Characteristic Jurassic Mollusks From Northern Alaska

GEOLOGICAL SURVEY PROFESSIONAL PAPER 274-D

Characteristic Jurassic Mollusks From Northern Alaska

By RALPH W. IMLAY

A SHORTER CONTRIBUTION TO GENERAL GEOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 274-D

A study showing that the northern Alaskan faunal succession agrees with that elsewhere in the Boreal region and in other parts of North America and in northwest Europe

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1955

UNITED STATES DEPARTMENT OF THE INTERIOR

Douglas McKay, *Secretary*

GEOLOGICAL SURVEY

W. E. Wrather, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - [redacted]ts (paper cover)
Price $1.00

CONTENTS

ILLUSTRATIONS

[Plates 8–13 follow index]

TABLES

CHARTS

A SHORTER CONTRIBUTION TO GENERAL GEOLOGY

CHARACTERISTIC JURASSIC MOLLUSKS FROM NORTHERN ALASKA

By Ralph W. Imlay

ABSTRACT

The fossils from the Jurassic strata of northern Alaska prove that the Lower, Middle, and Upper Jurassic series are represented but suggest that certain stages or parts of stages are not represented. There is no faunal evidence for the presence of the middle and upper parts of the Bajocian, the entire Bathonian, the upper part of the Callovian, the lower Oxfordian, or the upper Portlandian. Field evidence shows that a disconformity occurs at the stratigraphic position of the upper Portlandian. Both field and subsurface data suggest an unconformity immediately preceding the upper Oxfordian. The absence of faunal evidence for certain stages, or parts of stages, may be related to the fact that elsewhere in Alaska and in the western interior of North America major retreats of Jurassic seas occured during Bathonian, late Callovian, and Portlandian times.

Although the Jurassic strata in northern Alaska are generally impoverished faunally, nevertheless, in many places interpretations of the stratigraphy or the structure are based on the fossils present, or the fossils are used as supplementary evidence. Wherever the faunal succession can be determined in northern Alaska, it agrees essentially with that elsewhere in the Boreal region and in other parts of North America and in northwest Europe.

Faunal and lithologic relationships suggest that the eastward-trending Jurassic seaway of northern Alaska had rather uniform and moderately steep slopes along its northern and southern margins and that more than half of its sea bottom was stagnant and at least as deep as the lower part of the neritic zone. The existence of moderately deep water may explain the presence of the ammonites *Phylloceras*, *Lytoceras*, and *Reineckeia*, which are missing in the shallow-water Jurassic strata in the interior of North America, in east Greenland, and in the Barents Sea area. The scantiness of the fauna over much of the seaway is problably related to unfavorable bottom conditions and to an inadequate supply of certain materials such as phosphate. Fairly warm waters during Early Jurassic and early Middle Jurassic (Bajocian) time is indicated by the presence of ammonites that had a nearly worldwide distribution. Somewhat cooler waters and the presence of climatic zones during the Late Jurassic in Alaska, as in other parts of the Boreal region, is indicated by the presence of molluscan genera quite distinct from those in the Late Jurassic of the Mediterranean region.

INTRODUCTION

This study of the Jurassic macrofossils from northern Alaska is based on collections made by E. de K. Leffingwell in 1911 and by field parties from the United States Geological Survey since 1947. During the summer of 1950 the writer spent 10 days along the Canning River and 1 day along the Sagavanirktok River examining Jurassic outcrops. This provided some first-hand field information concerning the difficulties of mapping the Jurassic strata and of determining the stratigraphic succession. The brief descriptions of the stratigraphic and lithologic relationships presented herein as background for the ecologic and stratigraphic interpretations have been obtained mainly from discussions with the geologists who have recently studied the Jurassic rocks. These geologists, including George Gryc, C. L. Whittington, I. L. Tailleur, E. G. Sable, A. S. Keller, W. W. Patton, Jr., B. H. Kent, M. D. Mangus, J. T. Dutro, H. N. Reiser, R. L. Detterman, and R. H. Morris, have also checked or rewritten all locality descriptions and have plotted the positions of the localities on figure 20. Their efforts have contributed greatly toward increasing the accuracy and value of the data in this report. It is hoped that the interpretations of the data will have immediate use in northern Alaska and will have application in other parts of Alaska.

BIOLOGIC ANALYSIS

The Jurassic fossils from northern Alaska that are generically identifiable include 163 specimens of ammonites, 9 belemnites, 530 pelecypods, 5 scaphopods, 9 rhynchonellid brachiopods, and more than a hundred pieces of the crinoid *Pentacrinus*. Of the total of 707 individual mollusks at hand, 338 belong to the pelecypod *Aucella*, and 369 belong to other genera. The Aucellas are a mere sampling of the enormous numbers present in the outcrops, but the other 369 mollusks represent nearly all that could be obtained by the field geologists in the time available. This number is surprisingly small considering that many field parties have worked in the area during the past 50 years. It shows that the outcropping Jurassic strata are poorly fossiliferous except for *Aucella*. The number of specimens in the molluscan genera arranged according to their age is shown on table 1.

Many of the fossils in the collections are either crushed or fragmentary. Most of the pelecypods, other than *Aucella*, are so imperfectly preserved that they are not worthy of description and are merely listed generically. Most of the ammonites are merely compared specifically with European or American species. Three ammonites are identified specifically with ammonites occurring in southwestern Alaska. Four species of *Aucella* are identified with species that are common in Boreal Jurassic strata. Not a single species is described as new. Partly, this reflects the wretched preservation of the fossils. It is probable, however, that better preservation would allow positive identifications of a number of species with named species elsewhere in North America, in the Boreal region, or in northwest Europe.

TABLE 1.—*Relative abundance of specimens of Jurassic molluscan genera in northern Alaska*

Genera	Lower Jurassic rocks	Lower Bajocian rocks	Callovian rocks	Oxfordian and Kimmeridgian rocks
Grammatodon	2			
Plicatula	40			
Camptonectes	1	1		
Velopecten?	4			
Lima				6
Gryphaea	9			
Oxytoma	14	10		
Aucella				338
Posidonia		40		
Inoceramus	9	35	20	
Pholadomya	1			
Tancredia				3
Dentalium	5			
Cylindroteuthis	3	1		5
Phylloceras				2
Lytoceras	1			
"Arietites"	1			
Amaltheus	15			
Coeloceras	4			
Dactylioceras	20			
Pseudolioceras		48		
Erycites		5		
Tmetoceras		2		
Arcticoceras			9	
Pseudocadoceras			1	
Amoeboceras				20
Reineckeia			35	

It is surprising that so few pelycypod genera are represented in the Jurassic deposits of northern Alaska. There is a complete lack of such common genera as *Pleuromya*, *Trigonia*, *Astarte*, *Isocyprina*, and *Meleagrinella*. Other equally common Jurassic pelecypods such as *Grammatodon*, *Gryphaea*, and *Pholadomya* are known by single occurrences. Actually the only fairly common pelecypods are *Inoceramus* and *Aucella*, and these characteristically do not occur together.

Among ammonites, too, very few genera are represented, considering the amount of Jurassic time and strata present. It seems probable, however, that the subsurface Jurassic contains a greater variety of ammonites than the outcrops, judging by the few cores that have been obtained. Most of the ammonite genera present in Alaskan Jurassic rocks are fairly common elsewhere in Boreal Jurassic strata and in northwest Europe, but the presence of *Phylloceras*, *Lytoceras*, and *Reineckeia* north of the Arctic Circle in Jurassic deposits is unique (Spath, 1932, p. 149, 151). This is probably the first record of *Lytoceras* and *Reineckeia* from Jurassic rocks bordering the Arctic Ocean. The record of a *Reineckeia* is particularly interesting, because this genus has been considered as a characteristic element of Mediterranean faunas.

STRATIGRAPHIC SUMMARY

Detailed descriptions of the distribution, thicknesses, lithologic features, and subdivisions of the Jurassic strata exposed in northern Alaska are being prepared by geologists of the Alaskan Branch for publication by the Geological Survey. Completion of such detailed descriptions is essential before accurate generalized descriptions of the formations can be made or before well-substantiated interpretations of the origin and regional stratigraphic relationships of the formations can be formulated. For the present paper, therefore, only a summary of the gross features of the Jurassic strata is presented as background for the discussions concerning the fossils. This summary is based on discussions with geologists in the Alaskan Branch, on their published and unpublished papers, and on the writer's observations.

The Jurassic sedimentary rocks in northern Alaska are represented by three lithologic facies—one dominantly coarse clastic, another dominantly shale and siltstone, and a third glauconitic calcareous sandstone and siltstone interbedded with considerable shale. The coarsely clastic facies has been called the Tiglukpuk formation. The other facies are included under the term "Kingak shale."

The coarsely clastic facies has been found only in the foothills north of the Brooks Range extending from near the Lupine River southwestward at least as far as the Utukok River. It ranges in thickness from a featheredge to about 2,000 feet, is highly variable in thickness along the strike, and is absent locally within its belt of outcrop. It is characterized by conglomerate, graywacke, sandstone, chertlike material (possibly devitrified tuff), tuffs, sills, pillow lavas, and a few thin beds of limestone. Interbedded with these rocks are dark siltstone and shale which constitute as much as 50 percent of some sections and as little as 10 percent of others. Such features as crossbedding and ripple marks are almost unknown. The coarser constituents of the conglomerate range in size from granules to boulders and consist mostly of chert, igneous rocks, and metamorphic rocks. The matrix of the conglomerate is a graywacke. Sills have been identified only west of the Anaktuvuk River and lavas, only between Nuka River and Utukok River. Limestone occurs as thin coquinas composed of the pelecypod *Aucella*. The coarse clastic facies rests with angular discordance on Triassic and older rocks in the area between the Utukok and Ipnavik Rivers. Elsewhere, its lower contact is considered to represent an erosional surface.

The shale and siltstone facies (hereafter abbreviated to shale-siltstone) crops out in the foothills north of the Brooks Range extending from the West Fork of the Ivishak River northeastward at least as far as the Sadlerochit River and probably into Canada. It ranges in thickness from about 1,000 to 4,000 feet. It consists mainly of dark-gray to black noncalcareous shale but includes interbeds of rather hard pyritic siltstone, nodules and lenses of ironstone, and some septarian concretions. The shale is mostly chunky to fissile, but some is papery. Fossils occur rarely in siltstone lenses, in concretions, and in shale. This facies rests concordantly but sharply on Triassic limestone and shale.

A similar shale and siltstone facies about 1,000 feet thick overlies Triassic rocks from the Nuka River westward at least to the Kokolik River and probably extends to Cape Lisburne. This facies has not furnished fossils and could be either of Jurassic or earliest Cretaceous age (E. G. Sable, March 5, 1954, oral communication).

The facies characterized by calcareous, glauconitic quartz-bearing sandstone is interbedded with considerable dark shale and siltstone that is mostly noncalcareous. It locally contains pebbles of chert, slate, and sandstone. It has been found only in the subsurface of the Arctic Coastal Plain near Point Barrow and Cape Simpson and is entirely of Early Jurassic and early Middle Jurassic (Bajocian) age. It has been called a platform facies because it was deposited on the southern margin of an area that was probably a land mass during Paleozoic time, is much thinner than equivalent beds farther south, contains abundant microfossils and macrofossils, and its mineral composition indicates derivation from an area of metamorphic rocks to the north. This facies differs from the equivalent part of the shale-siltstone facies exposed in the valleys of the Canning and Sadlerochit Rivers by a much greater abundance of fossils, glauconite, and calcareous material. The platform facies rests on a few hundred feet of Upper Triassic strata which in turn overlie metamorphic rocks.

It is the opinion of the geologists who have mapped the Jurassic sedimentary rocks in northern Alaska that these rocks were laid down in an eastward-trending trough, about 150 miles wide, whose southern margin intersects the northern front of the Brooks Range in the area between the Ribdon and the Lupine Rivers. They consider that the clastic facies was deposited near the southern margin of the trough and that the shale-siltstone facies was deposited north of the clastic facies. The shale-siltstone facies happens to be exposed in the area between the Ivishak and Hulahula Rivers because of extensive post-Jurassic uplift in that area. The clastic facies is absent east of the Lupine River because of erosion that accompanied the uplift. The evidence for the uplift is both stratigraphic and structural and will be discussed amply in other publications being prepared by members of the Alaskan Branch of the Geological Survey. For the purpose of demonstrating the relationships of the shale-siltstone to the clastic facies and the reality of the uplift, a few pertinent facts will be listed. First, the Okpikruak formation of earliest Cretaceous age thins eastward from a maximum of at least 1,500 feet near the Sagavanirktok River to only a few feet about 2 miles west of the Canning River opposite Shublik Springs and is absent on the banks of the Canning River. Fossils collected throughout this interval demonstrate that the thinning is due to erosion. Second, the overlying Torok formation of latest Early Cretaceous (Albian) age thins eastward from a maximum of 3,400 feet near the Sagavanirktok River to a featheredge in the Shaviovik Valley. Third, on the west bank of the Canning River opposite the mouths of Eagle and Cache Creeks the Jurassic strata are nearly 4,000 feet thick, contain Oxfordian fossils at their top, and are overlain by beds of latest Early Cretaceous (Albian) age that have been correlated with the Tuktu member of the Umiat formation. Fourth, about 12 miles to the northeast in Ignek Valley, between Red Hill and the Katakturuk River, Jurassic strata are only about 1,000 feet thick, contain Toarcian (late Lias) ammonites at their top, and are overlain by beds that are correlated with the Tuktu member. Fifth, on the Sadlerochit River the Jurassic is at least 3,000 feet thick, contains Callovian ammonites in its upper part, and is overlain by beds that are probably equivalent to the Tuktu member. These facts demonstrate clearly that uplift and erosion of several thousand feet of Jurassic sediments and more than 1,500 feet of earliest Cretaceous sediments occurred during Early Cretaceous time. Of course, subsequent uplifts in the same area in Late Cretaceous or Cenozoic times, or both, are responsible for dissection of Upper Cretaceous sedimentary rocks and for the present day exposures.

It is interesting that, except for small outcrops of Middle Jurassic (Bajocian) age near the Kiruktagiak and Siksikpuk Rivers, the clastic facies appears to be entirely of Late Jurassic age and represents the upper Oxfordian and Kimmeridgian stages and possibly part of the Portlandian stage. In contrast, the shale-siltstone facies includes Lower, Middle, and Upper Jurassic at least as high as the Kimmeridgian, and in the Canning River area the beds of Oxfordian to Kimmeridgian age probably do not form more than one-fifth of the total Jurassic sequence. These age relationships, considering the distribution of the two facies, indicate that the Upper Jurassic beds overlap the Middle and Lower Jurassic beds and that the sequence in the subsurface may locally be as complete and as thick as in the Canning River area.

Mapping by A. S. Keller and R. L. Detterman, in the area between the Sagavanirktok and Canning Rivers, has shown that the Upper Jurassic beds do overlap the older Jurassic beds but that relationships within the Jurassic sequence are probably complicated by several intervals of erosion or of nondeposition. For example, on the Lupine River a collection (Mes. loc. 22769) made about 300 feet above the base of the Jurassic strata contains *Aucella concentrica* (Sowerby) *A. rugosa* (Fischer), and *A. mosquensis* (von Buch). This association indicates a middle Kimmeridgian age. About 5½ miles to the northeast, on Nose Bleed Creek, a collection (Mes. loc. 22747) made near the base of the Jurassic strata contains *Amaltheus* (*Pseudoamaltheus*) and *Lytoceras* cf. *L. fimbriatum* (Sowerby). These fossils are definitely of Early Jurassic age, and the presence of *Amaltheus* indicates a Pliensbachian age. About 6½ miles farther northeast, on the west fork of the Ivishak River, a collection (Mes. loc. 22745) made in the lower 400 feet of the Jurassic rocks contains *Pseudocadoceras grewingki* (Pompeckj). This fossil is excellent evidence for the middle Callovian age of the beds in which it occurs. The evidence at these three localities indicates rather strongly that the Lower Jurassic beds are overlapped by Upper Jurassic (Callovian) beds and the latter by Kimmeridgian beds.

Taking into consideration all the fossil evidence discussed under the heading Correlation, and the stratigraphic relationships in both outcrop and subsurface, it seems probable that the Jurassic sequence in northern Alaska includes three disconformities. The oldest disconformity corresponds to the middle and upper Bajocian and the Bathonian, the next younger to the upper Callovian and lower Oxfordian, and the youngest to all or part of the Portlandian. The probable occurrence of these unconformities throughout the Arctic Coastal Plain is indicated by the few wells that have penetrated Jurassic sedimentary rocks. (See table 3.) It is interesting that elsewhere in North America and in the Boreal region in general there is evidence for withdrawals or retreats of the seas from the continental areas during the Bathonian, the late Callovian, and the late Portlandian. As such large parts of the earth are involved, the withdrawals cannot be ascribed primarily to local tectonic movements, although local movements may have influenced the extent and duration of the disconformities.

No evidence for a disconformity exists within the Lower Jurassic sequence. In fact, the presence of the ammonite "*Arietites*" cf. "*A.*" *bucklandi* (Sowerby) in the Avak test well 1 at 464 feet above the base of the Jurassic rocks, as determined by lithology and microfossils, suggests that even the earliest Jurassic is represented. If an unconformity exists between the Lower Jurassic and the Triassic rocks, as is suggested by an abrupt lithologic change and a conspicuous microfaunal change, then the time represented by the unconformity is probably latest Triassic.

The total thickness of the Jurassic system in northern Alaska changes greatly from place to place, owing to overlap relationships, to disconformities within the Jurassic strata, to post-Jurassic erosion, and to differences in original thickness. The maximum thickness of the Lower Jurassic strata is about a thousand feet in the valley of the Canning River, but the Lower Jurassic thins westward noticeably from the Canning River and has not been identified west of the Lupine River. In the subsurface of the Arctic Coastal Plain there are not enough faunal data to separate the Lower Jurassic rocks from the Lower Bajocian, but the Lower Jurassic strata are at least 620 feet thick in the Simpson test well 1, at least 838 feet thick in the South Barrow test well 3, and nearly 500 feet thick in the Topagoruk test well 1.

The Bajocian strata have an estimated maximum thickness of a thousand feet in the valleys of the Canning and Sadlerochit Rivers. Elsewhere on the outcrop, they have been identified only in small areas near the Siksikpuk and Kiruktagiak Rivers where they are probably less than 300 feet thick. In the subsurface they are at least 81 feet thick in the South Barrow test well 2 and at least 291 feet thick in the Topagoruk test well 1.

The Callovian strata are at least 800 feet thick in the valleys of the Canning and Sadlerochit Rivers and may be as much as 2,000 feet thick. The only other exposures known in northern Alaska are on the west fork of the Ivishak River where the minimum thickness is 400 feet. It seems probable, however, that the Callovian beds are present from the Sadlerochit River eastward into Canada, because the United States Geological Survey has collections of *Arcticoceras* and *Cadoceras* from the Richardson Mountains, an eastward continuation of the Brooks Range. Also, the files of the United States Geological Survey contain a report from S. S. Buckman to E. M. Kindle that lists *Cadoceras* and *Pseudocadoceras* from the Firth River in Arctic Canada (O'Neill, 1924, p. 14a, 15a).

The upper Oxfordian to lower Portlandian strata range exceedingly in thickness in the outcrop belt north of the Brooks Range. The thickness at the Canning River is probably not greater than 800 feet, but the highest beds there are probably not younger than Oxfordian. West of the Canning River, thicknesses of 1,500 to 2,000 feet are common as far west as Driftwood Creek; although locally within the belt of outcrop, thicknesses are much less. The range in thickness must be due either to depositional or erosional differences in latest Jurassic time, because the underlying Triassic rocks maintain a fairly uniform thickness of 300 to 500 feet along the mountain front.

AGES OF FOSSILS

The Sinemurian, Pliensbachian, and Toarcian stages of the Lower Jurassic are represented faunally in northern Alaska, and there is an ample thickness of strata in some sections to account for the oldest stage, the Hettangian. The lower Sinemurian is identified by an ammonite "*Arietites*" cf. "*A.*" *bucklandi* (Sowerby) from the Avak test well 1 at the depth of 1,836 feet, which is 464 feet above the base of the Jurassic.

The Pliensbachian is identified by the ammonite *Amaltheus*, which in Europe is known only from that stage and occurs mostly in its upper part (Roman, 1938, p. 146, 147) underlying the lower Toarcian beds containing finely-ribbed *Dactylioceras* (Arkell, 1933, p. 153, 165). In the subsurface of northern Alaska, *Amaltheus* has a comparable stratigraphic position in the South Barrow test well 3 a short distance below beds containing *Dactylioceras*. (See table 4.) On the outcrop the Pliensbachian is represented by *Amaltheus* (*Pseudoamaltheus*) from near the base of the Jurassic rocks on Nose Bleed Creek. It is, also, probably represented from the Sadlerochit River area by a *Gryphaea* similar to *G. cymbium* Lamarck.

The lower Toarcian is identified by various specimens of *Dactylioceras* in the South Barrow test well 3 at depths of 1,772 feet and 2,016 to 2,018 feet. The specimens from depths of 2,016 to 2,018 feet are all finely ribbed and are closely comparable to species in England in the zones of *Dactylioceras tenuicostatum* and *Harpoceras serpentinum.* The specimens from the depth of 1,772 feet are all coarsely ribbed and are similar to species in the *Hildoceras bifrons* zone in England. Thus, the stratigraphic relation of the finely ribbed to the coarsely ribbed species is the same in Alaska as in England. Also, the finely ribbed species of *Dactylioceras* are only 51 feet above the highest occurrence of *Amaltheus*, so their stratigraphic position with respect to *Amaltheus* is the same as in England. Correlation of the beds containing the coarsely ribbed *Dactylioceras* with the *Hildoceras bifrons* zone is substantiated by some ammonites from Prince Patrick Island, about 700 miles northeast of Point Barrow. These ammonites (see pl. 11, figs. 1–18) include many coarsely ribbed *Dactylioceras*, a fragment of a keeled ammonite that is probably *Hildoceras*, and several examples of *Harpoceras* similar to *H. exaratum* (Young and Bird) (Wright, 1882, pl. 6).

The upper Toarcian is identified in northern Alaska only in Ignek Valley a few miles east of the Canning River by several specimens of *Pseudolioceras* similar to *P. lythense* (Young and Bird) (Wright, 1884, pl. 62, figs. 4–6) and *P. compactile* (Simpson) (Buckman, 1911, pl. 41a–c) from Europe. These species differ from species of *Pseudolioceras* in the lower Bajocian strata of Alaska by having the lower third of their flanks nearly smooth or only weak striate.

The lower Bajocian is identified in the subsurface by fragmentary ammonites referred to *Tmetoceras* and *Pseudolioceras* and in the outcrops in the valleys of the Canning and Sadlerochit Rivers by *Pseudolioceras whiteavesi* (White), *Erycites howelli* (White), and *Inoceramus lucifer* Eichwald. These species are common in southwestern Alaska in the lower part of the Kialagvik formation where the associated ammonites furnish a definite correlation with the lowermost Bajocian (Imlay, 1952, p. 978) rather than upper Toarcian. Of course, a fragment of *Pseudolioceras* such as occurs in the Topagoruk test well 1 at the depth of 8,111 feet might represent either upper Toarcian or lower Bajocian, but the *Tmetoceras* at the depth of 8,113 feet is characteristic of the lower Bajocian and probably does not occur in the Toarcian (Frebold, 1951b, p. 20).

It is surprising that the middle and upper Bajocian and the entire Bathonian have not been identified faunally in northern Alaska. Part of these stages may be represented on the high west bank of the Canning River, opposite the mouths of Eagle and Cache Creeks, where about 2,000 feet of beds are exposed between the lower Bajocian shales containing *Pseudolioceras* and the lower Callovian siltstones containing *Arcticoceras*, but the beds cannot be reached because they are undercut by the swift current of the river. From a distance of a quarter of a mile it is impossible to determine whether the inaccessible part of the section is continuous or is repeated by folding. It is interesting that lower Bajocian beds near the Siksikpuk and Kiruktagiak Rivers and in the Topagoruk test well 1 are overlain directly by upper Oxfordian or Kimmeridgian beds. This is evidence for a major unconformity but does not date the unconformity very closely. It might represent part of the Middle Jurassic or part of the Callovian, or both. Judging by the occurrences and magnitudes of Jurassic unconformities elsewhere in North America, the unconformity is probably mostly of late Callovian age. This receives some support by the presence of upper Bathonian beds characterized by the ammonite *Arctocephalites* in the Richardson Mountains in Canada just east of the Brooks Range.

The Callovian is identified in northern Alaska by two occurrences of *Arcticoceras* sp., one of *Pseudocadoceras grewingki* (Pompeckj), and one of *Reineckeia* (*Reineckeites*) cf. *R. stuebeli* Steinmann. This species of *Reineckeia* was obtained about 550 feet above *Arcticoceras* sp. on the west bank of the Canning River, but the species of *Pseudocadoceras* was found in another area within 400 feet of the base of the Jurassic rocks. *Arcticoceras* is considered to represent the lowest Collovian on the basis of its occurrence in the western interior of North America (Imlay, 1948, p. 14, 15; 1953a, p. 5) and in Greenland (Spath, 1932, p. 141, 142). *Pseudocadoceras* in Europe ranges from the zone of *Sigaloceras calloviense* to the zone of *Erymnoceras coronatum*. *P. grewingki* (Pompeckj) is common in southwestern Alaska and in the Cook Inlet area, Alaska, in beds that are correlated with the upper part of the European zone of *Sigaloceras calloviense* and the zone of *Kosmoceras jason* (Imlay, 1953b, p. 50, 53). The presence of the subgenus *Reineckeites* merely proves the Callovian age of the beds in which it occurs. If the identification with *R. stuebeli* Steinmann is correct, an assignment as high as the zone of *Peltoceras athleta* is possible (Arkell, 1939, p. 199), although some of the occurrences of *R. stuebeli* in Europe are probably in the underlying zone of *Erymnoceras coronatum* (Spath, 1928, p. 270).

The upper Oxfordian to lower Kimmeridigian strata contain *Amoeboceras* (*Prionodoceras?*), *Aucella spitiensis* Holdhaus, and *Aucella concentrica* (Sowerby). *Aucella concentrica* (Sowerby) is considered to be a reliable marker for the parts of the stages indicated only where it occurs in abundance and is not associated with *Aucella rugosa* (Fischer) or *A. mosquensis* (von Buch). There are five such occurrences in thin limestone beds in the area between the Shaviovik and Kukpowruk Rivers. *Aucella spitiensis* Holdhaus has been found only near the Canning River and in the most easterly branch of the Shaviovik River. It is associated with a few specimens of *A. concentrica* (Sowerby) and *Amoeboceras*. The specimens of *Amoeboceras* cannot be assigned definitely to any subgenus because they are all immature. Their features, however, suggest assignment to the subgenus *Prionodoceras*, which is much more common in uppeer Oxfordian than in lower Kimmeridgian beds in the Boreal region and in northwest Europe. It is probable that the beds containing *Aucella spitiensis* are lower stratigraphically than the beds containing abundant *A. concentrica* and that the latter are absent from the Canning River area owing to erosion. These probabilities are suggested by the post-Callovian (Jurassic) strata in the Canning River area being only one-third to one-half as thick as equivalent strata farther west; by ample evidence for repeated uplift and erosion in the area between the Canning and Sadlerochit River, as discussed under the stratigraphic summary; and by the fact that *Aucella concentrica* attained its greatest abundance in early Kimmeridgian time.

The middle Kimmeridgian to lower Portlandian strata in northern Alaska are identified by *Aucella rugosa* (Fischer) and *A. mosquensis* (von Buch). These occur together although *A. rugosa* is much more abundant. The same species are associated in Russia, Siberia, east Greenland, and the Barents Sea area in beds of late Kimmeridgian to early Portlandian age (zones of *Subplanites wheatleyensis* to *Zaraiskites albani* inclusive). (See Pavlow, 1907, p. 25, 26, 38, chart opposite p. 84; Spath, 1936, p. 166, 167.) It seems probable, however, that their total range is much greater. In Mexico *A. mosquensis* has been found with the ammonites *Kossmatia* and *Durangites* (Burckhardt, 1912, p. 206, 221, 236) in beds that are considered higher than the European zone of *Zaraiskites albani* (Imlay, 1952, pl. 2). *A. mosquensis* has also been found much lower associated with *Glochiceras fialar* and *Idoceras durangense* (Burckhardt, 1912, p. 216, 217) in beds that represent the middle Kimmeridgian and are probably equivalent to the European zone of *Aulacostephanus pseudomutabilis*. In northern Alaska, likewise, a middle Kimmeridgian age for some of the occurrences of *Aucella mosquensis* and *A. rugosa* (Mes. locs. 22766 and 22769) is indicated by their association with *A. concentrica*, which has not been recorded in Europe above the middle Kimmeridgian zone of *Aulacostephanus pseudomutabilis*. The same association has been noted by the writer throughout several hundred feet of beds near the middle part of the Naknek formation in the Talkeetna Mountains in south central Alaska. Field evidence that the upper part of the range of *A. concentrica* overlaps the lower part of the range of *A. rugosa* or *A. mosquensis* has been useful in mapping the Naknek formation and will be useful in interpreting the history of the Late Jurassic.

The upper Portlandian has not been identified faunally in northern Alaska and is probably not represented by strata. Field geologists have noted considerable local evidence for an erosional unconformity between the Jurassic beds and the overlying Okpikruak formation of earliest Cretaceous age. Because the Okpikruak formation contains Aucellas that represent both the Berriasian and Valanginian stages, the time of the unconformity must be latest Jurassic.

COMPARISONS WITH OTHER FAUNAS

The few fossils that have been obtained from the Lower Jurassic and the early Middle Jurassic (Bajocian) strata of northern Alaska can be matched very well specifically in the rich but mostly undescribed assemblages from Talkeetna Mountains, the Cook Inlet region, and southwest Alaska. (See chart 1.) They are similar to and probably in part identical with species in northwest Europe and the Boreal region. The resemblances of the Toarcian ammonites from South Barrow test well 3 to those on Prince Patrick Island and the resemblances of those from the latter to Toarcian ammonites from northwest Europe is striking. The lower Bajocian species of *Pseudolioceras* and *Erycites* in Alaska are equally similar to species in the Barents Sea area and in Europe. These genera have not been found on Prince Patrick Island, but the lower Bajocian is clearly represented there by another ammonite *Ludwigella maclintocki* (Haughton) (1857, p. 244, 245, pl. 9, fig. 2–4) which is similar to *L. cornu* Buckman (1887, p. 20, pl. 4, figs. 1–4). Recent collections from that island have furnished another specimen of *Ludwigella* (pl. 11, figs. 1–3) that is similar to *L. rudis* Buckman (1888, p. 103, pl. 15, figs. 11–13). These resemblances should be expected because the faunas of the Lower Jurassic and Bajocian are cosmopolitan. Nowhere in the world is this better demonstrated than in the Cook Inlet region and the Talkeetna Mountains of south central Alaska, where the ammonites can be matched zone for zone with northwest Europe. When these fossils are described, many species will probably be identified with species in Europe.

In keeping with the well-known provincial distribution of mollusks during the late Middle Jurassic (Bathonian) and Late Jurassic, the fossils from the Upper Jurassic strata of northern Alaska are dominantly Boreal but include a few genera, such as *Phylloceras*, *Lytoceras*, and *Reineckeia*, that generally are considered distinctive of the Mediterranean province of post-Bajocian time. As such genera also occur in southwest and south central Alaska, far north of their occurrence in Europe, it seems probable that they entered the Boreal sea from the Pacific Ocean.

In the Callovian strata the ammonites *Arcticoceras* and *Pseudocadoceras* are Boreal elements, and *Reineckeia* is a characteristic genus of the equatorial areas. *Arcticoceras* has been recorded previously from the basal Callovian at a number of places in the Arctic region and in the western interior of North America. *Pseudocadoceras* has been recorded from the middle Callovian in southwest and south central Alaska, Arctic Canada, the Barents Sea area, and Europe as far south as England and France. The presence of *Reineckeia* apparently identical with *R.* (*Reineckeites*) *stuebeli* Steinmann is surprising because the genus in Europe does not range north of southern England and southern Germany (Spath, 1932, p. 149). The species itself, or a very similar species, is widespread throughout a broad equatorial belt extending from India to Europe to Mexico and South America.

In the upper Oxfordian to lower Portlandian strata the only common fossils are Aucellas. These belong to species that are abundant in the Boreal Jurassic elsewhere, although ranging as far south as Mexico and northern India. *Amoeboceras* of upper Oxfordian or lower Kimmeridgian age represents another Boreal element that ranges southward into central Europe and into northern California. The occurrence of a few specimens of *Lytoceras?* and *Phylloceras* probably reflects a broad connection southward with the Pacific Ocean as these genera are common in the Upper Jurassic of southwest and south central Alaska.

ECOLOGICAL CONSIDERATIONS

The Jurassic sedimentary rocks of northern Alaska, according to Payne, Gryc, and Tappan (1951), were deposited in an eastward-trending trough about 150 miles wide in the area now occupied by the northern margin of the Brooks Range, the foothills of the Brooks Range, and the southern part of the Arctic Coastal Plain. The trough was bounded on the south by a rising landmass from which most of the sediments were derived. It was bounded on the north by the Barrow Platform, whose southern margin corresponds with the present northern part of the Arctic Coastal Plain. The sediments deposited in the trough attain a thickness of at least 4,000 feet. Their areal distribution shows that coarse clastics were deposited along the southern margin of the trough, dark pyritic noncalcareous clay and silt in the central part of the trough, and glauconitic calcareous sand and silt, interbedded with considerable clay, along the northern margin of the trough.

Part of the 1,500 to 2,000 feet of coarse clastic sediment was derived from the present site of the Brooks Range and part from areas as far south as the Baird Mountains. The composition of some of the conglomerates within the facies indicates local derivation from islands or headlands within a few miles, according to the field geologists. The lack of crossbedding, ripple marks, and genera of sessile benthonic mollusks other than *Aucella* is probably related to rapid sedimentation rather than to deposition in deep water, as *Aucella* thrived in places where thick clastic sediments were being deposited. The absence of the nearly ubiquitous pelecypod *Inoceramus* from beds containing *Aucella* and its rarity even in the same formations suggests that these genera lived under different environmental conditions. Although *Aucella* occurs characteristically in thin shell beds associated with clay shales and siltstones, its presence locally in pebbly beds or even in coarse conglomerates suggests that it may have lived in waters that were too agitated or too shallow for *Inoceramus* to exist.

The part of the shale-siltstone facies that is of upper Oxfordian to Portlandian age was deposited north of and in deeper water than the clastic facies. It is inferred that the parts older than the upper Oxfordian pass southward into coarse clastics that are overlapped by Late Jurassic strata, but evidence of this is meager. In fact, the presence of two major disconformities that have not resulted in appreciable lithologic changes in the adjoining strata suggests that there may not have been thick or extensive deposition of coarse clastics prior to the Oxfordian.

Conditions on the sea bottom and in the sea during deposition of the clays and silts were probably unfavorable for abundant life or for its preservation considering the scarcity of sessile and mud-dwelling benthos, Foraminifera, and such free-floating or swimming organisms as crinoids, ammonites, belemnites, and pectenids, except in a few widely separated beds. Sandstone units in the Lower Jurassic have furnished a few benthonic organisms such as *Oxytoma*, *Gryphaea*, *Pholadomya*, *Grammatodon?*, *Inoceramus*, and *Dentalium*. *Plicatula* attached to the matted remains of *Pentacrinus* has been found near the base of the Lower Jurassic. There are a few occurrences of *Inoceramus* and *Oxytoma* in the lower Bajocian and of *Inoceramus* and brachiopods in the Callovian. *Aucella* has been found in several concretions embedded in shale of late Oxfordian to Kimmeridgian age. All these fossils in the outcropping shale-siltstone facies are from only 30 localities. (See table 2.) This number is surprisingly small considering that nearly 4,000 feet of strata are involved, that outcrops are fairly extensive along the Canning and Sadlerochit Rivers, and that geologists have spent several thousand hours studying the area. The scarcity of outcrops in areas between the rivers can only partially explain the small number of fossils collected, as similar shales and siltstones in the Jurassic of the Cook Inlet region in south central Alaska are much more fossiliferous.

The scarcity of benthonic organisms might be due to such slow deposition that scavengers destroyed most of the organic remains, to such rapid deposition that most organisms could not establish themselves on the sea bottom, to deposition considerably below the neritic zone, to stagnant conditions on the sea bottom, to a scarcity of certain minerals essential for abundant organic growth, or to some combination of these possibilities. Concerning these, neither the thickness of sediments in relation to the time involved nor the characteristics of the sediments indicate exceedingly slow or exceedingly rapid deposition. Depth of water much below the neritic zone seems unlikely because the shale-siltstone facies apparently contains two major disconformities which involve some erosion in the area between the Lupine and Shaviovik Rivers as shown by the fieldwork of A. S. Keller and R. L. Detterman. Even if the disconformities are mostly nondepositional, the sameness of the strata throughout the shale-siltstone facies suggests that the depth of the sea did not vary by more than a few hundred feet between intervals of erosion, nondeposition, and deposition.

The possibility of stagnant conditions on the sea bottom is suggested by the presence of considerable disseminated pyrite and the absence of such mud-dwelling pelecypods as *Pleuromya*, *Panope*, *Thracia*, *Astarte*, and *Pinna*. If a major part of the sea bottom was stagnant, however, it was probably below wave base and probably at least as deep as the lower part of the neritic zone.

The scarcity of ammonites, belemnites, and Foraminifera may also be related to unfavorable bottom conditions or to destruction of the shells after death but probably reflects in addition an unfavorable food situation in general. Perhaps the food situation is related to the deposition of graywacke nearshore, lack of organic matter derived from the land, and dominance of sedimentary over metamorphic or igneous rocks in the source areas south of the Jurassic sea.

Formation	Kukpowruk River to Lupine River Tiglukpuk formation																													
Locality number on fig. 20	1	2	3	4		5	6	7	8	9	10			11	12		13		14		15			16			17	18		19	
Mesozoic locality number	22127	22126	22776	23577	23697	22507	22509	23598	21552	22591	22584	22585	22586	22582	22587	22588	22578	22579	22580	22581	22749	22750	22751	22766	22768	22769	22746	22747	22748	22745	22764
Pentacrinus subangularis var. alaska Springer																															
Brachiopods indet.																													X		X
Grammatodon sp.																															
Plicatula spp.																															
Entolium sp.																															
Camptonectes sp.																															
Lima sp.																															
Gryphaea cf. G. cymbium Lamarck																															
Oxytoma spp.																															
Aucella concentrica (Sowerby)		X				X								X			X							X		X					
A. spitiensis Holdhaus																															
A. mosquensis (von Buch)			X					?														?	X	X		X					
A. rugosa (Fischer)	X		?	X	X						?	?	?		X			X	X	X	X		X	X	X	X	X				
Posidonia cf. P. ornati Quenstedt																															
Inoceramus lucifer Eichwald									X																						
Inoceramus spp.										X																					X
Pholadomya sp.																															
Tancredia sp.																															
Dentalium sp.																															
Phylloceras (Partschiceras) sp.																															
P. (Macrophylloceras) sp.																															
Lytoceras cf. L. fimbriatum (Sowerby)																												X			
L.? sp.												X																			
Amaltheus (Pseudoamaltheus) sp.																												X			
Pseudolioceras whiteavesi (White)																															
P. cf. P. lythense (Young and Bird)																															
P. cf. P. compactile (Simpson)																															
P. sp. indet.																															
P.? sp.									X																						
Erycites howelli (White)																															
Erycites sp. indet.																															
Parkinsonia? sp. juv.										X																					
Arcticoceras sp.																															
Pseudocadoceras grewingki (Pompeckj)																														X	
Amoeboceras (Prionodoceras?) spp. juv.																															
Reineckeia (Reineckeites) cf. R. stuebeli Steinmann																															
Cylindroteuthis spp.																X															
Belemnites indet.																															

Formation	West Fork of Ivishak River to Sadlerochit River Kingak shale																												
Locality number on fig. 20	20	21	22	23		24	25			26			27				28		29	30		31	32		33		34	35	36	37
Mesozoic locality number	22759	22739	24011	21026	21027	24012	21024	22596	22597	21023	24033	22595	24013	24014	21028	22598	21025	24035	23772	21819	21820	22083	22081	22082	10308	10309	10307	23747	23749	23748
Pentacrinus subangularis var. alaska Springer			X			X											X			X	X									
Brachiopods indet.																														
Grammatodon sp.																			X											
Plicatula spp.						X											X													
Entolium sp.															X															
Camptonectes sp.																		X	X											
Lima sp.													X		X	X														
Gryphaea cf. G. cymbium Lamarck																														X
Oxytoma spp.																	X	X	X											X
Aucella concentrica (Sowerby)	X			X											X	X														
A. spitiensis Holdhaus				X									X	X	X	X														
A. mosquensis (von Buch)																														
A. rugosa (Fischer)					X																									
Posidonia cf. P. ornati Quenstedt																		X												
Inoceramus lucifer Eichwald										X														X		X	X			
Inoceramus spp.									X		X	X						X	X											
Pholadomya sp.																													X	
Tancredia sp.		X													X	X														
Dentalium sp.																												X		
Phylloceras (Partschiceras) sp.													X																	
P. (Macrophylloceras) sp.					X																									
Lytoceras cf. L. fimbriatum (Sowerby)																														
L.? sp.																														
Amaltheus (Pseudoamaltheus) sp.																														
Pseudolioceras whiteavesi (White)																		X									X			
P. cf. P. lythense (Young and Bird)																			X											
P. cf. P. compactile (Simpson)																			X											
P. sp. indet.										X		X											X		X					
P.? sp.																														
Erycites howelli (White)																									X					
Erycites sp. indet.																										X				
Parkinsonia? sp. juv.																														
Arcticoceras sp.								X														X								
Pseudocadoceras grewingki (Pompeckj)																														
Amoeboceras (Prionodoceras?) spp. juv.														X	X	X														
Reineckeia (Reineckeites) cf. R. stuebeli Steinmann							X		X		X																			
Cylindroteuthis spp.																			X											
Belemnites indet.														X				X	X											

TABLE 2.—*Geographic distribution of Jurassic macrofossils from outcrops in northern Alaska.*

It has been suggested that the source for the platform facies was to the north (Payne, Gryc, and Tappan, 1951) in large areas of metamorphosed rock of possible pre-Cambrian age. This is indicated by the presence of quartz sandstone, glauconite, and considerable calcareous material, which is rare or absent in the coarse clastic facies deposited along the southern part of the Jurassic seaway. Also, studies of the Jurassic rocks in the western interior of the United States show that glauconite is much more common in sandstones derived from areas of metamorphic or igneous rocks than from areas of sedimentary rocks (Imlay, 1950, p. 91). The greater amount of calcareous material in the platform facies may merely reflect a greater number of shell-building organisms, but their number in turn may be related to the kind and quantity of minerals being brought into the sea.

The macrofossils present in the platform facies include such sedentary types as brachiopods and the pelecypod *Oxytoma* and the free-swimming ammonites and pectinids. This is essentially the same assemblage as in the shale-siltstone facies, and similarly there is a conspicuous absence of mollusks that are common in muds in the shallower part of the neritic zone. It seems probable that the calcareous sandstones would be firm enough for the attachment of such pelecypods as *Ostrea* or *Meleagrinella*, if other conditions such as depth and temperature were suitable. The absence of such mollusks may have little significance concerning depth of water because the Jurassic strata pinch out northward in a distance of 12 miles between the South Barrow test wells 3 and 1 (Payne, Gryc, and Tappan, 1951), owing mainly to onlap rather than to erosion, as indicated by fossils (table 4). Rapid northward thinning of the Lower Jurassic sedimentary rocks is shown by the presence of lower Bajocian ammonites in the South Barrow test well 2 only 52 feet above the base of the Jurassic, whereas the Lower Jurassic in the South Barrow test well 3 is at least 838 feet thick. On the other hand, such rapid thinning might be interpreted as meaning that the sea bottom sloped steeply and that the subsurface Jurassic in the Simpson test well 1 and South Barrow test well 3, from which most of the fossils were obtained, was actually deposited in the deeper part of the neritic zone.

A rapid southward change of the platform facies into the shale-siltstone facies is shown by the Jurassic sequence in the Topagoruk test well 1, only about 27 miles south-southwest of the Simpson test well 1. In the Topagoruk well the Lower Jurassic and lower Bajocian strata consist entirely of noncalcareous pyritic siltstone and shale. The overlying upper Oxfordian to Kimmeridgian strata consist mostly of pyritic dark shale but include some limestone beds; scattered grains of quartz, chert, and glauconite; and basally are marked by a glauconitic sandstone. This sequence differs from the typical shale-siltstone facies as exposed in the Canning River area by the presence of quartz and a greater abundance of Foraminifera.

The writer has the impression, based on the faunal and lithologic relationships just discussed, that the sea bottoms along the northern and southern margins of the Jurassic seaway in northern Alaska sloped uniformly and moderately basinward and were at least in the lower part of the neritic zone at a distance of perhaps 30 miles from shore. This means quite different conditions of sedimentation than existed during the Jurassic in east Greenland (Spath, 1932, p. 154; 1936, p. 175), the Barents Sea area (Frebold, 1929, p. 23; 1932, p. 21–27; 1951a, p. 77–84), and the western interior of North America (Imlay, 1950, p. 93–98), where both fossils and lithologic features indicate deposition in the littoral zone and in the shallower part of the neritic zone. Perhaps the existence of deeper water in Alaska than in the other areas explains the presence in Alaska of such ammonites as *Phylloceras*, *Lytoceras*, and *Reineckeia*. As the same genera are fairly common in southwestern Alaska, a marine connection with northern Alaska is a certainty. One such connection almost certainly existed in the area now represented by Yukon Territory, Canada, but another probably existed in eastern Siberia.

Evidence of the faunas in northern Alaska indicates temperature conditions in the Jurassic sea similar to those in other parts of the Boreal region. The temperature during the Early Jurassic and the Bajocian was probably warm, as indicated by the cosmopolitan distribution of the ammonite genera represented. The presence of *Gryphaea* and of attached crinoids in the Lower Jurassic is considered to be a good indicator of fairly warm waters. In contrast, the Upper Jurassic rocks in northern Alaska contain such typical Boreal elements as *Aucella* and the Cardioceratinae and lack most elements typical of the Upper Jurassic of the Mediterranean region. This faunal differentiation has generally been interpreted as indicating the presence of climatic zones. The poverty of molluscan genera and species in the Jurassic beds of northern Alaska may also be related to the lower temperature of the sea water than in the Mediterranean province.

GEOGRAPHIC DISTRIBUTION

The occurrence by area and locality of the species described in this report is indicated in tables 2 to 4. The general position of each locality is shown on figure 20. Detailed descriptions of the individual localities are given in the following list.

Localities at which fossils were collected from outcrops of the Jurassic in northern Alaska

Locality number on fig. 20	Geological Survey Mesozoic locality	Collection field numbers	Collector and year of collection, description of locality, and stratigraphic assignment and age
1	22127	49ASa43	E. G. Sable, 1949. Kukpowruk River, approximate lat 68°42′30″ N., long 163°14′ W., eastern part of a large cut bank on southwest side of river. Sandstone and shale containing concretions. Stratigraphic position unknown. Upper Jurassic, Kimmeridgian to lower Portlandian.
2	22126	49ASa30	E. G. Sable, 1949. Near Kukpowruk River, on mountain ridge between first and second creeks west of large cut banks of black shale. Approximate lat 68°23′ N., long 162°43′ W. Sandstone and shale beds from 50 to 100 feet above top of Triassic strata. Upper Jurassic, upper Oxfordian or lower Kimmeridgian.
3	22776	51ASa56	E. G. Sable, 1951. West bank of easternmost fork of Driftwood Creek at first cutbank above small tributary from the west. Approximate lat 68°40′ N., long 160°26′28″ W. Conglomerate, conglomeratic shale, and chert, possibly near base of Kingak shale, fossils from concretions in shale. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
4	23577	51ATr266	I. L. Tailleur, 1951. Kiligwa river, lat 68°43′ N., long 158°25′ W. Coquinoid limestone overlain by shale, siltstone, and sandstone 3 feet above Triassic rocks. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
4	23697	51ATr257	I. L. Tailleur, 1951. Kiligwa River, lat 68°43′ N., long 158°25′ W. Coquinoid limestone in sequence of shale, chert, and chert breccia. Probably near base of overturned section. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
5	22507	50ATr166	I. L. Tailleur, 1950. Cutaway Creek, lat 68°36′ N., long 157°33′ W., 3 miles NW. of Rim Butte. Coquinoid limestone 10 feet above Triassic strata. Upper Jurassic, upper Oxfordian or lower Kimmeridgian.
6	22509	50ATr226	I. L. Tailleur, 1950. Lat 68°40′ N., long 157°08′ W., Ipnavik River, 4 miles north of Ekakevik Mountain. Coquinoid limestone 110 feet above Triassic strata. Upper Jurassic, upper Oxfordian or lower Kimmeridgian.
7	23598	51ATr19	I. L. Tailleur, 1951. Lat 68°23′ N., long 157°15′ W., Ipnavik River 2 miles south of mouth of Memorial Creek. Coarse- to fine-grained graywacke from 100 to 150 feet above Triassic strata. Upper Jurassic, probably middle Kimmeridgian to lower Portlandian.
8	21552	49ATr352	I. L. Tailleur, 1949. Lat 68°31′ N., long 153°03′ W., cutbank on Fortress Creek about 5 miles SSW. of Fortress Mountain. Medium-dark-green fine-grained graywacke containing much volcanic material. Middle Jurassic, lower Bajocian.
9	22591	50AKe263	A. S. Keller, 1950. Tiglukpuk Creek, lat 68°22′ N., long 151°50′ W. Graywacke. Middle Jurassic, Bajocian.
10	22584	50AKe132	A. S. Keller, 1950. Peregrine Creek, lat 68°26′ N., long 150°28′ W. Fine-grained sandstone. Upper Jurassic, probably Kimmeridgian.
10	22585	50AKe135	A. S. Keller, 1950. Peregrine Creek, lat 68°26′ N., long 150°28′ W. Same general locality as 22584. Fine-grained sandstone. Upper Jurassic, probably Kimmeridgian.
10	22585	50AKe93	A. S. Keller, 1950. East Fork of Manushuk River, NE¼SE¼ quad. 683; lat 68°27′ N., long. 150°20′W. Coquinoid limestone. Upper Jurassic, upper Oxfordian or lower Kimmeridgian.
10	22586	50AKe136	A. S. Keller, 1950. Peregrine Creek, lat 68°26′ N., long 150°28′ W. Same general locality as 22584. Fine-grained sandstone. Upper Jurassic, probably Kimmeridgian.
11	22582	50AKe121	A. S. Keller, 1950. Peregrine Creek, lat 68°28′ N., long 150°27′ W. Coquinoid limestone. Upper Jurassic, upper Oxfordian or lower Kimmeridgian.
12	22587	50AKe174	A. S. Keller, 1950. East Fork of Nanushuk River, lat 68°30′ N., long 150°24′ W. Coquinoid limestone. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
12	22588	50AKe175	A. S. Keller, 1950. East fork of Nanushuk River, lat 68°30′ N., long 150°24′ W., same location as 22587 Coquinoid limestone. Upper Jurassic, probably upper Oxfordian or lower Kimmeridgian.
13	22579	50AKe97	A. S. Keller, 1950. Lat 68°27′ N., long 150°20′ W., same general location as locality 22578. Coquinoid limestone. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
14	22580	50AKe109	A. S. Keller, 1950. May Creek, lat 68°26′ N., long 150°09′ W. Coquinoid limestone. Upper Jurassic, middle Kimmeridgian to Portlandian.

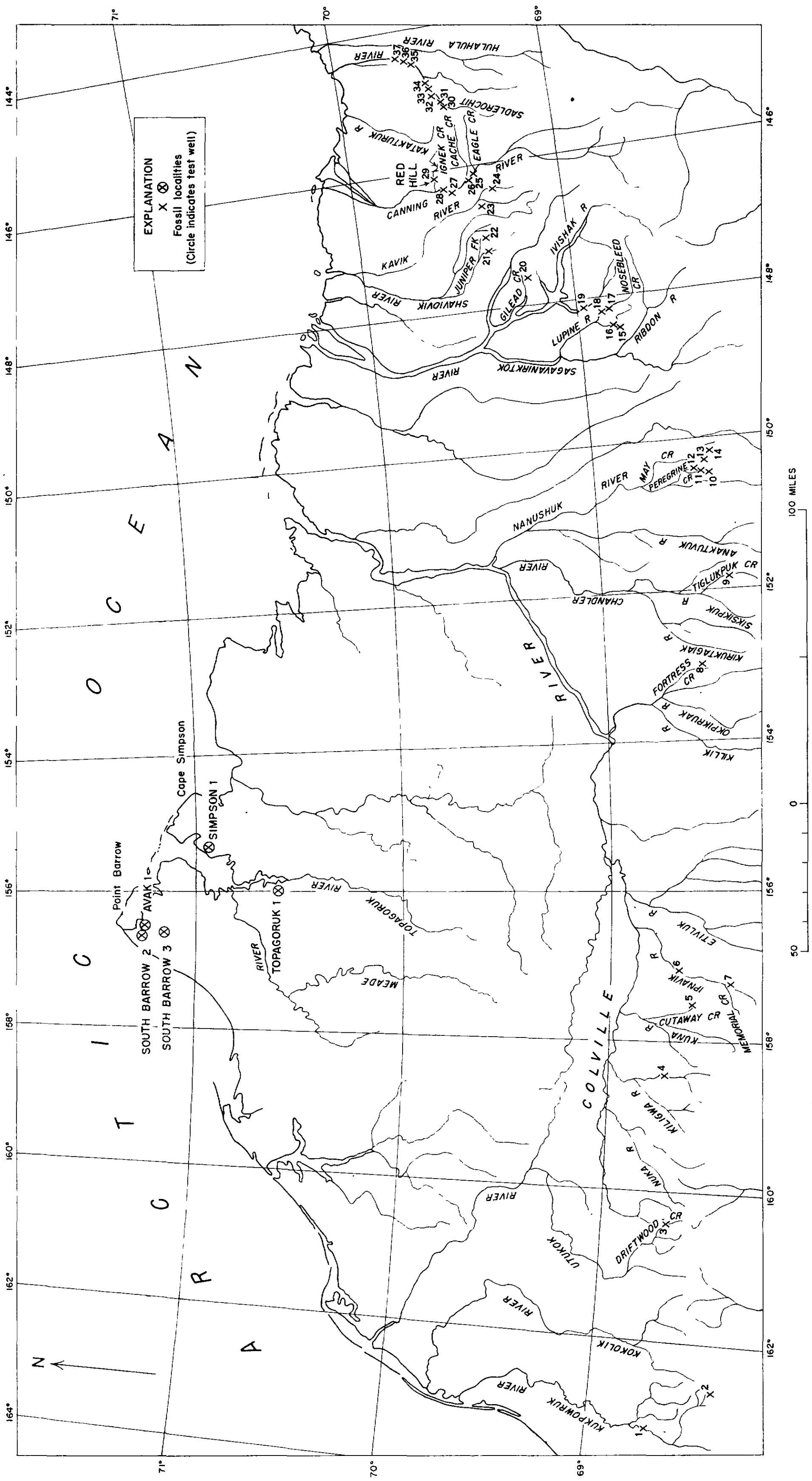


FIGURE 20.—Index map showing Jurassic fossil collection localities in northern Alaska.

Localities at which fossils were collected from outcrops of the Jurassic in northern Alaska—Continued

Locality number on fig. 20	Geological Survey Mesozoic locality	Collection field numbers	Collector and year of collection, description of locality, and stratigraphic assignment and age
14	22581	50AKe114	A. S. Keller, 1950. Same general location as Mes. loc. 22580, lat 68°26′ N., long 150°09′ W. Coquinoid limestone. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
15	22749	51ADt149	R. L. Detterman, 1951. About 1 mile west of Lupine River on long ridge, lat 68°47′ N., long 148°25′ W. Dark siltstone and silty shale, weathers metallic blue, contains fossil coquinas. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
15	22750	51ADt151	R. L. Detterman, 1951. Lupine River area. Cutbank in small stream one-fifth of a mile north of Mes. loc. 22749, lat 68°48′ N., long 148°25′ W. Dark siltstone having a blue metallic luster and fissile noncalcareous silty shale. Upper Jurassic, probably Kimmeridgian to Portlandian.
15	22751	51ADt152	R. L. Detterman, 1951. Lupine River area, cutbank three-tenths of a mile east of Mes. loc. 22750 in same stream, lat 68°49′ N., long 148°24′ W. Siltstone and silty shale as at Mes loc. 22750. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
16	22766	51AKe135	A. S. Keller, 1951. Lupine River, lat 68°52′ N., long 148°22′ W. Fissile clay to silt shale containing spheroidal concretions and sideritic lenses. About 500 feet above the base of the Kingak shale. Upper Jurassic, middle Kimmeridgian.
16	22768	51AKe153	A. S. Keller, 1951. Lupine River, lat 68°52′ N., long 148°22′ W. Shale as at Mes. loc. 22766 between 500 to 800 feet above base of Kingak shale. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
16	22769	51AKe154	A. S. Keller, 1951. Lupine River, lat 68°52′ N., long 148°22′ W. Shale as at Mes. loc. 22766. About 300 feet above base of Kingak shale. Upper Jurassic, middle Kimmeridgian.
17	22746	51ADt136	R. L. Detterman, 1951. Small divide nine-tenths of a mile east of Nosebleed Creek, lat 68° 50′ N., long 148°10′ W. Dark ferruginous brittle silty shale. Upper Jurassic, middle Kimmeridgian to lower Portlandian.
18	22747	51ADt144	R. L. Detterman, 1951. Long cutbank on west side of Nosebleed Creek, just below ice field, lat 68°52′ N., long 148°14′ W. Calcareous siltstone. Lower Jurassic, Pliensbachian.
18	22748	51ADt145	R. L. Detterman, 1951. Nosebleed Creek, about one-tenth of a mile north of Mes. loc. 22747 on same side, lat 68°52′ N., long 148°15′ W. Siltstone and silty shale. Lower Jurassic.
19	22745	51ADt134	R. L. Detterman, 1951. West fork of Ivishak River, lat 68°58′ N., long 148°07′ W. East side of river south of junction of tributary from east. Siltstone lenses in hard, splintery silty shale. Within lower 400 feet of Kingak shale. Upper Jurassic, middle Callovian.
19	22764	51AKe115	A. S. Keller, 1951. West fork of Ivishak River, lat 68°58′ N., long 148°05′ W. Pyritic siltstone and shale containing large spheroidal concretions within the lower 400 feet of the Kingak shale. Upper Jurassic, probably Callovian.
20	22759	51AKe48	A. S. Keller, 1951. Gilead Creek, lat 69°13′ N., long 147°40′ W. Isolated cutbank of dark-gray shale containing large lenses of light-gray ironstone. Kingak shale. Upper Jurassic, upper Oxfordian to lower Kimmeridgian.
21	22739	51ADt22	R. L. Detterman, 1951. West Fork of Shaviovik River, lat 69°23′ N., long 147°13′ W. Interbedded siltstone and sandstone 50 feet below basal sandstone of Okpikruak formation. Kingak shale. Upper Oxfordian or Kimmeridgian.
22	24011	52AMo4	R. H. Morris, 1952. Juniper Fork, lat 69°23′ N., long 146°59′ W. Lower part of Kingak shale. Ironstone lenses in black fissile shale. Lower Jurassic.
23	21026	47AGr32	George Gryc, 1947. Shaviovik River, main fork of most easterly branch, SE¼NE¼ quad. 682, lat 69°22′ N., long 146°32′ W. Black shale containing nodules and interbeds of ironstone and some limestone. Isolated outcrops of Kingak shale. Upper Jurassic, upper Oxfordian or lower Kimmeridgian.
23	21027	47AGr8	George Gryc, 1947. From same locality and about same stratigraphic position as Mes. loc. 21026. Upper Jurassic, Upper Oxfordian or lower Kimmeridgian.
24	24012	52AMo36	R. H. Morris, 1952. Kavik River, lat 69°19′ N., long 146°18′ W. Ironstone lenses in black pyritic shale. Lower Jurassic.
25	21024	47AGr205	George Gryc, 1947. Canning River, west bank, about 2,850 feet upstream from Mes. loc. 21023. Black shale containing ironstone beds. Upper Jurassic, Callovian.
25	22596	50AGr18	George Gryc, R. W. Imlay, Allan Kover, 1950. Canning River, west side, lat 69°23′30″ N., long 146°07′30″ W. Black shale containing ironstone beds, lenses and nodules about 2,300 feet above base of exposed section. Upper Jurassic, lower Callovian.
25	22597	50AGr24	George Gryc, R. W. Imlay, Allan Kover, 1950. Canning River, west bank, lat 69°23′20″ N., long 146°07′30″ W., same locality as Mes. locs. 21024 and 24033. Black shale containing beds and nodules of ironstone about 200 feet below top of exposed section. Upper Jurassic, middle Callovian.
25	24033	52AKe37	A. S. Keller, 1952. Canning River, lat 69°25′ N., long 146°08′ W. Fossils from slightly calcareous ironstone beds in upper part of Kingak shale, same locality as Mes. locs. 21024 and 22597. Upper Jurassic, Callovian.
26	21023	47AGr202	George Gryc, 1947. Canning River, west bank, at mouths of Eagle and Cache Creeks, lat 69°25′ N., long 146°08′ W. From base of pyritic black shale outcrops that contain nodules and lenses of ironstone. Middle Jurassic, lower Bajocian.
26	22595	50AGr9	George Gryc, R. W. Imlay, Allan Kover, 1950. Canning River, west bank, lat 69°25′ N., long 146°08′ W., same locality as Mes. loc. 21023. 150 feet above base of exposure. Black shale containing ironstone lenses and nodules. Middle Jurassic, lower Bajocian.
27	24013	52AMo48	R. H. Morris, 1952. Cutbank on west side of Canning River, lat 69°30′45″ N., long 146°18′45″ W. Black fissile shale containing limestone concretions 50 feet below top of Kingak shale. Upper Jurassic, upper Oxfordian or Kimmeridgian.
27	24014	52AMo50	R. H. Morris, 1952. Cutbank on west side of Canning River, lat 69°32′ N., long 146°18′ W. Black shale containing limestone concretions 50 feet below top of Kingak shale. Upper Jurassic, upper Oxfordian or lower Kimmeridgian.
27	21028	47AGr239	George Gryc, 1947. Canning River, 2½ miles south of Black Island, NE¼ NE¼ quad. 682, lat 69°30′45″ N., long 146°18′45″ W. Black shale containing ironstone interbeds near top of Kingak shale. Upper Jurassic, upper Oxfordian or lower Kimmeridgian.
27	22598	50AGr31	George Gryc, R. W. Imlay, Allan Kover, 1950. Canning River at same locality as Mes. loc. 21028. From 200 to 500 feet below top of Kingak shale. Upper Jurassic, upper Oxfordian or lower Kimmeridgian.
28	21025	47AGr257	George Gryc, 1947. Black Island in Canning River, lat 69°33′ N., long 146°15′ W. Black shale containing ironstone interbeds immediately overlying the Upper Triassic Shublik formation. Lower Jurassic.
28	24035	52AKe46	A. S. Keller, 1952. Canning River, lat 69°33′ N., long 146°15′ W. Middle Jurassic, lower Bajocian. Ironstone beds and shales from 1,000 to 1,500 feet below the top of the Kingak shale.
29	23772	50AGr61	George Gryc, R. W. Imlay, Allan Kover, 1950. Near Red Hill on Ignek Creek, lat 69°36′ N., long 146°06′ W. Shale underlying sandstone at base of Ignek formation. Lower Jurassic, Toarcian.
30	21819	48AWh130	C. L. Whittington, 1948. North bank of Sadlerochit River at mouth of tributary from northwest, about 4 miles upstream from mouth of Ignek Valley Fork; lat 69°30′ N., long 145°05′ W. Thin crinoid beds in gray shale containing ironstone interbeds near base of Kingak shale. Lower Jurassic.
30	21820	48AWh131	C. L. Whittington, 1948. Same general lithology as Mes. loc. 21819 but about 300 yards downstream. Lower Jurassic.
31	22083	48AWh132	C. L. Whittington, 1948. North bank of Sadlerochit River, lat 69°31′ N., long 145°02′ W. About 1¼ miles downstream from Mes. loc. 21819. Dull-black earthy shale at first outcrop downstream from Mes. loc. 21820 and about 500 feet higher stratigraphically unless covered interval conceals faults. Kingak shale. Upper Jurassic, lower Callovian.
32	22081	48ASa146	E. G. Sable, 1948. On south-flowing tributary of Sadlerochit River, two-fifths of a mile above mouth, approximate lat 69°32′10″ N., long 145°55′ W. Probably within middle third of Kingak shale and about 1,700 feet above its base in black earthy shale. Middle Jurassic, lower Bajocian.
32	22082	48ASa148	E. G. Sable, 1948. Downstream one-fifth of a mile from Mes. loc. 22081, approximate lat 69°32′ N., long 144°54′ W. Pyrite concretions in black shale about 2,600 feet above base of Kingak shale. Middle Jurassic, Bajocian.

Localities at which fossils were collected from outcrops of the Jurassic in northern Alaska—Continued

Locality number on fig. 20	Geological Survey Mesozoic locality	Collection field numbers	Collector and year of collection, description of locality, and stratigraphic assignment and age
33	10308	114a	E. de K. Leffingwell, 1911. Sadlerochit River, half a mile above mouth of Camp 263 Creek; lat 69°33′ N., long 144°47′ W. Fossils from concretions in black shale at foot of exposure and probably in lower 100 feet of Kingak shale. Middle Jurassic, lower Bajocian.
33	10309	114b	E. de K. Leffingwell, 1911. Sadlerochit River, north side, about a quarter of a mile downstream from Camp 263 Creek and 1½ miles upstream from mouth of Neruokpukkoonga Creek about 1,500 feet above base of Kingak shale; lat 69°33′ N., long 144°46′ W. Middle Jurassic, lower Bajocian.
34	10307	110	E. de K. Leffingwell, 1911. Sadlerochit River, cut on north side, about 3,000 feet above base of Jurassic, probably lat 69°33′ N., long 144°43′ W. Friable black shale containing pyrite concretions. Middle Jurassic, lower Bajocian.
35	23747	48ASa210	E. G. Sable, 1948. Cutbank on east side of Sadlerochit River near east end of Sadlerochit Mountains. First Cutbank north of tributary stream from south; lat 69°36′20″ N., long 144°27′30″ W. Massive sandstone containing conglomerate and ironstone lenses, probably within 75 feet of base of Jurassic. Lower Jurassic.
36	23749	48ASa229	E. G. Sable, 1948. Most prominent cliff on west side of Sadlerochit River near east end of Sadlerochit Mountains, lat 69°37′30″ N. long 144°25′ W. Sequence of interbedded sandstone, shale, siltstone, and conglomerate lenses about 120 feet above outcrops of Triassic rocks. Lower Jurassic.
37	23748	48ASa214	E. G. Sable, 1948. Cutbank on east bank of easternmost meander of Sadlerochit River near east end of Sadlerochit Mountains, lat 69°39′ N., long 144°23′ W. Pebbly fine-grained dark-gray sandstone at base of 480 feet of sandstone, shale, and conglomerate lenses. Lower Jurassic.

SUMMARY OF RESULTS

The Jurassic strata cropping out in northern Alaska are impoverished faunally in respect to genera, species, and individuals of macrofossils. Well cores from the Arctic Coastal Plain indicate that the subsurface Jurassic is much richer in individuals and somewhat richer in genera than the outcrops. The mollusks are represented by only 12 genera of pelecypods, 14 genera of cephalopods, and 1 genus of scaphopods. Other macrofossils include 1 brittle star, 1 crinoid, and 2 or 3 genera of brachiopods. The brachiopods, the brittle star, and many of the pelecypods are too poorly preserved to merit description. Only the mollusks are described. These include 7 species of pelecypods, 23 species of ammonites, and 1 belemnite. Because of poor preservation, most of these species are merely compared with European or American species. However, 4 species of *Aucella* are identified with species common in the Jurassic of the Boreal region, 3 species of ammonites are identified with species occurring in southwest Alaska, and 1 ammonite is identified with a species common to Europe and South America.

The stratigraphic positions of many of the fossil collections have not been determined very closely because of the great thicknesses of similar appearing strata involved, the lack of key beds, structural complications, limited exposures, and the presence of disconformities involving erosion and overlap. At one place or another, beds ranging in age from Early to Late Jurassic rest on Upper Triassic rocks. In many places interpretations of the stratigraphy or the structure are based on the fossils present, or the fossils are used as supplementary evidence. The age determinations of the fossils are based on the known ranges and faunal succession of the various genera and species elsewhere in the Boreal region or other parts of North America and in northwest Europe. The succession has been proven correct for northern Alaska whenever conditions have permitted stratigraphic collecting.

The Lower Jurassic includes no recognizable disconformities. In comparison with the Lower Jurassic of Europe, the oldest stage, the Hettangian, has not been identified faunally; but there is an ample thickness of strata in some sections to account for it. The next younger stage, the Sinemurian, is identified by the ammonite "*Arietites*" cf. "*A.*" *bucklandi* (Sowerby). The overlying Pliensbachian stage is identified by the ammonite *Amaltheus*. The lower Toarcian is identified by finely ribbed species of *Dactylioceras* which are succeeded by coarsely ribbed species of *Dactylioceras*. The upper Toarcian is identified by certain species of *Pseudolioceras*.

The lower Bajocian is identified by the ammonites *Tmetoceras*, *Pseudolioceras*, and *Erycites*. Two species of *Pseudolioceras* and *Erycites* are also common at the base of the Middle Jurassic in southwest Alaska.

The middle and upper Bajocian and the entire Bathonian have not been identified faunally in northern Alaska and are probably represented in part by a disconformity.

The lower Callovian is identified by the ammonite *Arcticoceras;* the middle Callovian, by *Pseudocadoceras*; and the middle to upper Callovian, by *Reineckeia* (*Reineckeites*).

The highest Callovian and the lower Oxfordian have not been identified faunally and are probably represented by a major disconformity.

The upper Oxfordian to lower Kimmeridgian strata are identified by the ammonite *Amoeboceras* and the pelecypods *Aucella spitiensis* Holdhaus and *A. concentrica* (Sowerby).

The middle Kimmeridgian to lower Portlandian strata are identified by *Aucella rugosa* (Fisher) and *A. mosquensis* (von Buch). The lower part of the range of these species overlaps the highest part of the range of *A. concentrica* (Sowerby).

The upper Portlandian has not been identified faunally in northern Alaska, and there is field evidence for an erosional unconformity during late Portlandian time.

TABLE 3.—*Test wells from which Jurassic fossils and stratigraphic data have been obtained*

Test well (See fig. 20.)	Location	Elevation at ground level in feet	Top of Jurassic in feet	Base of Jurassic in feet	Jurassic rocks represented		
					Lower Jurassic	Lower Bajocian	Upper Oxfordian and Kimmeridgian
Simpson 1	Lat 70°57′05″ N., long 155°21′45″ W.	15.0	5,550	6,300	Present	(?)	Absent.
South Barrow 2	Lat 71°15′51″ N., long 156°37′55″ W.	23.5	2,310	2,443	do	Present at 2,391.	Do.
South Barrow 3	Lat 71°09′40″ N., long 156°34′45″ W.	30.0	1,645	2,610	do	(?)	Do.
Topagoruk 1	Lat 70°37′30″ N., long 155°53′36″ W.	27.0	6,910	8,640	do	Present at 8,111 and 8,113.	Microfauna at 6,910 to 7,820.
Avak 1	Lat 71°15′02″ N., long 156°28′06″ W.	1.8	1,360	2,300	do	(?)	Absent.

TABLE 4.—*Jurassic macrofossils from well cores in northern Alaska*

Fossil	Depths in test wells, in feet, from which fossils were obtained				
	Simpson test well 1	South Barrow test well 2	South Barrow test well 3	Topagoruk test well 1	Avak test well 1
Brittle star			2,010		
Brachiopods			2,131; 2,132		
Velopecten? sp			2,165; 2,186; 2,199		
Oxytoma sp	6,174; 6,186		2,412		
"*Arietites*" cf. "*A.*" *bucklandi* (Sowerby)					1,836
Amaltheus cf. *A. nudus* (Quenstedt)			2,198		
cf. *A. depressus* (Simpson)			2,186		
cf. *A. margaritatus* (Montfort)			2,111		
sp. indet	5,680		2,069–2,198		
Coeloceras aff. *C. mucronatum* (D'Orbigny)			2,063		
Dactylioceras cf. *D. semicelatum* (Simpson)			2,017; 2,018		
cf. *D. kanense* McLearn			2,016		
cf. *D. crassiusculosum* (Simpson)			1,772		
cf. *D. delicatum* (Bean-Simpson)			1,772		
cf. *D. commune* (Sowerby)			1,772		
Pseudolioceras? sp				8,111	
Tmetoceras sp		2,391		8,113	

Faunal and lithologic relationships suggest that much of the Jurassic sea bottom in northern Alaska sloped moderately basinward and was stagnant, and at least as deep as the lower part of the neritic zone. The existence of such depths may explain the presence of the ammonites *Phylloceras*, *Lytoceras*, and *Reineckeia*, which are missing from the Jurassic in the interior of North America, east Greenland, and the Barents Sea area. The scantiness of the faunas over much of the seaway is probably related to unfavorable bottom conditions and also to derivation of most of the associated sediment from sedimentary rocks to the south. In contrast, the much more abundant faunas found along the northern margin of the seaway are associated with sediments derived from metamorphic rocks to the north and probably had a more ample supply of phosphate. The poverty of molluscan genera and species may also be related to a somewhat lower temperature of seawater in the Boreal region than in the Mediterranean region. Fairly warm water, at least during Early Jurassic and early Middle Jurassic (Bajocian) time, is indicated by the presence of *Gryphaea* and of ammonites that have a cosmopolitan distribution. Faunal differentiation in the Boreal region, including Alaska, during the Late Jurassic is considered evidence for the presence of climatic zones.

SYSTEMATIC DESCRIPTIONS

Class PELECYPODA

Genus GRYPHAEA Lamarck, 1801

Gryphaea cf. G. cymbium Lamarck

Plate 8, figures 2–4

Internal molds of 9 left valves and 4 right valves represent a species that probably is identical with *G. cymbium* Lamarck. The right valve is slightly convex on the figured specimen and is slightly concave on the other specimens. The left valve is short, plump, and bears a sulcus on its posterior side. The beak is blunt and incurved directly and in some specimens bears an attachment scar.

The Alaskan specimens compared to *G. cymbium* were found within several hundred feet of the base of the Jurassic. In England *Gryphaea cymbium* is typical of the middle Lias (equals upper Pliensbachian) (Arkell, 1933, p. 162) but has been recorded in the lower Pliensbachian (Arkell, 1933, p. 140, 144, 148). In central Europe it has the same range (Pfannenstiel, 1928, p. 390).

Figured specimens: USNM 108752. Kingak shale, USGS Mes. loc. 23748.

Genus AUCELLA Keyserling, 1846

Aucella concentrica (Sowerby)

Plate 9, figures 11–16

(For synonymy see Pavlow, 1907, Soc. Impériale Naturalistes, Moscou, Nouv. Mém., v. 17, livr. 1, p. 14; Sokolov, 1908, Com. géol. [Petrograd] Mém. Nouv. sér., livr. 36, p. 8; Waterston, 1951, Royal Soc. Edinburgh Trans., v. 62, p. 40).

This species has been thoroughly described and discussed in several publications (Lahusen, 1888, p. 32, 33; Pavlow, 1907, p. 14–16; Sokolov, 1908, p. 8–10, 27, 28; Sokolov and Bodylevsky, 1931, p. 34, 35, under the name *A. bronni* (Rouiller)). The careful work of Waterston (1951, p. 40, 41, pl. 1, figs 2a–c) has demonstrated, however, that the species was first described by Sowerby (1827, v. 4, p. 113, pl. 559, fig. 1) as *Plagiostoma concentrica.* Its valves are nearly equal, elongated obliquely, gently to moderately convex in the unbonal region, and flattened posteriorly. Its beaks are small, low, and curved inward. Its surface bears many sharp concentric ribs that are crossed by very fine closely spaced radial striae.

Minor variations in the convexity of the shell, degree of obliquity of the valves, and strength or pattern of the ribbing have been the basis for the naming of a number of species, most of which Sokolov (1908, p. 8) includes in *Aucella bronni* (Rouiller) (equals *P. concentrica* Sowerby) as normal varieties. This is a sensible procedure considering that the varieties are not known to have any stratigraphic significance.

In northern Alaska about 50 specimens of *Aucella concentrica* (Sowerby) have been collected from 11 localities in the foothills north of the Brooks Range. Some of these specimens are from thin coquinas which consist mainly of crushed and broken Aucellas. Others are from concretions and exhibit fairly complete shell outlines. The radial striae are generally better preserved on external molds than on internal molds, where they may be visible only at the points of intersection with concentric ribs. The specimens preserved in the coquinas are identified on the basis of their flattened valves, nearly microscopic radial striae, and rather low concentric ribs. Similar coquinas composed of *A. rugosa* (Fischer) have much more convex left valves and much higher concentric ribs.

Aucella concentrica (Sowerby) in northern Eurasia and the Barents Sea area ranges from late Oxfordian into the middle Kimmeridgian and attains its maximum abundance in the early Kimmeridgian (Lahusen, 1888, p. 8, 26, 33; Pavlow, 1907, table opposite p. 84; Sokolov, 1908, p. 2; Sokolov and Bodylevsky, 1931, p. 34, 35). Its highest occurrence is in the zone of *Aulacostephanus pseudomutabilis*, which probably corresponds to its occurrence in Mexico (Burckhardt, 1930, p. 80). Its lowest occurrence is within the zone of *Cardioceras cordatum* as used by the Russians, which includes much more than the northwest European zone of *Cardioceras cordatum* (Arkell, 1946, p. 25). It has not been recorded definitely below the zone of *Amoeboceras alternoides* and apparently is rare below the Russian zone of *Amoeboceras alternans* (Lahusen, 1888, p. 26).

The distribution of *Aucella concentrica* (Sowerby) in other parts of the Boreal region shows that it is not known below the lowest occurrence of *Amoeboceras.* In southern Germany some small Aucellas that probably represent only a variety of *A. concentrica* occur in the zone of *Amoeboceras alternans* (Pompeckj, 1901 p. 23, 24, 29). In Spitzbergen *A. concentrica* occurs with *Amoeboceras* (*Prionodoceras*) (Sokolow and Bodylevsky, 1931, p. 20, 83, 107, 136). It is reported to be associated there with *Cardioceras* aff. *C. cordatum* Sowerby, but the ammonite illustrated (Sokolov and Bodylevsky, 1931, p. 83, pl. 6, fig. 3) is an *Amoeboceras.* In southwestern Alaska and the Cook Inlet region of Alaska, *A. concentrica* is abundant in beds containing *Amoeboceras* (*Prionodoceras*) and has never been found associated with *Cardioceras.*

Some of the specimens of *Aucella concentrica* from northern Alaska are of middle Kimmeridgian age as they are associated at Mes. locs. 22769 and 22766 with *A. rugosa* (Fischer) and *A. mosquensis* (von Buch), which are not known in beds older than the middle Kimmeridgian. Most of the specimens of *A. concentrica* are from coquinas and are probably mainly of early Kimmeridgian age as indicated by the absence of other species of *Aucella* and by the fact that *A. concentrica* attained its greatest abundance during that time. A few specimens associated with *A. spitiensis* Holdhaus and the ammonite *Amoeboceras* (*Prionodoceras*) at Mes. locs. 21028 and 22598 are probably of late Oxfordian age, as *Prionodoceras* is characteristic of the late Oxfordian and is rare in the early Kimmeridgian.

Plesiotypes: USNM 108743, 108744, 108745, 108749. Kingak shale, USGS Mes. locs. 21026, 21028, 22126, 22507, 22509, 22578, 22582, 22598, 22759, 22766. 22769.

Aucella spitiensis Holdhaus

Plate 9, figures 1–10

Aucella spitiensis Holdhaus, 1913, Paleontologica Indica, ser. 15, v. 4, pt. 2, p. 408–410, pl. 97, figs. 7–13.
Aucella subspitiensis Krumbeck, 1934, Neues Jahrb., Beilage-Band 71B, p. 439–448, pl. 14, figs. 1–12, pl. 15, figs. 1–8.
Aucella cf. *A. subspitiensis* Wandel, 1936, Neues Jahrb., Beilage-Band 75B, p. 462–463.
Buchia subspitiensis Teichert, 1940, Royal Soc. Western Australia Jour., v. 26, p. 112–113, pl. 1, figs. 1–7.

Thirty-five specimens from northern Alaska are assigned to this species. They have obliquely elongated valves; the right valve is nearly flat, and the left valve is weakly to moderately convex. The beak on the right valve is short and blunt; the beak on the left valve is short, stout, and gently incurved. The surface bears concentric ribbing of irregular strength and spacing that is superposed on irregular concentric undulations. Weak scattered radial striae are generally restricted to the umbonal region and are visible only on some external molds and on specimens that retain some shelly material. Most internal molds do not show any trace of radial striae.

The appearance of the Alaskan specimens of *A. spitiensis* Holdhaus differs from that of the Indian specimens only by the presence of weak radial striae. The Indian specimens, however, are nearly all internal molds (Holdhaus, 1913, p. 404, 409) on which radial striae would scarcely show if weakly developed on the shell.

The Alaskan specimens of *A. spitiensis* Holdhaus appear to be identical with *A. subspitiensis* Krumbeck from the Malay Archipelago and Australia. The later species is reported by Krumbeck (1934, p. 445–446) to differ from *A. spitiensis* mainly by the left valve having radial striae and a more obliquely truncated anterior margin. However, concerning the weak radial striae, Krumbeck (1934, p. 443) states that they are lacking on most of the molds of the type collection of *A. subspitiensis* and are visible only on some of the best preserved fossils. Concerning the shape of the anterior margin of the left valve, Krumbeck (1934, p. 445) notes that one of the specimens from India figured by Holdhaus (1913, pl. 97, figs. 10a–c) as *A. spitiensis* has a similar shape to *A. subspitiensis* and may represent that species. As this particular specimen was considered by Holdhaus (1913, p. 410) as typical of the majority of specimens in his species, *A. spitiensis*, the differences noted by Krumbeck are not valid.

A. spitiensis Holdhaus resembles *A. concentrica* considerably in the oblique elongation of the shell but is readily distinguished by its conspicuous, irregular concentric undulations, by its more convex left valve, and by its irregularly developed radial striae.

The range of *A. spitiensis* Holdhaus is not known. Teichert (1940, p. 110, 111) has summarized the evidence and concluded that the possible maximum range is late Oxfordian to late Kimmeridgian. In northern Alaska *A. spitiensis* is associated at Mes. locs. 24014 and 22598 with the ammonite *Amoeboceras* (*Prinodoceras?*), whose presence is excellent evidence that *A. spitiensis* existed in the late Oxfordian or early Kimmeridgian. Its association in Alaska with *Aucella concentrica* (Sowerby) at Mes. locs. 21028 and 22598 and its nonassociation with *A. mosquensis* (von Buch) or *A. rugosa* (Fischer) suggest that it does not range as high as the middle Kimmeridgian.

Plesiotypes: USNM 108746a–f, 108747a, b. Kingak shales, USGS Mes. locs. 21026, 21028, 22598, 24013, 24014.

Aucella rugosa (Fischer)

Plate 9, figures 20–27

(For synonymy see Pavlow, A. P., 1907, Soc. Impériale Naturalistes Moscou, Nouv. Mém., v. 17, livr. 1, p. 36, 37; Spath, 1936, Meddelelser om Grönland, bind 99, nr. 3, p. 100.)

Aucella rugosa (Fischer) is the most common species of *Aucella* in the Upper Jurassic of northern Alaska and is represented in the United States Geological Survey collections by 50 well-preserved specimens and by 75 fragmentary or crushed specimens. The 75 specimens are a selection from coquinas that consist of enormous numbers of Aucellas. The species has been well described and illustrated by Pavlow (1907, p. 36–38, pl. 1, figs. 6a–c, 7a–c). Its shape is similar to that of *A. mosquensis* (von Buch), with which it is commonly associated. Most specimens are less elongated posteriorly, are broader and flatter, and have less strongly incurved beaks. The distinguishing feature, however, is the ribbing. On *A. rugosa* (Fischer) the concentric ribs are high, thin, and widely and generally regularly spaced. These are crossed by extremely fine dense radial striae. In contrast, on *A. mosquensis* (von Buch) the concentric ribs are much lower and are irregular in strength and spacing; the radial markings, when present, are broader, lower, and scattered; and the surface of the shell is marked by constrictions at irregular intervals. If internal molds only are compared the differences in ribbing are not so striking, and the identification is based mainly on rib pattern and the density of radial striae when viewed under oblique lighting.

In discussing the Aucellas of east Greenland, Spath (1936, p. 100) notes that the specimens he assigned to *A. rugosa* (Fischer) are connected by transitions with typical *A. mosquensis* (von Buch); and he doubts, therefore, whether *A. rugosa* is a distinct species. The writer's opinion, after handling hundreds of specimens from the Naknek formation of the Cook Inlet region, is that most specimens are definitely referable to one species or to the other. A few specimens, such as the one shown on pl. 9, fig. 26, have ribbing characteristic of *A. rugosa* in the umbonal region but posteriorly develop constrictions and irregular ribbing similar to that of *A. mosquensis*. Such specimens are possibly transitional between the two species or are possibly a variant of *A. rugosa*. The latter is most likely because of the presence of ribbing characteristic of *A. rugosa* on the umbonal region and because constrictions and swellings have been developed on a number of species of *Aucella* that are otherwise very different.

Plesiotypes: USNM 108740, 108741a–c, 108742a–c. Kingak shale, USGS Mes. locs. 21027, 22127, 22579–22581, 22587, 22746, 22749, 22751, 22766, 22768, 22769, 23577, 23697. Possibly present at Mes. locs. 22584–22586, 22776.

Aucella mosquensis (von Buch)

Plate 9, figures 17–19

(For most of the synonymy see Pavlow, 1907, Soc. Impériale Naturalistes Moscou, Nouv. Mém., v. 17, livr. 1, p. 22; Spath, 1936, Meddelelser on Grönland, bind 99, no. 3, p. 98, 99.)

?*Aucella blanfordiana* Stoliczka. Holdhaus, 1913, Paleontologia Indica, ser. 15, v. 4, pt. 2, p. 412–413, pl. 98, figs. 1–9.

?*Aucella subpallasi* Krumbeck. 1934, Neues Jahrb., Beilage-Band 71–B, p. 450–454, pl. 15, fig. 11; pl. 16, figs. 1–10.

?*Aucella* aff. *A. mosquensis* (von Buch). Anderson, 1945, Geol. Soc. America Bull., v. 56, p. 966, pl. 4, figs. 12a, b; pl. 12, fig. 3.

This species is represented from northern Alaska by 19 specimens, of which 13 show the features of the left valve very well. The shell is elongate, very inequivalved and very inequilateral. During growth it becomes more elongate posteriorly, and its ventral margin becomes more curved. The left valve is strongly convex; its umbo is stout; and its beak is long, much incurved, and has a slight forward twist. The right valve is gently convex; and its beak is low. The surface of the valves bears concentric ribs of irregular strength and spacing and irregularly spaced undulations and constrictions. Fine radial markings are visible on some specimens under oblique lighting.

A. mosquensis (von Buch) is similar to several other species of Aucellas in both the Jurassic and Lower Cretaceous and even resembles the genus *Aucellina* of the Aptian and Albian stages of the Cretaceous. The combination of swollen left valve, posteriorly elongate form, stout umbo, strongly incurved beak, and irregular concentric ornamentation generally serves to distinguish *A. mosquensis* from other species, but only well-preserved specimens can be certainly identified. Fortunately, in Alaska *A. mosquensis* is generally associated with *A. rugosa* (Fischer), which is generally easily identified.

The range of *A. mosquensis* (von Buch) in northern Europe has been shown by Spath (1936, p. 166, 167) to be between the zones of *Subplanites wheatleyensis* and *Zaraiskites albani* inclusive, that is, upper Kimmeridgian and basal Portlandian. It seems probable that the total range of the species is somewhat greater. In California and Mexico it, or a closely similar species, has been found with *Kossmatia* and *Durangites* (Anderson, 1945, p. 940; Burckhardt, 1912, p. 206, 221, 236) in beds that are correlated with the middle part of the Portlandian stage (Imlay, 1952, pl. 2, opposite p. 992). In Mexico it has been found also in lower beds associated with *Glochiceras fialar* and *Idoceras durangense* (Burckhardt, 1906, p. 144, 155). This occurrence of *A. mosquensis* with *Glochiceras fialar* represents the middle Kimmeridgian, probably equivalent to the European zone of *Aulacostephanus pseudomutabilis*, and is considerably older than any known occurrence in Europe.

Considering the wide distribution and fair abundance of *A. mosquensis* (von Buch) in Europe as far south as France and Austria and in North America as far south as Mexico, it is rather astonishing that the species has not been identified among the collections of Aucellas from India or the Malay Archipelago. The possibility that *A. mosquensis* is present there but called by another name is suggested by comparisons with *A. blanfordiana* Stoliczka (Holdhaus, 1913, p. 412–414, pl. 98, figs. 1–9) and the statement by Holdhaus (1913, p. 414) that he cannot "establish any criteria that will in all instances clearly distinguish the two species." Krumbeck (1934, p. 453) notes that *A. blanfordiana* may be distinguished from *A. pallasi* Lahusen (equals *A. mosquensis* as used herein) by its left valve having a more swollen umbonal region, more irregular concentric ribbing, perhaps by lacking radial striae, and probably by certain apparent differences in the ears on both valves. However, if the illustrations of *A. blanfordiana* published by Holdhaus are accurate, separation of the two species from a mixed lot would indeed be difficult.

Another similar species, *A. subpallasi* Krumbeck (1934, p. 450–454, pl. 15, fig. 11; pl. 16, figs. 1–10), from the Malay Archipelago and western Australia (Teichert, 1940, p. 113, 114, pl. 1, figs. 8–12), is distinguished from *A. pallasi* Lahusen (that is *A. mosquensis*), according to Krumbeck (1934, p. 452), mainly by having a more prominent umbo and a more strongly incoiled beak and by the absence of a posterior ear on the left valve, which feature is slightly developed in *A. mosquensis*. Krumbeck (1934, p. 453) considers that *A. subpallasi* resembles *A. blanfordiana* even more than it resembles *A. mosquensis* but may be distinguished from the former by a more swollen right valve, a more swollen and more strongly incurved beak on the left valve, a differently shaped byssal ear, and perhaps the presence of radial striae.

Comparisons of the published photographs of the type specimens of *A. subpallasi* Krumbeck with 11 well-preserved specimens of *A. mosquensis* (von Buch) from Russia leaves considerable doubt as to whether the two species are distinct. Several specimens from near Moscow and near Vetlanka Creek in Orenburg province have as prominent umbos and as tightly incoiled beaks as any of the specimens of *A. subpallasi* figured by Krumbeck. The differences in the ears noted by Krumbeck may be a matter of preservation or of individual variation and probably do not justify more than a varietal name.

Plesiotypes: USNM 108748a–c. Kingak shale, USGS Mes. locs 22751, 22766, 22769, 22776. Probably present at Mes. locs 22750 and 23598.

Genus POSIDONIA Bronn, 1828

Posidonia cf. P. ornata Quenstedt

Plate 10, figure 21

One small slab from the basal Middle Jurassic exposed on the banks of the Canning River bears about 40 specimens of *Posidonia* that are within the range of variation of *P. ornata* Quenstedt as illustrated by Guillaume (1927, p. 222, pl. 10, figs. 4–13). This species has been recorded from beds of lowest Bajocian to Callovian age in many parts of the world. (See Steinmann, 1881, p. 257, pl. 10, figs. 3, 5; Ravn, 1911, p. 462, pl. 33, figs. 2, 3; Roman, *in* Sayn and Roman, 1928, p. 114; Weir, 1930, p. 84.) The specimens from the Canning River area are smaller than the average for the species, but Guillaume (1927, p. 225) notes that the oldest representatives of the species (see Quenstedt, 1858, p. 31, pl. 42, fig. 4) are the smallest.

Figured specimens: USNM 108750. Kingak shale, USGS Mes. loc. 24035.

Genus INOCERAMUS J. Sowerby, 1819

Inoceramus lucifer Eichwald

Plate 8, figures 1, 5–10

Inoceramus lucifer Eichwald, 1871, Geognostisch-Palaeontologische Bemerkungen über de Halbinsel Mangischlak und die Aleutischen Inseln, p. 194, 195, pl. 18, figs. 5–7.

This species in northern Alaska is represented by 35 specimens of various sizes that show variations in sculpture similar to specimens from southwestern Alaska and Cook Inlet. For purposes of comparison, three specimens from Tuxedni Bay, the type locality, are illustrated on plate 8, figures 5, 7, 9, 10.

The species has a long mytiloid outline, terminal beaks, a fairly short hingeline, and a concave anterior margin below the umbones. Its surface bears concentric ribbing that ranges considerably in strength and spacing even on a single specimen. The umbonal region is smooth or nearly smooth and is generally separated from the remainder of the shell by a constriction. Some specimens have more than one constriction. The coarsest ribbing generally occurs near the constrictions, but the surfaces between constrictions may bear very weak ribs.

In northern Alaska *I. lucifer* is associated with the ammonites *Erycites* and *Pseudolioceras*. In southwestern Alaska at Wide Bay it occurs with these ammonites in the lowest exposed part of the Kialagvik formation but ranges to the top of the formation where it is associated with *Emileia*, *Sonninia*, and *Stemmatoceras*. In Cook Inlet on the Iniskin Peninsula in ranges as high as the siltstone underlying the Gaikema sandstone member of the Tuxedni formation. Near Fossil Point on Tuxedni Bay it occurs in units 30 to 35 of the section measured by Martin and Stanton (Martin, 1926, p. 142, 143). In its highest occurrence on the Iniskin Peninsula and on Tuxedni Bay, it is associated with the ammonites *Stemmatoceras*, *Emileia*, *Sonninia*, *Lissoceras*, and rare *Otoites*. Its range, therefore, is through the lower and middle Bajocian and not higher than the European zone of *Otoites sauzei*.

Plesiotypes: USNM 108751a–c. Kingak shale, USGS Mes. locs. 10307, 10309, 21023, 21552, 22082.

Class CEPHALOPDA

Genus PHYLLOCERAS Suess, 1865

Subgenus PARTSCHICERAS Fucini, 1923

Phylloceras (Partschiceras) sp.

Plate 10, figures 18, 19

One specimen of *Partschiceras* is available from northern Alaska. The body chamber of this specimen appears to be complete and represents nearly a complete whorl. The ornamentation consists only of faint moderately dense ribs on the ventral region. At a diameter of 20 millimeters the whorl height is 14 millimeters, and the whorl thickness is 8.5 millimeters. This species differs from *P. subobtusiforme* (Pompeckj) (1900, p. 247, pl. 7, figs. 1a–d), from the Callovian of the Cook Inlet area, Alaska, in its more compressed whorl section and weaker ribbing. It apparently differs from *P. chantrei* Munier-Chalmas (see Sayn and Roman, 1930, p. 216, pl. 21, figs. 11, 11 a; text fig. 33) from the Callovian and Oxfordian of Europe only in its finer ribbing.

Figured specimen: USNM 108775. Kingak shale, USGS Mes. loc. 24013.

Subgenus MACROPHYLLOCERAS, Spath, 1927

Phylloceras (Macrophylloceras) sp.

Plate 10, figure 20

The occurrence of *Macrophylloceras* in northern Alaska is based on one large fragment of an internal mold. Not a trace of the ornamentation is preserved, but the suture line shows the high external lobe and the moderately broad saddles that are characteristic of this subgenus. The lack of constrictions on the mold also confirms the assignment.

Figured specimen: USNM 108774. Kingak shale, USGS Mes. loc. 21027.

Genus AMALTHEUS Montfort, 1808

Amaltheus spp.

Plate 10, figures 1–5

Many strongly compressed specimens of *Amaltheus* have been obtained from the South Barrow test well 1 at depths ranging from 2,069 to 2,198 feet. These show clearly such generic features as the flexuous primary ribs that tend to fade on the upper parts of the flanks, the forwardly inclined indistinct secondary ribs, and the noded cordlike keel. Two specimens show weak spiral lines on the upper parts of the flanks. The specimens from depths of 2,177 to 2,198 feet have weaker more closely spaced ribs than the specimens from the higher beds. One specimen from the depth of 2,186 feet becomes nearly smooth anteriorly and may be compared to *A. depressus* Simpson (Buckman, 1911, v. 1, pl. 25). Another, from the depth of 2,198 feet, has stronger ribs on the upper parts of the flanks as in *A. nudus* (Quenstedt) (1858, p. 167, pl. 20, fig. 4; 1885, p. 321, pl. 41, figs. 1, 2). Much stronger and more widely spaced primary ribs are present on a specimen from the depth of 2,111 feet. This specimen resembles *A. margaritatus* (Montfort) as figured by Arkell (1933, pl. 31, fig. 2).

Figured specimens: USNM 108765–108770. Kingak shale, South Barrow test well 3 at depths from 2,069 to 2,198 feet. Simpson test well 1 at a depth of 5,680 feet.

Subgenus PSEUDOAMALTHEUS Frebold, 1922

Amaltheus (Pseudoamaltheus) sp.

Plate 10, figure 17

One fragment of an ammonite shows features similar to those of *A.* (*Pseudoamaltheus*) *engelhardti* D'Orbigny (1844, p. 245, pl. 66; Wright, 1882, p. 400; Wright, 1883, pl. 70) from the upper Pliensbachian of northwest Europe. The fragment belongs to a species having a fairly narrow umbilicus and flattened flanks. Its ornamentation consists of widely spaced low spiral ribs and faint radial striae. The striae produce faint denticulations at their intersections with the spiral ribs. The venter is not preserved.

Figured specimen: USNM 108764. Kingak shale, USGS Mes. loc. 22747.

Genus ARIETITES Waagen, 1869

"Arietites" cf. "A." bucklandi (Sowerby)

Plate 10, figures 7, 8

One ammonite is represented by parts of two whorls. It has highly evolute coiling, a subquadrate whorl section, triple keels, and prominent, widely spaced ribs that incline forward slightly on the flanks and end abruptly ventrally near the keels. The ventral terminations of the ribs have a slight forward twist. The median keel is a little higher than the other keels, as shown by an external mold, and is separated from them by smooth furrows.

The shape and ornamentation of this ammonite greatly resemble the inner whorls of *Ammonites bucklandi* Sowerby (Wright, 1881, p. 269, pl. 1, figs. 1–3; Buckman, 1919, pl. 131), which is a zone fossil for the lower Sinemurian stage of northwest Europe.

Whether the generic name should be *Ammonites*, *Arietites*, or *Coroniceras* will have to be decided by the International Commission on Zoological Nomenclature. In any case, the group of species to which *A. bucklandi* belongs is characteristic of the Sinemurian, and the Alaskan ammonite figured herein should represent the lower part of the Lower Jurassic. It is interesting, therefore, that the ammonite was obtained 464 feet above the base of the Jurassic as determined by lithologic characteristics and by Foraminifera.

Figured specimen: USNM 108778. Kingak shale, Avak test well 1 at a depth of 1,836 feet.

Genus DACTYLIOCERAS Hyatt, 1867

Dactylioceras aff. D. semicelatum (Simpson)

Plate 10, figures 6, 13

Four crushed specimens are characterized by very fine fairly widely spaced ribs that arch forward on the venter and by swellings rather than tubercles at the ventral ends of the primary ribs. Many of the secondary ribs are indistinctly connected with the primary ribs or begin below the ventral ends of the primary ribs. These specimens bear a general resemblance in rib pattern to *D. semicelatum* (Simpson) (Buckman, 1911, pl. 31) and to a species from east Greenland (Rosenkrantz, 1934 p. 89, pl. 5, figs. 4, 5) but have weaker and more widely spaced ribbing, especially on their inner whorls. The fineness of this ribbing resembles that of *D. kanense* McLearn (1932, p. 59, pl. 3, fig. 5; pl. 4, figs. 1–7, 9; pl. 5, figs. 6–9) from British Columbia.

Figure specimens: USNM 108763a, b. Kingak shale, South Barrow test well 3 at depths of 2,017 and 2,018 feet.

Dactylioceras cf. D. kanense McLearn

Plate 10, figure 14

One fragment may be compared to the internal whorls of the holotype of *D. kanense* McLearn (1932, p. 59, pl. 4, fig. 1) from the lower part of the Maude formation of British Columbia, or to the inner whorls of *D. attenuatus* (Simpson) (Buckman, 1926, pl. 655) from England. It is characterized by having fine hair-like, rather dense ribbing and by bearing small elongate tubercles at the ends of the primary ribs. Its ribbing is considerably denser than in the specimens herein shown on pl. 10, figs 6, 13 that resemble *D. semicelatum* (Simpson). *D. tenuicostatum* (Young and Bird) (Buckman, 1920, pl. 157; 1927, pl. 157A) has slightly coarser and denser ribbing.

In England finely ribbed *Dactylioceras* occur in the lower Toarcian in the zones of *Dactylioceras tenuicostatum* and *Harpoceras serpentinum.* The same age for the finely ribbed *Dactylioceras* from Alaska is shown by their position in the South Barrow test well 3 only 51 feet above the highest occurrence of *Amaltheus* and 244 feet below a coarsely ribbed species of *Dactylioceras.*

Figured specimen: USNM 108762. Kingak shale, South Barrow test well 3 at a depth of 2,016 feet.

Dactylioceras spp.

Plate 10, figures 9–12, 15, 16

Many fragments of immature specimens of *Dactylioceras* obtained from a well core belong to coarsely ribbed species such as occur in the *Hildoceras bifrons* zone in Europe. The fragments shown on plate 10, figures 10–12 have a compressed whorl section and coarse ribbing similar to *D. commune* (Sowerby) (Wright, 1884, pl. 84, figs. 1, 2; Buckman, 1927, pl. 707). The primary ribs incline forward on the flanks, and about half of them divide high on the flanks into two ribs that arch forward considerably on the venter. The fragments (pl. 10, figs. 15, 16) have a stouter whorl section and may be compared to *D. delicatum* (Bean-Simpson) (Buckman, 1926, pl. 656). Their primary ribs are high, thin, fairly widely spaced, and nearly radial, and most of them bifurcate high on the flanks into two weaker secondary ribs that arch forward gently on the venter. The points of furcation are marked by tubercles that become weaker anteriorly. Another fragment (pl. 10, fig. 9) differs from the others in the same core in its coarser more widely spaced primary ribs, lower whorl section, and slower rate of coiling. It may be compared to the inner whorls of *Dactylioceras crassiusculosum* (Simpson) (Buckman, 1912, pl. 62) or the inner whorls of *D. braunianum* (D'Orbigny) as illustrated by Buckman (1926, pl. 658).

The correctness of the generic and age assignments of these fragments is shown by comparison with specimens of *Dactylioceras* of various sizes from Prince Patrick Island, which is about 700 miles northeast of Point Barrow, Alaska. The specimens from Prince Patrick Island (see pl. 11, figs. 4–11, 14, 16–18) may readily be compared to European species such as *D. crassiusculosum* Simpson, *D. commune* (Sowerby) (Buckman, 1927, pl. 707), and *D. directum* (Buckman) (1926, pl. 654). One of the collections from Prince Patrick Island contains a fragment of a keeled ammonite that is probably *Hildoceras.* Another collection contains several external molds of *Harpoceras* (see pl. 11, figs. 12, 13, 15) that greatly resemble *H. exaratum* (Young and Bird) (Wright, 1882, pl. 62, figs. 1–3).

Figured specimens: USNM 108759, 108760, 108761a–d. Kingak shale, South Barrow test well 3 at a depth of 1,772 feet.

Genus COELOCERAS Hyatt, 1867

Coeloceras aff. C. mucronatum (D'Orbigny)

Plate 12, figures 12–14

One ammonite represented by both external and internal molds of four specimens is characterized by a highly evolute form and by prominent widely spaced nearly radial primary ribs that end high on the flanks in large tubercles. From these pass two or three narrow, weak secondary ribs. The bundles of forked ribs are generally separated by single, weak ribs that begin at or just above the zone of tuberculation. The ribbing along the midventral line is not preserved.

In lateral view this ammonite appears to be nearly identical with *Coeloceras mucronatum* (D'Orbigny) (1845, p. 328, pl. 104, figs. 4–8). In ventral view it appears to have slightly weaker and more numerous secondary ribs, although D'Orbigny figures a variety having three secondary ribs for each primary rib. Some of the specimens illustrated by Wright (1884, pl. 86, figs. 3, 4, pl. 87, figs. 5, 6) as "*Stephanoceras braunianum*" (D'Orbigny) appear to differ from the Alaskan ammonite mainly by having fewer and weaker secondary ribs. *C. grenouillouxi* (D'Orbigny) (1844, p. 307, pl. 96) has even sparser ventral ribbing. The Alaskan species is referred to *Coeloceras* rather than to *Dactylioceras* because of its large tubercles and the considerable difference in size between its primary and secondary ribs. It does not have any of the button-and-loop ornamentation that characterizes *Peronoceras.* Buckman

(1927, p. 43) designated *Ammonites mucronatus* D'Orbigny as the genotype of his new genus *Mucrodactylites*. Except for the presence of a weak groove along the midventral line, the species appears to be a typical *Coeloceras*.

The Alaskan species of *Coeloceras* was obtained in the South Barrow test well 3, 6 feet above the highest occurrence of *Amaltheus* and 45 feet below the lowest occurrence of finely ribbed *Dactylioceras*. This position indicates that it is of upper Pliensbachian age, because *Amaltheus* does not range to the top of the Pliensbachian and finely ribbed *Dactylioceras* are typical of the lower Toarcian. In Europe *Coeloceras* is most common in the lower Pliensbachian but has been recorded higher from beds containing *Amaltheus* (Beurlen, 1924, p. 150). *Coeloceras mucronatum* D'Orbigny is reported (Roman, 1938, p. 183) to be of Toarcian age. Such genera as *Nodicoeloceras* and *Crassicoeloceras* Buckman (1926, p. 42), which resemble *Coeloceras*, are common in the lower Toarcian (Daviess, *in* Buckman, 1930, p. 38–40). The ages of these ammonites show that the occurrence of a *Coeloceras* in Alaska at or near the top of the local range of *Amaltheus* is not out of line with the occurrence of *Coeloceras* in Europe.

Figured specimen: USNM 108758a–c. Kingak shale, South Barrow test well 3 at a depth of 2,063 feet.

Genus PSEUDOLIOCERAS Buckman, 1888

Pseudolioceras whiteavesi (White)

Plate 12, figures 15, 16

Ammonites (*Amaltheus*) *whiteavesi* White, 1889, U. S. Geol. Survey Bull. 51, p. 69–90, pl. 13, figs. 1–5.

Harpoceras whiteavesi Kellum, Daviess, and Swinney, 1945. U. S. Geol. Survey Prelim. Repts. on geology and oil possibilities of the southwestern part of the Wide Bay anticline, figs. 4e, f.

This species is represented in northern Alaska by at least 15 specimens, of which some are illustrated for comparison with the type specimens from southwestern Alaska. The species is characterized by a very narrow umbilicus, a sharp raised umbilical edge, and strongly falcoid ribs. The pattern and strength of the ribs resembles that of *P. beyrichi* (Schloenbach) as figured by Buckman (1888, pl. 20, figs. 7, 8), but the raised umbilical edge on *P. whiteavesi* is a possible distinction between the species. Detailed comparisons with European species must await study of the abundant and well-preserved material from Wide Bay in southwestern Alaska. At that place *P. whiteavesi* occurs at the base of the Middle Jurassic associated with *Tmetoceras*, *Erycites, and Hammatoceras* (Imlay, 1952, p. 978).

Cotypes: USNM 20110; plesiotypes, USNM 108754, 108755. Kingak shale, USGS Mes. locs. 10307 and 24035.

Pseudolioceras cf. P. lythense (Young and Bird)

Plate 12, figure 20

One specimen, represented by both external and internal molds, greatly resembles *P. lythense* (Young and Bird) (Wright, 1884, p. 444, pl. 62, figs. 4–6; Rosenkrantz, 1934, pl. 6, fig. 1), from the Toarcian of Europe and Greenland, in character of ribbing, width of umbilicus, and prominence of keel. The strongly falciform moderately prominent ribs rise from the striae on the lower third of the flanks and disappear ventrally before reaching the keel. The keel is bordered by weak furrows that are separated from the ribs by a narrow smooth area. The ribbing on the lower part of the flanks is much finer than on any of the species of *Pseudolioceras* in the lower part of the Kialagvik formation in southwestern Alaska.

Figured specimen: USNM 108757. Kingak shale, USGS Mes. loc. 23772.

Pseudolioceras cf. P. compactile (Simpson)

Plate 12, figures 17, 18, 21

Two specimens from the uppermost beds of the Kingak shale in Ignek Valley have much compressed whorl sections and weak ribbing similar to that of *P. compactile* (Simpson) (Buckman, 1911, pl. 41 a–c) from the upper Toarcian of Europe. The smaller specimen (pl. 12, figs. 17, 18) is smooth except for faint falciform striae near its anterior end and a low rounded keel that is bordered by weak furrows. Its posterior portion only is sutured. The larger specimen (pl. 12, fig. 21) is nearly smooth on the lower third of the flanks. The upper two-thirds of the flank bear faint broad falciform ribs that disappear ventrally before reaching the keel. The keel, exposed at several places, is low, rounded, and bordered on each side by weak furrows.

Figured specimens: USNM 108753, 108756. Kingak shale, USGS Mes. loc. 23772.

Genus TMETOCERAS Buckman, 1891

Tmetoceras sp.

Plate 12, figures 7–10

Small fragments of *Tmetoceras* were obtained from both South Barrow test well 2 and Topagoruk test well 1. In the latter the genus was obtained only 2 feet higher than some molds of *Pseudolioceras*. The fragments of *Tmetoceras* show evolute coiling, simple high thin, slightly flexuous ribs, tongue-shaped tubercles at the ventral ends of the ribs, and a narrow smooth midventral area. They resemble closely the inner whorls of well-preserved specimens of *Tmetoceras* from the lowermost exposed beds of the Kialagvik formation on Wide Bay in the Alaskan Peninsula.

Figured specimens: USNM 108779, 108780. Kingak shale, South Barrow test well 2 at a depth of 2,391 feet; Topagoruk test well 1 at a depth of 8,113 feet.

Genus ERYCITES Gemmellaro, 1886

Erycites howelli (White)

Plate 13, figures 12, 13

Ammonites (*Lillia*) *howelli* White, 1889, U. S. Geol. Survey Bull. 51, p. 68–69, pl. 12, figs. 1, 2; pl. 14, figs. 1–3.

Hammatoceras howelli Pompeckj, 1900, Russ. K. min. Gesell. Verh., ser. 2, Band 38, p. 275.

"*Hammatoceras*" *howelli* Kellum, Daviess, and Swinney, 1945, U. S. Geol. Survey Prelim. Repts. on geology and oil possibilities of the southwestern part of the Wide Bay anticline, figs. 4a, b.

One fragment of the anterior part of a penultimate whorl agrees perfectly in whorl shape and ornamentation with the holotype of *E. howelli* (White) from the basal part of the Middle Jurassic beds at Wide Bay in southwestern Alaska. The associated ammonites at Wide Bay include *Pseudolioceras whiteavesi* (White) and *Tmetoceras.* These occur directly beneath beds containing *Emileia*, *Sonninia*, *Erycites*, and *Pseudolioceras.* The fragment from northern Alaska is associated with *Pseudolioceras.*

Figured specimen: USNM 108777. Kingak shale, USGS Mes. loc. 10308.

Genus ARCTICOCERAS Spath, 1932

Arcticoceras sp.

Plate 12, figures 11, 19

Nine fragments of *Arcticoceras* obtained from the Canning and Sadlerochit Rivers in northern Alaska are too poorly preserved for specific identification. However, they show the essential generic features very well. The fragment illustrated (pl. 12, fig. 11) may be compared to immature densely ribbed variety of *A. kochi* Spath (1932, p. 55, pl. 14, figs. 2, 3) from east Greenland or to *A. ishmae* (Keyserling) (Spath, 1932, pl. 15, figs. 7a, b) from Pechora land. It has an extremely small umbilicus, rather sharp primary ribs that bifurcate near the middle of the flanks, and forwardly arched secondary ribs. Another fragment (pl. 12, fig. 19) shows the characteristics of the anterior part of the adult body whorl of the genus. This part is smooth except for very faint growth lines, is retracted considerably from the remainder of the shell near the aperture, and has a deep forwardly inclined constriction preceding the aperture. The aperture is inclined forward more strongly than the constriction and is produced into a long ventral lappet. The general appearance is similar to that of the adult whorl of *A. kochi* (Spath) (1932, pl. 14, fig. 1) except for size.

Figured specimens: USNM 108782 a, b. Kingak shale, USGS Mes. locs. 22083 and 22596.

Genus PSEUDOCADOCERAS Buckman, 1919

Pseudocadoceras grewingki (Pompeckj)

Plate 12, figure 1

(For synonomy see Imlay, 1953, U. S. Geol. Survey Prof. Paper 249–B, p. 93.)

One external mold of *P. grewingki* (Pompeckj) shows the form and ornamentation of the species very well. Even the imprint of the suture line is preserved. The cast of this mold is essentially identical with a specimen from the Shelikof formation figured by the writer (Imlay, 1953b, pl. 49, figs. 1, 2, 8). The species is characteristic of the middle three-fifths of the Shelikof formation of the Alaska Peninsula and the Chinitna formation of the Cook Inlet area. Its presence is considered to be excellent evidence of the middle Callovian (Upper Jurassic) age of the beds in which it occurs.

The occurrence of *P. grewingki* in northern Alaska is of particular interest stratigraphically, because the only specimen found was within the lower 400 feet of the Kingak shale on the West Fork of the Ivishak River. It appears, therefore, that the entire Lower and Middle Jurassic, which are present in nearby areas north of the Brooks Range, have been overlapped at that point.

Plesiotype: USNM 108781. Kingak shale, USGS Mes. loc. 22745.

Genus AMOEBOCERAS Hyatt, 1900

Subgenus PRIONODOCERAS Buckman, 1920

Amoeboceras (Prionodoceras?) spp. juv.

Plate 12, figures 2–6

Twenty fragments from the upper few hundred feet of the Kingak shale exposed on the west bank of the Canning River are assigned to *Amoeboceras* rather than *Cardioceras*, because some of them possess a finely denticulated keel. Definite subgeneric assignment is not possible because adult whorls are not present.

Some of the fragments (pl. 12, figs. 2, 3) are comparable to an immature specimen illustrated by Spath (1932, pl. 1, fig. 5). They have sharp ribs that incline forward gently on the flanks and curve strongly forward on the ventral margin. Small tubercles are present on the middle of the flanks and much stronger tubercles, near the ventral ends of the ribs. About one rib in three bifurcates near the middle of the flanks or is followed by a short secondary rib. There are at least three denticles on the keel for every ventrolateral tubercle. Other fragments (pl. 12, figs. 4–6) have much stronger ribbing, fewer secondaries ribs, and more conspicuous tubercles. The ventral ends of the ribs are inclined strongly forward and unite in a continuous lateral keel that is much lower than the median keel. Comparisons may be made to *A. prorsum* Spath (1932, p. 24, pl. 5, fig. 5) from Greenland or to a small specimen of *A. sokolovi* (Sokolov and Bodylevsky) (1931, pl. 6, fig. 2) from Spitzbergen.

Figured specimens: USNM 108772a–c, 108773 a, b. Kingak shale, USGS Mes. locs. 21028, 22598, and 24014.

Genus REINECKEIA Bayle, 1878

Subgenus REINECKEITES Buckman, 1924

Reineckeia (Reineckeites) cf. R. stuebeli Steinmann

Plate 13, figures 1–7

Reineckeia anceps D'Orbigny, 1849, Pal. Franc., Terr. Jur., vol. 1, pl. 166, figs. 3, 4.
Reineckeia stuebeli Steinmann, 1881, Neues Jahrb., Beilage-Band 1, p. 290, pl. 11, fig. 7.
Reineckeia douvillei Steinmann, 1881, Neues Jahrb., Beilage-Band 1, p. 289, pl. 12, figs. 2–4, 8.
Reineckeia stuebeli Petitclerc, 1915, Essai sur la faune du Callovien du Département des Deux-Sèvres . . . etc., p. 101, pl. 6, fig. 2; pl. 9, fig. 5; pl. 10, fig. 3.
Reineckeia douvillei Petitclerc, idem, p. 83, pl. 4, fig. 5, pl. 10, figs. 2, 4, 1915.
Reineckeia douvillei Loczy, 1915, Geologica Hungarica v. 1, p. 375, pl. 13, figs. 1, 2.
?*Reineckeia stuebeli* Stehn, 1924, Neues Jahrb., Beilage-Band 49, (1923) p. 111, pl. 7, fig. 2; fig. 17.
Reineckeites duplex Buchman, 1924, Type Ammonites, v. 5, pl. 522.
Reineckeites stuebeli Spath, 1928, Palaeontologia Indica, v. 9, p. 256, 268–270, pl. 34, fig. 6.
Reineckeia stuebeli Corroy, 1932, Carte géol. France Mém., p. 119, pl. 14, figs. 1, 2, 7.
Reineckeia steubeli var. *douvillei* Corroy, 1932, idem, p. 121, pl. 14, figs. 3–6.

Thirty-five specimens of a fairly evolute species of *Reineckeia* were obtained from a single, thin bed of hard siltstone exposed on the west bank of the Canning River about 550 feet stratigraphically above an occurrence of *Arcticoceras*. The specimens have been crushed laterally, and generally the body whorl has been crushed more than the other whorls. None of the specimens exhibit a complete view of the venter. The inner whorls at diameters of less than 40 to 45 millimeters bear prominent primary ribs that give rise to conical spines at about one-third of the height of the flanks. From most of these pass pairs of secondary ribs that are nearly as prominent as the primaries. Rarely a primary rib does not fork at the tubercle but is continued ventrally as a single rib. At greater diameters the tubercles disappear; the points of furcation become less distinct and lower on the flanks; and the ribs become broader and lower. On the inner whorls the secondary ribs become slightly compressed ventrally in a manner that suggests the presence of a narrow midventral groove. On the body whorl the presence or absence of a midventral groove cannot be confirmed because of defective preservation.

The specimens from the Canning River agree very well in ornamentation and manner of coiling with the specimens from South America and Europe that have been assigned to *Reineckeia* (*Reineckeites*) *stuebeli* Steinmann. The suture line, fairly well exposed on two specimens, agrees in plan with that figured by Corroy (1932, p. 120). Particularly noticeable are the small oblique second lateral lobe, the greater width of the saddles than of the lobes, and the obliquity of the suture with respect to the radius of the shell.

Spath (1928, p. 268–270) and Corroy (1932, p. 121) have discussed the considerable variation in ornamentation and whorl shape of this species and have expressed the opinion that the associated *R. douvillei* Steinmann does not seem to be separable specifically. Corroy notes that the name *R. douville* has generally been applied to specimens having a more compressed whorl section than the type of *R. stuebeli*. Spath points out that the Indian species, *R. waageni* Till, differs from *R. stuebeli* only by having less regularly bifurcating ribs in its body chamber and suggests that it is probably the Indian equivalent. The widespread distribution of *R. stuebeli* or of closely similar species in several continents and even north of the Arctic Circle is unusual for ammonites. The genus *Reineckeia* particularly has been considered a Mediterranean element (Spath, 1932, p. 148–149).

Plesiotypes: USNM 108771a–f. Kingak shale, USGS Mes. locs. 21024, 22597, and 24033.

Genus CYLINDROTEUTHIS Bayle, 1878

Cylindroteuthis spp.

Plate 13, figures 8–11, 14–17

Eight specimens are referred to this genus because of their long, slender, nearly cylindrical guards and probably short alveolar cavities. The specimen shown on plate 13, figures 9–11, 14, 15, is flattened ventrally throughout its entire length and bears a weak ventral groove near its apical end. Its sides converge slightly toward the dorsum. Its alveolar cavity is confined to the anterior third of the guard. The point of the alveolus is slightly closer to the ventral than to the dorsal side. The specimen shown on plate 13, figures 8, 16, 17, is much more cylindrical, is flattened slightly only toward the apical end, and shows the beginning of the alveolar cavity at its extreme anterior end.

Figured specimens: USNM 108783a, b. Kingak shale, USGS Mes. locs. 22588 and 23772.

LITERATURE CITED

Anderson, F. M., 1938, Lower Cretaceous deposits in California and Oregon: Geol. Soc. America Special Paper 16, 339 p., 85 pls., 6 figs.

——— 1945, Knoxville Series in the California Mesozoic: Geol. Soc. America Bull., v. 56, p. 909–1014, 15 pls.

Arkell, W. J., 1933, The Jurassic system in Great Britain: Oxford, Clarendon Press.

——— 1939, The Ammonite succession at the Woodham Brick Company's Pit, Akeman Street Station, Buckinghamshire, and its bearing on the classification of the Oxford Clay: Geol. Soc. London Quart. Jour., v. 95, p. 135–222, pls. 8–11.

——— 1946, Standard of the European Jurassic: Geol. Soc. America Bull., v. 57, p. 1–34, 4 tables.

Beurlen, Karl, 1924, Ueber einige neue und seltene ammoniten aus dem Lias δ des schwäbischen Jura: Centralbl. Mineralogie, p. 147–160, 4 figs.

Buckman, S. S., 1887–1907, A monograph of the Inferior Oolite ammonites of the British Islands: Palaeontographical Soc., 456 p., 118 pls.

——— 1909–30, Type Ammonites, 7 v.

Burckhardt, Carlos, 1906, La faune jurassique de Mazapil avec un appendice sur les fossiles du crétacique inférieur: Inst. geol. México Parergones, Bol. 23, 216 p., 3 pls.

——— 1912, Faunes jurassiques et crétaciques de San Pedro del Gallo: Inst. geol. México, Bol. 29, 264 p., 46 pls.

——— 1930, Étude synthétique sur le Mésozoïque Mexicain: Soc. paléont. Suisse Mém., v. 49, p. 1–123.

Corroy, G., 1932 La Callovien de la Bordure Orientale du Bassin de Paris: Carte géol. France Mém., 337 p., 29 pls., 4 figs.

Frebold, Hans, 1929, Oberer Lias und unteres Callovien in Spitzbergen: Skrifter om Svalbard Og Ishavet, Nr. 20, p. 5–24, 2 pls.

——— 1932, Grundzüge der tektonischen entwicklung Ostgrönlands in postdevonischer zeit: Meddelelser om Grönland, bind 94, nr. 2, 112 p., 3 pls., 17 figs.

——— 1951a, Geologie des Barenteschelfes: Akad. Wiss. Berlin, Math.—nature. Kl., Abh. 1950, No. 5, 150 p., 82 figs.

——— 1951b, Lowermost Middle Jurassic fauna in Whitesail Lake Map-area, British Columbia, *in* Contributions to the Paleontology and Stratigraphy of the Jurassic system in Canada: Geol. Survey Canada Bull. 18, 54 p., 18 pls., 2 figs.

Guillaume, Louis, 1927, Revision des Posidonomyes Jurassiques: Soc. géol. France Bull., sér. 4, v. 27, p. 217–234, pl. 10.

Haughton, Samuel, 1857, Geological notes and illustrations *in* M'Clintock's Reminiscences of Arctic Ice Travel, Royal Dublin Soc., Jour. 1, p. 183–250, illus., map.

Holdhaus, K., 1913, The fauna of the Spiti shales, fasc. 4, Lamellibranchiata and Gastropoda: Paleontologica Indica, Mem., ser. 15, v. 4, pt. 2, p. 397–456, pls. 94–100.

Imlay, R. W., 1948, Characteristic marine Jurassic fossils from the western interior of the United States: U. S. Geol. Survey Prof. Paper 214–B, p. 13–33, pls. 5–9.

——— 1950, Paleoecology of Jurassic seas in the western interior of the United States: Nat. Research Council, Report of the Committee on a treatise on marine ecology and paleoecology, 1948–49, no. 9, p. 72–104, 8 figs., 1 table.

——— 1952, Correlation of the Jurassic formations of North America exclusive of Canada: Geol. Soc. America Bull., v. 63, p. 953–992, 2 pls.

Imlay, R. W., 1953a, Callovian (Jurassic) ammonites from the United States and Alaska, Part 1. Western Interior United States: U. S. Geol. Survey Prof. Paper 249–A, p. 1–39, pls. 1–24, 2 figs.

——— 1953b, Callovian (Jurassic) ammonites from the United States and Alaska, Part 2. Callovian ammonites from the Alaska Peninsula and Cook Inlet regions: U. S. Geol. Survey Prof. Paper 149–B, p. 41–108, pls. 25–55, 6 figs.

Krumbeck, Lothar, 1934, Die Aucellen von Misol: Neues Jahrb. Beilage-Band 71, Abt. B, p. 422–469, pls. 14–16.

Lahusen, J., 1888, Über die russischen Aucellen: Com. géol. St. Petersbourg Mém., Band 8, no. 1, p. 1–46, 5 pls.

Martin, G. C., 1926, The Mesozoic stratigraphy of Alaska: U. S. Geol. Survey Bull. 776, 493 p., 13 figs.

McLearn, F. H., 1932, Contributions to the stratigraphy and paleontology of Skidgate Inlet, Queen Charlotte Islands, British Columbia, (2d pt): Royal Soc. Canada Trans., 3d ser., v. 26, sec. 4, p. 51–84, 10 pls.

O'Neill, J. J., 1924, The geology of the Arctic coast of Canada west of the Kent Peninsula: Canadian Arctic Expedition 1913–18, Rept., v. 11, pt. A, 107 p., 6 figs., 35 pls., 3 maps.

Orbigny, Alcide d', 1842–51, Paléontologie Française. Terrains Jurassiques, v. 1.

Pavlow, A. P., 1907, Enchaînement des aucelles et aucellines du Crétacé Russe: Soc. imp. naturalistes Moscou, Nouv. Mém., v. 17 (22), p. 1–93, pls. 1–6, correlation table opposite p. 84.

Payne, T. G., Gryc, George, Tappan, Helen, and others, 1951, Geology of the Arctic slope of Alaska: U. S. Geol. Survey OM 126, Oil and Gas Inv. Ser., 3 sheets, colored.

Pfanensteil, M., 1928, Organisation und Entwicklung der Gryphäen: Palaeobiologica, v. 1, p. 381–418.

Pompeckj, J. F., 1900, Jurafossilien aus Alaska: Russ. K. min. Gesell. Verh., St. Petersburg, 2d ser., v. 38, p. 239–278, pls. 5–7.

——— 1901, Aucellen in Fränkischen Jura: Neues Jahrb. 1901, Band 1, p. 18–36, pl. 4.

Quenstedt, F. A. V., 1858, Der Jura: Tübingen, 842 p., atlas of 100 pls.

——— 1883–88, Die Ammoniten des Schwäbischen Jura: Stuttgart, 3 v., 1140 p., 126 pls.

Ravn, J. P. J., 1911, On Jurassic and Cretaceous fossils from Northeast Greenland: Meddel. om Grönland, bind 45, p. 433–500, pls. 32–38.

Roman, Frédéric, 1938, Les Ammonites Jurassiques et Crétacées: 554 p., 53 pls.

Rosenkrantz, Alfred, 1934, The Lower Jurassic rocks of East Greenland: Meddel. om Grönland, bind 110, Nr. 1, 122 pages, 13 pls.

Sayn, G. and Roman, F., 1928–30, Monographie stratigraphique et paléontologique du Jurassique moyen de la Voulte-sur-Rhône: Lyon Univ., Lab. géologie Travaux, mém. 11, fasc. 13, 14, 256 p., 21 pls.

Sokolov, D., 1908, Aucellen von Timan und von Spitzenbergen: Com. géol. St. Pétersbourg Mém., Nouv. sér., livr. 36, p. 1–29, 3 pls.

Sokolov, D., and Bodylevsky, W., 1931, Jura-und-Kreidefaunen von Spitzenbergen: Skrifter om Svalbard og Ishavet, Nr. 35, 151 p., 14 pls.

Sowerby, James, and Sowerby, J. de C., 1812–46, Mineral Conchology: 7 v., pls. 1–337 (1812–22) by J. Sowerby; pls. 338–648 (1822–46) by J. de C. Sowerby.

Spath, L. F., 1932, The invertebrate faunas of the Bathonian-Callovian deposits of Jameson Land (East Greenland): Meddel, om Grönland, bind 87, nr. 7, 158 p., 26 pls., 14 figs.

——— 1927–33, Revision of the Jurassic cephalopod fauna of Kachh (Cutch): Paleontologia Indica, new ser. v. 9, 6 pts., 945 p., 130 pls.

——— 1936, The Upper Jurassic Invertebrate Fauna of Cape Leslie, Milne Land. II. Upper Kimmeridgian and Portlandian: Meddel. om Grönland, bind 99, Nr. 3, 180 p., 50 pls., 2 figs.

Steinmann, G., 1881, Zur Kenntnis der Jura-und Kreideformation von Caracoles (Bolivia): Neues Jahrb., Beilage-Band 1, p. 239–301, pls. 9–14.

Teichert, Curt, 1940, Marine Jurassic of East Indian affinities at Broome, Northwestern Australia: Royal Soc. Western Australia Jour., v. 26, p. 103–118, pl. 1.

Wandel, Gerhard, 1936, Beiträge zur Kenntnis der jurassischen Molluskenfauna von Misol, Ost-Celebes, Buton, Seran und Jamdena: Neues Jahrb., Beilage-Band 75, Abt. B, p. 447–526, pls. 15–20, 13 text figs.

Waterston, C. D., 1951, The stratigraphy and palaeontology of the Jurassic rocks of Eathie (Cromarty); Royal Soc. Edinburgh Trans., v. 62, p. 33–52, 2 pls., 4 figs.

Weir, John, 1930, Mesozoic brachiopods and mollusca from Mombosa, *in* Reports on geological collections from the coastlands of Kenya Colony made by Miss M. McKinnon Wood: Hunterian Mus. Mon., v. 4, pt. 4, p. 77–102, pls. 9–11.

White, C. A., 1889, On invertebrate fossils from the Pacific Coast: U. S. Geol. Survey Bull. 51, 102 p., illus.

Wright, T., 1878–86, Monograph on the Lias Ammonites of the British Islands: Palaeontographical Soc., 503 p., 88 pls.

INDEX

[Italic numbers indicate descriptions]

PLATES 8–13

PLATE 8

[All figures natural size]

FIGURES 1, 5–10. *Inoceramus lucifer* Eichwald (p. 86).

1, 6, 8. Left valves of plesiotypes, USNM 108751, from USGS Mes. loc. 21552.

5, 7. Plesiotypes, USNM 108784, from USGS Mes. loc. 3009, Tuxedni Bay, southern Alaska. Shows variation in coarseness of ribbing.

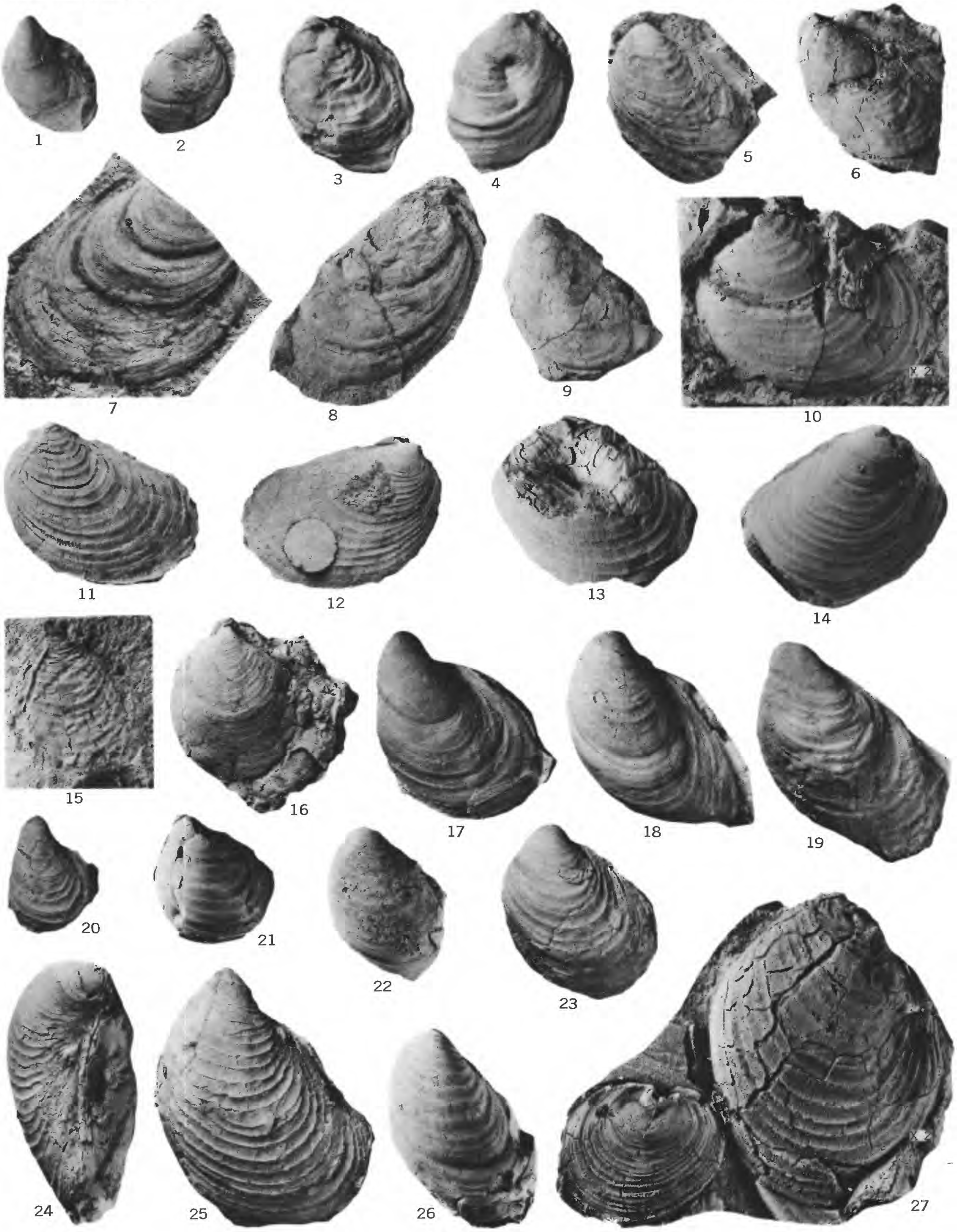
9, 10. Left valve and dorsal view of plesiotype, USNM 108776, from USGS Mes. loc. 3005, Tuxedni Bay, southern Alaska. Shows highly constricted umbos.

2–4. *Gryphaea* cf. *G. cymbium* Lamarck (p. 82).

2, 3. Posterior and lateral views of left valve of specimen, USNM 108752a, from USGS Mes. loc. 23748.

4. Right valve of specimen, USNM 108752b, from USGS Mes. loc. 23748.

INOCERAMUS AND *GRYPHAEA*



AUCELLA

PLATE 9

[Figures natural size unless otherwise indicated]

FIGURES 1–10. *Aucella spitiensis* Holdhaus (p. 84)

1, 2. Left and right valve of plesiotype, USNM 108746a, from USGS Mes. loc. 21028.

3, 4. Left and right valves of plesiotype, USNM 108746b, from USGS Mes. loc. 21028.

5, 6. Left valves of plesiotypes, USNM 108747a, b, from USGS Mes. loc. 22598.

7, 8. Right valves of plesiotypes, USNM 108746c, d, from USGS Mes. loc. 21028.

9. Left valve of plesiotypes, USNM 108746e, f, from USGS Mes. loc. 21028.

11–16. *Aucella concentrica* (J. de C. Sowerby) (p. 83).

11, 12. Left and right valves of plesiotype, USNM 108749, from USGS Mes. loc. 10248 near Katmai Bay, southwest Alaska.

13, 14. Left and right valves of plesiotype, USNM 108745, from USGS Mes. loc. 22769.

15. Left valve of plesiotype, USNM 108744, from USGS Mes. loc. 22598.

16. Left valve of plesiotype, USNM 108743, from USGS Mes. loc. 22509.

17–19. *Aucella mosquensis* (von Buch) (p. 85).

Left valves of plesiotypes, USNM 108748, from USGS Mes. loc. 22769.

20–27. *Aucella rugosa* (Fischer) (p. 84).

20, 23–25. Left valves of plesiotypes, USNM 108741, from USGS Mes. loc. 22768. Shows the character of the ribs where the shell is preserved. Fig. 24 is a ventrodorsal view showing the greater convexity of the left valve.

21, 22, 26. Left valves of plesiotypes, USNM 108742, from Mes. loc. 22769. Shows the character of the ribs on the internal mold.

27. Small right valve and larger left valve of plesiotype, USNM 108740, from USGS Mes. loc. 22127. Enlarged two times to show radial ribbing.

PLATE 10

[Figures natural size unless otherwise indicated]

FIGURE 1. *Amaltheus* cf. *A. depressus* Simpson (p. 87).
USNM 108770, from depth of 2,186 feet in South Barrow test well 3.

2. *Amaltheus* sp. (p. 87).
USNM 108765, from depth of 2,074 feet in South Barrow test well 3.

3. *Amaltheus* sp. (p. 87).
USNM 108766, from depth of 2,090 feet in South Barrow test well 3. Shows spiral markings on keel.

4. *Amaltheus* cf. *A. margaritatus* (Montfort) (p. 87).
USNM 108768, from depth of 2,111 feet in South Barrow test well 3.

5. *Amaltheus* cf. *A. nudus* (Quenstedt) (p. 87).
USNM 108769, from depth of 2,198 feet in South Barrow test well 3.

6, 13. *Dactylioceras* aff. *D. semicelatum* (Simpson) (p. 87).
USNM 108763, from depth of 2,018 feet in the South Barrow test well 3.

7, 8. "*Arietites*" cf. "*A.*" *bucklandi* (Sowerby) (p. 87).
Lateral and ventral views of specimen, USNM 108778, from depth of 1,836 feet in the Avak test well 1.

9. *Dactylioceras* cf. *D. crassiusculosum* (Simpson) (p. 88).
USNM 108760, from depth of 1,772 feet in South Barrow test well 3.

10–12. *Dactylioceras* cf. *D. commune* (Sowerby) (p. 88).
USNM 108761, from depth of 1,772 feet in South Barrow test well 3.

14. *Dactylioceras* cf. *D. kanense* (McLearn) (p. 88).
USNM 108762, from depth of 2,016 feet in South Barrow test well 3.

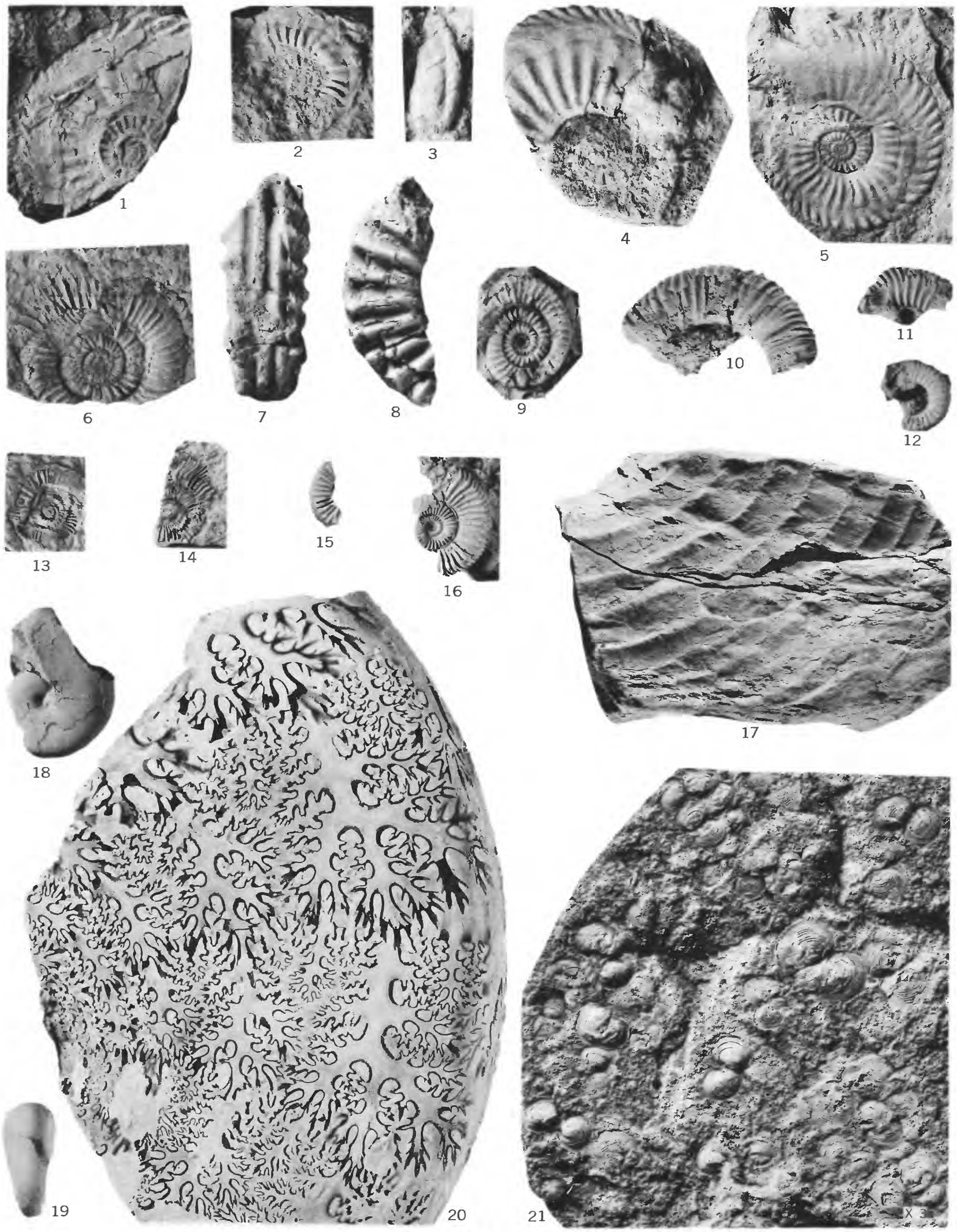
15, 16. *Dactylioceras* cf. *D. delicatum* (Bean-Simpson) (p. 88).
USNM 108759, from depth of 1,772 feet in South Barrow test well 3.

17. *Amaltheus* (*Pseudoamaltheus*) cf. *A. engelhardti* (D'Orbigny) (p. 87).
Fragment of outer whorl, USNM 108764, from USGS Mes. loc. 22747.

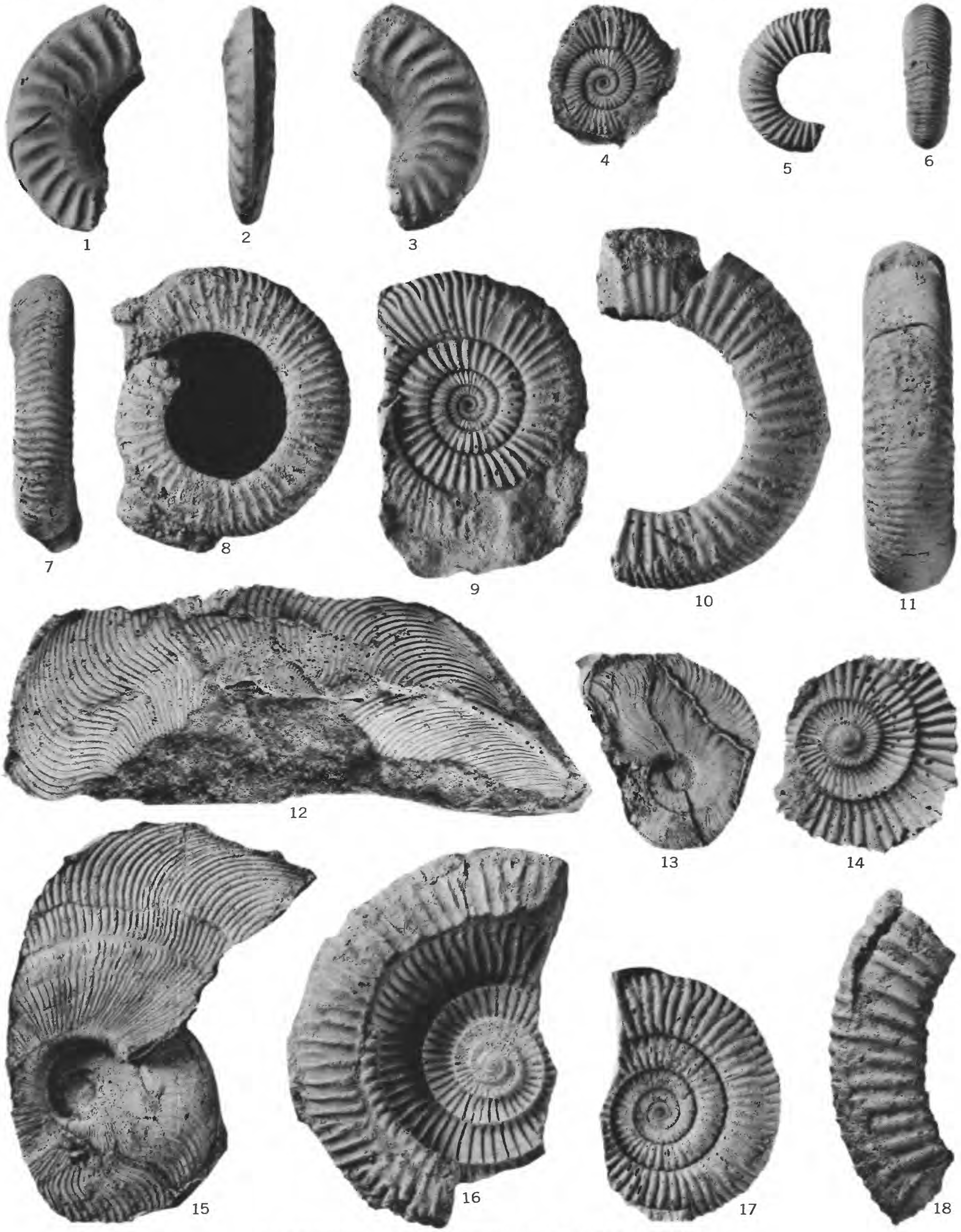
18, 19. *Phylloceras* (*Partschiceras*) sp. (p. 86).
USNM 108775, from USGS Mes. loc. 24013.

20. *Phylloceras* (*Macrophylloceras*) sp. (p. 87).
USNM 108774, from USGS Mes. loc. 21027.

21. *Posidonia* cf. *P. ornata* (Quenstedt) (p. 86).
USNM 108750, from USGS Mes. loc. 24035.



AMALTHEUS, DACTYLIOCERAS, "ARIETITES," PHYLLOCERAS, AND *POSIDONIA*



LUDWIGELLA, *DACTYLIOCERAS*, AND *HARPOCERAS*

PLATE 11

[All figures natural size]

FIGURES 1–3. *Ludwigella?* cf. *L. rudis* (Buckman) (p. 75).

USNM 108790, from elevation of 400 feet on Big Rag Mountain, about 6 miles northeast of Mould Bay Weather Station, Prince Patrick Island.

4–6. *Dactylioceras* cf. *D. commune* (Sowerby) (p. 88).

4. View of rubber cast of external mold of the same specimen shown in figs. 5 and 6, USNM 108787, from elevation of about 400 feet just east of summit of a ridge about 5 miles east-northeast of Mould Bay Weather Station, Prince Patrick Island.

7–9. Ventral and lateral views of internal mold and lateral view of rubber cast made from the external mold of

7–11, 14. *Dactylioceras* cf. *D. directum* (Buckman) (p. 88).

same specimen, USNM 108785, from elevation of 600 feet about 4 miles northeast of Mould Bay Weather Station, Prince Patrick Island.

10, 11, 14. Lateral and ventral views of internal mold and lateral view of rubber cast of external mold of same specimen, USNM 108786, from same locality as specimen shown in figs. 4–6.

12, 13, 15. *Harpoceras* cf. *H. exaratum* (Young and Bird) (p. 88).

Views of rubber casts of external molds, USNM 108789, from elevation of 700 feet near summit of southeast face of main southern ridge near Crozier Channel east of the Mould Bay Weather Station, Prince Patrick Island.

16–18. *Dactylioceras* cf. *D. crassiusculosum* (Simpson) (p. 88).

16. View showing internal mold of outer whorl and external mold of inner whorls, USNM 108788a.

17. View of rubber cast of internal whorls shown in fig. 16.

18. Internal mold of an outer whorl, USNM 108788b. Both specimens are from the same locality as the ammonites shown in figs. 12, 13, and 15.

PLATE 12

[Figures natural size unless otherwise indicated]

FIGURE 1. *Pseudocadoceras grewingki* (Pompeckj) (p. 90).
Plesiotype, USNM 108781, from USGS Mes. loc. 22745.

2–6. *Amoeboceras* (*Prionodoceras?*) spp. juv. (p. 90).
2, 6. Specimens, USNM 108773, from USGS Mes. loc. 22598.
3–5. Specimens, USNM 108772, from USGS Mes. loc. 21028.

7–10. *Tmetoceras* sp. (p. 89).
7–9, 7, Ventural view of rubber cast of external mold, USNM 108780; 8, 9, internal mold of part of same specimen shown in fig. 7. From depth of 2,391 feet in South Barrow test well 2.
10. Mold of specimen, USNM 108779, from depth of 8,113 feet in Topagaruk test well 1.

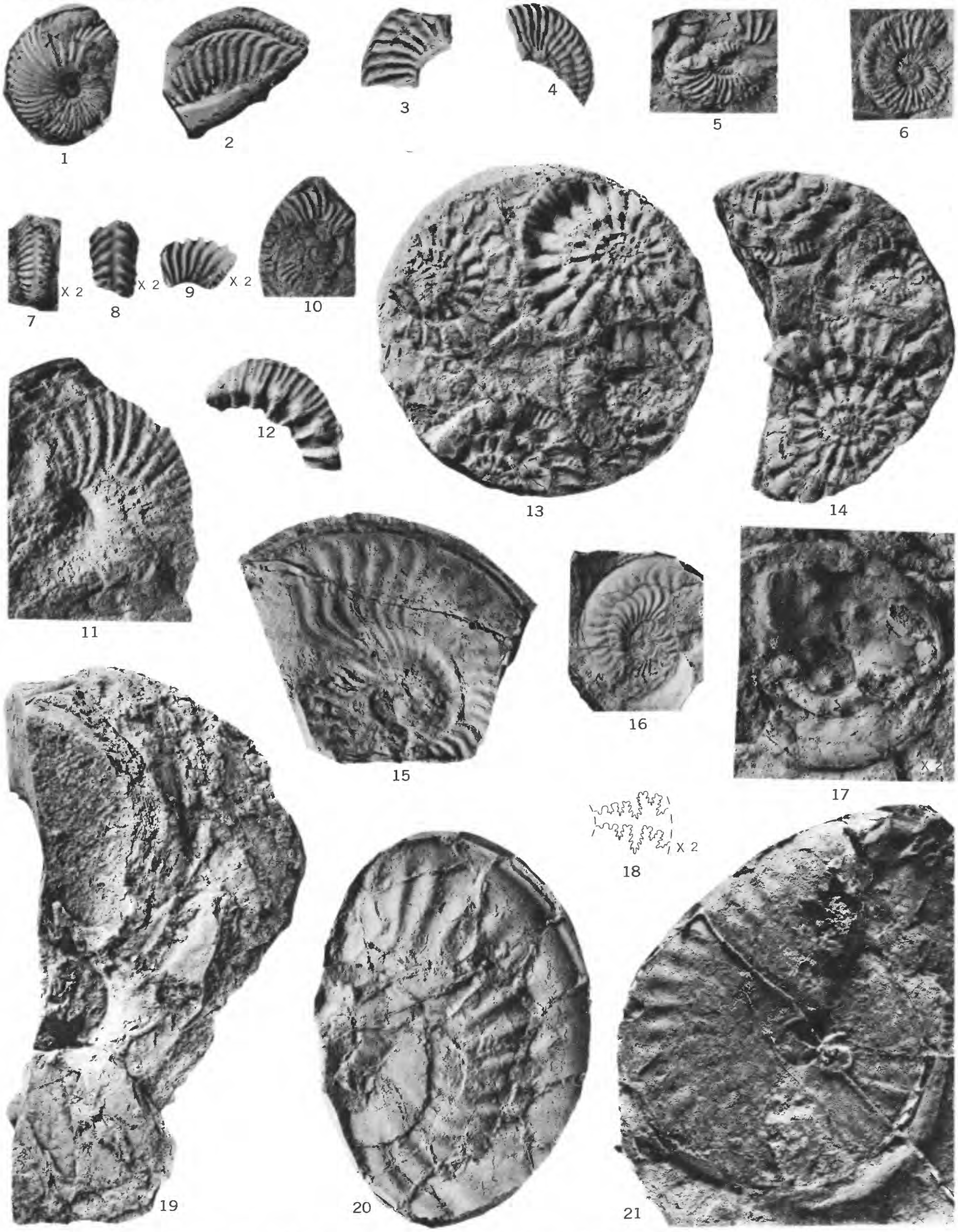
11, 19. *Arcticoceras* sp. (p. 90).
Lateral views of ribbed inner whorl and smooth body whorld showing apertural constriction. USNM 108782, from USGS Mes. loc. 22596.

12–14. *Coeloceras* cf. *C. mucronatum* (D'Orbigny) (p. 88).
Lateral views of specimens, USNM 108758a–c, in a well core at depth of 2,063 feet in the South Barrow test well 3.

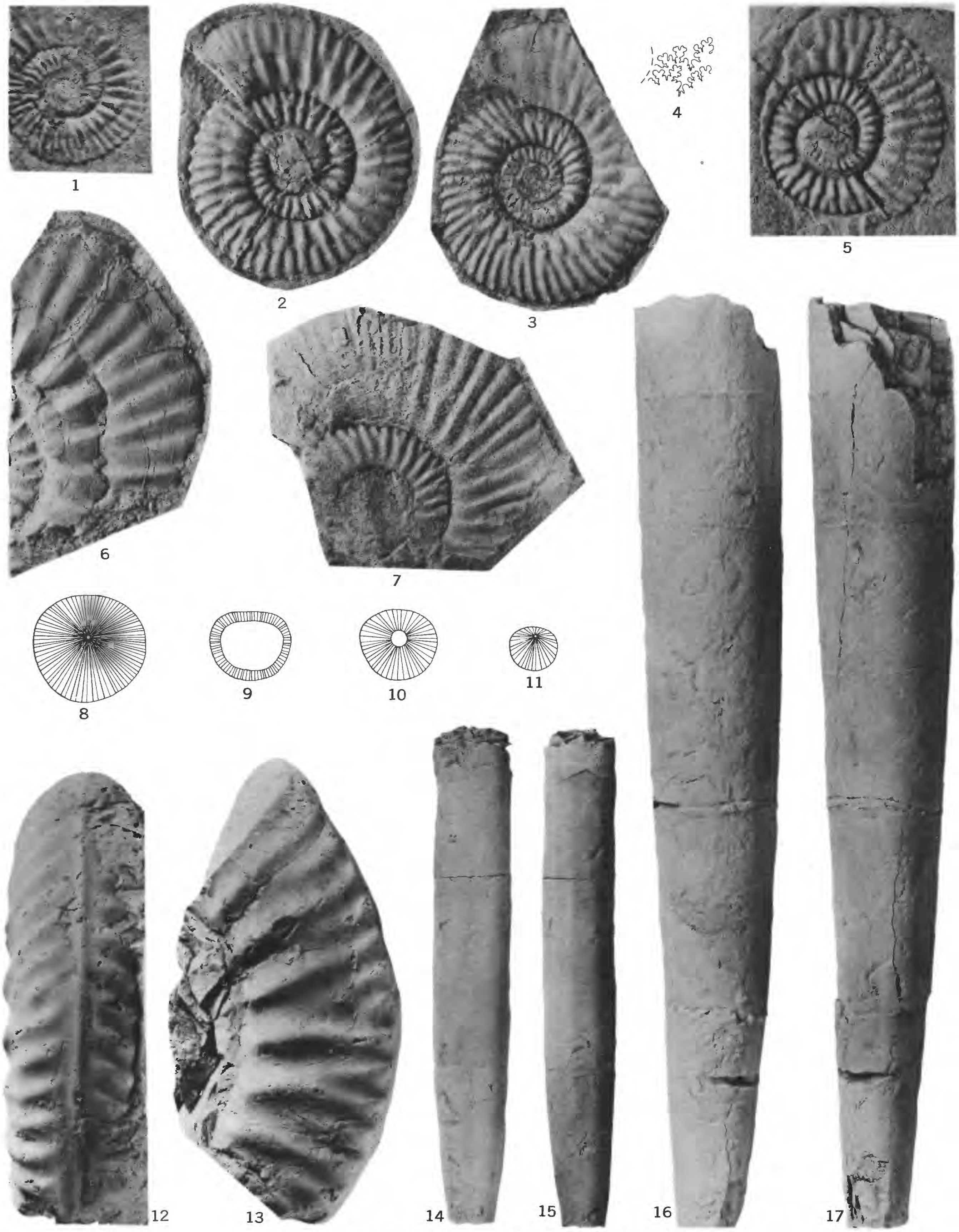
15, 16. *Pseudolioceras whiteavesi* (White) (p. 89).
15. View of rubber cast of plesiotype, USNM 108755, from USGS Mes. loc. 24035.
16. View of rubber cast of plesiotype, USNM 108754, from USGS Mes. loc. 10307.

17, 18, 21. *Pseudolioceras* cf. *P. compactile* (Simpson) (p. 89).
17, 18. Internal mold and suture lines of an immature specimen, USNM 108756, from USGS Mes. loc. 23772.
21. View of rubber cast of a mature specimen, USNM 108753, from USGS Mes. Loc. 23772.

20. *Pseudolioceras* cf. *P. lythense* (Young and Bird) (p. 89).
View of rubber cast of specimen, USNM 108757, from USGS Mes. loc. 23772.



PSEUDOCADOCERAS, *ARCTICOCERAS*, *AMOEBOCERAS*, *TMETOCERAS*, *COELOCERAS*, AND *PSEUDOLIOCERAS*



REINECKEIA, *ERYCITES*, AND *CYLINDROTEUTHIS*

PLATE 13

[All figures natural size]

FIGURES 1–7. *Reineckeia* (*Reineckeites*) cf. *R. stuebeli* Steinmann (p. 91).
Lateral view and suture line of specimens, USNM 108771, from USGS Mes. loc. 22597. Suture line drawn from anterior end of septate whorl shown in fig. 5.

8, 16, 17. *Cylindroteuthis* sp. (p. 91).
8. Cross section at diameter of 23 mm.
16. Ventral view.
17. Lateral view of specimen. All USNM 108783a, from USGS Mes. loc. 22588.

9–11, 14, 15. *Cylindrotheuthis* sp. (p. 91).
9. Cross section at alveolar end.
10. Section about 28 mm posterior to alveolar end.
11. Section at broken apical end.
14. Ventral view.
15. Lateral view of specimen, USNM 108783b, from USGS Mes. loc. 22588.

12, 13. *Erycites howelli* (White) (p. 90).
Ventral and lateral views of plesiotype, USNM 108777, from USGS Mes. loc. 10308.