Upper Cretaceous Pelecypods of the Genus *Inoceramus* from Northern Alaska

By DAVID L. JONES *and* GEORGE GRYC

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A description of five species which are important guide fossils to the Upper Cretaceous rocks of the midwestern interior of North America and northern Alaska

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By David L. Jones and George Gryc

ABSTRACT

Upper Cretaceous rocks in the Colville River region of northern Alaska contain a fauna consisting of five species of *Inoceramus*, all of which are known from other localities, either in the United States, Canada, Europe, or elsewhere. Associated fossils include a small number of pelecypod species, a few species of gastropods, and several species of ammonites. The species of *Inoceramus* range in age from Cenomanian to late Santonian or early Campanian, but none are of Coniacian age.

Upper Cretaceous rocks in the Colville River region are divided into three formations, which are, in ascending order, the Ninuluk, the Seabee, and the Schrader Bluff. *Inoceramus* (*Inoceramus*) *dunveganensis* McLearn, of Cenomanian age, is abundant in the Ninuluk formation. *Inoceramus* (*Mytiloides*) *labiatus* (Schlotheim) and *I.* aff *I.* (*Inoceramus*) *cuvierii* Sowerby occur in the lower part of the Seabee formation of early Turonian age. *Inoceramus* aff. *I.* (*I.*) *cuvierii* occurs alone in the upper part of the Seabee, which probably is of middle to late Turonian age. There is no evidence that this species extends into the Coniacian in northern Alaska. The Barrow Trail member of the Schrader Bluff formation contains *Inoceramus* (*Sphenoceramus*) *patootensis* de Loriol and *I.* (*S.*) *steenstrupi* de Loriol, both of late Santonian to early Campanian age. The precise age of the lower and upper members of the Schrader Bluff formation is not certain.

INTRODUCTION

Before 1943 the geology of northern Alaska was known only from exploratory and reconnaissance surveys. Schrader (1902 and 1904) made the first geologic traverse of the region and mapped the geology along the Anaktuvuk and lower Colville Rivers. Later Collier (1906), Leffingwell (1919), and Smith and Mertie (1930) made major contributions to the geology of northern Alaska. These studies indicated the presence of extensive deposits of fossiliferous Cretaceous rocks, but little stratigraphic detail was recorded and few fossils were collected. Several occurrences of *Inoceramus* are noted in the reports of Schrader, Leffingwell, and Smith and Mertie.

In 1943 the U.S. Geological Survey renewed its mapping activities in northern Alaska in support of the U.S. Navy's program to explore Naval Petroleum Reserve No. 4 and determine the petroleum possibilities of the region. This program began in 1944 and was suspended in 1953. The Survey cooperated in all the geologic aspects, including detailed and semidetailed mapping of nearly all the bedrock exposures. Many Cretaceous fossils from several hundred localities were collected. Several species of *Inoceramus* and the general sequence of Cretaceous faunas were reported by Gryc, Patton, and Payne (1951).

This study of the subfamily Inoceraminae from northern Alaska is based on collections made from 1944 through 1953. The collectors include: Robert S. Bickel, William P. Brosgé, Robert R. Coats, Robert L. Detterman, Robert E. Fellows, George Gryc, Charles E. Kirschner, Allan N. Kover, Richard G. Ray, Karl Stefansson, Lawrence A. Warner, and Edward J. Webber.

The stratigraphic relationships, locality descriptions, and positions of localities on figure 31 have been prepared primarily by William P. Brosgé, Robert L. Detterman, George Gryc, and Charles L. Whittington.

In the following text, Jones discusses the fossils and interregional correlations. Gryc describes the formations and their stratigraphic relations.

CRETACEOUS ROCKS

Upper Cretaceous rocks were first recognized and mapped in northern Alaska along the Anaktuvuk River by Schrader. The age of these rocks was determined from the presence of the ammonite *Scaphites* and several pelecypods, including *Inoceramus* (Schrader, 1904, p. 80). Smith and Mertie (1930) added descriptions of the lithologic characteristics and distribution of the Upper Cretaceous rocks but did not define formations.

After the U.S. Navy began its oil exploration program in the Arctic, detailed stratigraphic information was rapidly accumulated and a formational nomenclature was developed. In May 1951, Gryc, Patton, and Payne published the first formal definitions and descriptions of Upper Cretaceous formations in northern Alaska. A summary of the geology of the Arctic Slope and further stratigraphic details were published by Payne and others later that year. In February 1956, Gryc and others revised the stratigraphic terminology for the Mesozoic sequence in the Colville River region (fig. 30). In November 1956, Sable extended the use of part of this terminology to northwestern Alaska.

Upper Cretaceous rocks and Lower Cretaceous rocks of Albian age, constitute a stratigraphic sequence that rests with marked angular discordance on older Cretaceous (Neocomian, Okpikruak formation) and pre-Cretaceous rocks.

Lower Cretaceous rocks (fig. 30) include up to 12,000 feet of predominantly marine shale, and up to 1,000 feet of graywacke sandstone. The Tuktu formation (Albian) is overlain to the south by the nonmarine Chandler formation and to the north by the predominantly marine Grandstand formation. The contact of the Tuktu with the overlying units is marked by white quartz in the sandstone. The Lower Cretaceous formations defined in the outcrop belt cannot be readily distinguished lithologically in the subsurface of the coastal plain. Thus two subsurface units, the Oumalik and Topagoruk formations have been defined (Robinson, and others, 1956).

UPPER CRETACEOUS ROCKS

NANUSHUK GROUP (PART)

The position of the Lower Cretaceous-Upper Cretaceous contact in northern Alaska has been in question for several years. The next highest readily mappable unit above the ridge-forming Lower Cretaceous Tuktu formation is the black shale of the Upper Cretaceous Seabee formation, which overlies the coarser sedimentary rocks of the Ninuluk formation or, to the south, the Niakogon tongue of the Chandler formation. Because of the apparent depositional continuity from the Tuktu to the base of the Seabee, this sequence was defined as the Nanushuk group (Gryc and others 1951, p. 162). In 1954 Imlay and Reeside (p. 243) stated,

> At the top of the Nanushuk group in the foothills of the Brooks Range abundant *Inoceramus* have been found in marine intercalations in the Niakogon tongue of the Chandler formation. The common species include *I. athabaskensis* McLearn and *I. dunveganensis* McLearn. These have been identified elsewhere in Alaska in the lower part of the Upper Cretaceous sequence * * *.

These "marine intercalations" have since been defined by Detterman (1956, p. 241, 242) as the Ninuluk formation of Late Cretaceous age. At the type locality it is 657 feet thick. In the northern part of the outcrop area and in the subsurface of the coastal plain the Ninuluk formation overlies beds of the Grandstand formation which contain a Lower Cretaceous microfauna. In these areas the Lower Cretaceous-Upper Cretaceous contact can be determined. However, in the southern part of the outcrop area, the Ninuluk formation overlies nonfossiliferous beds of the Chandler formation and the lower limit of the Upper Cretaceous sequence is indeterminate. Imlay (1960) has described the Lower Cretaceous megafauna and Tappan (written communication) is studying the microfauna. The megafossils are commonly associated with red-weathering conglomeratic sandstone.

Sable (1956) applied the name Nanushuk group to rocks in northwestern Alaska but stated that precise correlations with the formations of the Colville River region cannot be made. Sable described two formations, the Kukpowruk and the Corwin, in the Utukok-Corwin area (fig. 30) and gives the age as "late Early and Late Cretaceous, not older than middle Albian" (Sable, 1956, p. 2641).

COLVILLE GROUP

The Colville group unconformably overlies the Nanushuk group. Whittington states (1956, p. 244),

> The group consists of a sequence of intertonguing marine and non-marine rocks and is about 5,500 feet thick in the type section. Northward and eastward non-marine units become thinner and tend to disappear. Rock types include clay shale, claystone, silt shale, siltstone, sandstone, conglomerate, bentonite, tuff, coal, clay ironstone, and limestone * * * Bentonite and tuff are much more prevalent than in the Nanushuk group.

The Seabee formation, about 1,500 feet thick at the type locality, marks the base of the Colville group. It is divided into two units: an unnamed member and the Ayiyak member (Detterman, 1956). The unnamed member is characterized by thick units of black, oil-shale which, when weathered, commonly splits into paper-thin sheets. Fossiliferous, thin beds, lenses, and

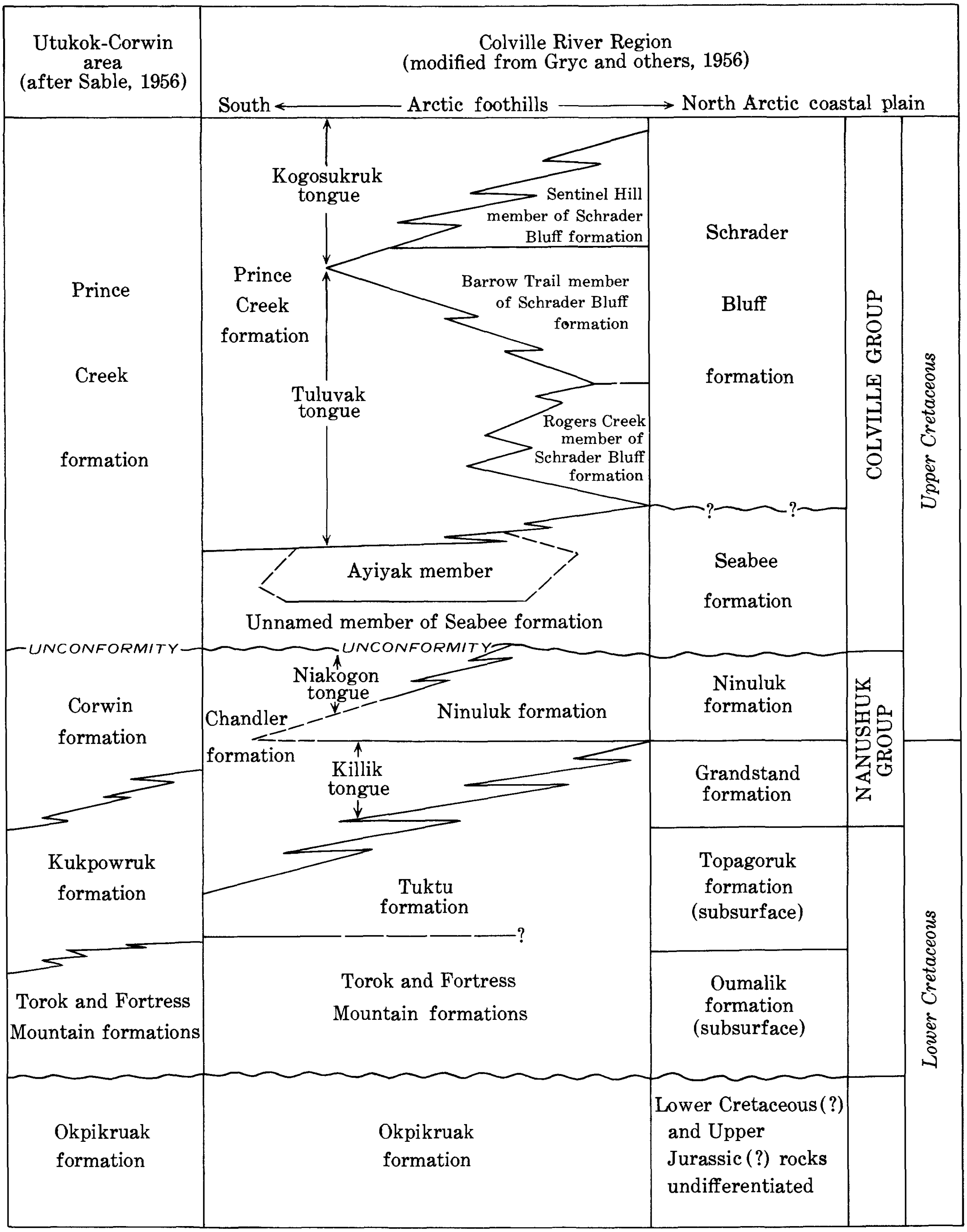

FIGURE 30.—Diagrammatic sections showing terminology and relationship of Cretaceous lithologic units in northern Alaska.

concretions of limestone are common. Fossils are also common in the shale but are mostly crushed and poorly preserved. The sandy beds in the upper part of the formation contain a similar, but more limited fauna and were defined as the Ayiyak member by Detterman in 1956.

The marine Schrader Bluff formation (approximately 2,300 ft. thick) overlies the Seabee formation with apparent unconformity. The Schrader Bluff has been divided into three members, the Rogers Creek, Barrow Trail, and Sentinel Hill (Gryc and others, 1951, p. 166; Whittington, 1956, p. 250–251). Fossils have been found in all three but are abundant only in the middle member and are commonly associated with a very fine grained tuffaceous sandstone.

The Prince Creek formation is the approximate nonmarine equivalent of the Schrader Bluff and probably part of the upper part of the Ayiyak member of the Seabee formation. The Prince Creek is about 1,700 feet thick and is subdivided into the Tuluvak tongue and the Kogosukruk tongue, which is the top unit in the Upper Cretaceous sequence in northern Alaska.

East of the Anaktuvuk-Colville Rivers, the Upper Cretaceous is unconformably overlain by the Tertiary Sagavanirktok formation (Gryc and others, 1951, p. 167). West of the Anaktuvuk-Colville Rivers, no Tertiary beds have been identified and the Gubik formation of Pleistocene age unconformably overlies the Cretaceous. The Gubik also extends to the east where it overlies the Sagavanirktok formation.

AGE AND CORRELATION

The species of *Inoceramus* collected from the Colville River region are known also from Alberta, British Columbia, and other parts of Canada, as well as from the western interior of the United States. Several of the species also occur in England, Greenland, and northern Europe, and one species, *I.* (*Mytiloides*) *labiatus*, has worldwide distribution.

The number of species of *Inoceramus* found in northern Alaska is very small compared with that found in Cretaceous rocks of the same age in the western interior of the United States and in southern Canada. Likewise, many of the ammonites that characteristically are associated with the extensive *Inoceramus* faunas of the western interior are missing in northern Alaska. *Inoceramus* (*Inoceramus*) *dunveganensis* is typically a northern species. The southern known limit of this species is in Montana. *Inoceramus* (*Mytiloides*) *labiatus* is known throughout the world, and is not indicative of any faunal province. *Inoceramus* (*Sphenoceramus*) *patootensis* and *I.* (*S.*) *steenstrupi* are both northern species, occurring in Canada, the western interior of the United States, Greenland, England, Germany, and elsewhere. *I.* (*I.*) *cuvierii* has a wide distribution, but seems most typically to be a northern species. Although the *Inoceramus* fauna from the Colville River region has strong affinities with the western interior of the United States and Canada, and with the faunas of northern Europe, it shows very little relationship to the *Inoceramus* of the Indo-Pacific faunal province, known from southwestern Alaska, Vancouver Island, British Columbia, California, Japan, and elsewhere. With exception of *I. labiatus* and possibly *I. cuvierii*, no species of *Inoceramus* from northern Alaska is known to occur in the Indo-Pacific Province.

The oldest species of *Inoceramus* known from the Upper Cretaceous rocks of the Colville River region is *I. dunveganensis* McLearn, s. l., which occurs in the Ninuluk formation. As herein interpreted, this species ranges from late Albian to late Cenomanian (fig. 31). No ammonites have been found in the Colville River region in association with *I. dunveganensis*, so it is impossible to determine precisely the upper and lower age limits of the Ninuluk formation, or to locate the Lower and Upper Cretaceous boundary in this area. The Ninuluk is probably nearly equivalent to the Belle Fourche shale of the western interior of the United States and the Dunvegan formation of British Columbia, both of which are believed to be Cenomanian in age (fig. 32).

The Seabee formation, which unconformably overlies the Ninuluk formation, contains a fauna consisting of *Inoceramus* (*Mytiloides*) *labiatus* (Schlotheim), *I.* aff. *I.* (*I.*) *cuvierii* Sowerby, *Watinoceras* sp., *Scaphites* sp., and *Borissiakoceras* (*Borissjakoceras*) sp. *I. labiatus* seems to be restricted to rocks of early Turonian age. In the western interior of the United States, this species is very abundant in the Pfeifer shale member of the Greenhorn limestone, and also occurs in the overlying Fairport chalky member of the Carlile shale (zone of *Collignoniceras woollgari*) (William A. Cobban, oral communication.) *I. cuvierii* Sowerby in England ranges from about middle Turonian to late Santonian. In North America, *I.* aff. *I. cuvierii* ranges from the zone of *Collignoniceras hyatti* to the zone of *Scaphites*

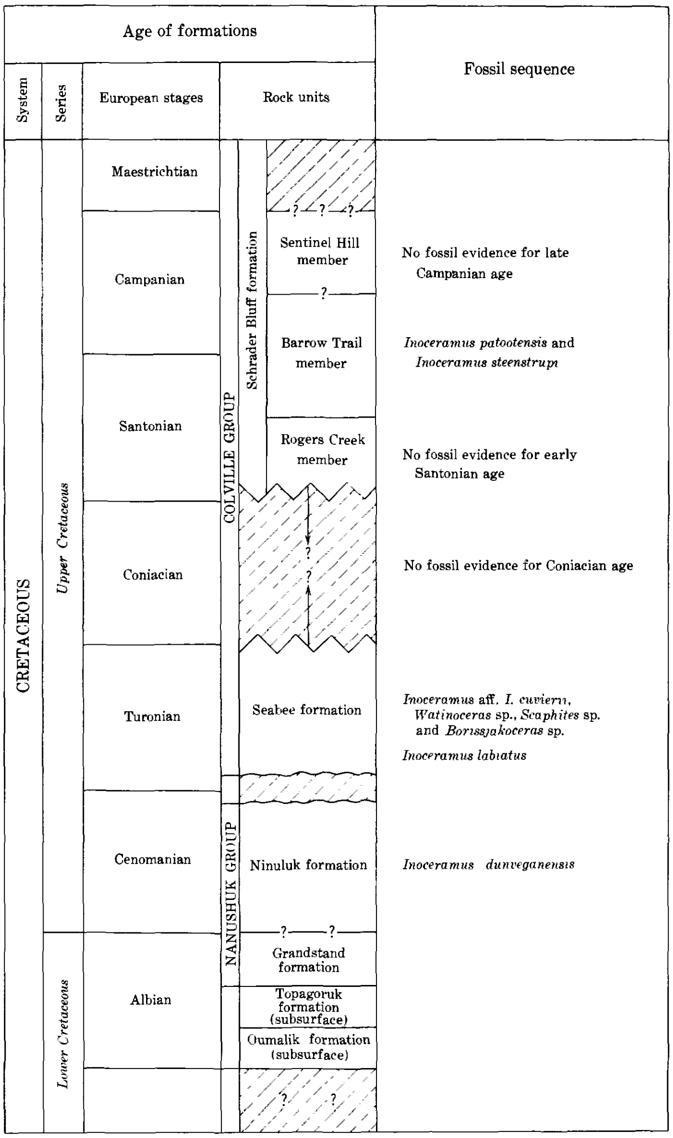

FIGURE 31.—Age of formations and fossil sequence.

corvensis (middle to late Turonian), but has not been found above the Turonian. The genus *Watinoceras* is restricted to the lower Turonian according to Wright (1957, p. L416). Morrow (1935, p. 465) reports species of *Borissjakoceras* from the Graneros shale (late Cenomanian) and the Blue Hill shale member of the Carlile shale (early Turonian) in Kansas. All this evidence indicates that the unnamed member of the Seabee formation is probably early Turonian, and is a correlative of the upper part of the Greenhorn limestone and possibly the lower part of the Carlile shale of the western interior. If this correlation is correct, *I. cuvierii* may have a slightly lower range in North America than it does in Europe.

The Ayiyak member of the Seabee formation contains only *Inoceramus* aff. *I. cuvierii*, and is probably the correlative of the upper part of the Carlile shale (late Turonian). There are no indications that the upper part of this member extends into the Coniacian.

The Schrader Bluff formation overlies the Seabee formation with apparent conformity, but strata of Coniacian age may be missing and an unconformity may separate the two formations. In northeastern British Columbia, McLearn and Kindle (1950) report a faunal sequence consisting of *Watinoceras* cf. *W. coloradoense* Henderson and *Inoceramus labiatus* from the Smoky group, followed by *I. pontoni* and *Scaphites ventricosus* in the Kotaneelee formation, with *I.* cf. *I. tuberculatus* Woods (equals *I. steenstrupi* de Loriol) in the upper part of the formation. This faunal sequence is similar to that of the Colville River region, except that the *Scaphites ventricosus* fauna has not been found in northern Alaska. The age of *Scaphites ventricosus* in the western interior of the United States is about middle Coniacian, and the absence of this species in the Colville River region suggests that some Coniacian strata may be missing. The upper limit of the Seabee formation is not known, and no diagnostic fossils are known from the Rogers Creek member of the Schrader Bluff formation. Either one, or both, of these units may be, in part, of Coniacian age.

The Barrow Trail member of the Schrader Bluff formation contains *Inoceramus* (*Sphenoceramus*) *patootensis* de Loriol and *I.* (*S.*) *steenstrupi* de Loriol of middle Santonian to early Campanian age. These two species are also known from Canada, Greenland, England, Germany, and elsewhere. No fossils are available to date the overlying Sentinel Hill member. The Schrader Bluff is probably Santonian to early Campanian in age, and is nearly equivalent to the upper part of the Niobrara formation, the Telegraph Creek formation, the Eagle sandstone, and possibly the lower part of the Pierre shale of the western interior of the United States.

GEOGRAPHIC DISTRIBUTION

The occurrence by locality and formation of the species of *Inoceramus* described in this report is shown on table 1.

The general position of each locality is shown on figure 33.

Detailed descriptions of the localities, as well as stratigraphic data, are given in table 2.

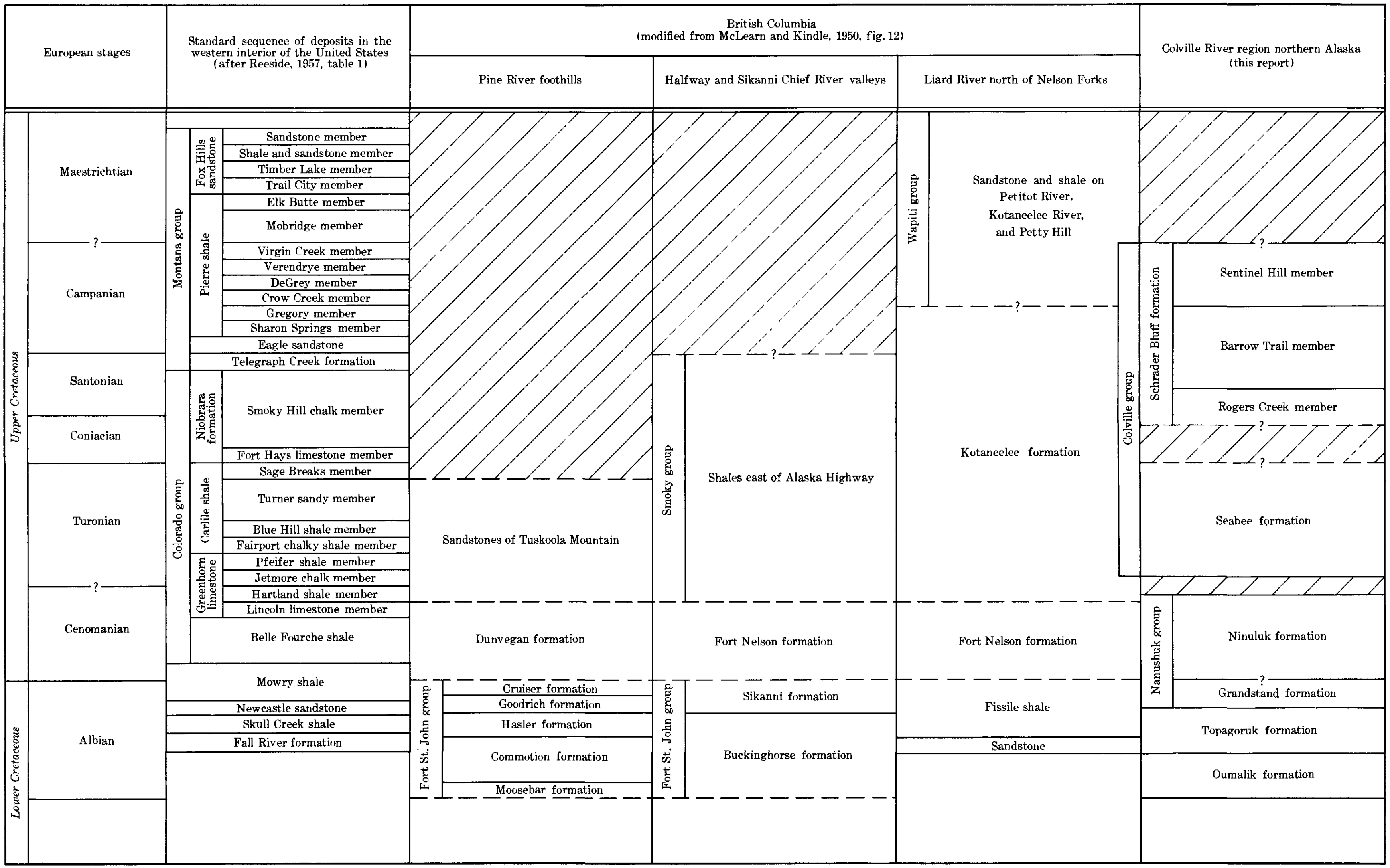

FIGURE 32.—Correlation of Cretaceous formations.

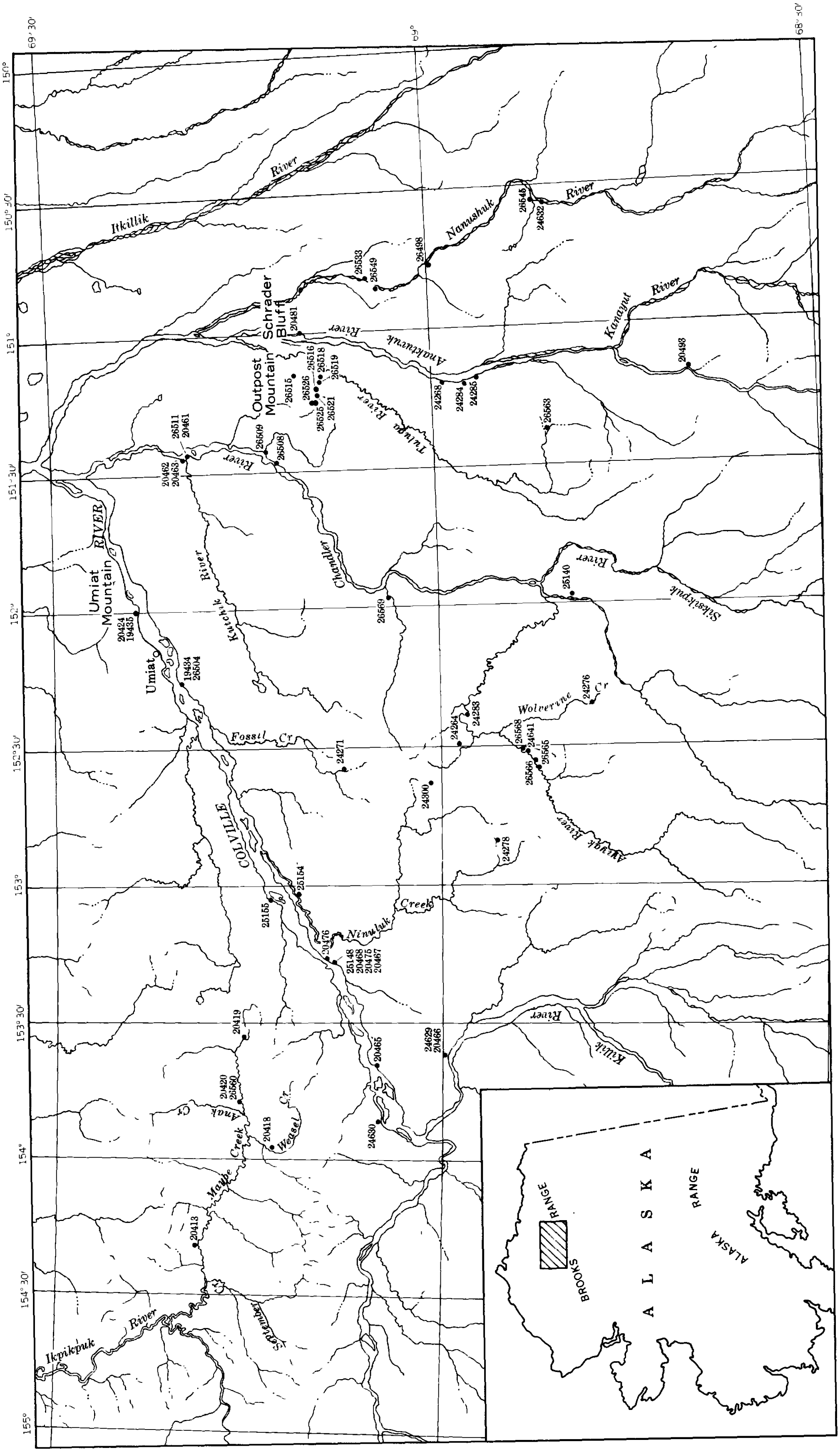

Figure 33.—Index map of the Colville River region showing *Inoceramus* bearing localities.

TABLE 1.—*Geographic distribution of* Inoceramus *in northern Alaska*

[× indicates present]

USGS Mesozoic locality (fig. 33)	*I. (Inoceramus) dunveganensis*	*I. (Mytiloides) labiatus*	*I.* aff. *I. (I.) cuvierii*	*I. (Sphenoceramus) patootensis*	*I. (Sphenoceramus) steenstrupi*
20465	×				
20466	×				
20467	×				
20468	×				
20475	×				
20476	×				
20418	×				
20419	×				
25148	×				
25154	×				
25155	×				
25140	×				
24264	×				
24268	×				
24276	×				
24278	×				
24283	×				
24284	×				
24285	×				
24300	×				
24271	×				
24629	×				
24630	×				
19435		×			
20424		×			
20413		×	×		
20420		×			
26545		×			
26549		×			
26560		×	×		
26563		×	×		
26565		×			
26566		×			
24641		×			
26568		×			
26569			×		
26533			×		
24632			×		
19434				×	
20461				×	
20462				×	
20463				×	
20481				×	×
20493					×
26498				×	×
26504					×
26508				×	
26509				×	
26511				×	
26515				×	
26516				×	
26518				×	
26519				×	
26521				×	×
26525				×?	
26526					×

TABLE 2.—Inoceramus-*bearing localities in the Upper Cretaceous rocks of the Colville River region*

USGS Mesozoic loc. (fig. 33)	Field No.	Stratigraphic position	Locality, lithology, and collector
		Ninuluk formation, 657 ft thick at type locality	
20465	45AWa97	Basal part of formation.	Colville River, south bank, lat 69°04′30″ N., long 153°41′ W. Sandstone and conglomerate. Collector, W. A. Warner, 1945.
20466	45AWa82	10 ft above base	Killik River, northeast bank about 10 miles upstream from Colville River, lat 68°59′ N., long 153°36′30″ W. Same locality as 24629. Collector, W. A. Warner, 1945.
20467	45AWa122	Basal part of formation.	Colville River, south bank, lat 69°08′ N., long 153°18′ W. Same locality as 25148. Sandstone float. Collector, W. A. Warner, 1945.
20468	45AWa123A	10 ft above base	Colville River, south bank, same locality as 20467. Collector, W. A. Warner, 1945.

TABLE 2.—Inoceramus-*bearing localities in the Upper Cretaceous rocks of the Colville River region*—Continued

USGS Meso-zoic loc. (fig. 33)	Field No.	Stratigraphic position	Locality, lithology, and collector
		Ninuluk formation, 657 ft thick at type locality—Continued	
20475	45AKr155	420 ft above base.	Colville River, south bank, lat 69°08′ N., long 153°18′ W. Collector, C. E. Kirschner, 1945.
20476	45AKr162	Basal 100 ft of formation.	Colville River, south bank; lat 69°09′ N., long 153°15′ W. Sandstone. Collector, C. E. Kirschner, 1945.
20418	46ARy100B	600–650 ft below top.	Weasel Creek, 2.5 miles southwest of confluence with Maybe Creek, lat 69°13′ N., long 153°58′ W. Cut bank on east side of stream, poorly exposed massive to slabby sandstone, 50–60 ft thick. Collector, R. G. Ray, 1946.
20419	46ARy125E	Probably same as 20418.	On an unnamed stream 1.6 miles southeast of its confluence with Maybe Creek, lat 69°15′30″ N., long 153°33′ W. Cut bank on northeast side of stream imperfectly exposing about 100 ft of sandstone with subordinate shale and coal. Fossils occur in talus. Collector, R. G. Ray, 1946.
25148	47ADt107	100 ft above base.	Colville River, south bank, lat 69°08′ N., long 153°18′ W. Thin-bedded sandstone. Collector, R. L. Detterman, 1947.
25154	47ADt158	Near base of formation.	On ridge south of tributary of Ninuluk Creek, lat 69°11′ N., long 153°02′ W. Sandstone and conglomerate. Collector, R. L. Detterman, 1947.
25155	47ADt163	Basal part of formation.	Colville River, north bank, lat 69°13′30″ N., long 153°03′ W. Interbedded sandstone, siltstone, and clay shale. Collector, R. L. Detterman, 1947.
25140	48ADt215	Basal 100 ft of formation.	Chandler River, east bank, lat 68°49′15″ N., long 151°57′30″ W. Sandstone and conglomerate. Collector, R. L. Detterman, 1948.
24264	52ABl45	Basal part of formation	On ridge west of Ayiyak River, lat 68°57′30″ N., long 152°28′ W. Green to yellow-red sandstone. Collector, R. S. Bickel, 1952.
24268	52ABl181	Near base of formation.	Anaktuvuk River, lat 68°55′ N., long 151°11′30″ W. Collector, R. S. Bickel, 1952.
24276	52ADt32	Base of formation.	Wolverine Creek, east bank of east fork, lat 68°45′ N., long 152°22′ W. Massive conglomerate and sandstone. Collector, R. L. Detterman, 1952.
24278	52ADt74	Middle of formation.	On ridge top, lat 68°59′30″ N., long 152°51′ W. Medium-bedded, salt-and-pepper sandstone. Collector, R. L. Detterman, 1952.
24283	52ADt102	100–150 ft above base.	On ridge south of Ayiyak River, lat 68°55′ N., long 152°23′ W. Medium-bedded gray sandstone. Collector, R. L. Detterman, 1952.
24284	52ADt155A	Basal 100 ft of formation.	Anaktuvuk River, west bank, lat 68°56′30″ N., long 151°10′30″ W. Sandstone and conglomerate. Collector, R. L. Detterman, 1952.
24285	52ADt168	Basal part of formation.	Anaktuvuk River, west bank, lat 68°51′ N., long 151°09′ W. Thick-bedded sandstone. Collector, R. L. Detterman, 1952.
24300	52ADt230	Basal part of formation.	On hillside about 1 mile from small tributary of Ninuluk Creek, lat 69°05′30″ N., long 152°38′ W. Thin-bedded greenish sandstone. Collector, R. L. Detterman, 1952.

TABLE 2.—Inoceramus-*bearing localities in the Upper Cretaceous rocks of the Colville River region*—Continued

USGS Mesozoic loc. (fig. 33)	Field No.	Stratigraphic position	Locality, lithology, and collector
Ninuluk formation, 675 ft thick at type locality—Continued			
24271	52AB1273	Lower part of formation.	On ridge east of small tributary of Fossil Creek, lat 69°07′ N., long 152°36′ W. Thin-bedded green sandstone. Collector, R. S. Bickel, 1952.
24629	53ADt62	Basal 10 ft of formation.	Killik River, northeast bank, about 10 miles upstream from Colville River, lat 69°59′ N., long 153°36′ W. Thick-bedded, ferruginous sandstone. Collector, R. L. Detterman, 1953.
24630	53ADt84	Basal 10 ft of formation.	Colville River, north bank, about 4 miles downstream from Killik River, lat 69°04′ N., long 153°52′ W. Thick-bedded ferruginous sandstone and conglomerate, same as 24629. Collector, R. L. Detterman 1953.
Seabee formation, Unnamed member, 250–1,250 ft thick			
19435	44AC525	375–550 ft above base.	Bluff on north side Colville River at Umiat Mtn., lat 69°23′30″ N., long 152° W. Dark fossiliferous shale with dark fossiliferous calcareous concretions and many light-colored bentonite laminae and thin beds. Forms conspicuous black cliff. Collector, R. R. Coats, 1944.
20424	46ASt3	Same as 19435	Location and lithology same as 19435. Collector, K. Stefansson, 1946.
20413	46ARy68a	180 ft below top	Maybe Creek, north bank, 3.75 miles above mouth of September Creek, lat 69°19′ N., long 154°19′ W. Float of gray-brown fine-grained calcareous sandstone. Collector, R. G. Ray, 1946.
20413	46ARy68b	180 ft below top	Location and lithology same as 46-ARy68a. Collector, R. G. Ray, 1946.
20420	46ARy131	255–265 ft below top.	Maybe Creek, north bank, 1.5 miles above mouth of Anak Creek, lat 69°16′ N., long 153°47′ W. Dark-gray limestone concretions in black shale. Collector, R. G. Ray, 1946.
26545	47AWb63	About 850 ft below top.	Nanushuk River, west bank, lat 68°50′30″ N., long 150°33′ W. Bentonitic clay shale and limestone concretions. Collector, E. J. Webber, 1947.
26549	47AWb177	About 1,100 ft below top.	Nanushuk River, west bank, lat 69°03′ N., long 150°51′ W. Black paper shale and limestone concretions. Collector, E. J. Webber, 1947.
26560	49ABe1	255–265 ft below top.	Lat 69°16′ N., long 153°47′ W. Same as 20420. Collector, W. P. Brosgé, 1949.
26563	51AGr34	60–100 ft below top.	Tuluga River, east fork, north bank, lat 68°50′45″ N., long 151°25′ W. Limestone concretions in shale. Collector, G. Gryc, 1951.
26565	52ADt57	160 ft below top	Ayiyak River, east bank, lat 68°51′30″ N., long 152°36′ W. Interbedded silty shale, clay shale, siltstone, and sandstone. Collector, R. L. Detterman, 1952.
26566	52ADt61	130 ft below top	Ayiyak River, east bank, lat 68°52′ N., long 152°33′30″ W. Siltstone, silty shale and clay shale. Collector, R. L. Detterman, 1952.
24641	52AB131	20–30 ft below top.	Ayiyak River, east bank, lat 68°52′30″ N., long 152°32′ W. Bentonitic clay shale and thin, green sandstone. Collector, R. S. Bickel, 1952.
Seabee formation, Unnamed member, 250–1,250 ft thick—Continued			
26568	52AB133	Near contact with Ayiyak member.	Ayiyak River, east bank, lat 68°53′ N., long 152°30′30″ W. Bentonitic clay shale and green sandstone. Collector, R. S. Bickel, 1952.
26569	52AB1259	400–450 ft below top.	On small tributary of Chandler River, lat 69°02′15″ N., long 151°58′ W. Bentonitic black paper shale and limestone concretions. Collector, R. S. Bickel, 1952.
Seabee formation, Ayiyak member, 360 ft thick at type locality			
26533	47AWb264	130 ft below top	Nanushuk River, west bank, lat 69°04′ N., long 150°50′ W. Interbedded sandstone, siltstone, silt, and clay shale. Collector, E. J. Webber, 1947.
24632	53ADt116	300 ft below top	Nanushuk River, west bank, lat 68°50′30″ N., long 150°32′30″ W. Greenish-yellow sandstone and conglomerate. Collector, R. L. Detterman, 1953.
Schrader Bluff formation, Barrow Trail member, 700–900 ft thick			
19434	44AC522	325–355 ft below top.	Colville River, south side, prominent bluff near Umiat, about 7 miles southwest of Umiat Mtn., lat 69°29′ N., long. 152°15′ W. Seven-inch conglomerate and 25-foot tuffaceous sandstone. Collector, George Gryc, 1944.
20461	45AGr195	250–350 ft above base.	Chandler River, west bank at mouth of Kutchik River, lat 69°19′ N., long 151°25′ W. Tuffaceous sandstone. Collector, George Gryc, 1945.
20462	45AGr200	200–300 ft above base.	Chandler River, west bank, lat 69°20′ N., long 151°25′ W. Light buff sandstone. Collector, George Gryc, 1945.
20463	45AGr201	Same as above	Same as above.
20481	45AFs116f	Upper 600 ft	Anaktuvuk River, east bank at Schrader Bluff, lat 69°10′ N., long 150° W. Tuffaceous sandstone and siltstone. Collector, R. E. Fellows, 1945.
20493	45AFs29	Exact position not known.	Anaktuvuk River, east bank, lat 68°29′ N., long 151°17′ W. Collector, R. E. Fellows, 1945.
26498	47AWb136	Lower 120 ft	Nanushuk River, northeast bank, lat 68°59′15″ N., long 150°42′ W. Laminated, tuffaceous sandstone. Collector, E. J. Webber, 1947.
26504	47ADt293	220 ft below top	Colville River, south bank about 3.6 miles southwest of Umiat, lat 69°20′30″ N., long 152°15′ W. Tuffaceous sandstone. Collector, R. L. Detterman, 1947.
26508	48ADt387	80–150 ft above base.	Chandler River, east bank, lat 69°12′15″ N., long 151°26′30″ W. Tuffaceous sandstone, siltstone, and clay shale. Collector, R. L. Detterman, 1948.
26509	48ADt410	540–600 ft above base.	Chandler River, east bank, lat 69°13′ N., long 151°25′30″ W. Tuffaceous siltstone, silty shale, clay shale. Collector, R. L. Detterman, 1948.
26511	48ADt449	900–1,040 ft above base.	Chandler River, west bank at the junction of Kutchik River, lat 69°19′15″ N., long 151°25′ W. Siltstone and silty shale. Collector, R. L. Detterman, 1948.

TABLE 2.—Inoceramus-*bearing localities in the Upper Cretaceous rocks of the Colville River region*—Continued

USGS Mesozoic loc. (fig. 33)	Field No.	Stratigraphic position	Locality, lithology, and collector
Schrader Bluff formation, Barrow Trail member, 700–900 ft thick—Continued			
26515	52ADt175	500–520 ft above base.	Outpost Mtn., north side, about 1.5 miles west of Tuluga River, lat 69°10′30″ N., long 151°08′45″ W. Tuffaceous sandstone. Collector, R. I. Detterman, 1952.
26516	52ADt176	550–560 ft above base.	Outpost Mtn., about 1 mile southwest of 26515, lat 69°09′30″ N., long 151°10′ W. Tuffaceous sandstone. Collector, R. L. Detterman, 1952.
26518	52ABl194	670 ft above base.	Outpost Mtn., south side, about 1 mile southwest of 26515, lat 69°09′ N., long 151°09′ W. Tuffaceous sandstone and siltstone. Collector, R. S. Bickel, 1952.
26519	52ABl195	630 ft above base.	Outpost Mtn., about 0.3 mile west of 26518, lat 69°09′ N., long 151°10′ W. Tuffaceous siltstone. Collector, R. S. Bickel, 1952.
26521	52ABl197	430–450 ft above base.	Outpost Mtn., about 0.5 mile west of 26518, lat 69°09′ N., long 151°10′45″ W. Tuffaceous siltstone. Collector, R. S. Bickel, 1952.
26525	52ABl202	430–450 ft above base.	Outpost Mtn., lat 69°09′15″ N., long 151°14′30″ W. Tuffaceous sandstone and siltstone. Collector, R. S. Bickel, 1952.
26526	52ABl203	500–530 ft above base.	Outpost Mtn., lat 69°09′30″ N., long 151°13′30″ W. Tuffaceous sandstone. Collector, R. S. Bickel, 1952.

SYSTEMATIC DESCRIPTIONS

Class PELECYPODA
Family ISOGNOMONIDAE Iredale
Subfamily INOCERAMINAE Zittel, 1881
Genus INOCERAMUS Sowerby, 1814

1814. *Inoceramus* Sowerby, Annals Philosophy, p. 448.

Type species: *Inoceramus cuvierii* Sowerby, 1814. (International Commission on Zoological Nomenclature decision pending.)

Subgenus INOCERAMUS

Type species: *Inoceramus cuvierii* Sowerby, 1814.

Inoceramus aff. I. (Inoceramus) cuvierii Sowerby, 1814

Plate 18, figure 3; plate 19, figures 1, 5.

1814. *Inoceramus cuvierii* Sowerby, Annals Philosophy, p. 448.

1912. *Inoceramus lamarcki* var. *cuvieri* Sowerby. Woods, Paleontographical Soc., v. 65, p. 307–327, pl. 53, fig. 7; text figs. 78–83. (See Woods' paper for complete synonymy up to 1912.)

?1930. *Inoceramus allani* Warren, Research Council Alberta, Rept. 21, app., p. 62, pl. 3, fig. 1.

Shell equivalve, very inequilateral, subquadrate, moderately inflated, height[1] greater than length; beaks anterior, incurved; hinge line moderately long, forming angle greater than 90° with anterior margin; posterodorsal area compressed to form wing; anterior margin truncated, straight to concave, and may extend anteriorly beyond position of beaks; ventral margin broadly rounded; posterior margin slightly rounded. Ornamentation consists of rounded, fairly prominent, unsymmetrically curved, concentric ribs which are marked by more than one growth line. This type of concentric ribbing that carries multiple growth lines was named Anwachsreifen (growth bands) by Heinz (1928b, p. 1–39).

Woods (1912, p. 307–327) has shown that *Inoceramus cuvierii* varies greatly in the prominence of the concentric ribs, the degree of convexity of the valves, the size of the posterior wing, and the angle formed between the hinge line and the anterior margin. Most of the northern Alaskan specimens are poorly preserved and fragmentary, but they agree with Woods' illustrations of *I. cuvierii* in general outline and convexity of the valves, the presence of the posterior wing, and in the *Anwachsreifen* type of ornamentation. The specimen illustrated by Warren (1930, p. 62, pl. 3, fig. 1) as *I. allani* has not been examined by the writer, but as Warren's figure agrees very well in general shape and outline with Woods' (1912, p. 315, text fig. 73) illustration of the type of *I. cuvierii*, it is tentatively regarded as a synonym of *I. cuvierii*. Warren's species seems to have less prominent ornamentation, but this probably is not significant.

Inoceramus aff. *I. cuvierii* is reported by Cobban (oral communication) from the Carlile shale (upper Turonian) of the western interior of the United States. According to Donovan (1953, p. 93; 1954, p. 17), poorly preserved specimens with ornamentation said to be similar to that of *I. cuvierii* occur in deposits of Turonian age in Greenland. There is no evidence that *I.* aff. *I. cuvierii* extends above the Turonian in North America or Greenland.

The range of *Inoceramus cuvierii* in England is, according to Woods (1912, p. 332), from the zone of *Terebratulina lata* (middle Turonian) to the zone of *Micraster coranguinum* (lower Santonian). In northern Alaska, *I.* aff. *I. cuvierii* occurs with *I. labiatus* in the upper part of the unnamed member of the Seabee formation, and it is found along throughout the overlying Ayiyak member. The age of *I. labiatus* is probably early Turonian, so possibly the lowest limit of *I. cuvierii* is slightly lower in northern Alaska than it is in England. The Ayiyak member is probably late Turonian in age and possibly, in part, early Coniacian, but no fossils are present to establish a more precise age.

[1] Height is measured from the dorsal margin to the ventral margin; length is measured from the anterior margin to the posterior margin; width is measured normal to the plane of the valves.

Number of specimens: 33 (mostly fragments).

Figured specimens: USNM[2] 129226, 129227, 129228.

Localities: Unnamed and Ayiyak members of Seabee formation; USGS Mesozoic locs. 20413, 24632, 26533, 26560, 26563, 26569.

Inoceramus (Inoceramus) dunveganensis McLearn, 1926

Plate 15, figures 1–13; plate 16, figures 1–5; plate 17, figures 1–5; plate 18, figures 1, 2, 4; plate 19, figures 2, 4; plate 20, figures 2, 3, 6; plate 21, figures 1–4, 6.

1926. *Inoceramus dunveganensis* McLearn, Canada Dept. Mines, Geol. Ser. 45, Bull. 42, p. 122, pl. 20, fig. 5.
1930. *Inoceramus mcconnelli* Warren, Research Council Alberta, Rept. 21, app., p. 60, pl. 4, figs. 1–3.
1931. *Inoceramus nahwisi* McLearn, Royal Soc. Canada Proc. & Trans., ser. 3, v. 25, p. 7, pl. 2, fig. 1.
1943. *Inoceramus athabaskensis* McLearn, The Canadian Field Naturalist, v. 57, p. 44.
1943. *Inoceramus nahwisi* var. *goodrichensis* McLearn, idem, p. 45.
?1943. *Inoceramus nahwisi* var. *moberliensis* McLearn, idem, p. 46.
1945. *Inoceramus athabaskensis* McLearn, Canada Geol. Survey Paper 45–27, pl. 2, fig. 10; pl. 5, fig. 1; pl. 6, fig. 1.
1945. *Inoceramus dunveganensis* McLearn, idem, pl. 2, fig. 11; pl. 4, figs. 1, 2.
1945. *Posidonomya nahwisi* (McLearn), Canada Geol. Survey Paper 44–17, pl. 9, figs. 1, 2; pl. 10, fig. 1.
1945. *Posidonomya nahwisi* var. *goodrichensis* (McLearn), idem, pl. 10, fig. 3; pl. 11, figs. 4, 5.
?1945. *Posidonomya nahwisi* var. *moberliensis* (McLearn), idem, pl. 10, fig. 7.
1945. *Inoceramus dunveganensis* var. *mcconnelli* Warren, McLearn, idem, pl. 3, fig. 2.

Shell equivalve(?), very inequilateral, height greater than length, slightly oblique, moderately convex; anterior margin nearly straight to broadly rounded, compressed in some specimens to form anterior wing; ventral margin broadly and regularly rounded; posterior margin slightly rounded; posterodorsal area compressed to form wing; hinge line short to moderately long, forming angle of more than 90° with anterior margin; ornamentation consists of coarse, distantly spaced, rounded, irregular, concentric ribs which are generally more prominent on anterior and posterior parts of the valves than on central portion, where ribs may be completely lacking. Growth axis forms angle of 80° to 90° with hinge line.

The posterior adductor muscle scar is slightly behind the median line of the valves. (See pl. 15, figs. 6, 8, 12, 13; pl. 16, figs. 3, 5; pl. 21, fig. 2.) The anterior adductor muscle scar is not visible; apparently, this muscle was greatly reduced in size. A series of disconnected attachment scars extends in a broad curve from near the posterior adductor muscle scar to the anterior part of the umbo. The purpose of these attachment scars is not known, but presumably they served as attachments for the mantle.

MacLearn's and Warren's original descriptions of *Inoceramus dunveganensis*, *I. athabaskensis*, *I. nahwisi* and its varieties, and *I. mcconnelli* were based on very few specimens. The much larger collections from northern Alaska, consisting of 107 specimens, show that the holotypes of their species are only isolated examples of one variable species, and that transitions exist between all the holotypes, except possibly for *I. nahwisi moberliensis*. Therefore, all these specimens are included under the oldest name, *I. dunveganensis* McLearn. This species is actually not as variable as many other species of *Inoceramus*. The main variations observed in *I. dunveganensis s. l.* are:

Height of valves: The specimens range in height from 1 inch to more than 15 inches and distinct size groups cannot be recognized. This range in size seems to be a normal characteristic of *Inoceramus*, and differentiation of species on the basis of size alone is not valid.

Ratio of length of hinge line to height of valve: This ratio ranges from about 0.2 to more than 0.4, (pl. 16, figs. 2, 5; pl. 17, fig. 2) but clearly defined groups with either a short hinge line (near 0.2) or a moderately long hinge (near 0.4) are not recognizable.

Ratio of width of valve to height of valve: The width and height of the valves cannot be measured accurately because complete specimens are rarely preserved. However, approximate measurements show a transition between specimens with a ratio of width to height of about 0.5 to specimens with a ratio of about 0.8. None of the specimens have a ratio of 1.0 or greater.

Degree of rounding of the anterior margin and presence of an anterior wing: These features cannot be measured accurately and expressed numerically. The curvature of the anterior margin is extremely variable, not only among specimens, but also in the growth stages of an individual. During early growth stages, the anterior margin is nearly straight, truncated, and forms an angle of about 90° with the hinge line (pl. 15, figs. 1–10). After a height of 1 to 2 inches or more, the anterior marginal area becomes flat and new shell material is added to form a broadly rounded skirt (pl. 15, fig. 13; pl. 16, figs. 3, 5). In some specimens this skirt is very wide and projects anteriorly beyond the beaks to form an anterior wing (pl. 20, fig. 6; pl. 21, fig. 1, 6); in other specimens the skirt is narrow and no wing is

[2] United States National Museum.

formed (pl. 18, figs. 1, 2; pl. 20, fig. 2). Thus, the degree of development of the anterior wing is variable, and its presence or absence is not of specific importance in this species.

Ornamentation: The ornamentation consists of rounded, concentric ribs which generally are more prominent on the anterior and posterior sides than on the central part of the valve (pl. 15, fig. 13; pl. 17, fig. 1; pl. 20, fig. 6). However, in some specimens the ribs formed during early growth stages continue without diminishing in prominence across the central part of the valve, and only those ribs formed in later growth stages are interrupted (pl. 15, fig. 12; pl. 16, fig. 5). Other specimens lack ribs when small, but develop them as the shell becomes larger. *Inoceramus mcconnelli* Warren, which is similar in shape and outline to *I. dunveganensis s. l.*, has this type of ornamentation.

Obliquity of the valves: The angle between the hinge line and the axis of growth (the line connecting the point of maximum curvature of successive concentric ribs) ranges from about 80° to 90° in all of the specimens studied, including the holotypes of McLearn's *Inoceramus dunveganensis*, *I. athabaskensis*, *I. nahwisi* and *I. nahwisi goodrichensis*, and of Warren's *I. mcconnelli*. However, *I. nahwisi moberliensis* has a growth angle of about 60° during its early stages, and an even smaller angle in later stages (pl. 21, figs. 3, 4). None of the specimens from northern Alaska have as small an angle, so it cannot be shown that the specimens with large angles are transitional into those with smaller angles. Therefore, *I. nahwisi moberliensis* is only tentatively regarded as a synonym of *I. dunveganensis*. If this oblique type can be shown to have stratigraphic significance, the name probably should be retained.

In northeastern British Columbia, McLearn and Kindle (1950, p. 82, 84, 93) report the occurrence of *Inoceramus nahwisi goodrichensis* in the Goodrich formation, and the ammonite *Neogastroplites*, of latest Albian or earliest Cenomanian age (see Reeside, 1957, table 1, opposite p. 540). *I. dunveganensis* s. s., *I. athabaskensis*, and *I. mcconnelli* occur in the Dunvegan formation in northeast British Columbia in association with ammonite *Dunveganoceras* (see McLearn and Kindle, 1950, p. 99; McLearn, 1943, fig. 1), which, according to Reeside (1957, table 1, opposite p. 540), is restricted to the upper Cenomanian. As the author can find no morphologic basis for separating any of these species, *I. dunveganensis* is interpreted as ranging in age from late Albian to middle or late Cenomanian.

I. dunveganensis occurs in the western interior of Canada, in the Ninuluk formation of northern Alaska, and also in the sandy beds that are equivalent to the Mowry shale of Montana (J. B. Reeside, Jr., oral communication). One questionable occurrence is also reported in the Kuskokwim region of Alaska (USGS Mes. loc. 19388).

Number of specimens: 107.

Figured Specimens: USNM 129210, 129211, 129212, 129213, 129214, 129215, 129216, 129217, 129218, 129219, 129220, 129221, 129222, 129223, 129224, 129225. Plastotypes CGS[3] 6106, 6344, 8937, 8945, 8938, 9710, 9713, 9811, 9813, 9816, 9817. Plastotype Univ. Alberta CT 417, CT 418.

Localities: Ninuluk formation, USGS Messazoic locs. 20418, 20419, 20465, 20466, 20467, 20468, 20475, 20476, 20488, 24264, 24267, 24268, 24271, 24276, 24278, 24283, 24284, 24285, 24300, 24629, 24630, 25140, 15148, 15154, 25155.

Subgenus MYTILOIDES Brongniart, 1822

Type species: *Inoceramus labiatus* (Schlotheim).

Inoceramus (Mytiloides) labiatus (Schlotheim), 1813

Plate 19, figure 3; plate 20, figures 1, 4, 5.

1813. *Ostracites labiatus* Schlotheim, Leonard, Taschenbuch für Mineralogie, v. 7, p. 93 (fide Woods, 1911, p. 281). (For synonymy to 1911, see Woods, 1911, p. 281).

Shell mytiliform, nearly equivalve, moderately inflated, extremely inequilateral, oblique, height much greater than length; beaks anterior, slightly incurved; hinge line short to medium in length and generally forms an angle of less than 90° with anterior margin; anterior margin broadly rounded, posterior margin nearly straight. Ornamentation consists of low, fairly regular, rounded, concentric ribs.

Inoceramus labiatus s. l. is found throughout the world in deposits of Turonian age. Specimens show much variation in the length of the hinge line, the angle formed between the anterior margin and the hinge line, the convexity of the valves, and the degree of posterior obliquity. Unfortunately, no worldwide study of this species has been made in sufficient detail to ascertain if geographic or stratigraphic subspecies exist. Seitz (1935) recognized five subspecies of *I. labiatus*, but the validity of his work is questioned because none of his published samples contains more than eight specimens, which is not a sufficient number to show adequately the range of variation.

According to Woods (1911, p. 283), *Inoceramus labiatus* in England is found mainly in the zone of *Rhynchonella cuvierii* (early Turonian), but it also occurs in the zone of *Terebratulina lata* (late Turonian). In Germany Heinz (1928a, pl. 3) and Andert

[3] Geological Survey Canada.

(1934, p. 41) record *I. labiatus* only from the lowermost Turonian beds. This species is also common in the uppermost part of the Greenhorn limestone and its equivalents in the western interior of the United States where, according to Cobban and Reeside (1952, p. 1018), it occurs with the early Turonian ammonites *Thomasites* and *Vascoceras*. Thus, *I. labiatus* is a Turonian species, and perhaps is confined to lower Turonian beds, but such a restricted range has not been conclusively proved.

Number of specimens: 54.

Figured specimens: USNM 129229, 129230, 129231, 129232.

Localities: Unnamed member of Seabee formation; USGS Mesozoic locs. 19435, 20413, 20420, 20424, 24641, 26545, 26549, 26560, 26563, 26565, 26566, 26568.

Subgenus SPHENOCERAMUS Boehm, 1915

Type species: *Inoceramus cardissoides* Goldfuss, 1836.

Inoceramus (Sphenoceramus) patootensis de Loriol, 1883

Plate 21, figure 5; plate 22, figures 1–3; plate 23, figure 3.

1877. *Inoceramus lobatus* Goldfuss, Schülter, Palaeontographica, v. 24, p. 275, pl. 39, figs. 1, 2.
1883. *Inoceramus patootensis* de Loriol, Medd. on Grönland, v. 5, no. 4, p. 211.
1918. *Inoceramus patootensis* de Loriol, Ravn, Medd. om Grönland, v. 56, p. 337, pl. 5, fig. 1; pl. 6, figs. 1–2.
1929. *Inoceramus lundbreckensis* McLearn, Canada Nat. Mus. Bull. 58, p. 77, pl. 15, fig. 4; pl. 16, fig. 2.
1936. *Inoceramus patootensis* de Loriol forma *typica* Beyenburg, Deutsche geol. Gessell. Zeitschr., v. 88, no. 2, p. 107. (See Beyenburg's 1936 paper for more complete synonymy up to 1936.)
1936. *Inoceramus patootensis* de Loriol var. *angusta* Beyenburg, idem, p. 110, pl. 25, fig. 4.
1953. *Inoceramus (Sphenoceramus) patootensis* de Loriol, Donovan, Medd. om Grönland, v. 3, no. 4, p. 95.
1955. *Inoceramus lobatus Goldfuss*, Cobban, Billings Geol. Soc. Guidebook, 6th annual field conf., p. 207, pl. 4.

Shell equivalve(?), very inequilateral, moderately inflated, oblique, divided into a V-shaped, inflated, anterior part and a compressed, sharply distinct, posterodorsal wing; height much greater than length; hinge line moderately long, forming an angle of 90° or more with anterior margin; beaks anterior, sharply pointed; anterior margin straight, long, truncated; a shallow furrow extends obliquely from behind beaks to posteroventral margin; posterior side of furrow bounded by an oblique, narrow ridge or line of nodes. Ornamentation on V-shaped portion consists of concentric ribs of two sizes: small, closely spaced, rounded ribs, and larger, distantly spaced, very irregular ribs; concentric ribs have unsymmetrical curvature where they cross the posterior furrow; ornamentation on wing less prominent and more regular than on V-shaped part; small, radial riblets may occur on inflated, central part of valve; nodes formed along anterior margin, on ridge bordering the furrow, and along dorsal margin of posterior wing.

Inoceramus patootensis has been identified by many writers as *I. lobatus* Goldfuss, but their interpretation of *I. lobatus* was based upon specimens illustrated by Schlüter (1877, pl. 39, figs. 1, 2), not by Goldfuss (1836, pl. 110, fig. 3). Goldfuss based *I. lobatus* on one small, crushed, apparently juvenile specimen, and it is questionable whether this species is recognizable. Schlüter's specimens are well preserved and adequately illustrated, and there is little question about the identity of his species. A comparison of a plaster cast of Goldfuss' type with specimens very similar to Schlüter's types indicates that the two species are probably distinct. The distinction between *I. lobatus* Schlüter and *I. lobatus* Goldfuss was previously pointed out by Stolley (1916, p. 72–73), Heinz (1928a, p. 79), Riedel (1931, p. 653), Beyenburg (1936, p. 107), and others. Heinz first recognized that *I. lobatus* Schlüter and *I. patootensis* de Loriol are identical, and he applied de Loriol's name to Schlüter's species.

Beyenburg (1936, p. 107–111) split *Inoceramus patootensis* into five varieties, as follows: *I. patootensis* forma *typica; media* Beyenburg; *angusta* Beyenburg; *lingua* Goldfuss; and *cancellata* Goldfuss.

Of these varieties, *angusta* is unnecessary as it falls within the range of variation of *I. patootensis*. On the other hand, *I. lingua* seems to be distinct from *I. patootensis* as its ribbing is regular throughout. The variety *media* seems to be more closely associated with *I. lingua* than with *I. patootensis*, and *I. cancellatus* may fall within the range of variation of *I. cardissoides* Goldfuss.

A study of large collections of *I. patootensis* and *I. lingua* may indeed show a transition between the two species. So far, this transition has not been demonstrated so it seems best to keep the two species separate. If a transition is shown to exist, the name *I. patootensis* must be rejected as a synonym of *I. lingua*; Beyenburg's designation of *I. lingua* as a variety of *I. patootensis* was done without regard for priority of names. If *I. cancellatus* is also found to fall within the range of variation of *I. patootensis*, the name *I. cancellatus* should have priority over *I. lingua* as it has line precedence (Goldfuss, 1836, p. 113).

Inoceramus patootensis is common in northern Europe, Greenland, and the western interior of North America. According to Woods (1912, p. 302), in England this species probably occurs in the zone of *Actinocamax quadratus* (early Campanian). Riedel (1931, p. 653) reports that in Germany this species has a range from late Santonian to early Campanian. In North America, Cobban (1955, p. 207) has shown that *I. patootensis* (equals *I. lobatus*) is an excellent guide fossil to the uppermost part of the Colorado shale, the Telegraph Creek formation, and the Eagle sandstone. Its range is through the ammonite zones of *Desmoscaphites erdmanni*, *Desmoscaphites bassleri*, and *Scaphites hippocrepis* (middle Santonian through early Campanian). Thus, on the basis of the presence of *I. patootensis*, the age of the Barrow Trail member of the Schrader Bluff formation is between middle Santonian to early Campanian.

Number of specimens: 20.

Figured specimens: USNM 129233, 129234, 129235, 129236; National Museum Canada 9037.

Localities: Barrow Trail member of Schrader Bluff formation; USGS Mesozoic locs. 19434, 20461, 20462, 20463, 20481, 26498, 26508, 26509, 26511, 26515, 26516, 26518, 26519, 26521, 26525.

Inoceramus (Sphenoceramus) steenstrupi de Loriol, 1883

Plate 19, figure 6; plate 23, figures 1, 2.

1883. *Inoceramus steenstrupi* de Loriol, Medd. om Grönland, v. 5, no. 4, p. 211.

1912. *Inoceramus tuberculatus* Woods, Paleontographical Soc., v. 65, p. 302, pl. 54, fig. 8; text fig. 59.

1918. *Inoceramus steenstrupi* de Loriol, Ravn, Medd. om Grönland, v. 56, p. 336, pl. 5, fig. 2.

1931. *Inoceramus steenstrupi* de Loriol, Riedel, Preussische geol. Landesanstalt Jahrb., v. 51, p. 660. (See Riedel's paper for complete synonymy up to 1931.)

1953. *Inoceramus (Sphenoceramus) steenstrupi* de Loriol, Donovan, Medd. om Grönland, v. 3, no. 4, p. 95.

The specimens of *Inoceramus steenstrupi* from northern Alaska are fragmentary and the identification of this species is based on the characteristic tuberculate ornamentation. Ravn (1918, p. 336–337) described topotype material from Patoot, Greenland, as follows:

> Shell very large, slightly convex, very inequilateral. Height greater than length. Ornamentation consists of numerous strong, but comparatively narrow, concentric ribs, separated by rather wide interspaces. The ventral slope of the ribs steeper than the dorsal slope. In the middle part of the shell the ribs are crossed by radial furrows, so that the ribs appear to consist of rows of tubercles; in the spaces between the ribs these furrows are indistinct or quite absent.

The northern Alaska specimens clearly show the strong concentric ribs and the tubercles on the central part of the valve. Although none of the specimens are complete and nothing is known about the hinge line or the general shape and outline of the valves, the name *Inoceramus steenstrupi* can be applied to these fragments with reasonable assurance on the basis of the tubercles alone. No other species is known to have this type of ornamentation so prominently developed.

The degree of development of the tubercles on *I. steenstrupi* is variable; some specimens have very large, protruding tubercles (pl. 23, fig. 1), but others have small and inconspicuous tubercles (pl. 19, fig. 6; pl. 23, fig. 2). Possibly a transition exists between *I. steenstrupi* with tubercles and *I. patootensis* without tubercles, but large collections of each species must be studied before this question can be answered.

Woods (1912, p. 302) states that *Inoceramus tuberculatus* Woods (equals *I. steenstrupi*) occurs in England in the zone *Actinocamax quadratus* (early Campanian) along with *I. lobatus* (equals *I. patootensis*). In Germany Riedel (1931, p. 626) indicates that *I. steenstrupi* occurs stratigraphically below *I. patootensis* in beds of Santonian age. In Greenland and northern Alaska, *I. patootensis* and *I. steenstrupi* occur together (see Ravn, 1918, p. 336–337) and are, at least in part, of the same age. Thus, the range of *I. steenstrupi* is probably about the same as the range of *I. patootensis*, that is, from middle Santonian to early Campanian.

Number of specimens: 8.

Figured specimens: USNM 129237, 129238, 129239.

Localities: Barrow Trail member of Schrader Bluff formation; USGS Mesozoic locs. 20481, 20493, 26498, 26504, 26521, 26526.

LITERATURE CITED

Andert, Hermann, 1934, Die Kreideablagerungen zwischen Elbe und Jeschken, pt. 3 Die Fauna der obersten Kreide in Sachsen, Boehmen und Schlesien: Preussische geol. Landesanstalt Abh., Neue Folge, no. 159, p. 1–477, 19 pls.

Arkell, W. J., Kummel, Bernhard, and Wright, C. W. Mesozoic Ammonoidea *in* Joint Committee on Invertebrate Paleontology, Treatise on Invertebrate Paleontology, part L—Mollusca 4: Geol. Soc. America and Univ. Kansas Press.

Beyenburg, Edmund, 1936, Neue Fossilfunde aus dem Untersenon der Westfälischen Kreide: Deutsche geol. Gesell. Zeitschr., v. 88, no. 2, p. 104–115, 2 pls.

Cobban, W. A., 1955, Some guide fossils from the Colorado shale and Telegraph Creek formation, northwestern Montana: Billings Geol. Soc., Guidebook, 6th annual field conf., p. 198–207, 4 pls.

Cobban, W. A., and Reeside, J. B., Jr., 1952, Correlation of the Cretaceous formations in the western interior of the United States: Geol. Soc. America Bull., v. 63, p. 1011–1044.

Collier, A. J., 1906, Geology and coal resources of the Cape Lisburne region, Alaska: U.S. Geol. Survey Bull. 278 p.

Detterman, R. L., 1956, New and redefined nomenclature of Nanushuk group: Am. Assoc. Petroleum Geologists Bull., v. 40, no. 2, p. 233–244.

Donovan, D. T., 1953, The Jurassic and Cretaceous stratigraphy and paleontology of Trail Ö, East Greenland: Medd. om Grönland, v. 111, no. 4, p. 1–150, 25 pls.

——— 1954, Upper Cretaceous fossils from Traill and Geographical Society Öer, East Greenland: Medd. om Grönland, v. 72, no. 6, p. 1–33, 3 pls.

Goldfuss, G. A., 1836, Petrefacta Germaniae, v. 2.

Gryc, George, 1951, "Paleontology," *in* T. G. Payne and others, Geology of Arctic Slope U. S. Geol. Survey Oil and Gas Inv. Map OM 126.

Gryc, George, Patton, W. W., and Payne, T. G., 1951, Present Cretaceous stratigraphic nomenclature of northern Alaska: Washington Acad. Sci. Jour., v. 41, no. 5.

Gryc, George, and others, 1956, Mesozoic sequence in Colville River region, northern Alaska: Am Assoc. Petroleum Geologists Bull., v. 40, no. 2, p. 209–254.

Heinz, Rudolf, 1928a, Das Inoceramen-Profil der oberen Kreide Lüneburgs: Niedersächsische geol. Ver. [Hannover] Jahrb., no. 21, p. 65–81, 2 pls.

——— 1928b, Ueber die bisher wenig beachtete Skulptur der Inoceramen-Shale: Hamburg min.-geol. Staatsinst. Mitt., no. 10, p. 1–39.

Imlay, R. W., 1960, Lower Cretaceous megafossils from northern Alaska: U.S. Geol. Survey Prof. Paper 335, 74 p.

Imlay, R. W., and Reeside, J. B., Jr. 1954, Correlation of the Cretaceous formations of Greenland and Alaska: Geol. Soc. America Bull, v. 65, p. 233–246.

Leffingwell, E. de K., 1919, The Canning River Region, northern Alaska: U.S. Geol. Survey Prof. Paper 109, 251 p.

De Loriol, Percival, 1883, Om Fossile Saltvandsdyr fra Nordgrönland: Medd. om Grönland, v. 5, no. 4, p. 203–213.

McLearn, F. H., 1943, Trends in some Canadian Cretaceous species of *Inoceramus*: The Canadian Field Naturalist, v. 57, p. 36–46, 1 fig.

McLearn, F. H., and Kindle, E. D., 1950, Geology of northeastern British Columbia: Canada Geol. Survey Mem. 259, 236 p., 16 figs., maps.

Morrow, A. L., 1935, Cephalopods from the Upper Cretaceous of Kansas: Jour. Paleontology, v. 9, no. 6, p. 463–473, pls. 49–53, text figs. 1–8.

Payne, T. G. and others, 1951, Geology of Arctic Slope of Alaska: U.S. Geol. Survey Oil and Gas Inv. Map, OM–126.

Ravn, J. P. J., 1918, De marine Kridtaflejringer i Vestgrönland og deres Fauna: Medd. om Grönland, v. 56, p. 313–336, 5 pls.

Reeside, J. B., Jr., 1957, Paleoecology of the Cretaceous seas of the western interior of the United States: Geol. Soc. America Mem. 67, p. 505–542, 21 figs.

Riedel, Leonhard, 1931, Zur Stratigraphie und Faciesbildung im Oberemscher am Südrande des Beckens von munster: Preussische geol. Landesanstalt Jahrb., v. 31, p. 605–713, 8 pls., 6 text figs.

Robinson, F. M., Rucker, F. P., and Bergquist, H. R., 1956, Two subsurface formations of Early Cretaceous Age: Am. Assoc. Petroleum Geologists Bull., v. 40, no. 2, p. 223–233.

Sable, E. G., 1956, New and redefined Cretaceous formations in western part of northern Alaska: Am. Assoc. Petroleum Geologists Bull., v. 40, no. 11, p. 2635–2643.

Schlüter, Clemens, 1877, Zur Gattung *Inoceramus*: Palaeontographica, v. 24, p. 248–290, 4 pls.

Schrader, F. C., 1902, Geological section of the Rocky Mountains in northern Alaska: Geol. Soc. America Bull., v. 13, p. 233–252.

——— 1904, A reconnaissance in northern Alaska: U.S Geol. Survey Prof. Paper 20, 139 p.

Seitz, Otto, 1935, Die Variabilität des *Inoceramus labiatus* v. Schloth.: Preussische geol. Landesanstalt Jahrb., v. 55, no. 1 (für 1934), p. 429–474, 5 pls., 9 figs., 9 diagrams.

Smith, P. S., and Mertie, J. B., Jr., 1930, Geology and mineral resources of northwestern Alaska: U.S. Geol. Survey Bull. 815. 351 p.

Stolley, Ernst, 1916, Neue Beiträge zur Kenntnis der norddeutschen oberen Kreide, I–IV: Niedersächsische geol. Ver. [Hannover] Jahrb., p. 69–108, 5 pls.

Warren, P. S., 1930, New species of fossils from Smoky River and Dunvegan formations, Albert: Alberta Research Council Geol. Survey Rept. 21, p. 57–68, 5 pls.

Woods, Henry, 1911, A monograph of the Cretaceous Lamellibranchia of England, v. 2, pt. 7, *Inoceramus*: Palaeontographical Soc., v. 64, p. 261–284, pls. 45–50.

——— 1912, A monograph of the Cretaceous Lamellibranchia of England, v. 2, pt. 8, *Inoceramus*: Palaeontographical Soc., v. 65, p. 285–340, pls. 51–54.

Whittington, C. L., 1956, Revised stratigraphic nomenclature of Colville group: Am. Assoc. Petroleum Geologists Bull., v. 40, no. 2, p. 244–253.

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[Italic numbers indicate descriptions]

PLATE 15

[All figures natural size]

FIGURES 1–13. *Inoceramus* (*Inoceramus*) *dunveganensis* McLearn (p. 159)

1. Right valve, plesiotype USNM 129217. From USGS Mesozoic loc. 24268.
2. Left valve, plesiotype USNM 129218. From USGS Mesozoic loc. 24268.
3. Left valve, *I. athabaskensis* McLearn, plastoplesiotype, CGS 9811; McLearn, 1945, Paper 45–27, plate 2, figure 10. From Dunvegan formation, Monkman Pass, British Columbia.
4. Left valve, plesiotype USNM 129219. From USGS Mesozoic loc. 20475.

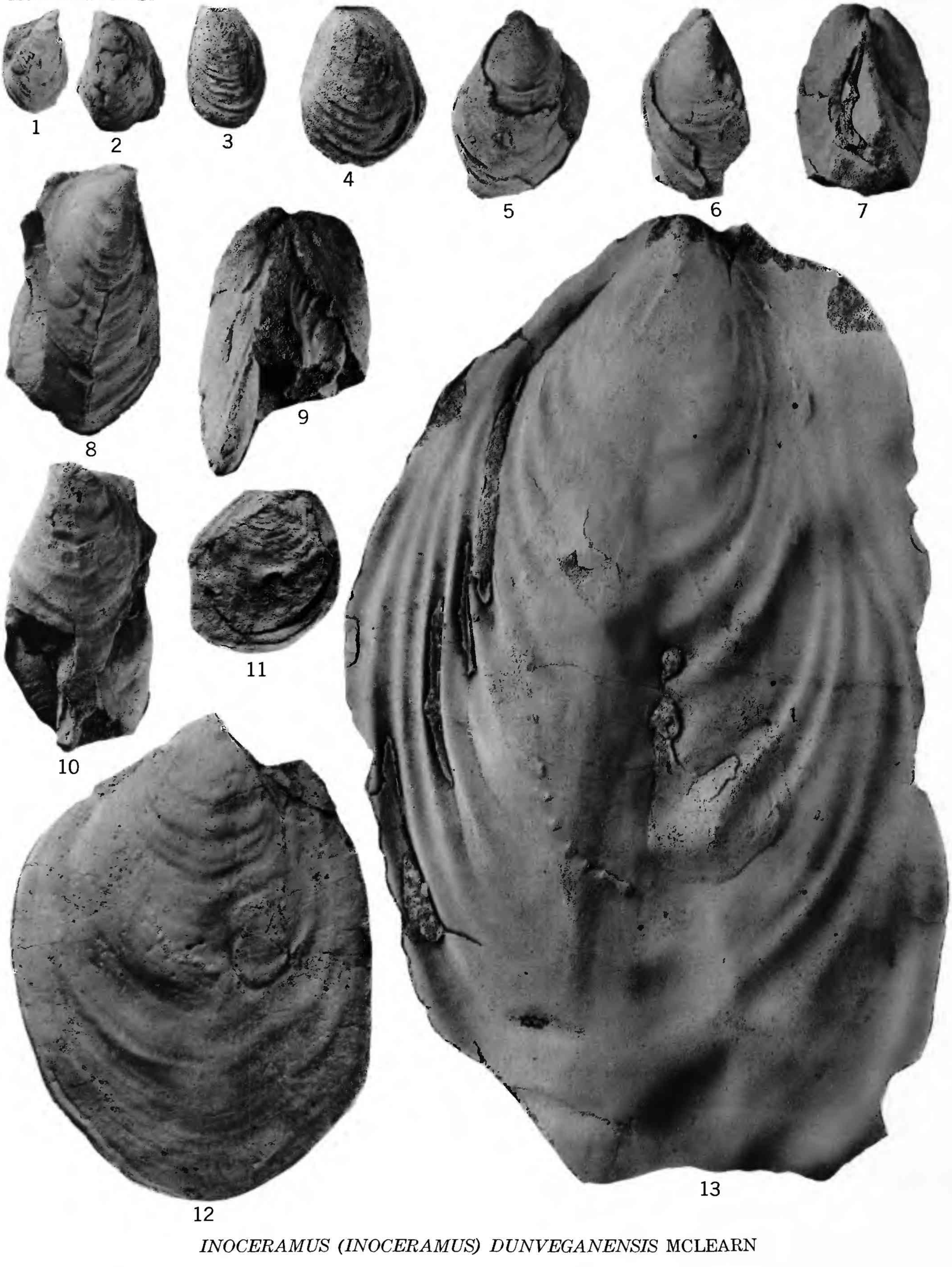
5–7. Left, right, and posterior views, plesiotype USNM 129220. From USGS Mesozoic loc. 24630.

8–10. Right, anterior, and left views, plesiotype USNM 129221. From USGS Mesozoic loc. 24630.

11. Right valve (?), *I. nahwisi* McLearn, 1944, Paper 44–17, plate 9, figure 1, CGS 9705. From Shaftebury formation, east of Cache Creek, Peace River, Alberta.

12. Left valve, *I. dunveganensis* McLearn, plastoplesiotype, CGS unfigured specimen. From Dunvegan formation, Peace River, opposite mouth of Spirit River, Alberta.

13. Left valve, plesiotype USNM 129222. From USGS Mesozoic loc. 20465.



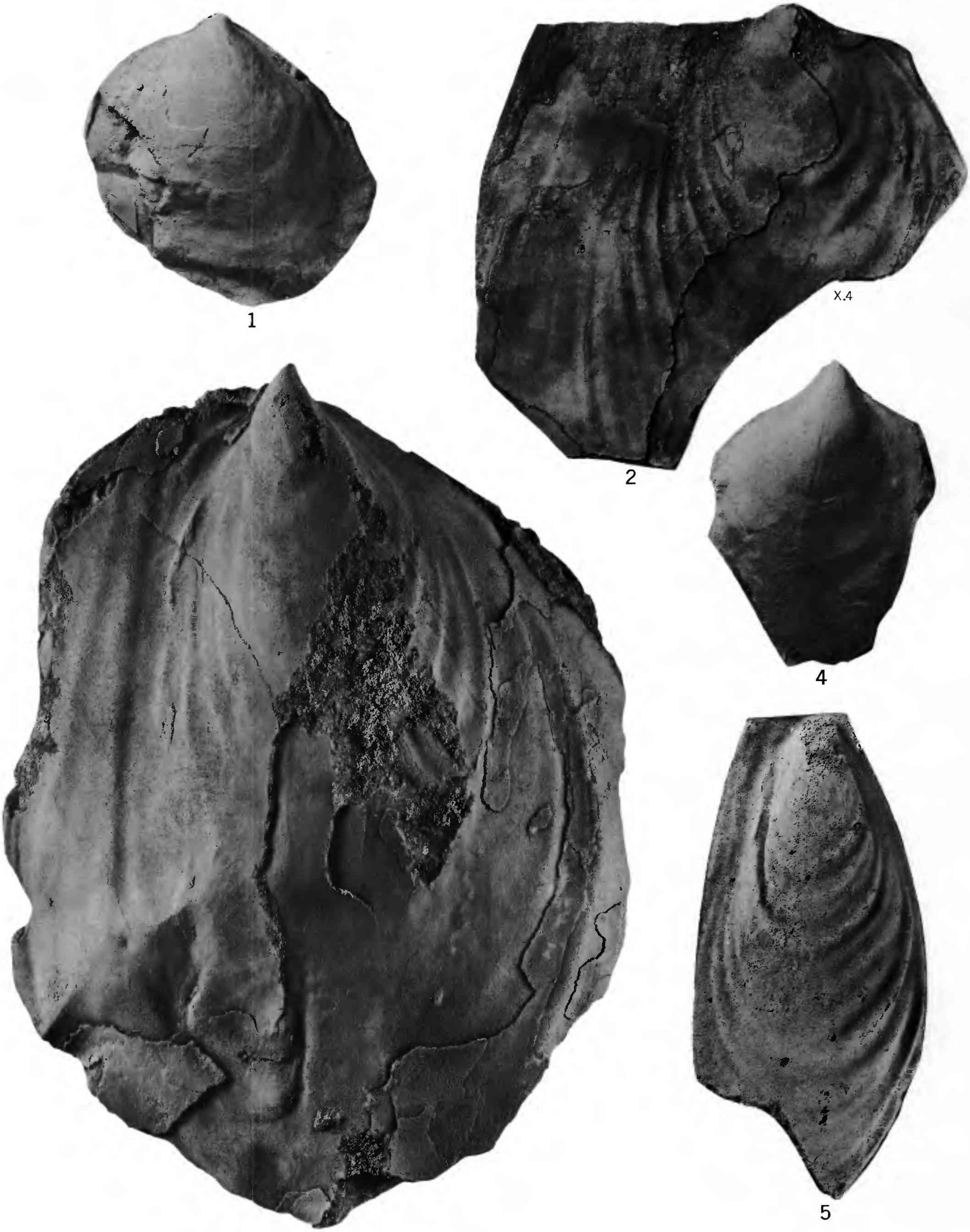
INOCERAMUS (INOCERAMUS) DUNVEGANENSIS MCLEARN

PLATE 16

[All figures natural size except as indicated on plate]

FIGURES 1–5. *Inoceramus* (*Inoceramus*) *dunveganensis* McLearn (p. 159)

1. Right valve, *I. mcconnelli* Warren, plastocotype, Univ. Alberta CT. 417. From Dunvegan formation north bank Peace River, sec. 3, T. 80, R. 3, Alberta.
2. Right valve, *I. athabaskensis* McLearn, plastoholotype, CGS 8937. From La Biche shale, Athabaska River, about 2½ miles below Stony Rapids, Alberta.
3. Right valve, plesiotype USNM 129210. From Colville River region, locality unknown.
4. Left valve, *I. mcconnelli* Warren, plastocotype, Univ. Alberta CT. 418, localtiy as in figure 1.
5. Right valve, plesiotype USNM 129213. From USGS Mesozoic loc. 20475.



INOCERAMUS (INOCERAMUS) DUNVEGANENSIS MCLEARN

PLATE 17

[All figures natural size except as indicated on plate]

FIGURES 1–5. *Inoceramus* (*Inoceramus*) *dunveganensis* McLearn (p. 159)

1. Right valve, *I. athabaskensis* McLearn, plastoparatype, CGS 8938; McLearn, 1945, Paper 45–27, plate 6, figure 1. From La Biche shale, west bank of Athabaska River, just above Stony Rapids, Alberta.
2. Right valve, plesiotype USNM 129223. From USGS Mesozoic loc. 25140.
3. Right valve, plesiotype USNM 129224. From USGS Mesozoic loc. 24271.
4. Left valve, plesiotype USNM 129225. From USGS Mesozoic loc. 20467.
5. Right valve, *I. dunveganensis* McLearn, plastoholotype, CGS 6106; McLearn, 1945. Paper 45–27, plate 4, figure 1. From Dunvegan formation, north bank of Peace River, about 6 miles west of mouth of Rivière du Brulé, British Columbia.

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INOCERAMUS (INOCERAMUS) DUNVEGANENSIS MCLEARN

PLATE 18

[All figures natural size]

FIGURES 1, 2, 4. *Inoceramus* (*Inoceramus*) *dunveganensis* McLearn (p. 159)

1. Right valve, *I. dunveganensis* McLearn, unnamed variety, plastohypotype, CGS 9816; McLearn, 1945, Paper 45–27, plate 4, figure 2.
2. Right valve, plesiotype USNM 129214. From USGS Mesozoic loc. 24271.
4. Right valve (?), *Inoceramus nahiwsi* McLearn, plastoholotype, CGS 6344; McLearn, 1944, Paper 44–17, plate 10, figure 1. From Shaftsbury formation, Peace River, British Columbia.

3. *Inoceramus* aff. *I.* (*Inoceramus*) *cuvierii* Sowerby (p. 158)

Right valve of specimen, USNM 129226. From USGS Mesozoic loc. 26533.

INOCERAMUS (INOCERAMUS) DUNVEGANENSIS MCLEARN AND *INOCERAMUS* AFF. *I. (INOCERAMUS) CUVIERII* SOWERBY

PLATE 19

[All specimens natural size]

FIGURES 1, 5. *Inoceramus* aff. *I.* (*Inoceramus*) *cuvierii* Sowerby (p. 158)

1. Right valve of specimen, USNM 129227. From USGS Mesozoic loc. 20413.
5. Left valve of specimen, USNM 129228. From USGS Mesozoic loc. 24632.

2, 4. *Inoceramus* (*Inoceramus*) *dunveganensis* McLearn (p. 159)

2. Right valve, *Inoceramus nahwisi* McLearn, var. *goodrichensis* McLearn, plastoplesiotype CGS 9713; McLearn 1944, Paper. 44–17, plate 11, figure 4. From first sandstone of the Sikanni formation, Cypress and Halfway, British Columbia.
4. Left valve (?), *Inoceramus athabaskensis* McLearn, plastohypotype, CGS 9817; McLearn, 1945, Paper 45–27, plate 5, figure 1. From Dunvegan formation, locality unknown.

3. *Inoceramus* (*Mytiloides*) *labiatus* (Schlotheim), (p. 160)

Right valve, plesiotype USNM 129229. From USGS Mesozoic loc. 24641.

6. *Inoceramus* (*Sphenoceramus*) *steenstrupi* de Loriol (p. 162)

Left valve, plesiotype USNM 129239. From USGS Mesozoic loc. 20481.

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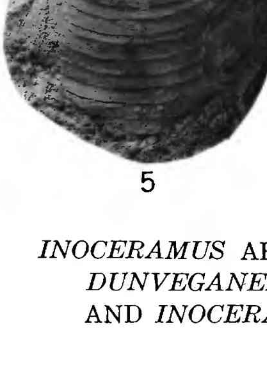

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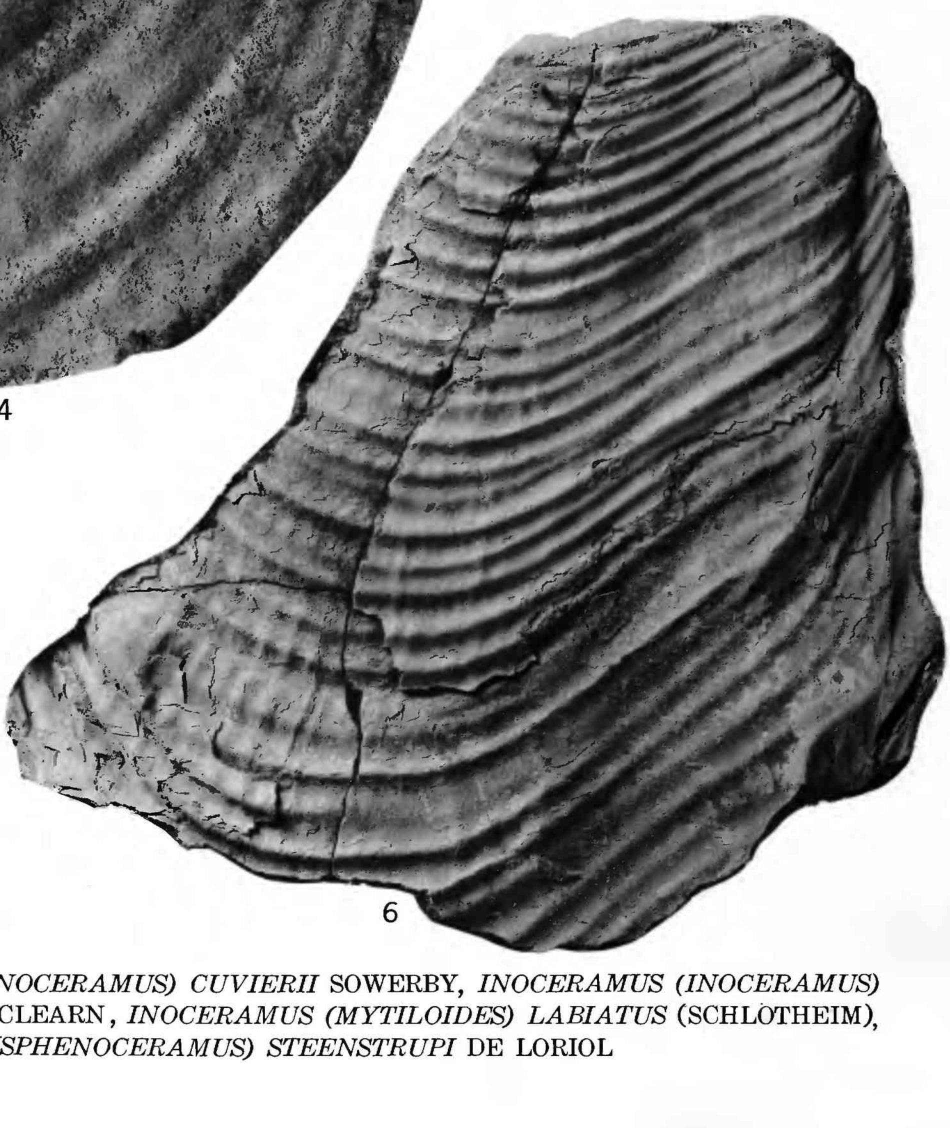

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INOCERAMUS AFF. *I. (INOCERAMUS) CUVIERII* SOWERBY, *INOCERAMUS (INOCERAMUS) DUNVEGANENSIS* MCLEARN, *INOCERAMUS (MYTILOIDES) LABIATUS* (SCHLÖTHEIM), AND *INOCERAMUS (SPHENOCERAMUS) STEENSTRUPI* DE LORIOL

PLATE 20

[All figures natural size]

FIGURES 1, 4, 5. *Inoceramus* (*Mytiloides*) *labiatus* (Schlotheim) (p. 160)

1. Right valve, plesiotype USNM 129230. From USGS Mesozoic loc. 26545.
4. Right valve, plesiotype USNM 129231. From USGS Mesozoic loc. 20420.
5. Right valve, plesiotype USNM 129232. From USGS Mesozoic loc. 24641.

2, 3, 6. *Inoceramus* (*Inoceramus*) *dunveganensis* McLearn (p. 158)

2. Right valve, plesiotype USNM 129215. From USGS Mesozoic loc. 24283.
3. Right valve, *Inoceramus dunveganensis* McLearn, plastoplesiotype, CGS 9813; McLearn, 1945, Paper 45-27, plate 2, figure 2. From Dunvegan formation, British Columbia.
6. Left valve, plesiotype USNM 129216. From USGS Mesozoic loc. 24630.

INOCERAMUS (MYTILOIDES) LABIATUS (SCHLOTHEIM) AND *INOCERAMUS (INOCERAMUS) DUNVEGANENSIS* MCLEARN

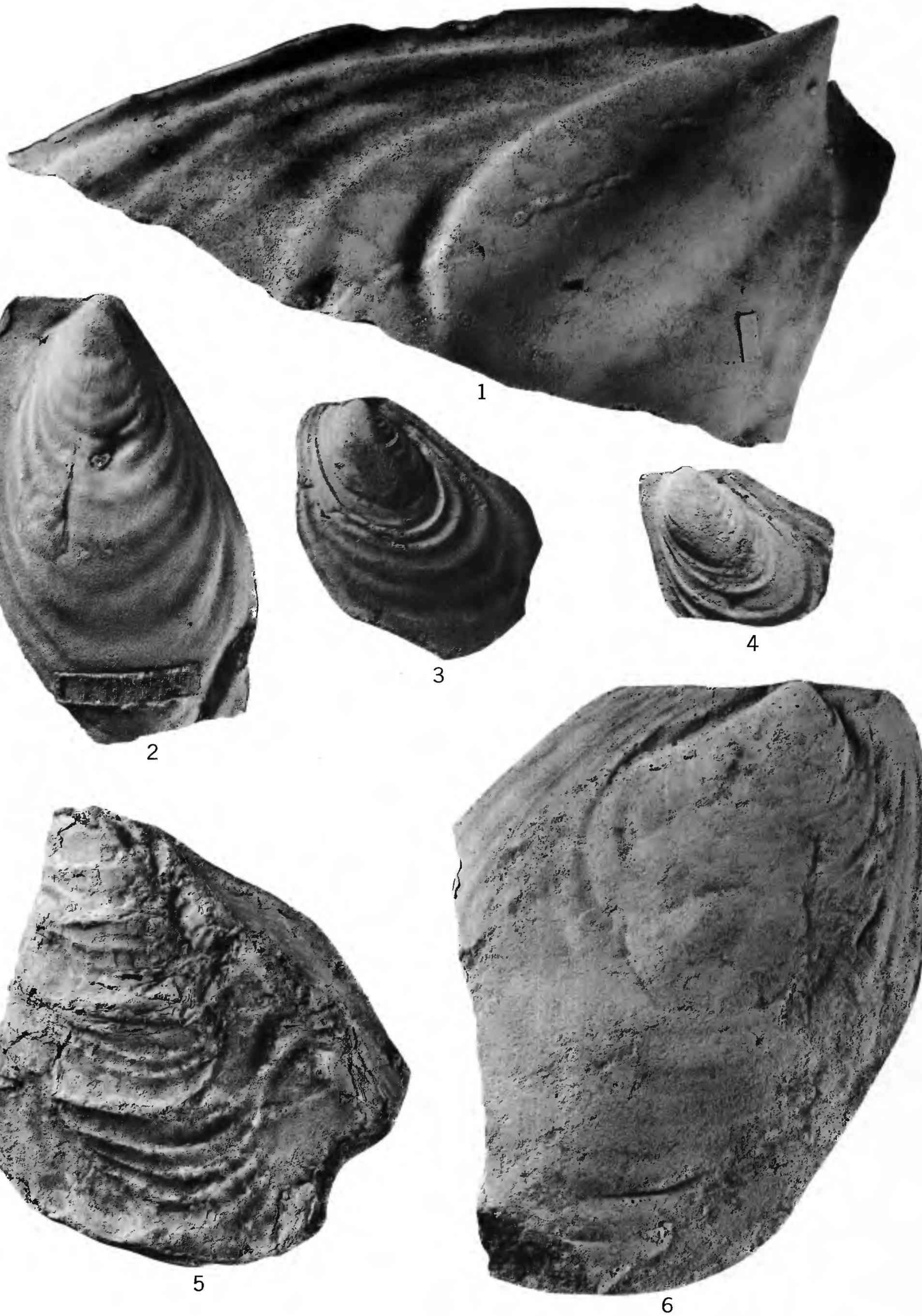
PLATE 21

[All figures natural size]

FIGURES 1–4, 6. *Inoceramus* (*Inoceramus*) *dunveganensis* McLearn (p. 158)

1. Left valve, plesiotype USNM 129211. From USGS Mesozoic loc. 20468.
2. Right valve, plesiotype USNM 129212. From USGS Mesozoic loc. 20476.
3. Left valve, *Inoceramus nahwisi moberliensis* McLearn, plastoholotype CGS 8945; McLearn, 1944, Paper 44–17, plate 10, figure 7. From the Goodrich formation, Cool Creek, south of Peace River Canyon, British Columbia.
4. Left valve, *Inoceramus nahwisi moberliensis* McLearn; unfigured plastoparatype CGS 8945; location as above.
6. Right valve, *Inoceramus nahwisi* McLearn *goodrichensis* McLearn, plastoplesiotype CGS 9710; McLearn, 1944, Paper 44–17, plate 2, figure 5. From Sikanni formation, talus in creek, Sikanni Chief River, 3 miles east of highway bridge.

5. *Inoceramus* (*Sphenoceramus*) *patootensis* de Loriol (p. 161)
Left valve, plesiotype USNM 129235. From USGS Mesozoic loc. 26498.



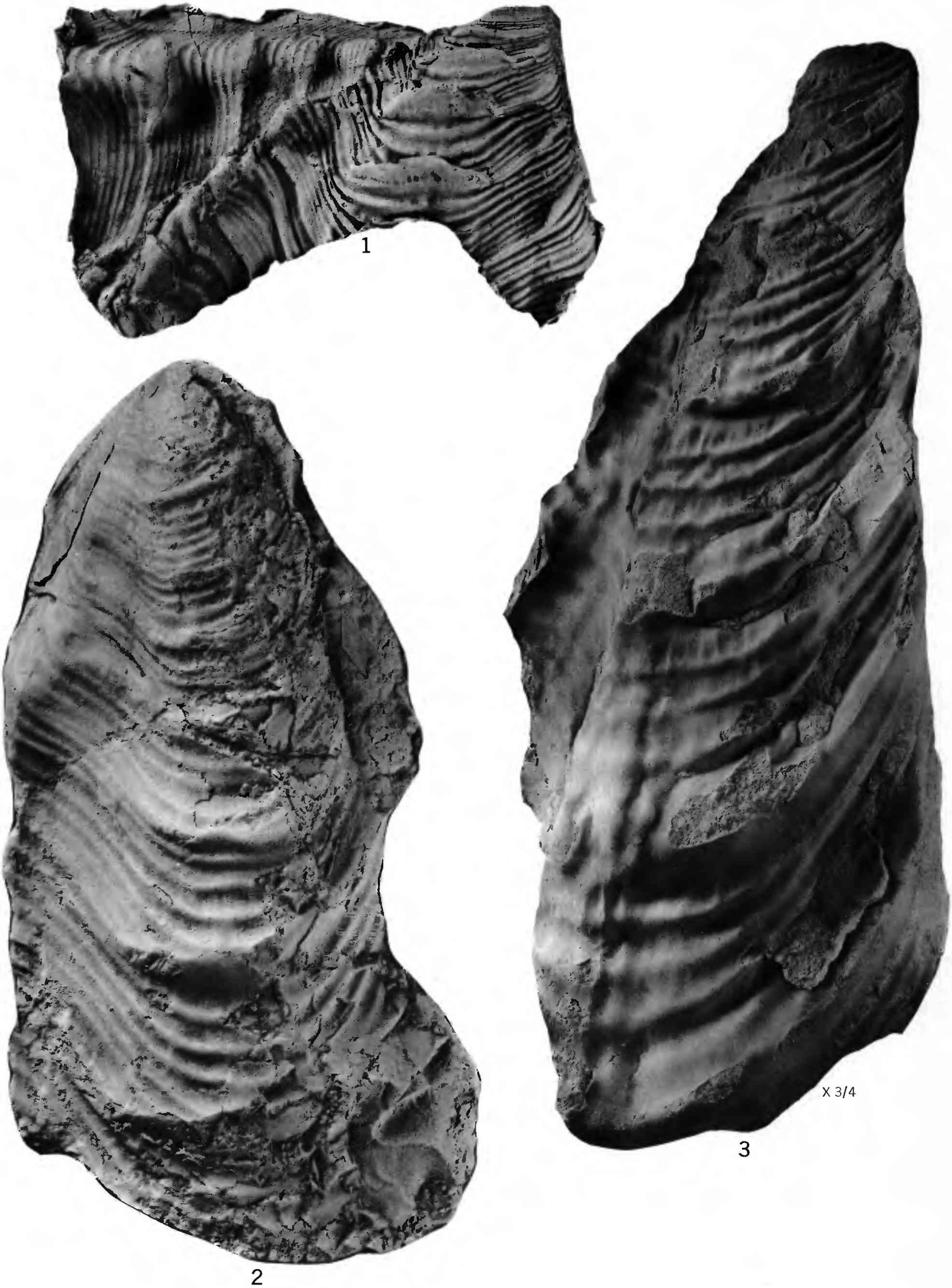
INOCERAMUS (INOCERAMUS) DUNVEGANENSIS MCLEARN AND
INOCERAMUS (SPHENOCERAMUS) PATOOTENSIS DE LORIOL

PLATE 22

[All figures natural size except as noted on plate]

FIGURES 1–3. *Inoceramus* (*Sphenoceramus*) *patootensis* de Loriol (p. 161)

1. Rubber cast of right valve, plesiotype USNM 129233. From USGS Mesozoic loc. 26509.
2. Right valve, *Inoceramus lundbreckensis* McLearn, plastoholotype, Natl. Mus. Canada 9037. From Alberta shale, 50 feet from top, Crowsnest River, Alberta.
3. Right valve, plesiotype USNM 129234. From USGS Mesozoic loc. 26509.



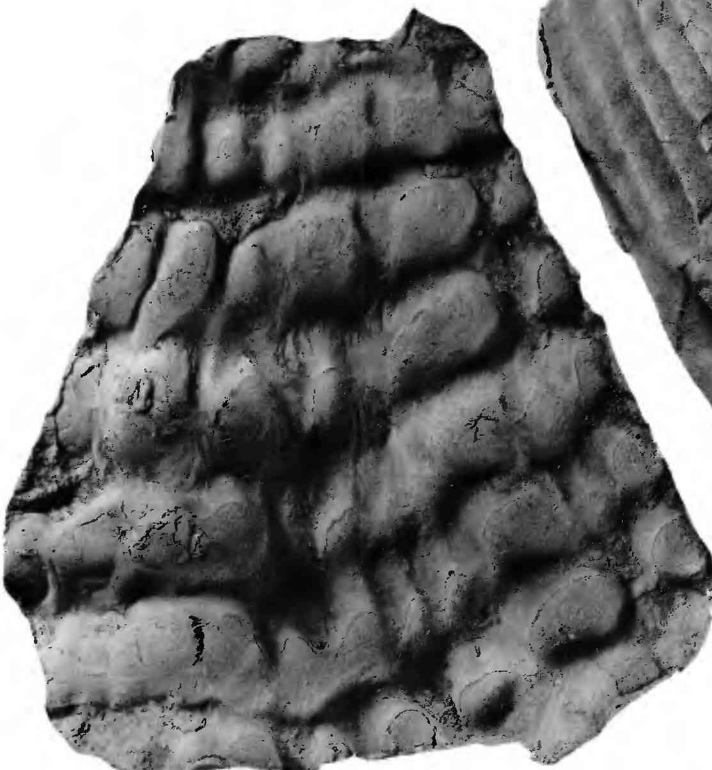
INOCERAMUS (SPHENOCERAMUS) PATOOTENSIS DE LORIOL

PLATE 23

[All figures natural size]

FIGURES 1, 2. *Inoceramus* (*Sphenoceramus*) *steenstrupi* de Loriol (p. 162)
1. Fragment, valve unknown, plesiotype USNM 129238. From USGS Mesozoic loc. 26504.
2. Right valve (?), plesiotype USNM 129237. From USGS Mesozoic loc. 20493.

3. *Inoceramus* (*Sphenoceramus*) *patootensis* de Loriol
Right valve, plesiotype USNM 129236. From USGS Mesozoic loc. 20461.



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INOCERAMUS (SPHENOCERAMUS) STEENSTRUPI DE LORIOL AND
INOCERAMUS (SPHENOCERAMUS) PATOOTENSIS DE LORIOL

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