maximus* Bisat. More recently, Bisat (1952, p. 161, 162) pointed out that there is still considerable doubt as to the exact stratigraphic relationship of beds containing *Goniatites maximus* Bisat and *Beyrichoceras micronotum* (Phillips) to those containing *Goniatites crenistria* Phillips. Schmidt (1925, p. 568, 569, pl. 21, fig. 6) identified as *G. sphaericus* specimens from zone III β, overlying the *G. crenistria* (zone IIIα) in Germany.

Although the exact stratigraphic equivalence is not clear, it may be said with some assurance that, in Alaska, the sandstone which contains *G.* cf. *G. sphaericus* (Sowerby) is close in age to the goniatite beds on the Kiruktagiak River containing *G. crenistria* and *B. micronotum*. This sandstone is either late Middle Viséan or early Late Viséan in age.

Figured specimens: USNM 118971.

Occurrence: USGS locality 14153, unnamed sandstone of Mississippian age, west fork of Kiligwa River, near headwaters, De Long Mountains, Brooks Range.

Goniatites cf. G. granosus Portlock

Plate 6, figs. 8, 9, text fig. 19

1843. *Goniatites granosus* Portlock, Report on the geology of Londonderry, and Parts of Tyrone and Fermanagh, p. 407, pl. 29A, fig. 9.

This record is based on four partly distorted to flattened specimens, each from a different locality in the Calico Bluff formation, at or near its type section on the Yukon River. The best preserved of these specimens consists of a little more than half of a phragmacone, and is the one figured on plate 6.

The conch is thick-discoidal, rounded quadrilateral in cross section, with a broadly and shallowly rounded venter, well-rounded ventro-lateral shoulders, nearly flat sides, and subangular umbilical shoulders; the width of umbilicus is roughly one-seventh of the diameter.

Surface sculpture consists of strong longitudinal lirae with slightly wider interspaces and rather strong transverse growth constrictions. Owing to the imperfect preservation of the shell the exact number of longitudinal lirae cannot be determined but there are about 70 of them on the sides and venter between the umbilical shoulders. There are three growth constrictions on the fragment, spaced a quarter of a whorl apart. They are radial across the sides and almost straight across the venter.

FIGURE 19.—*Goniatites* cf. *G. granosus* Portlock. External suture of a specimen (USNM 118972) at a shell diameter of 30 mm, ×2.

The external suture at a shell diameter of about 28 mm has a ventral lobe with divergent sigmoidal sides, indented to not quite half its height by a rather narrow median sinus with sigmoidal sides; first lateral saddle strongly rounded orad, but not pointed; first lateral lobe rather broad, bell shaped, with a terminal spike; second lateral saddle broad and asymmetrically rounded.

Dimensions: diameter (D), 30.5 mm; height of last whorl (H), 16.5 mm; width of last whorl (W), 20.5 mm; width of umbilicus (U), 4.5 mm. Shell ratios are as follows: U/D=0.15, W/D=0.67, W/H=1.24. Owing to the slight distortion of this shell, these measurements are only approximate.

The rounded-quadrilateral cross section of this shell, together with the relatively low number of longitudinal lirae ornamenting the surface of the conch ally it with *Goniatites granosus* Portlock. The holotype of *G. granosus* comes from Carboniferous limestone near Clogher, County Tyrone, Ireland and is no. 31860 in the collection of the Geological Survey of Great Britain in London, England, where it has been examined by the writer. A slightly crushed specimen with a diameter of approximately 30 mm, it has about 80 longitudinal lirae on the sides and venter and three faint constrictions on the final whorl. Another specimen (GSGB Zi746) from near Bundoran, Donegal, Ireland, partly distorted and somewhat smaller than the holotype, has 69 lirae on the sides and venter.

The suture has not been seen on the Irish specimens but has been illustrated by Moore (1936, pl. 3, fig. 12) from an English specimen collected at Dinckley, Lancashire. It is similar to the suture of the Alaskan form, except that its first lateral saddle is pointed orad and its first lateral lobe does not have a conspicuous apicad spike. A specimen in the U. S. Geological Survey collections, from Eastby Beck, near Skipton, Yorkshire, sent by E. W. J. Moore to G. H. Girty, has a pointed first lateral saddle together with a conspicuous spike on the first lateral lobe. As the amount of variation in the suture of *G. granosus* is not known, and there appear to be no other described paucilirate species of *Goniatites* to which the rather poorly preserved Alaskan shell can be referred, we are comparing it with the Irish species without positive identification.

The Alaskan specimen described above was cited by Girty in a list of fossils published by Mertie (1932, p. 422) as *Goniatites* cf. *G. choctawensis* Shumard. Typical *G. choctawensis*, however, lacks the rounded-quadrilateral cross section of *G. granosus* and has over 200 longitudinal lirae on the sides and venter of the adult conch. Girty had a broad concept of *G. choctawensis* and in his report on the Caney shale fauna (1909, pp. 59–62), included in the Oklahoma species several specimens that probably are conspecific with the Alaskan shell under consideration. These Oklahoma specimens will be discussed further in a paper in preparation on the Carboniferous cephalopods of Arkansas, where a more complete synonymy of *G. granosus* will be given.

In western Europe and the British Isles, *G. granosus* is limited to the *Goniatites granosus* or upper *Posidonia* zone (P_2 of Bisat and III γ of Schmidt), the uppermost goniatite zone of the Viséan stage. Goniatites of this zone have not been found in the Brooks Range.

Figured specimen: USNM 118972.

Occurrence: Calico Bluff formation at the following localities in the Eagle-Circle district of eastern Alaska: USGS locality 5279, north bank of Yukon River, 1 mile above Seventymile River; USGS locality 5843, just below base of zone *b*, Calico Bluff, Yukon River; USGS locality 6841, shale bluff a quarter of a mile west of limestone point on north side of Tatonduk River, about 2½ miles from mouth; and USGS locality 6846A, argillaceous limestone in bench 2 miles northeast of Miller's cabin at mouth of Tatonduk River.

Goniatites? spp.

Text fig. 20

Goniatites from two localities are included under this title. A silicified fragment of shell from the Cape Lisburne region preserves part of the interior of the phragmacone, from venter to umbilicus, and includes six septa. This fragment, embedded in brown shale, indicates that the shell had a broadly rounded venter and moderately large umbilicus with an angular shoulder. The only sculpture that can be seen is some very faint close-spaced transverse growth lines at the umbilical shoulder, nearly obliterated by silicification of the shell. Two of the septa have been broken back to show the suture pattern, reproduced in text figure 20. The suture suggests the genus *Goniatites*, particularly in the sigmoidal sides of the first lateral saddle, but this saddle lacks the pointed or sharply rounded orad termination normally seen in this genus. The ventral lobe is short and broad and does not extend as far apicad as the acuminate first lateral lobe. This suture is not identical with that of any of the other species described in this paper. The rounding of the first lateral saddle suggests a relation to *Goniatites elegans* Bisat of the P_{1c} subzone of northern England, but because not enough of the shell is preserved and because the surface sculpture pattern cannot be seen, even the generic assignment is uncertain.

FIGURE 20.—*Goniatites*? sp. External suture of a specimen from the Cape Lisburne region (USNM 118995), ×2

Also considered here are several crushed and partly silicified goniatites from the Anaktuvuk River valley. About a dozen specimens are rather involute—an average one, crushed laterally, measures roughly 25 mm across, the umbilicus about 5 mm across. Faint surface sculpture on several specimens shows a very broad shallow orad bow on the sides, probably rounding into a shallow sinus over the venter. No sutures are preserved.

Associated with these are several larger less involute fragments of shell with umbilici stepped within and having subangular umbilical shoulders. Coarse silicification has destroyed the surface sculpture.

Figured specimen: USNM 118995.

Occurrence: USGS locality 3586 green, Lisburne group, 3 miles southeast of Wevok, Cape Lisburne region; USGS locality 11764, Alapah limestone, upper part of black shale and chert member, dip slope of hill on west side of Anaktuvuk River valley; Brooks Range.

Genus SUDETICERAS Patteisky 1930

Sudeticeras alaskae Gordon n. sp.

Plate 6, figs. 12–18, text fig. 21, A, B

Diagnosis: Conch thick-discoidal, moderately involute; surface sculpture crenistriate, becoming longitudinally lirate on the ventrolateral shoulder in the adult; transverse striae increasing by intercalation. External suture with a broad, rather short, bifid ventral lobe with slightly divergent points.

The holotype is a completely septate shell, thick-discoidal, the width of the whorl slightly greater than the height; the umbilicus open, about one-sixth of the diameter. The venter is broadly rounded, the ventrolateral shoulder strongly rounded, the side very gently rounded, and the umbilical shoulder sharply rounded; the umbilicus stepped within; the umbilical wall gently convex.

Surface sculpture consists of gently sinuous fine striae crossed by longitudinal lirae. The striae divide the shell surface into narrow flat lamellae that are almost imperceptibly raised orad and crenulated by the longitudinal lirae. Some of the transverse striae are introduced by intercalation at the mid-flanks between others that extend to the umbilicus and increase in strength over the ventro-lateral shoulder and venter. The striae are nearly straight across the inner flanks near the umbilicus, bend gently orad to form a well-rounded ventro-lateral salient, and swing apicad across the venter in a shallow hyponomic sinus. The orad projection of the salients at a diameter of 25 mm is about 1 mm and the depth of the hyponomic sinus about 2.5 mm. The longitudinal lirae are weaker in most places than the transverse sculpture, but by a diameter of 24 mm they equal or slightly surpass the strength of the lamellae on the ventro-lateral shoulder and outer flanks, where there are about 18 in the space of 5 mm. At this same place there are about 25 transverse striae in 5 mm. The longitudinal lirae are weaker over the venter and flanks, dying out near the middle of the flanks and absent near the umbilicus.

The external suture has a bifid ventral lobe with acuminate and slightly divergent tips. At a shell diameter of 29 mm the tips are 5 mm apart and the ventral lobe has a median width of 5.5 mm and a depth, measured along the venter of 7.0 mm; the first lateral saddle is bluntly spatulate, with sigmoidal sides and a median width of about 3.5 mm; the first lateral lobe is V-shaped, acuminate, with gently convex sides and a median width of about 3.5 mm; and the second lateral saddle curves broadly and asymmetrically to the umbilical shoulder. The short lobe on each umbilical wall is not exposed in the specimen. The internal suture consists of three narrow bluntly pointed lobes, the center one the longest, separated by narrow saddles with strongly rounded ends, and from the umbilical areas by gently curved asymmetrical saddles.

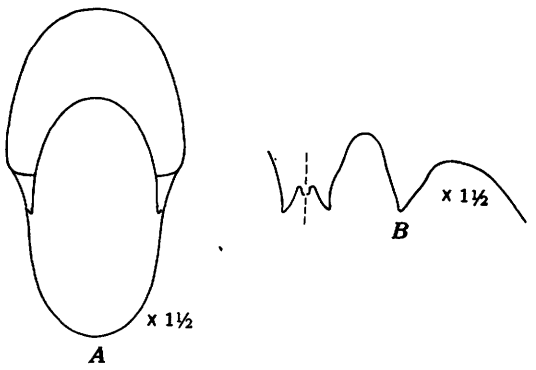

FIGURE 21.—*Sudeticeras alaskae* Gordon, n. sp. *A*, Front view in outline of the holotype (USNM 118973), ×1½. *B*, External suture of the holotype at a shell diameter of 28 mm, ×1½.

Dimensions and proportions	*Holotype*	*Paratype*
Diameter (D)——mm	29. 5	8. 3
Height of last whorl (H)——mm	15. 3	5. 0
Width of last whorl (W)——mm	16. 5	6. 5
Width of umbilicus (U)——mm	4. 6	1. 1
U/D	. 16	. 13
W/D	. 56	. 78
W/H	1. 08	1. 30

The two paratypes are a partly crushed fragment of a mature shell and a small specimen whose dimensions are given above. The small specimen is proportionally broader than the mature holotype, as is typical in young shells in this genus. It is a partly silicified cast of a phragmacone and shows four shallow slightly sinuous constrictions with gentle ventrolateral salients and a shallow hyponomic sinus. Visible parts of two adjacent sutures reveal that the first lateral saddle is more evenly rounded than in the adult.

Sudeticeras alaskae is the first representative of this genus to be described from the Western Hemisphere. Several species of the genus occur in beds of latest Viséan age in Europe—in the upper Bollandian (P_2 zone) and upper part of the lower Bollandian (P_1c subzone) of northern England, the upper part of the V_3c substage in Belgium, and zone III γ in East Germany and the Sudetenland of Czechoslovakia. The genus

has been discussed at some length by Patteisky (1930), Ruprecht (1937), and Moore (1950).

The Alaskan species is perhaps most similar to *Sudeticeras regina* Bisat (1952, p. 178–180, pl. 1, figs. 1–3, text fig. 2i) from the *Goniatites elegans* (P_1c) subzone of northern England, the shells of the two species having nearly identical proportions. Unfortunately, *S. regina* was described from almost completely exfoliated specimens so that the fine details of the surface sculpture cannot be compared. Bisat's drawing of the suture of *S. regina* indicates that this species has a more pointed first lateral saddle than *S. alaskae* and the two divisions of the ventral lobe do not appear to diverge as in *S. alaskae*.

The intercalation of the transverse striae in *S. alaskae* is like that in the Czechoslovakian species *S. stolbergi* (Patteisky) and the British species *S. procerum* Moore (1950, p. 42), but *S. stolbergi* has stronger longitudinal sculpture than *S. alaskae* and *S. procerum* has a slender ventral lobe with narrower divisions than the Alaskan species. *S. crenistriatum* (Bisat, 1928, p. 132) from the base of the *Goniatites granosus* (P_2) zone in northern England is another species similar to *S. alaskae* in arrangement and strength of the transverse and longitudinal sculpture, except that *S. crenistriatum* has a smaller umbilicus encircled by spiral lirae and the tips of the ventral lobe of its suture do not diverge as in *S. alaskae*.

Holotype, USNM 118973. Paratypes, USNM 118974, two additional specimens collected with the holotype.

Type locality: USGS locality 11804, black chert and shale member of the Alapah limestone, 525 feet below top of measured section B19, southern part of the Siksikpuk River Valley, Brooks Range.

Occurrence: Associated with *Eothalassoceras aurorale* Gordon, n. sp. at the type locality.

Genus NEOGLYPHIOCERAS Brüning 1923

Neoglyphioceras sp.

Plate 6, figs. 10, 11

Five crushed goniatites ornamented by strong longitudinal lirae, from a locality in the Eagle-Circle district, are referred to the genus *Neoglyphioceras*. These specimens were identified by Girty in a faunal list published by Mertie (1932, p. 422) as *Gastrioceras* cf. *G. caneyanum* Girty, a species now placed in *Neoglyphioceras*.

The largest is about 30 mm across. This and another specimen almost as large, both crushed laterally, have the umbilicus roughly a quarter as wide as the flattened shell and about 17 lirae on the exposed surface of the whorl. They are crossed by three or four conspicuous sickle-shaped growth constrictions. Another specimen (pl. 6, fig. 11), flattened ventrally so that parts of the sides are visible, shows about 33 longitudinal lirae, rather closely spaced and crossed by a conspicuous growth constriction that forms a U-shaped sinus across the venter. In number of lirae and relative width of the umbilicus, these specimens resemble *Neoglyphioceras caneyanum* (Girty), but the imperfect preservation precludes certain identification.

Two smaller specimens, crushed laterally and somewhat excentrically, appear to have fewer and sparser longitudinal lirae on the flanks, roughly 13 to 15 on the side, the larger figure representing a count from approximately the middle of the venter; and the width of the umbilicus is roughly a third of the diameter (pl. 6, fig. 10). These specimens appear closer to *Neoglyphioceras cloudi* (Miller and Youngquist) but are also too poorly preserved for positive identification. Nor can it be determined whether one or two species are present. None of the specimens preserves the suture, but the character of the surface sculpture is sufficient to identify the genus.

In northwestern Europe the genus *Neoglyphioceras* is confined to the *Goniatites granosus* or Upper *Posodonia* zone (P_2 of the British Isles, IIIα of central Europe). The presence of *Goniatites* cf. *G. granosus* Portlock at the same Alaskan locality in a limestone underlying the shale in which *Neoglyphioceras* was found partly confirms the generic and stratigraphic assignment.

Figured specimens: USNM 118975.

Occurrence: USGS locality 6846B, Calico Bluff formation, shale overlying limestone in bench 2 miles northeast of Miller's cabin at mouth of Tatonduk River, Eagle-Circle district.

Genus CRAVENOCERAS Bisat 1928

Cravenoceras sp.

Referred to this genus are six laterally crushed specimens in black shale from a locality in the Eagle-Circle district. They range in diameter from 20 to 50 mm. As the orginal shape of the shell has been obliterated in all the specimens it is impossible to tell what species is represented. The shell was moderately evolute (in flattened specimens the width of the umbilicus is two-fifths to not quite one-half the diameter of the shell) with a subangular umbilical shoulder and thus resembles those of such species as *Cravenoceras africanum* Delépine, *C. arcticum* Librovitch, *C. holmesi* Bisat, *C. kingi* (Hall and Whitfield), *C. malhamense* (Bisat), and *C. petrenkoi* Librovitch. Two specimens preserve the transverse lamellae typical of *Cravenoceras*, very gently bowed orad on the flanks and with a very shallow hyponomic sinus in the region of the venter. The suture is not preserved on any specimen.

Occurrence: USGS locality 10251, Yukon River, northeast bank, about 1 to 1½ miles upstream from mouth of Seventymile

River, Calico Bluff formation, from float at about middle of exposure, Eagle-Circle district.

Genus GIRTYOCERAS Wedekind 1918

Girtyoceras arcticum Gordon n. sp.

Plate 6, figs. 19–26, text figs. 22,A–C

Diagnosis: Conch thick-discoidal, moderately involute, venter rounded during immaturity, subangular in the adult, umbilical shoulder ribbed in young. Surface sculpture of gently sinuous growth lirae forming ventral sinus and very fine crowded longitudinal striae. Suture with broad ventral lobe, wider than first lateral saddle, which is broadly spatulate, first lateral lobe narrow, acuminate.

The holotype is a phragmacone with less than a tenth of a volution of the body chamber attached. At At the beginning of the final volution the venter is narrowly rounded, the ventrol-lateral shoulders more broadly rounded, the sides gently rounded and sloping ventrad, and the umbilical shoulders subangular; by the end of the phragmacone the venter is rounded-subangular in cross section. The umbilicus is equal to two-ninths the shell diameter; the umbilical wall is almost flat and vertical and shallowly channeled just within the umbilical shoulder by a sulcus less than 2 mm wide. The surface is ornamented by closely spaced sinuous growth lines that are preserved only in a few places on the holotype.

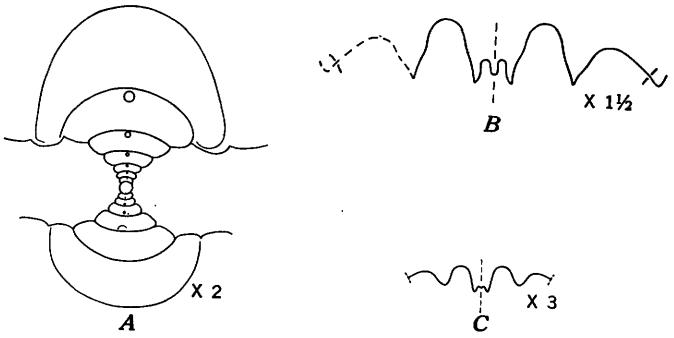

FIGURE 22.—*Girtyoceras arcticum* Gordon, n. sp. *A*, Cross section showing the inner whorls of a large paratype (USNM 118977), ×2. *B*, External suture of the holotype (USNM 118976) at a shell diameter of 23 mm, ×1½. *C*, External suture of a small paratype (USNM 118978) at a shell diameter of 6 mm, ×3.

There are 17 sutures on the final volution of the phragmacone, the last four or five a little more crowded then the rest. The twelfth from the last suture (text fig. 22,*B*), at a diameter of approximately 23 mm, has a broad ventral lobe, 6.1 mm in height, with a base 3.8 mm wide, with divergent and slightly bulging sides and a median width of 4.4 mm, and is indented to a depth of 2.7 mm by a rather broad median saddle; the first lateral saddle is broadly spatulate, with a median width of 3.5 mm; the first lateral lobe is V-shaped, acuminate, slightly convex in the middle, and narrow and pointed apicad; the second lateral saddle is of moderate width, asymmetrically rounded to the umbilical shoulder; the umbilical lobe is small and pointed, and lies just inside the umbilical shoulder.

Details of surface sculpture and the early growth stages are seen on several of the paratypes. Surface sculpture consists of sinuous closely spaced growth lirae, forming shallow broad bows at the ventro-lateral and umbilical shoulders, with a shallow lateral sinus between them on each flank, and a broad shallow sinus over the venter. Where growth constrictions are present they are approximately parallel to the transverse lirae, shallow, inconspicuous, about two to the whorl, and not expressed on the outer shell. The best preserved shells show fine longitudinal striae, usually closely crowded, finely incised, and interrupted by the transverse lirae; in some specimens, however, several fine fairly continuous longitudinal lirae occupy the venter.

The early whorls are broad and widen abruptly, so that the shell is barrel shaped and widely umbilicate, the venter is broad and shallowly convex and the sides narrowly rounded. On the middle of the first whorl small riblets appear on the umbilical wall, strongest at the shoulder, but they are commonly so fine that they are not easily seen until the second whorl; there are from 41 to 53 of these on the third and fourth whorls; they are less distinct and die out on the fifth whorl. In the fifth whorl the width of the umbilicus is slightly more than one half the diameter of the conch. At the end of the fifth whorl, the whorl increases gradually in height, the venter becomes more convex, the shell narrower, and the umbilicus proportionally smaller, as shown in the table of dimensions below.

The suture of the immature shell (text fig. 22,*C*) resembles that of the adult, except that the lobes are shorter and less sharply pointed, and the median sinus of the ventral lobe is shallow.

The robust thick-discoidal shell, the broadly spatulate first lateral saddle of the suture, and the gently sinuous transverse lirae are the distinguishing features of this species. *G. endicottense*, n. sp. has a similar broad first lateral saddle, but the ventral lobe is much narrower than that of *G. arcticum* and it has a smaller subdiscoidal shell with a peripheral groove. The North American species *G. meslerianum* (Girty) and *G. limatum* (Miller and Faber) have subdiscoidal shells on which the growth lirae form more pronounced ventro-lateral salients and the first lateral saddles of the suture are more narrowly spatulate.

All of the British species described by Moore (1946) in a review of this genus have more narrowly spatulate, or even subacute, first lateral saddles and with the possible exceptions of *G. shorrocksi* Moore and *G. waitei*

Dimensions and proportions	Holotype	Paratypes						
		A	B	C	D	E	F	G
Diameter (D)----------mm--	35. 6	30. 0	24. 2	19. 7	17. 2	13. 0	12. 0	8. 7
Height of last whorl (H)----------mm--	18. 5	15. 5	11. 3	9. 5	8. 1	5. 5	4. 6	3. 8
Width of last whorl (W)----------mm--	18. 1	16. 2	13. 4	12. 6	11. 5	8. 9	8. 9	6. 7
Width of umbilicus (U)----------mm--	7. 8	6. 8	6. 8	5. 5	5. 2	5. 2	5. 7	5. 0
U/D----------	. 22	. 23	. 28	. 28	. 30	. 40	. 48	. 57
W/D----------	. 51	. 54	. 55	. 64	. 67	. 68	. 74	. 77
W/H----------	. 98	1. 04	1. 09	1. 33	1. 42	1. 62	1. 93	1. 76

Holotype and paratypes A, C, D, and E from USGS locality 14149; paratypes B, F, and G from USGS locality 10864.

Moore, which are nearly as robust, all have narrower shells than *G. arcticum*. Both *G. shorrocksi* and *G. waitei* have umbilici slightly narrower than *G. arcticum*, and both are found at a higher stratigraphic level, in the upper part of the *Goniatites granosus* (P_2) zone.

Bisat (1952, p. 164–166, 171) has suggested that species similar to *Girtyoceras* but with a wide ventral lobe and narrowly rounded or acute first lateral saddles should be referred to the genus *Sagittoceras* Hind, 1918, which in recent years has generally been placed in the synonymy of *Girtyoceras*. At present the writer feels that despite its rather wide ventral lobe, the broadly rounded first lateral saddle of *G. arcticum* is closer to that of typical *Girtyoceras*.

Holotype, USNM 118976. Figured paratypes, 4 specimens collected with the holotype, USNM 118977; USNM 118978, 4 additional specimens from the same locality.

Type locality: USGS locality 14149, black chert and shale member of Alapah limestone, Kiruktagiak River, 13 miles southwest of its confluence with Castle Creek, Brooks Range, 61 specimens. Additional paratypes are from USGS locality 10864, same locality as 14149, 36 specimens.

Girtyoceras endicottense Gordon n. sp.

Plate 6, figs. 28–33, text fig. 23

Diagnosis: Conch small, subdiscoidal; venter with a longitudinal groove; shell surface with closely spaced radial transverse lirae forming shallow ventro-lateral salients and ventral sinus. Suture with fairly narrow ventral lobe having divergent sides, broadly rounded first lateral saddle and narrow V-shaped lateral lobe.

The type lot consists of four partly crushed specimens. The holotype is a phragmacone and two-thirds of a volution of the body chamber, the phragmacone retaining its original shape, but the body chamber partly crushed, especially on the right side. The conch is subdiscoidal, the venter and ventro-lateral shoulders well rounded, the sides gently rounded, and the umbilical shoulder subangular. The umbilicus is about a fourth to a fifth the diameter of the shell in adult specimens; the umbilical wall is nearly flat and approximately vertical. A shallow longitudinal groove, about 1 mm wide, occupies the center of the venter, at least on the last part of the phragmacone and early part of the body whorl, and seems to die out about a quarter of a turn from the end of the holotype. Similar grooves are present on all specimens in the type lot.

Surface sculpture consists of fine closely spaced transverse growth lirae that form broad, very shallow salients on the ventro-lateral and umbilical shoulders, with a shallow lateral sinus between them on each side and a narrow sinus of moderate depth over the venter. On the middle of the body whorl the ventral sinus is about 2 mm deep. There also are subparallel growth constrictions, about four to the whorl and between these, on the internal mold, finer indistinct depressions that parallel the sinuous growth lirae are discontinuous over the venter and deepest near the umbilical shoulder. The gently sinuous lirae and constrictions are approximately radial across the sides of the conch.

FIGURE 23.—*Girtyoceras endicottense* Gordon, n. sp. External suture and umbilical lobe of the holotype (USNM 118979) at a shell diameter of 13 mm, ×3.

The suture at a diameter of 13 mm (estimated) has a rather narrow ventral lobe about 3 mm high, with widely divergent sides that are subparallel for a short distance at the apicad end, notched to about one-fifth of its height by a broad subtriangular median sinus; the first lateral saddle is spatulate, broadly and asymmetrically rounded orad, its median width 1⅓ times that of the ventral lobe; the first lateral lobe narrower than the first lateral saddle, V-shaped, acuminate, with very slightly convex sides and an apicad nipple; second lateral saddle moderately broad and asymmetrically rounded to the umbilical shoulder; umbilical lobe short, subangular.

Dimensions and proportions	*Holotype*	*Paratype*
Diameter (D)----------mm--	26. 4	14. 4
Height of last whorl (H)----------mm--	10. 5	6. 8
Width of last whorl (W)----------mm--	[1]10. 0	6. 3
Width of umbilicus (U)----------mm--	5. 4	3. 7
U/D----------	. 20	. 26
W/D----------	. 38	. 44
W/H----------	. 95	. 93

[1] Twice the half-width.

Girtyoceras endicottense is easily distinguished from *G. arcticum*, n. sp., by its smaller, more compressed shell and narrower umbilicus, and by the presence of a groove along the middle of the venter, not seen in *G. arcticum*. It somewhat resembles *G. limatum* (Miller and Faber), which has a similar ventral groove and is also a compressed species ornamented by closely spaced fine transverse lirae. *G. limatum*, however, is smaller, has a slightly wider umbilicus than *G. endicottense*, and the ventro-lateral salients project orad to form a conspicuous narrow lingua, making the lirae and constrictions protractive across the sides of the whorl. In general shape, *G. endicottense* resembles *G. meslerianum* (Girty), the type species of the genus, but *G. meslerianum* differs in lacking the ventral groove and in having the lirae and constrictions produced into linguae at the ventro lateral shoulders, which makes them slightly protractive across the sides of the whorl.

Holotype, USNM 118979. Paratypes, USNM 118980, three specimens collected with the holotype.

Type locality: USGS locality 12084, limestone nodules from black chert and shale member of the Alapah limestone, on ridge 1,500 feet east of Kanaktuk Lake, Anaktukuk Valley, Endicott Mountains, Brooks Range.

Occurrence: Known only from the type locality, where it is associated with *Beyrichoceras (Bollandites) bowsheri*, n. sp.

Girtyoceras? spp.

Five specimens from two localities in the Calico Bluff formation, all imprints in black shale, resemble *Girtyoceras* somewhat. They were found associated with *Goniatites* cf. *G. granosus* Portlock. The laterally crushed shells range in size from 4 to 13 mm across, the largest a specimen of about six postnuclear whorls The early whorls are coiled planorbital but after the end of the fourth whorl the whorl height increases rather abruptly. The early whorls appear smooth, as the fine details of sculpture are not preserved. On the later whorls closely spaced fine strongly protractive growth lines form a shallow lateral sinus and swing well orad at or near the position of the ventro-lateral shoulder. The largest specimen shows remnants of two or three growth constrictions with approximately the same configuration as the growth lines.

Although the general proportions of the whorls and the strongly protractive growth lines are reminiscent of such species as *Girtyoceras limatum* (Miller and Faber) the absence of umbilical riblets on the younger whorls, perhaps due to the imperfect preservation, makes even the generic assignment to *Girtyoceras* open to question.

Two specimens from the black chert and shale member of the Alapah limestone, silicified and nearly flattened laterally, are doubtfully referred to *Girtyoceras*. The larger is about 15 mm across with an umbilicus roughly 3 mm in diameter, and the smaller about 9 mm across with an umbilicus roughly 2½ mm in diameter. Both show remains of axial riblets on the early whorls. On the later whorls narrow raised transverse lirae with subequal interspaces, are slightly protractive and curve orad very gentlv across the flanks. The surface sculpture is rather similar to that of *Girtyoceras endicottense*, n. sp., described from the same member at another locality in the same valley, but the preservation of these shells is too poor for definite assignment.

Occurrence: USGS locality 5279, Calico Bluff formation, north bank of Yukon River nearly opposite Seventymile River: USGS locality 6841, Calico Bluff formation, shale bluff on north side of Tatonduk River, 2¼ miles upstream from mouth; Eagle-Circle district. USGS locality 11764, near top of black chert and shale member of Alapah limestone, dip slope of hill on west side of Anaktuvuk River valley, 8 miles northeast of Anaktuvuk Pass, Brooks Range.

Genus ENTOGONITES Kittl 1904

1904. *Tetragonites* Kittl (not *Tetragonites* Kossmat, 1895), K. K. Geol. Reichsanstalt, Jahrbuch, Band 53, p. 677.
1904. *Entogonites* Kittl (n. nom. for *Tetragonites* Kittl), K. K. Geol. Reichsanstalt, Verh. no. 14, p. 322.
1925. *Nomismoceras* Hyatt (part). Schmidt, Preuss. geol. Landesanstalt, Jahrbuch, Band 45, p. 555–556.

Diagnosis: Shell subdiscoidal to discoidal, with a moderately wide umbilicus; young whorls coiled tetragonally, later whorls coiled normally. Whorls laterally compressed, with well rounded venter, ventro-lateral and umbilical shoulders, and somewhat flattened sides, ornamented by radial ribs, strongest on the sides; the ribs bifurcated or intercalated at the ventro-lateral shoulders, with ventro-lateral salient on each, separated by conspicuous hyponomic sinus over the venter; roughly parallel growth constrictions also present. Suture goniatitid with rounded saddles and bluntly pointed lobes; ventral lobe with divergent or subparallel sides.

Type of genus: *Tetragonites grimmeri* Kittl, 1904, by monotypy.

Kittl described his genus *Tetragonites*, based on the single species *T. grimmeri* Kittl, unaware that Kossmat had already used the same name for a genus of Cretaceous ammonites. On learning of the homonymy, he proposed the name *Entogonites* for this genus from the Bosnian Culm facies. In Kittl's illustration of the supposed external suture of *E. grimmeri*, the "external lobe" apparently is the dorsal lobe. Schmidt's figure (1925, pl. 20, fig. 14) of the suture of this species resembles that of *Nomismoceras*, Hyatt, 1884, with the sides of the ventral lobe diverging nearly at a right angle. European Carboniferous caphalopod specialists have followed Schmidt in assigning *E. grimmeri* to *Nomismoceras*.

The Alaskan species here described has the tetragonal coiling of the early whorls and the bifurcating radial ribs typical of *E. grimmeri*. It differs, however, in proportions of the conch, number of ribs, and details of the suture. Its suture has a ventral lobe with subparallel sides, thus raising the question as to whether Schmidt's drawing of the suture of *"Nomismoceras" grimmeri* (Kittl) accurately represents the actual suture of this species. The Alaskan species differs (in what are regarded as generic characteristics of coiling, ribbing, and suture line) from typical *Nomismoceras*. As he believes it is congeneric with *E. grimmeri*, the writer is resurrecting Kittl's generic name to include the two species.

Distribution: The genus *Entogonites* apparently has a stratigraphic distribution limited to the *Goniatites crenistria* zone (Schmidt's zone IIIα) in Germany and Yugoslavia, as well as at other widespread points in the northern hemisphere. Bisat (1952, p. 162) recently mentioned the occurrence of *E. grimmeri* at Black Wheel on the River Hodder, England. During the 19th International Geological Congress in 1952 the writer collected two young specimens of *Entogonites* cf. *E. grimmeri* associated with *Goniatites crenistria* Phillips 12 kilometers south of Derkaoua in southern Morocco. The Alaskan specimens of *Entogonites borealis*, n. sp. are associated with a stout form of *G. crenistria*. *Entogonites* appears, therefore, to be widespread and useful in stratigraphic zonation.

Entogonites borealis Gordon n. sp.

Plate 6, figs. 34–40, text figs. 24, *A*, *B*

Diagnosis: Conch subdiscoidal, evolute, the early whorls coiled tetragonally, the sides of the whorls ornamented by 35 to 40 nearly vertical ribs that bifurcate on the ventro-lateral shoulder and form a rounded ventrol-lateral salient and a hyponomic sinus. Ventral lobe of the suture with subparallel sides, the first lateral lobe rounded to bluntly pointed in the adult, and the saddles asymmetrically rounded.

The holotype, an entirely septate specimen of not quite seven whorls, is subdiscoidal, evolute; the umbilicus is stepped within, its width is equal to roughly two-fifths of the diameter.

The protoconch, which is suboval in section and wider than high, is broadly enveloped by the first whorl, which is about as wide as the protoconch, tightly coiled around it and devoid of sculpture. A suture visible on the first whorl shows a tiny narrow ventral lobe with no visible median notch, flanked by a broad lateral saddle at each side, extending to the umbilical shoulder. The early whorls are broad, two to three times as wide as high, but with growth the height increases more rapidly than the width so that on the last whorl the width and height are subequal. The venter is rounded in the adult, the sides gently rounded, and the ventro-lateral and umbilical shoulders strongly rounded. Tetragonal coiling begins with the second and extends through the fifth whorl.

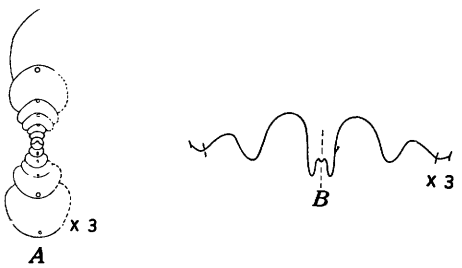

FIGURE 24.—*Entogonites borealis* Gordon, n. sp. *A*, Cross section of a paratype (USNM 118982), ×3. *B*, External suture and umbilical lobes from another paratype (USNM 118984) at a shell diameter of 12 mm, ×3.

Strong transverse ribs begin to appear on the third whorl extending across the umbilical shoulder and encroaching on the umbilical wall; on later whorls they do not cross the umbilical shoulder. About 30 of these ribs can be counted on each of the early whorls, but the number increases on the later whorls and there are about 40 on the final turn. The ribs on the last whorl are almost rectilinear near the umbilicus with a very faint sinus on the outer flank. Each rib bifurcates into a pair of riblets and forms a rounded salient over the ventro-lateral shoulder and a marked hyponomic sinus over the venter. Several of the ribs divide on the flanks near the umbilical shoulder. In addition to the ribs there are two to three transverse constructions of growth visible on each of the later whorls.

The suture on the final whorl has a ventral lobe with slightly converging sides, divided by a short squarish median saddle into narrow lobelets, the first lateral saddle moderately wide and asymmetrically rounded; the first lateral lobe is narrower than the first lateral saddle and rounded to very bluntly pointed in the last several sutures; the second lateral saddle is asymmetrically rounded, shallower and narrower than the first; the umbilical lobe is broad and gently rounded.

Dimensions and proportions	*Holotype*	*Paratype*
Diameter (D)----------mm--	11. 1	13. 0
Height of last whorl (H)----------mm--	4. 4	4. 0
Width of last whorl (W)----------mm--	4. 3	4. 2
Width of umbilicus (U)----------mm--	4. 5	6. 9
U/D----------	. 41	. 53
W/D----------	. 39	. 32
W/H----------	. 98	1. 05

The figured paratype indicates the range of variation in this species at its type locality. It is slightly narrower than the holotype and a little more evolute. The ribs are stronger and fewer (35 on the last whorl)

and none divide at the umbilical shoulder. The forward swing of the ventro-lateral salient is about 1 mm and the depth of the hyponomic sinus, 1.2 mm on this specimen. The sides of the ventral lobe of the suture are nearly parallel on the last whorl, on which there are 17 septa and three constrictions of growth.

Entogonites grimmeri (Kittl), the type of the genus, is narrower and has more ribs (about 50 on the last whorl) than *E. borealis*. Also, if Schmidt's figure (1925, pl. 20, fig. 14) truly represents the suture of this species, the sides of the ventral lobe of *E. grimmeri* are considerably more divergent than those of *E. borealis*.

Holotype, USNM 118981, from USGS locality 10864. Paratypes, USNM 118982, another specimen from the same lot as the holotype; USNM 11893, two specimens from USGS locality 12870; USNM 118984, six specimens from USGS locality 14149.

Type locality: USGS locality 10864, black chert and shale member of the Alapah limestone, Kiruktagiak River, 12½ miles upstream from its junction with Castle River, Brooks Range, Alaska; USGS locality 12870, same bed but on Monotis Creek; USGS locality 14149 is the same as 10864.

Occurrence: Known only from the type locality, where it is associated with *Goniatites crenistria* Phillips, *Girtyoceras arcticum* n. sp., and several other species.

Genus EOTHALASSOCERAS Miller and Furnish, 1940

Eothalassoceras aurorale Gordon n. sp.

Plate 3, figs. 16–19, text fig. 25, A, B

Diagnosis: *Eothalassoceras* with thick-discoidal shell and well rounded venter. Rounded apicad ends of the lobes of the external suture very weakly and irregularly digitate.

The holotype is a nearly complete specimen, approximately 30 mm in diameter, the body chamber of two-thirds of a volution distorted and laterally compressed by crushing. The phragmacone is thick-discoidal with a well-rounded venter and gently rounded sides. At the end of the phragmacone the height and width of the whorl are subequal. Umbilicus depressed but apparently closed by a callus, its width equal to about one-fifth of the diameter; umbilical shoulder rounded-subangular.

Surface ornamented by sinuous lines of growth. These and the aperture form a rounded lateral sinus on each side of a moderately shallow hyponomic sinus, with a well-rounded ventro-lateral salient between, and a smaller salient at each umbilical shoulder. At the aperture, the projection orad of the ventro-lateral salients is not quite 2 mm and the depth of the hyponomic sinus, about 4 mm. On the last quarter of a volution of the body chamber, on the internal mold, faint longitudinal grooves are visible crossing the lines of growth.

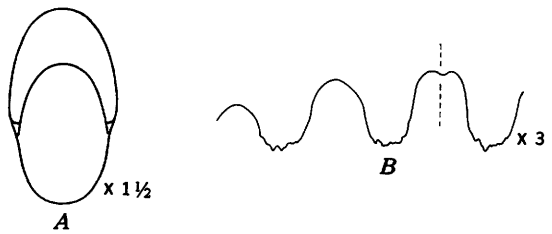

FIGURE 25.—*Eothalassoceras aurorale* Gordon, n. sp. *A*, Front view in outline, near end of phragmacone, taken from the holotype (USNM 118988), ×1½. *B*, External suture of the holotype, somewhat diagrammatic, at a shell diameter of 14 mm, ×3.

Sutures are fairly crowded, about 15 occurring on the last half volution of the phragmacone. The external suture (text fig. 25B) has a broad ventral lobe divided by a rather wide U-shaped median saddle almost as deep as the first lateral saddle, rounded orad and shallowly notched by the siphuncle; the two divisions of the ventral lobe have slightly convex sides converging gradually toward the rounded faintly digitate ends; the first lateral saddle is well rounded; the first lateral lobe is a little narrower than the first lateral saddle, in shape and digitation similar to the divisions of the ventral lobe; the second lateral saddle is asymmetrically rounded, its apex approximately at the umbilical shoulder; the umbilical lobe is not visible on the specimen. The internal suture was not seen. Dimensions based on the uncrushed phragmacone.

Diameter (D)	mm	18. 0
Height of last whorl (H)	mm	10. 0
Width of last whorl (W)	mm	[1] 10. 3
Width of umbilicus (U)	mm	4. 0
U/D		. 22
W/D		. 57
W/H		1. 03

[1] Twice the half-width.

The stratigraphic range of the thalassoceratids has been extended increasingly downward since the first *Thalassoceras* was described from the Permian Sosio beds of Sicily. The type of the genus *Eothalassoceras* Miller and Furnish (1940a, p. 105), *Prothalassoceras inexpectans* Miller and Owen (1937, p. 418-420, pl. 52, figs. 12-15, text fig. 4A–E), comes from Oklahoma and owes its trivail name to its authors' surprise at finding a thalassoceratid at such a low horizon in the Pennsylvanian section as the Coffeyville formation of Des Moines age. The species here described from beds of Late Viséan age in northern Alaska extends the range of thalassoceratids well below the horizon of the Oklahoma form.

Miller and Furnish (1940a, p. 105) proposed to suppress the genus *Prothalassoceras* Böse (1919, p. 102) as they regarded the type of that genus, *P. welleri* Böse

(1919, p. 102, pl. 5, figs. 14-18) to be congeneric with *Thalassoceras* Gemmellaro 1887 and assigned other thalassoceratids of Pennsylvanian age to *Eothalassoceras*. Ruzhencev (1950, p. 103-114) accepted both *Eothalassoceras* and *Prothalassoceras* as valid genera and, restricting *Eothalassoceras* to its type species, placed upper Pennsylvanian species of the United States and Upper Carboniferous species of the U.S.S.R. in *Prothalassoceras*. The new Alaskan species belongs in *Eothalassoceras* as restricted by Ruzhencev, rather than in *Prothalassoceras*.

Eothalassoceras aurorale is very close to *E. inexpectans* and differs from it principally in having a slightly broader venter and less tapering sides and in weaker digitation of the lobes of the external suture than *E. inexpectans*. The degree of digitation of these lobes in the mature holotype of *E. aurorale* is similar to that illustrated by Miller and Owen (1937, text fig. 4B) for *E. inexpectans* at a diameter of 4.2 mm. The median saddle of *E. aurorale* is a little wider and the sides of the lobes a little more slanting than in the suture of *E. inexpectans*.

Holotype, USNM 118988, from USGS locality 11804.

Type locality: Black chert and shale member of the Alapah limestone, approximately 525 feet below the top of measured section B19, southern part of the Siksikpuk River valley, Brooks Range.

Occurrence: Known only from the type locality where it is associated with *Sudeticeras alaskae* n. sp.

Genus DIMORPHOCERAS Hyatt, 1884

Dimorphoceras algens Gordon n. sp.

Plate 3, figs. 10–15, text figs. 26, A, B

Diagnosis: Conch narrowly lenticular, involute, umbilicus closed or nearly so. Outer surface with sinuous growth lines, in places closely longitudinally lirate. Suture with each half of the ventral lobe divided into two lobelets by a small subsidiary saddle, the first lobelet smaller and shorter than the second, the first lateral lobe undivided.

The holotype, an entirely septate individual, is lenticular, the width equal to approximately two-fifths of the diameter. The sides are gently rounded but almost flat and converge gradually toward the venter, which is narrowly rounded; umbilical shoulder sharply rounded, the umbilicus dimpled and apparently filled with shell material. At a calculated diameter of 5¼ mm, nearly one whorl from the end, the sides and venter are ornamented by fine longitudinal lirae, about 12 in the space of 1 mm. These become obsolete with growth and are absent on the flanks near the umbilicus at diameters greater than 10 mm and weak and interrupted near the ventro-lateral shoulder.

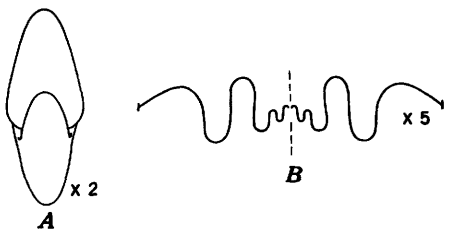

FIGURE 26.—*Dimorphoceras algens* Gordon, n. sp, *A*, Front view in outline of the holotype (USNM 118985), ×2. *B*, External suture of the holotype at a shell diameter of 9 mm, ×5.

The external suture has the same number of elements as that of *Dimorphoceras gilbertsoni* (Phillips). Each half of the ventral lobe is divided into two small subsidiary lobes by a subsidiary saddle about twice as deep as the siphonal saddle. The subsidiary lobe nearest the siphuncle is narrow, short, and bent slightly toward the umbilicus; the one farther away from the siphuncle is not quite twice the height and width of the inner one, bluntly pointed, and very slightly bent toward the siphuncle. The first lateral saddle is deeper than the subsidiary saddle of the ventral lobe and asymmetrically rounded above. The first lateral lobe, at its middle, is about as wide as the first lateral saddle, has sigmoidal sides, and is parallel tothe venter. The second lateral saddle is asymmetrically arched and extends across the umbilical shoulder on to the umbilical slope. The umbilical lobe is covered by matrix on the specimen.

Dimensions and proportions	*Holotype*	*Paratype*
Diameter (D)----------mm--	12. 9	10. 4
Height of last whorl (H)----------mm--	7. 6	6. 4
Width of last whorl (W)----------mm--	5. 3	4. 2
W/D----------	. 41	. 40
W/H----------	. 70	. 66

The paratype figured on plate 3, figures 13–15 has a different pattern of surface sculpture from that observed on the holotype. It resembles that of *Dimorphoceras gilbertsoni* (Phillips). No longitudinal lirae can be seen on this paratype, but sinuous lines of growth make a distinctive pattern. The growth lines are nearly straight at the umbilicus, then curve sharply back in a rounded lateral sinus on the mid-flanks. There is a prominent lingua near the ventro-lateral shoulder and a narrow hyponomic sinus on the venter. At a diameter of about 10 mm, the backward swing of the growth lines to the bottom of the lateral sinus is about 1 mm; the forward swing from the bottom of the sinus to the end of the lingua is 2.2 mm; and the depth of the hyponomic sinus, nearly 4 mm. This specimen shows no suture line, but another, from USGS locality 10864, combines a similar though faint growth-line pattern with a suture like that of the holotype. The spiral sculpture seen on the holotype becomes obsolete with

growth and probably ranges considerably in strength among individuals.

Dimorphoceras algens is one of the earlier and simpler forms of the group and is closely related to the type of the genus *D. gilbertsoni* from which it differs particularly in the ventral lobe of its suture, which has a very short siphonal saddle and the first subsidiary lobe of the ventral lobe much shorter than the second. In *D. gilbertsoni* the two subsidiary lobes are subequal in length.

The species closest to *D. algens* is *D. brancoi* Holzapfel, from the *Pericyclus kochi* zone (IIγ) of Germany, in that the first subsidiary lobe of the ventral lobe is likewise shorter than the second. In *D. brancoi*, however, the subsidiary divisions of the ventral lobe are shorter and more pointed than in *D. algens*, judging from the figures of Schmidt (1925, pl. 22, fig. 18), and the venter is acute in the adult.

Holotype, USNM 118985, from USGS locality 14149. Paratypes: USNM 118986, three specimens collected with the holotype; USNM 118987, two additional specimens from the same locality (USGS loc. 10864).

Type locality: Black chert and shale member of the Alapah limestone, west side of the Kiruktagiak River, 13 miles southwest of its junction with Castle Creek, Brooks Range.

Genus PROTOCANITES Schmidt 1924

Protocanites? sp.

A small crushed prolecanitid in a matrix of gray siliceous limestone has a diameter of approximately 8 mm. Nearly four whorls can be distinguished, the protoconch, and at least part of the first whorl covered by matrix that could not be removed without injuring the specimen; whorls planorbital, each one slightly impressed in the succeeding whorl. Of the last half whorl only the impression remains; on the sides of the two preceding whorls can be distinguished part of the external suture. Crushing has destroyed the ventral part. There are two lateral lobes, the first a little longer than the second, the sides of both parallel and their ends bluntly rounded and flattened on slight and opposite angles so that the deepest point lies ventrad on the first lateral and dorsad on the second lateral lobe. The second and third lateral saddles are asymmetrically rounded.

The suture, at a maximum diameter of 5 mm, resembles that of *Protocanites*, having the same number of lateral lobes as that Tournaisian genus. But as the shell is relatively immature, it may possibly be a young *Merocanites*, a genus found in rocks of early and middle Viséan age.

Occurrence: USGS locality 13241, Lisburne group undifferentiated, from about 30 feet above the top of a 105-foot sill of igneous rock on east slope of northward-trending ridge of De Long Mountains between two main branches of the Kiligwa River, Brooks Range.

Genus PRONORITES Mojsisovics, 1882

Pronorites? sp.

Plate 6, fig. 27

A single external mold in impure black calcareous shale is referred to the genus *Pronorites* on the basis of its general proportions and sculptural details of the conch. In the absence of any indication as to the configuration of the suture line, the generic assignment can only be regarded as tentative. A latex cast of this mold is figured.

The specimen is approximately 32 mm in diameter and shows almost four whorls, the protoconch and first whorl or whorl and a half not exposed. The shell is compressed, probably discoidal; the final whorl at the aperture is 14 mm high, with flattened sides and gently rounded ventro-lateral and umbilical shoulders; the umbilicus is bowl shaped, gently stepped within, its boundaries indistinct, roughly 12 mm in diameter; the umbilical wall is sloping and convex.

No trace of surface sculpture can be seen. Where the shell has been peeled away there is a very fine pattern of closely spaced nearly continuous subparallel minutely wrinkled striae, forming a very gentle orad bow on the side of the whorl near the umbilicus, not exposed near the venter.

Similar finely striate patterns on the surface of the internal cast have been observed by the writer in other specimens of the genus *Pronorites*. In one fairly complete specimen, from the Fayetteville shale of Arkansas, the fine striae are confined to the umbilical wall and dorsad half of the side of the shell, dying out about half way between the umbilical and dorso-lateral shoulders. These fine striae have not been observed in the several specimens of *Prolecanites* and *Epicanites* examined by the writer. However, the possibility exists that they were once present but not preserved in the specimens examined.

The whorl height, greater than the width of the umbilicus in this specimen, also suggests the genus *Pronorites*, rather than *Prolecanites*, *Merocanites*, or *Protocanites*, which are usually more evolute, and the stratigraphic position of the Alaskan specimen, in association with *Goniatites crenistria* Phillips, likewise weighs against its assignment to *Merocanites* or *Protocanites*. The genera *Pronorites*, *Prolecanites*, and *Epicanites*, are all known from the lower *Posidonia* (P_1) zone of the upper Viséan in northwest Europe, which includes the *Goniatites crenistria* (P_1a) subzone.

Figured specimen: USNM 118951.

Occurrence: USGS locality 11828, black chert and shale member of the Alapah limestone, four miles south of Lisburne Ridge, near the Etivluk River, Brooks Range.

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INDEX

[Italic numbers indicate descriptions]

PLATES 1–6

PLATE 1

[All figures natural size except as indicated otherwise on plate]

FIGURES 1, 2, 9. *Rayonnoceras rangifer* Gordon, n. sp.

1, 2. Side and apicad end views of part of the internal mold of a phragmacone, the holotype, USNM 118931, from USGS locality 11865.

9. Cross section (dorso-ventral) through part of a paratype, showing 3½ chambers, USNM 118992, from USGS locality 2644A. Endosiphuncle, siphuncular connecting rings, septa, and episeptal and hyposeptal cameral deposits are shown.

3–6. *Michelinoceras dutroi* Gordon, n. sp.

3, 5. Enlarged and natural size views of the holotype, USNM 118990, from USGS locality 11764, sectioned to show the orthochoanitic siphuncle.

4, 6. Enlarged and natural size views of the paratype, USNM 118991, from the same locality.

7, 8. *Rayonnoceras*? sp.

Side and apicad end views of a partly decorticate fragment of body chamber, USNM 118932, from USGS locality 10866.

10. *Bactrites*? *carbonarius* Smith?

A crushed fragment of the shell of a body chamber showing internal and external sculpture patterns, USNM 118946, from USGS locality 10866.

11–13. *Bactrites*? *carbonarius* Smith

11, 12. Side and apicad end views of part of a phragmacone, USNM 118945, from USGS locality 9188.

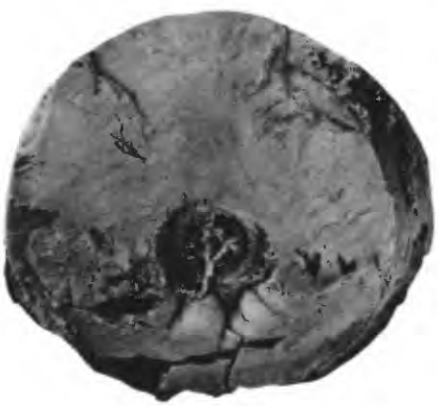
13. Enlargement showing part of the surface of the same specimen.

1

3 X 3

4 X 3

7



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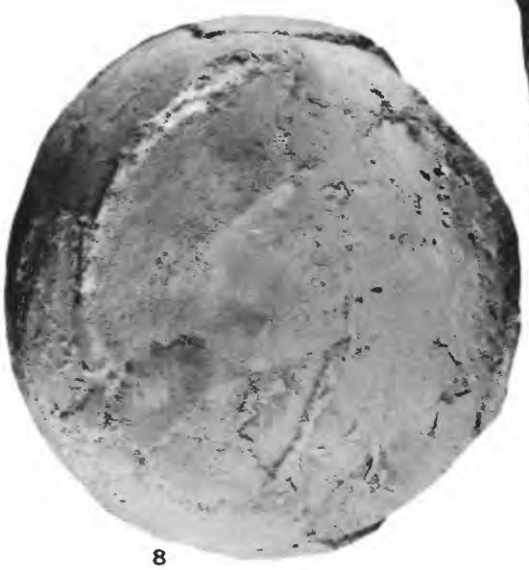
10



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9 X 2

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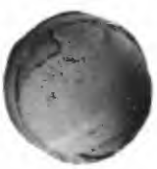
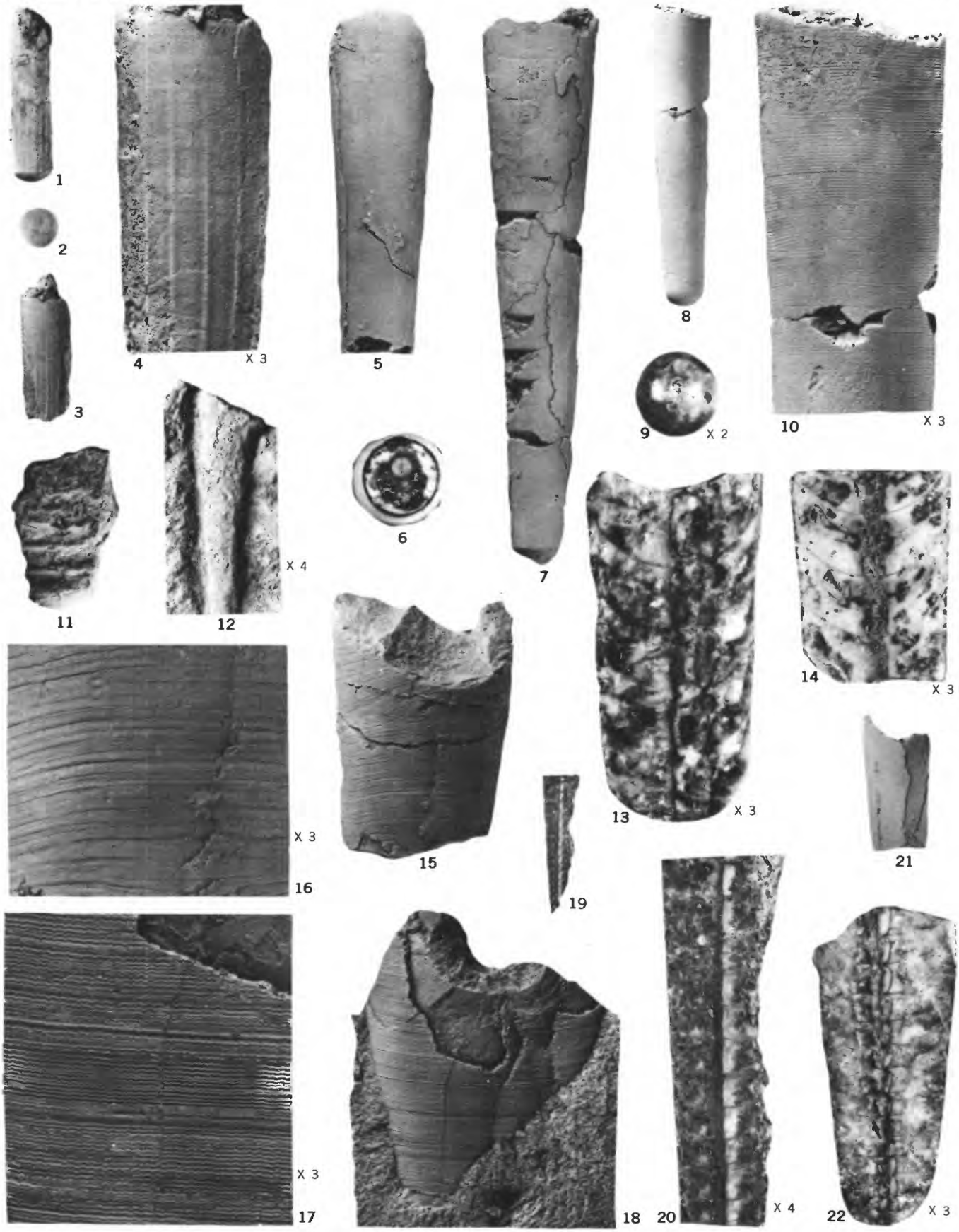


12

13 X 3

RAYONNOCERAS, MICHELINOCERAS, AND *BACTRITES?*



KIONOCERAS?, *ADNATOCERAS*, *DOLORTHOCERAS*, *CYCLOCERAS*, *EULOXOCERAS*, AND *PSEUDORTHOCERAS*

PLATE 2

[All figures natural size except as indicated otherwise on plate]

FIGURES 1–4. *Kionoceras?* sp. A

1, 2. Side and apicad end views of an internal mold of part of the body chamber, USNM 118935, from USGS locality 13100.

3, 4. Side view and enlargement showing surface details of another specimen, USNM 118934, from USGS locality 11867.

5–7, 13. *Adnatoceras alaskense* Gordon, n. sp.

5, 6. Dorsal and apicad end views of part of the phragmacone of a paratype, USNM 118941, from USGS locality 9188.

7. Ventral view of a phragmacone, the holotype, USNM 118940, from USGS locality 12084.

13. Enlarged cross section of part of the phragmacone of the holotype, showing the large excentric siphuncle.

8–10. *Dolorthoceras?* aff. *D. crebriliratum* (Girty)

Side and enlarged apicad views, and view showing surface details of part of the body chamber of a specimen, USNM 118944, from USGS locality 9188.

11. *Cycloceras* sp.

Side view of the best preserved fragment, part of the internal mold of a phragmacone, USNM 118933, from USGS locality 11857.

12. *Kionoceras?* sp. B

A small poorly preserved fragment in matrix, enlarged, showing faint longitudinal lirae in the upper left part, USNM 118936, from USGS locality 12785.

14, 21. *Dolorthoceras medium* Gordon, n. sp.

14. Enlarged cross section of part of the phragmacone, showing the comparatively small subcentral cyrtochoanitic siphuncle of the holotype, USNM 118937, from USGS locality 10866.

21. Side view of another part of the holotype.

15, 16. *Kionoceras?* sp. C

View and enlargement showing surface details of part of a body chamber, USNM 118942, from USGS locality 10866.

17, 18. *Kionoceras?* sp. D

Enlargement showing surface details and natural size view of part of a crushed body chamber, USNM 118943, from USGS locality 10866.

19, 20. *Euloxoceras* sp.

View and enlarged portion of a vertical section, showing white calcareous cameral deposits against the dark siphuncle, USNM 118989, from USGS locality 11804.

22. *Pseudorthoceras* sp.

Enlarged vertical section, USNM 118994, from USGS locality 10251.

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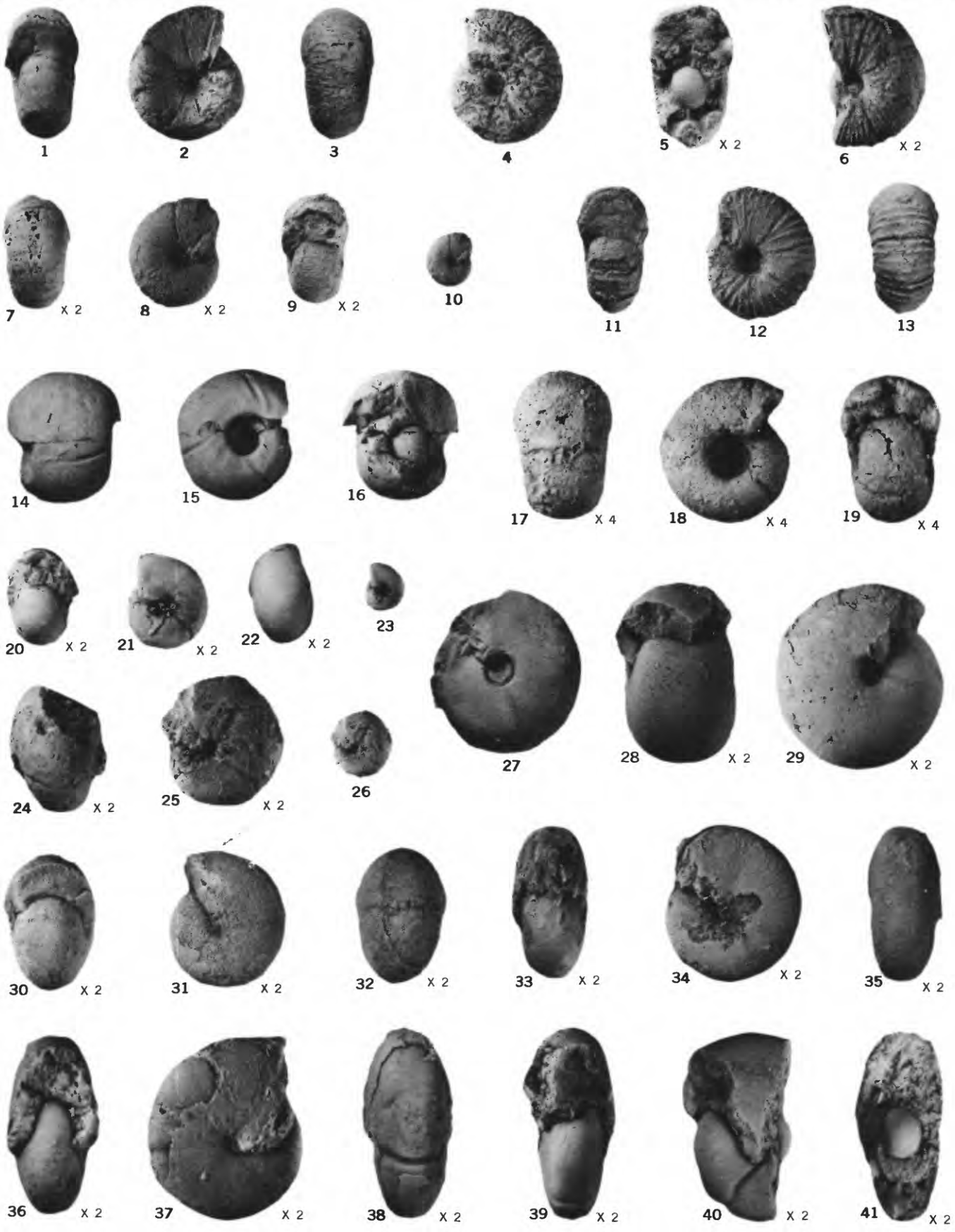
PLATE 3

[All figures natural size except as indicated otherwise on plate]

FIGURES 1–4. *Stroboceras crispum* Gordon, n. sp.
1, 2. Side view and enlargement showing details of the surface sculpture of the paratype, USNM 118950, from USGS locality 10866.
3, 4. Front and side views of the holotype, USNM 118949, from the same locality.
5–8. *Knightoceras pattoni* Gordon, n. sp.
5. Enlarged side view showing the apicad part of the holotype, USNM 118947, from USGS locality 10864.
6–8. Dorsal, side, and ventral aspects of the holotype.
9. *Knightoceras* sp.
Side view of a partly reconstructed silicified internal mold, USNM 118948, from USGS locality 10883.
10–15. *Dimorphoceras algens* Gordon, n. sp.
10–12. Enlarged front, side, and rear views of an internal mold, the holotype, USNM 118985, from USGS locality 14149.
13–15. Enlarged rear, side, and front views of a paratype, USNM 118986, from the same locality.
16–19. *Eothalassoceras aurorale* Gordon, n. sp.
16. Side view of the complete holotype, USNM 118988, from USGS locality 11804, showing the sigmoidal aperture.
17–19. Enlarged rear, side, and front views of the same specimen with most of the partly crushed body chamber removed.

STROBOCERAS, KNIGHTOCERAS, DIMORPHOCERAS, AND *EOTHALASSOCERAS*



AMMONELLIPSITES, MÜNSTEROCERAS, BOLLANDITES, AND *BEYRICHOCERAS*

PLATE 4

[All figures natural size except as indicated otherwise on plate]

FIGURES 1–13. *Ammonellipsites* (*Fascipericyclus*) *polaris* Gordon, n. sp.

1–4. Front, left side, rear, and right side views of the holotype, USNM 118952, from USGS locality 11857.

5, 6. Enlarged front and side views of a partly broken paratype, USNM 118953, from the same locality, showing the sculpture of a young whorl.

7–10. Enlarged rear, side, and front views and natural size side view of a small internal mold of the phragmacone. a paratype, USNM 118953, from the same locality.

11–13. Front, side, and rear views of a hypotype with coarser and straighter transverse sculpture exhibiting intercalation, USNM 118954, from the same locality.

14–16. *Münsteroceras saginatum* Gordon, n. sp.

Rear, side, and front views of a partly broken phragmacone, the holotype; USNM 118956, from USGS locality 11877.

17–19. *Bollandites* cf. *B. sulcatum* Bisat

Enlarged rear, side, and front views of a small silicified phragmacone, USNM 118963, from USGS locality 11818.

20–26. *Bollandites kiligwae* Gordon, n. sp.

20–23. Enlarged front, side, and rear views and natural size side view of a paratype, USNM 118962, from USGS locality 13204.

24–26. Enlarged rear and side views and natural size side view of the holotype, USNM 118961, from the same locality.

27–29. *Bollandites bowsheri* Gordon, n. sp.

27. Side view of a specimen referred to this species with some question, USNM 118960, from USGS locality 12787.

28, 29. Enlarged front and side views of the holotype, USNM 118958, from USGS locality 12084.

30–32. *Beyrichoceras* sp.

Enlarged front, side, and rear views of the only specimen, USNM 118967, from USGS locality 10866.

33–41. *Beyrichoceras micronotum* (Phillips)

33–35. Enlarged front, side, and rear views of a well preserved specimen, USNM 118965, from USGS locality 10866.

36–38. Enlarged front, side, and rear views of another specimen, USNM 118964, from USGS locality 10864.

39–41. Enlarged front, side, and rear views of a partly broken septate specimen showing the shape of the young whorl, USNM 118965, from USGS locality 10866.

PLATE 5

[All figures natural size except as indicated otherwise on plate]

Figures 1–16. *Goniatites crenistria* Phillips

1–3. Front, side, and rear views of the largest specimen of the wide form, USNM 118968, from USGS locality 9188.

4–6. Front, side, and rear views of a smaller specimen from the same locality.

8. Polished cross section of another specimen from approximately the same locality, showing the extremely narrow umbilicus, USNM 118969, from USGS locality 10866.

9–11. Front, side, and rear views of the typical form, USNM 118970, from USGS locality 11828.

12–15. Side and enlarged front, side, and rear views of a young specimen of the wide form, USNM 118968, from USGS locality 9188.

16. Enlarged view showing details of the surface sculpture of a specimen from the same locality.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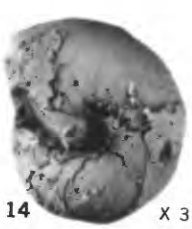
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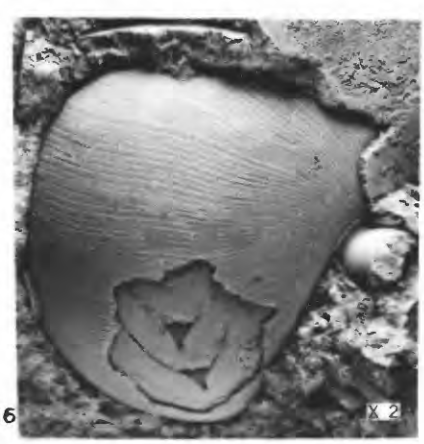
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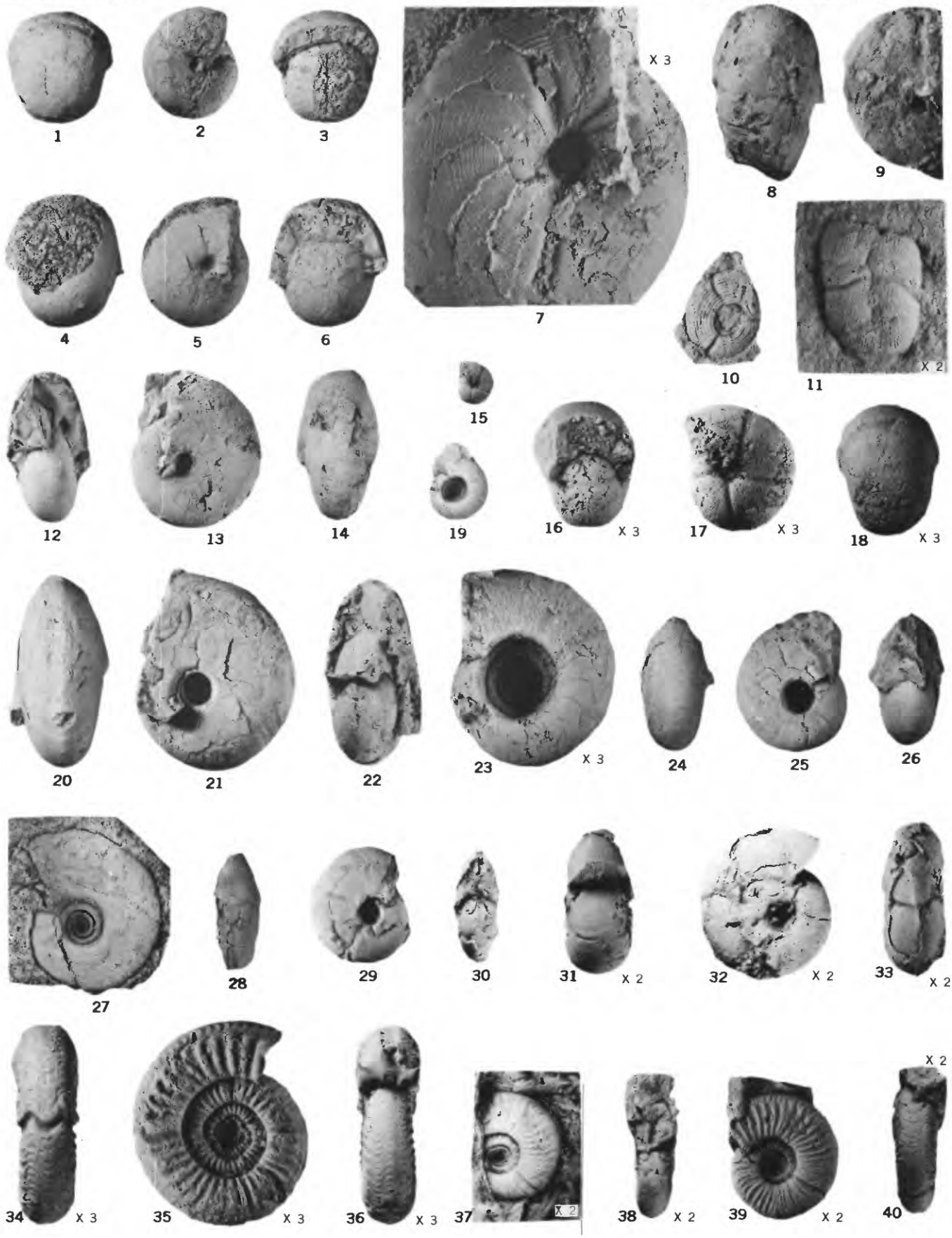
GONIATITES



CONIATITES, NEOGLYPHIOCERAS, SUDETICERAS, GIRTYOCERAS, PRONORITES?, AND *ENTOGONITES*

PLATE 6

[All figures natural size except as indicated otherwise on plate]

Figures 1–7. *Goniatites* cf. *G. sphaericus* (Sowerby)
1–3. Rear, side, and front views of a small globose specimen in early maturity, USNM 118971, from USGS locality 14153.
4–7. Rear, side, and front views and an enlargement showing surface details of a more mature specimen from the same locality.
8, 9. *Goniatites* cf. *G. granosus* Portlock
Rear and side views of the best preserved specimen, USNM 118972, from USGS locality 6846A.
10, 11. *Neoglyphioceras* sp.
Side and enlarged rear views of two crushed specimens in shale, USNM 118975, from USGS locality 6846B.
12–18. *Sudeticeras alaskae* Gordon, n. sp.
12–14. Front, side, and rear views of the holotype, USNM 118973, from USGS locality 11804.
15–18. Side and enlarged front, side, and rear views of a small paratype, USNM 118974, from the same locality.
19–26. *Girtyoceras arcticum* Gordon, n. sp.
19, 23. Side and enlarged side view of a small paratype, USNM 118978, from USGS locality 10864, showing umbilical ribs on the early whorls.
20–22. Rear, side, and front views of the holotype, USNM 118976, from USGS locality 14149.
24–26. Rear, side, and front views of a paratype, USNM 118978, from USGS locality 10864.
27. *Pronorites?* sp.
Side view of a latex cast, USNM 118951, from USGS locality 11828.
28–33. *Girtyoceras endicottense* Gordon, n. sp.
28–30. Rear, side, and front views of the holotype, USNM 118979, from USGS locality 12084.
31–33. Enlarged front, side, and rear views of a paratype, USNM 118980, from the same locality.
34–40. *Entogonites borealis* Gordon, n. sp.
34–36. Enlarged rear, side, and front views of a paratype, USNM 118984, from USGS locality 14149.
37. Enlarged view of a latex cast made from the external mold of the holotype, USNM 118981, from USGS locality 10864.
38–40. Enlarged front, side, and rear views of the holotype, an internal mold of the phragmacone.

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